Surgical Need & Capacity

in Low and Middle Income Countries

Reinou S. Groen

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Surgery as a public health intervention: common misconceptions versus the truth

Jin Yung Bae, Reinou S Groen & Adam L Kushner

The world's attention has recently been fo- cused on the escalation of violence in north and west Africa. Daily reports of deaths and injuries from the region have raised concerns. What is missing from the pic- ture, however, is the fact that many of these countries lack surgical capacity to treat the injured, and this inability to provide surgical care is contributing to a significant rise in the death toll. A recent World Health Or- ganization (WHO) study found that more than 90% of deaths from injuries occur in low- and middle-income countries.[1] This is not surprising, considering that the poorest third of the world's population receives only 3.5% of the surgical operations undertaken worldwide.[2] Many hospitals in these coun- tries do not have a reliable supply of clean water, oxygen, electricity and anaesthetics, making it extremely challenging to perform even the most basic surgical operations.[3]

Despite such a surgical imbalance around the world, surgery is still "the neglect- ed stepchild of global health".[4] No global funding organization focuses specifically on the provision of surgical care, and none of the major donors are willing to support and acknowledge surgery as an imperative part of global public health. This is largely due to the following common misperceptions about surgery that are not grounded in truth.

First, many people think that surgical care can only address a very limited part of the global burden of diseases and thus is of low priority. In reality, injuries kill more than five million people worldwide each year, accounting for nearly one out of every ten deaths globally.[5] Many of the victims are primary breadwinners in their households. According to a recent study, one third of injury-related mortalities affect those aged 15–44 years, the most economically productive segment of the population.[6] Moreover, the role of surgical care extends beyond treatment of injuries. Surgery is one of the key elements of pri- mary care, and includes managing traumatic joint dislocations, treating open fractures to prevent osteomyelitis and draining abscesses. It is also an essential interven- tion to limit maternal and child mortality. In a recent report, WHO estimated that approximately 260 000 deaths worldwide were caused by congenital anomalies[7] and 342 900 deaths were due to maternal mor- tality.[8] A significant portion of these deaths could have been avoided by implementing simple, cost-effective surgical care.

Second, there is a common notion that surgical care is too expensive to be implemented as part of public health interventions. However, surgery can be remarkably cost-effective, even in compari- son to non-surgical interventions that are commonly implemented as public health measures. The cost per DALY (disability- adjusted life year) of emergency obstetric care at a rural hospital in Bangladesh was $ 10.93 United States dollars (US$) per DALY averted.[9] The same measurement for all surgical care services provided by a hospital in Sierra Leone was US$ 32.78/ DALY averted.[10] This compares favourably to many other primary interventions such as vitamin A distribution (US$ 9/DALY averted), acute lower respiratory infection detection and home treatment (US$ 20/ DALY averted) or measles immunization (US$ 30/DALY averted).[9,10]

Lastly, the focus of the global health community on the issue of surgical imbal- ance has been largely confined to providing short-term relief through medical missions. While these missions have played and con- tinue to play an important role in providing immediate relief in crisis situations, they can- not substitute for a long-term investment in local health infrastructure and staff training that would allow low- and middle-income countries to develop their own long-term surgical capacity.

In short, surgery can and should be recognized as an important global health intervention. To achieve this goal, it is critical to improve the local surgical capacity in low- and middle-income countries. While the ac- complishment of this goal will not be easy it is certainly possible, especially when we join forces with providers and policy-makers that set the direction of a public health move- ment that has seen a dramatic change and increase in its authority over the past decade. As Paul Farmer, co-founder of international organization Partners in Health, recently noted, "global health need not be a competi- tive race for scarce resources…we can build a coherent movement that comes to include surgery."[3] WHO should exercise its leader- ship in advancing the status of surgical care in global health, and should organize action plans to meet the unmet surgical burdens. ■

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INTRODUCTION

INTRODUCTION

Universal access to surgical care in low and middle income countries (LMICs) is inadequate and far behind that in well developed countries. An estimated 2 billion people worldwide live practically without any access to surgical care [1]. Even in areas where some surgical facilities are present it is highly debatable that safe and adequate surgical care can, or is, provided on a continuous basis [2,3]. The consequences of this serious lack in access to surgical care for the inhabitants of LMICs is evidenced by the overwhelming statistic of 342,900 maternal deaths per year and a death rate from accidents of 5 million per year [4-6]. There is little doubt that many of these deaths could have been averted by timely surgical care. In addition to these impressive data on avoidable death rates, there is also a known growing need for cancer care, including breast and cervical cancer [7]. However, upgrading surgical care has not been part of the discussion on non-communicable diseases held by the United Nations (UN) [8,9], has only been marginally discussed in relation to maternal mortality[10], and has hardly been mentioned in relation to the rising incidence of trauma and injuries [4-6].

As mentioned in the prologue of this thesis, surgical care is conceived by various national and international agencies as an expensive investment [11]. Contrary to popular belief, recent efforts have shown that surgical care is quite competitive in terms of cost and benefit for the community. Lifesaving surgical care was calculated in an Indian district hospital to be only 10.9$ per Disability Averted Life Year (DALY) [12]. This was compared to a cost in their district of 9$ per DALY for vitamin A distribution, 30$ for breastfeeding promotion and 35$ for ORS in case of diarrhea treatment. Similar calculations were repeated in Sierra Leone in a hospital run by a Non-Governmental Organization (NGO), giving 32.78$ per DALY for surgical care while in a Cambodian trauma hospital 77.4$ per DALY for surgical care [13-14]. This indicates that cost-effectiveness studies need to be placed in the context of the facility and local economy.

Doctors, including surgeons, are seeking new means of cost saving for the care they provide, besides maintaining the DALY calculations. Active management for patients with burns, using early debridement and if needed skin-grafting, has resulted in cost-reduction in South-Africa [15], while open burn management instead of daily dressing changes has not only proven to be effective but significantly reduced costs as well [16]. In the case of hernia repairs mosquito mesh has been proven to be a safe alternative for the expensive commercial meshes [17-18]. Thus, not only has provision of appropriate surgical care in these underserved areas been effective, but has been now shown to be highly cost effective in most situations through innovation and ingenuity of the practitioners in place.

Whether surgical care is cost effective or not, surgical care plays a critical role in curative interventional medicine for many wounds, burns, bone fractures, acquired or congenital deformities, masses, swellings and especially, intra-abdominal pathologies. In addition, surgical care plays an important role in preventive care, such as primary prevention of testicular cancer in cases of ectopic testis, prevention of intestinal strangulation of an inguinal hernia as well as prevention of deformities and disabilities by providing adequate trauma care. Lastly, surgery has another vital role in secondary prevention of diseases through establishment of screening programs, including e.g. biopsies for breast masses, as well as prevention of progression of disease (tertiary prevention), as needs to be done for cancerous lesions whose timely excision prevents subsequent metastases and eventual fatalities. In the cases of placenta previa, fetal asphyxia and cephalopelvic disproportion (CPD), surgery in the form of a cesarean section is the only safe means of preventing permanent multiple disabilities and/or death in the newborn. Although there is not a single Millennium Developmental Goal (MDG) on access to surgical care, adequate access to surgical deliveries is of primary importance to achieve the MDG4 on child health and MDG5 on maternal mortality. The failure to even mention the need for surgical care to achieve the MDG goals illustrates the lack of focus of these important undertakings which needs to be corrected.

Following Farmer's pronouncement in 2008, many refer to surgery as the 'neglected stepchild of global health', on the basis of three main reasons that were identified: (1) that the global health agenda was dominated by communicable diseases, (2) that surgeons have only recently become involved in raising awareness of the importance of surgical care from a public health perspective and (3) that surgery involves an expensive initial investment [11]. Although there is a high initial investment for surgical capacity, surgically treatable conditions

appear to be a high burden for the populations in LMICs. Estimation of the surgical burden of disease in LMIC's was attempted by Debas in Chapter 65 of the 2nd edition of the Disease Control priorities in Developing countries. Results of a survey, in which physicians from all over the world were asked to estimate their daily case load related to surgical care, provided estimates of surgically treatable conditions within the health care seeking population [19]. The resultant figure of 11%, is now widely quoted as the 'burden of surgical disease' which is inaccurate since this only tells us what a physician "thinks" constitutes that part of the total burden of disease that could be surgically treated.

There is a major gap in understanding the burden of surgical disease which is partly related to the broad spectrum of diseases which can be treated surgically. The Global Burden of Surgical Disease Working Group defines surgery as '… suturing, incision, excision, or manipulation of tissue; or other invasive procedure that usually, but not always, requires local, regional, or general anesthesia.' [20] The available measurements of the global burden of surgical disease is usually reported as disease specific or originates from frequently inaccurate and sometimes fragmentary individual hospital data or from Ministry of Health Annual Reports. In 2000 a population based survey in Kenya revealed an incidence of injuries of 15,000/100,000 people per year, only counting those who attended successively a clinic or hospital [21]. A small household survey (162 households) on burns in Ethiopia, estimated a cumulative lifetime incidence of 5-11% [22]; hospital data from Eastern Africa combined with the population size resulted in a report of an estimated need for hernia repair of 175/100,000 and an incidence of strangulated hernias of 30/100,000 yearly [23]. Mock et al. have investigated road traffic injury related health problems with a population based survey in Ghana, and others have followed with the same survey for subgroups of the population or in other LMIC's [24- 26]. Based on these disease specific examples, we hypothesized that there is a major incidence of presently unrecognized and non-recorded illnesses which can be surgically treated, and that these conditions (including burns, hernias, deformities) are quite common among the general public of Sierra Leone, as well as in other low income countries.

The aims of this thesis are twofold. The first aim is to document the need for surgical care in Sierra Leone and the second aim is to determine the surgical capacity, including safety measures for health care personnel. Sierra Leone is used as an initial case study because of its long standing collaboration with Surgeons OverSeas (SOS) [27,28] and willingness on the side of individuals and the Ministry of Health and Sanitation as well as the National Statistics bureau (Statistics Sierra Leone (SSL). Sierra Leone is a small west-African country (population 6 million; area 72,000 km²) and ranks 180 of the 187 nations on the UN Development Index, with a Gross National Income (GNI) of 340 US$ per person per year and a poverty ratio of over 70% [29]. The major health indicators for Sierra Leone reveal that life expectancy at birth is 48 years, an estimated 174 per 1,000 children die before their fifth birthday, and maternal mortality rates are among the highest in the world [30].

Surgical need

In order to investigate the epidemiology of surgical needs, I developed a surgical survey tool for SOS as their Surgical Research fellow. The draft survey questionnaire was based on the following documents: 1) World Health Organization (WHO) Guidelines [31], 2) a Demographic Health Survey (DHS) [32] and 3) the survey on road traffic incidents used by Mock et al. [33]. Figure 1 illustrates the experimental design process.

The surgical conditions included in the survey were selected in order to be recognizable by lay-persons and which are in need for the greatest attention, because of their frequency and potential for treatment with available resources, and which fit best in the broader categories such as: a variety of wounds, masses, burns and congenital and acquired deformities, as well as a group of symptoms like recurrent discharge for osteomyelitis, and incontinence from urinary fistulas. A SOS Research Group was formed following the creation of an investigative tool to provide comments and suggestions for improvement of the questionnaire through e-mail correspondence. This group ultimately consisted of 46 surgeons, health experts, nurses, medical students and residents from academic and rural medical centers in 23 countries. An additional outcome of the discussions was the decision to use iPads (Apple, California) in the data collecting process. The arguments against computer assisted data entry included initial investment, need for the programming, possible breakage or theft, and the need for training; the arguments for this investment were overwhelming and included better standardization of the methodology, facilitating the collection of the data and their recording, as well as their eventual statistical

analysis and evaluations. The advantages that the use of iPad offered for better data control and conditional formatting far outweighed the risks involved. It even potentially provided for less cost for the execution of the survey since it required only limited printing and avoided the need for data-entry personnel. Most importantly, the data would be available throughout data collection, which could give instant feedback to the enumerators.

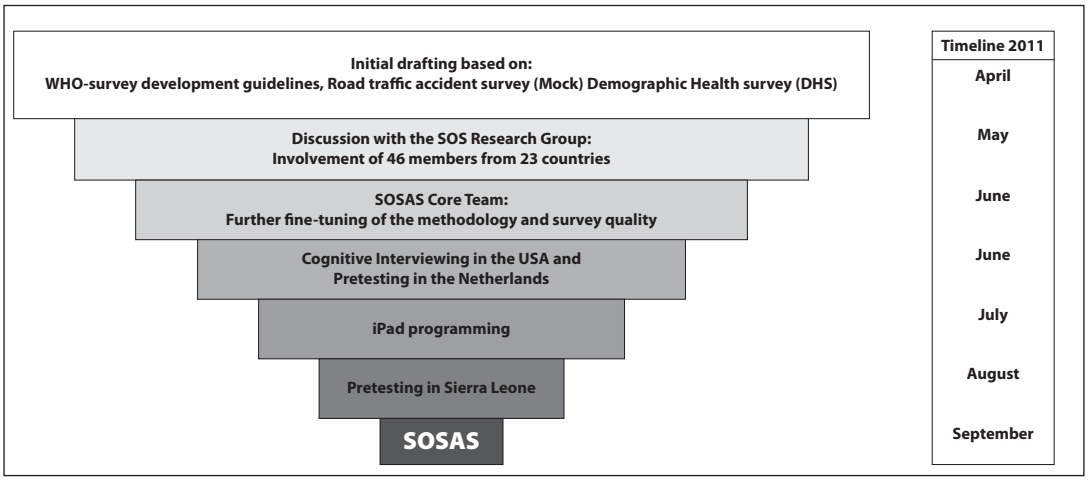

Figure 1: SOSAS (Surgeons OverSeas Assessment of Surgical Need) survey tool development and timeline.

Collaboration with the University of Virginia Center for Survey Research led to the establishment of a proper survey methodology. The survey underwent initial trials of cognitive interviewing and pre-testing prior to its use in pilot studies and its subsequent implementation. The Royal Tropical Institute in Amsterdam further sharpened the research project with comments from their ethical board and by the critical review by Statistics Sierra Leone (SSL) as well as the College Of Medicine and Allied Health Sciences (COMAHS) of Freetown Sierra Leone.

More detailed information about SOSAS and the execution as well as results of this study can be found in chapters 1 through 6. Chapter 1 discusses the pilot testing of SOSAS in Sierra Leone. The overall results can be found in Chapter 2; Chapters 3 through 5 present and discuss the results of the study in detail, with special attention focused in each on trauma (Chapter 3), specific pediatric needs (Chapter 4), and specific needs for women (Chapter 5) respectively. Chapter 6 discusses the execution and results of SOSAS conducted in Rwanda which explores the needs in Rwanda as well as confirms the reproducibility of SOSAS in another site (country) by another principle investigator and different local personnel.

Surgical Capacity

The logical sequence of investigations in regard to a national surgical care delivery system, we feel, should first address the surgical needs of the population for which we designed the SOSAS tool and applied it in 2 countries so far. Once surgical need is determined, surgical capacity can be addressed in a purposeful manner. Currently there are more published manuscripts [3, 34- 46] about the scarce surgical capacity than about surgical epidemiology. Such initial assessment of the current capacity in an area or a country may be misleading as the first step in addressing capacity building unless the need for the services in the area is first known. This approach is most likely a direct result of the more readily available tools to estimate the surgical capacity (eg. number of operating rooms, surgeons, anesthesiologists, equipment etc.) and therefore dictated by relative ease of evaluation and calculation. This may not, however, provide the needed information for what capacity is required in relation to the need for surgical services in the community or in the country.

The surgical capacity of Sierra Leone is extremely limited; one source reveals 10 local practicing surgeons and 4 fulltime medical officers who provide surgical care at government hospitals [37] while another reference describes only five registered surgeons [47] in the country; there are only 5 gynecologists serving in the governmental health care system [45]. The peri-operative specialized nursing care is also limited. Surgical relief

efforts from Non-Governmental Organizations (NGOs) that worked in Sierra Leone during or shortly after the ten year civil war (till 2002) have mostly left the country, resulting in a greater scarcity of surgical care than existed during the conflict [48-52].

In 2008 an assessment of surgical capacity of Sierra Leone was done in the 10 governmental hospitals which were designated as providers of surgical care. The initial assessment used the 'Tool for Situational Analysis to Assess Emergency and Essential Surgical Care' constructed by WHO Global Initiative of Emergency and Essential Surgical Care (GIEESC) [37]. This assessment showed a major lack of infrastructure, anesthesia materials (such as respirators and oxygen supply tanks), basic surgical equipment and lack of surgeons or surgically skilled personnel. When comparing the assessment in Sierra Leone of 2008 with hospitals in the USA during the Civil War (1861-1865), Kushner et al showed that the hospitals in USA in the mid- 19th century had better supplies and equipment than are available in the hospitals in Sierra Leone in 2008 [53].

A re-assessment of the surgical capacity of the hospitals in Sierra Leone was done in 2011 with an improved survey tool using a comparison index. Chapter 7 presents the comparison between hospitals in Sierra Leone as well trends over time in surgical capacity. Chapter 8 and 9 emphasize the current surgical capacity for the pediatric population in the light of Millennium Development Goal number 4 (MDG 4) which seeks reduction of the child mortality. Chapter 8 uses the surgical capacity survey tool and Chapter 9 analyzes this in greater detail by reviewing the surgical log books for pediatric cases in Connaught Hospital, the only tertiary hospital in Sierra Leone, where most of the pediatric surgical cases are referred. Surgical capacity includes safety of the procedures for patient and health care providers. The exposure to blood borne diseases by the scarce surgical health care workers is therefore addressed in Chapter 10, which addresses the availability in the operating rooms of protective measures like eye protection, aprons, sterile gloves, sterilizers and suction pumps. This thesis concludes with an overall discussion of our findings on key topics and their significance and suggests directions for further research.

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PART I – SURGICAL NEED

Chapter 1

Pilot testing of a population-based surgical survey tool in Sierra Leone.
Groen RS, Samai M, Petroze RT, Kamara TB, Yambasu SE, Calland JF, Kingham TP, Guterbock TM, Choo B, Kushner AL. *World J Surg. 2012;36(4):771-4.*

Abstract

Background The prevalence of surgical diseases in low income countries is thought to be very high, but to date no population-based survey has documented the need for their care. The Surgeons OverSeas Assessment of Surgical Need (SOSAS) is a survey tool programmed for use with iPads to measure the prevalence of surgical conditions.

Methods To assess the appropriateness and utility of SOSAS, a pilot test was undertaken in Sierra Leone. Local medical students were trained in sampling, interviewing, and SOSAS specifics. Five clusters of 10 households were randomly selected and 100 individuals were interviewed. Problems with the tool, iPad use, and respondent answers were collected. Daily debriefings with the enumerators aimed to identify problems and ways for improvement.

Results Administering SOSAS via iPads was found to be easy and facilitated data entry. Quick analysis of the data allowed for rapid feedback. Although the survey has 450 possible data entry points, by using conditional formatting, the enumerators were able to collect household demographics and interview two randomly selected household members in an average of 25 min. The survey methodology was acceptable, with a response rate of 96%. Five major sections were amended after the pilot.

Discussion Pilot testing of SOSAS showed that a population-based survey measuring the prevalence of surgical disease could be undertaken in a low income country. It is recommended that SOSAS be used with a larger sample size to calculate the prevalence of surgical disease in low income countries.

Pilot Testing of a Population-based Surgical Survey Tool in Sierra Leone

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Introduction

The prevalence of surgical conditions in low and middle income countries (LMICs) is thought to be very large [1, 2]; however, no formal studies have documented the presumed unmet need.

To document this unmet need, Surgeons OverSeas (SOS) developed the Surgeons OverSeas Assessment of Surgical Need (SOSAS). The draft of SOSAS was initiated by combining elements of the World Health Organization guidelines for conducting community surveys on injuries and violence [3], demographic health surveys [4], and a survey on road traffic incidents developed by Mock et al. [5] with additional items on maternal, congenital, neoplastic, and infectious surgically treatable conditions. An initial version was then completed via consensus agreement among 46 members of the SOS Research Group, and validation was initiated with cognitive interviewing in the United States with recent African immigrants, and by pretesting the tool with five individuals in the Netherlands and four individuals in Sierra Leone. The tool was programmed with FileMaker Pro for data entry through iPads.

In order to plan for a countrywide survey to accurately assess the prevalence of surgical conditions with a large sample size, it was first decided to pilot test the survey. Given the long-standing relationship between SOS and surgeons at Connaught Hospital and the Ministry of Health and Sanitation (MOH&S) in Sierra Leone [6, 7], a decision was made to execute the pilot testing in and around Freetown, the capital. Sierra Leone is a small West African Country with a documented lack of surgical capacity [8] where it is expected to have a huge backlog of untreated surgical conditions.

Methods

In Sierra Leone, two medical students (one male, one female) from the Sierra Leone College of Medicine and Allied Health Sciences (COMAHS) were recruited and underwent 3 days of training in questionnaire content, interview techniques, sampling strategies, and iPad use. Translational aspects of the survey were discussed in detail with an experienced enumerator from Statistics Sierra Leone (SSL), the official national statistics bureau. As there are multiple languages in Sierra Leone, a decision was made to keep the survey in English and have the medical students translate into Krio, the lingua franca of Sierra Leone, or if needed find a local translator.

Prior to execution, Institutional Review Board (IRB) approval for the pilot was obtained from the University of Virginia medical Human Subjects Committee, with additional approval from the Directorate of Training, Non-Communicable Diseases, and Research of MOH&S of Sierra Leone.

Ten households in five different clusters were randomly selected in the Freetown area. The enumerators then approached household representatives to collect household demographic data and information on household member deaths. Subsequently two household members were randomly selected and interviewed. The interview consisted of questions to the household representative about the number of persons living in the household (household denominator), household means for transportation to health facilities, and household deaths in the previous 12 months. The interviews for the two randomly selected individuals of the household consisted of general health questions followed by detailed questions about surgical conditions covering distinct body sections: head/face and neck, chest and breast, back, abdomen, groin, and—lastly—extremities. For the females, detailed questions about their menstrual cycle were included.

All the questions for the different body sections were standardized. The first question asked was if there was any problem in the designated anatomical area. If there was, specific questions were asked regarding the problem. The answer options were standardized like: wounds, masses, deformities, or other issues, depending on the anatomical location. This series of questions was followed by specific questions about the cause of the problem, whether the problem was still present, and whether treatment had been sought and received. If no surgical care was obtained for a specific problem, a follow-up question was asked regarding reasons why not. The last question of each section was whether the condition was disabling. All questions in the survey were categorized, and to facilitate data processing, no open-ended questions were asked.

The iPad programming included automatic timestamps for analyzing the time the interviewers needed to complete each interview. The enumerators kept notes regarding the response rate of the people being questioned; they also noted whether individuals were not present at the time of the survey and needed to be revisited. Informed consent was obtained from all interviewees.

Daily debriefings were conducted with the two enumerators in an effort to identify problems and to assess the quality of the data collected. To better understand the administration of the survey questions, the logistics of choosing households, and ways of identifying possible problems with the survey, one author (R.G.) spent one day with the enumerators and collected data on eight households and the randomly selected individuals for interview.

Data were downloaded daily and analyzed. Enumerators were provided with immediate feedback, and issues with the questions or the survey were recorded.

Results

The pilot testing of SOSAS was easily completed over 3 days. Of the 100 attempted interviews, 96 individuals agreed to complete the survey, for a response rate of 96%. Of the 50 households visited, 10 required revisiting because individuals selected for interview were not present at the time of the initial visit. One household was replaced because a household representative was not available. Of the four individuals who were not interviewed, three were not present after interviewers attempted to revisit the household, and one refused to participate. Household sizes ranged from 2 to 25 members, which immediately prompted the need to increase the number of data positions for the household denominator from the initial 20 to 30.

Analysis of the time stamp data showed that, on average, household data were collected in 11 min (range: 3–28 min) and that the individual data could be collected in 7 min (range: 2–15 min). This results in an average household visit of 25 min, which included the time for interviewing both the household representative and the two randomly selected household members. The range in the time needed for an interview was closely linked to the total number of household members and the number of surgical treatable conditions reported by the respondent.

The two enumerators expressed confidence that 3 days of training was sufficient for them to administer the survey and use the iPad. 3 days was also sufficient to undertake the pilot; however, help with the survey was provided on one day by one of the authors (R.G.).

The data were downloaded each evening from the iPads into an Excel spreadsheet (Microsoft, Redmond, WA) for later analysis. A quick analysis using the limited sample size identified 14 (14.6%) respondents as reporting a surgically treatable condition; however, seven of those identified reported also that they did not have a need for surgical care (e.g., the condition was minor or not bothering the person, or after a hospital consultation an operation was not deemed necessary). The other 7 (7.3%) respondents were thought to be in need of a consultation and possibly an intervention. Of the 7 respondents who had a condition that would need surgical attention, 4 had a swelling/mass in the groin/genitalia area; 2 had a wound (one in the face/head/neck area one on the lower leg), and one had a burn in the groin/genitalia area. These conditions could represent hernias, wounds, or cancer.

Nine households (18%) reported a death of a household member in the previous 12 months and two (22%) of these deaths may have been prevented with surgical intervention: a 22-year-old man who died en route to a hospital after a road traffic injury and a 54-year-old male with suspicion of an esophageal malignancy.

Based on the debriefings of the enumerators and issues with the survey, five major changes were made to the questionnaire: (1) more data-entry possibilities for the household denominator were added; (2) the questions for means of transportation were revised to include questions on transport waiting time, available means of transportation, and the amount of money needed; (3) a free response space was added to record specific information about the (surgical) household deaths to aid in the assessment of the classification of the cause of death; (4) the questions about timing of the surgical problem were adapted to allow calculation of acute and chronic conditions separately; and (5) for the anatomical location classified as face/head/neck, subdivisions of eye, ear/nose/throat, dental/lips/mouth, neck and head were added.

A final version of SOSAS in .pdf format reflecting the changes made after the pilot testing is available on the resources page of the SOS website at: www.surgeonsoverseas.org. Other versions in .doc or .fmp format are available from the corresponding author.

Discussion

The pilot testing of SOSAS was successfully completed in Sierra Leone and showed that a population-based survey documenting the prevalence of surgical conditions in a developing country could be undertaken. The survey methodology, use of iPads, using medical students as enumerators, and logistics were successful, but it must be stressed that assistance of local colleagues from Connaught Hospital, the MOH&S, and SSL was essential.

The 3 days of training was adequate to familiarize the enumerators with the survey questions and with the iPad, but it was recognized that having medical personnel undertake such a survey is an important point to consider. Although there was no physical exam component to the survey, using medical students was helpful in the categorization of the answers. Of note, though, there was a steep learning curve once enumerators began data collection in the field and possibly a longer training time would be warranted, especially if a larger group is going to be trained.

The use of computers in face-to-face interviews, known as computer-assisted personal interviewing (CAPI) is well established, but the use of the iPad as a CAPI tool in a non-Western setting has not often been attempted [9]. The use of the iPad was very helpful in conducting the interviews in that they visually simulated paper forms and were lightweight and easy to handle, especially when it was necessary to skip a section of the survey or to return to a question to add additional relevant information that the respondent remembered later in the interview. Data entry problems

decreased as the students were exposed to more interviews, but accuracy was also enhanced by the conditional formatting, which automatically skipped questions that became irrelevant due to earlier answers. The enumerators also reported that the high-tech method of data collection did not appear to cause difficulty or unease on the part of respondents, either in the urban or rural clusters.

Data confidentiality was secured by the use of automatic locks and PIN numbers known only to the enumerators. In the case of loss or theft of the device, an application "Find My iPad" was installed on each iPad that would allow for remote tracking and even remote deletion of any data. It is for this reason that the 3G version of the iPad is recommended, in which a local SIM card can be inserted and the local telephone network can be used.

The timestamps in the programmed survey helped in calculating the approximate time needed to conduct the interviews and will be helpful in planning full country surveys. It is important to recognize, though, that although household surveys resulted in an average of 25 min per household, additional time was spent in initial greetings, introductions, and explanations to village leaders, as well as identification of the household representatives before entering the household and starting the formal consent. It was only after consent was obtained that the timing of the interview was initiated. It was also felt that timestamps would be useful in detecting fraud if data were entered too rapidly, which was not an issue during the pilot testing. iPad use also facilitated data analysis, which allowed for almost instantaneous feedback.

Drawbacks of the use of the iPad must also be considered. Their initial cost is high, and there was a significant investment of time for programming. However these investments are partially returned by not having to print surveys and not needing to spend resources and time for data entry. The battery life was found to be sufficient for two full interview days, which was fine for the interviewing in and around Freetown, but backup was needed when visiting remote locations.

The surgical conditions identified by SOSAS do not provide a definitive diagnosis but rather descriptions of probable surgical problems identified by non-medical populations in urban and rural settings in Sierra Leone. Although definitive diagnoses cannot be made, the survey results do indicate at a minimum the need for a surgical consultation, and they probably underestimate the unmet need for surgery due to a lack of screening for cancer.

It was recognized that having SOSAS validated with a physical exam component would strengthen the tool; however, this step will require a more intrusive study which will require better educated medical personnel. Furthermore such a validation study will require different logistics and appropriate ethical approvals and informed consent.

Conclusions

The SOSAS pilot testing was successfully conducted in Sierra Leone and showed that a population-based survey could be accomplished in a LMIC setting. Data from the pilot helped to make SOSAS a stronger tool. The use of the iPad was found to be useful in the data collection and handling and was easily learned by local enumerators. It is hoped that full country surveys will be conducted using the SOSAS tool to measure the prevalence of surgical conditions.

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Conflict of interest None of the authors is funded for their contribution. Surgeons OverSeas (SOS) assisted the logistics and payment of enumerators and transportation with funding from private contributions. MOHS contributed with local transportation and administrative assistance.

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Chapter 2

Untreated surgical conditions in Sierra Leone: a cluster randomised, cross-sectional, countrywide survey.

Groen RS, Samai M, Stewart KA, Cassidy LD, Kamara TB, Yambasu SE, Kingham TP, Kushner AL *Lancet. 2012;380(9847):1082-7.*

Abstract

Background Surgical care is increasingly recognised as an important part of global health yet data for the burden of surgical disease are scarce. The Surgeons OverSeas Assessment of Surgical Need (SOSAS) was developed to measure the prevalence of surgical conditions and surgically treatable deaths in low-income and middle-income countries. We administered this survey countrywide in Sierra Leone, which ranks 180 of the 187 nations on the UN Development Index.

Methods The study was done between Jan 9 and Feb 3, 2012. 75 of 9671 enumeration areas, the smallest administrative units in Sierra Leone, were randomly selected for the study clusters, with a probability proportional to the population size. In each cluster 25 households were randomly selected to take part in the survey. Data were collected via handheld tablets by trained local medical and nursing students. A household representative was interviewed to establish the number of household members (defined as those who ate from the same pot and slept in the same structure the night before the interview), identify deaths in the household during the previous year, and establish whether any of the deceased household members had a condition needing surgery in the week before death. Two randomly selected household members underwent a head-to-toe verbal examination and need for surgical care was recorded on the basis of the response to whether they had a condition that they believed needed surgical assessment or care.

Results Of the 1875 targeted households, data were analysed for 1843 (98%). 896 of 3645 (25%; 95% CI 22·9–26·2) respondents reported a surgical condition needing attention and 179 of 709 (25%; 95% CI 22·5–27·9) deaths of household members in the previous year might have been averted by timely surgical care.

Discussion Our results show a large unmet need for surgical consultations in Sierra Leone and provide a baseline against which future surgical programmes can be measured. Additional surveys in other low-income and middle income countries are needed to document and confirm what seems to be a neglected component of global health.

Untreated surgical conditions in Sierra Leone: a cluster randomised, cross-sectional, countrywide survey

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See Comment page 1040

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Summary

Background **Surgical care is increasingly recognised as an important part of global health yet data for the burden of surgical disease are scarce. The Surgeons OverSeas Assessment of Surgical Need (SOSAS) was developed to measure the prevalence of surgical conditions and surgically treatable deaths in low-income and middle-income countries. We administered this survey countrywide in Sierra Leone, which ranks 180 of the 187 nations on the UN Development Index.**

Methods **The study was done between Jan 9 and Feb 3, 2012. 75 of 9671 enumeration areas, the smallest administrative units in Sierra Leone, were randomly selected for the study clusters, with a probability proportional to the population size. In each cluster 25 households were randomly selected to take part in the survey. Data were collected via handheld tablets by trained local medical and nursing students. A household representative was interviewed to establish the number of household members (defined as those who ate from the same pot and slept in the same structure the night before the interview), identify deaths in the household during the previous year, and establish whether any of the deceased household members had a condition needing surgery in the week before death. Two randomly selected household members underwent a head-to-toe verbal examination and need for surgical care was recorded on the basis of the response to whether they had a condition that they believed needed surgical assessment or care.**

Findings **Of the 1875 targeted households, data were analysed for 1843 (98%). 896 of 3645 (25%; 95% CI 22·9–26·2) respondents reported a surgical condition needing attention and 179 of 709 (25%; 95% CI 22·5–27·9) deaths of household members in the previous year might have been averted by timely surgical care.**

Interpretation **Our results show a large unmet need for surgical consultations in Sierra Leone and provide a baseline against which future surgical programmes can be measured. Additional surveys in other low-income and middle-income countries are needed to document and confirm what seems to be a neglected component of global health.**

Funding **Surgeons OverSeas, Thompson Family Foundation.**

Introduction

Although global health efforts increasingly emphasise health-system strengthening, the surgical needs of populations are frequently neglected.[1,2] Safe and appropriate surgical care is needed to decrease maternal mortality; improve the health of women and children; treat congenital deformities; diagnose, treat, and palliate cancer; and care for people who are injured.[3] Globally, improvement of surgical care is needed to save substantial numbers of lives and reduce or avoid permanent disabilities.[4]

The actual prevalence of surgical conditions is unknown. In its place, estimates of the burden of surgically treatable diseases in low-income and middle-income countries rely on rough approximations and extrapolations from short surveys of physicians, data from high-income countries, or hospital registries.[4–7] These estimates have helped to raise awareness of the surgical need of populations, but have rarely been robust enough to stimulate development of large countrywide surgical programmes. They have also not been suffcient to firmly convince donors of the magnitude of surgically treatable conditions or to provide policy makers and ministries of health with the requisite data needed to plan interventions. To address these deficiencies, calls for community-level research to quantify the surgical need of populations have been repeatedly voiced.[8–10]

In an effort to measure the prevalence of surgical conditions and to identify deaths potentially preventable with surgical care, the Surgeons OverSeas Assessment of Surgical Need (SOSAS) was developed for use in low-income and middle-income countries. SOSAS is a population-based household survey that was developed collaboratively by an international group of experts and piloted in Sierra Leone.[11] We aimed to establish the countrywide prevalence of surgically treatable conditions and potentially preventable deaths in a low-income country by administering the survey in Sierra Leone.

Methods

Setting

Sierra Leone is a small west African country (population 6 million; area 72 000 km²) and ranks 180 of the 187 nations on the UN Development Index.[12] Health indicators for Sierra Leone are indicative of scarce access to health care: life expectancy at birth is 48 years, an estimated 174 per 1000 children die before their fifth birthday, and maternal mortality rates are among the highest in the world.[13] Sierra Leone was chosen for

the implementation of SOSAS because of the long-standing collaboration between Surgeons OverSeas and surgeons and the Ministry of Health and Sanitation in the country.[14]

Study design

The total sample size was estimated to be 3745 individuals based on $n=Z^2p(1–p)/L^2$, where L is accepted range around the estimated prevalence of the disorder (1%), Z is CI (95%–Z is 1·96), and p is (estimated) prevalence of the condition (7·3%). Estimated prevalence was established in a pilot study of the same survey in Sierra Leone in August, 2011, when 95% of the targeted population were eligible, and the same proportion responded.[11] The calculated sample size was multiplied by a small design-factor of 1·3, assuming that surgical conditions are not very clustered. 75 of 9671 enumeration areas, the smallest administrative units in Sierra Leone, were randomly selected for the study clusters, in two-stages with a probability proportional to population size after stratification for districts and urban and rural population distribution. The sample was self-weighted by randomly selecting 25 households in each cluster.[15] Random selection of households and individuals was done on the basis of principles established for countries without full population registries.[15,16] This method includes a first structure count (house count) of the enumeration area and thereafter random assignment of the structures. If more than one household was living in a house, an extra listing was made. Random assignment of the house- holds was done with a random calculator. Household members were defined as those who ate from the same pot and slept in the same structure the night before the interview. The same definition is used for the Demo- graphic and Health Survey in Sierra Leone.[17] Deceased individuals were judged to be household members if they were mainly eating from the same pot and sleeping in the same household in the year before they died.

Procedures

The study was done from Jan 9 to Feb 3, 2012. Students from the Sierra Leone Faculty of Nursing and Sierra Leone College of Medicine and Allied Health Sciences and staff from Statistics Sierra Leone were trained to be enumerators. The appendix shows the instruction

Figure: **Distribution of cluster points**

	SOSAS	DHS*
Household data		
Respondents	1843/1875 (98%)	89%
Urban	715/1843 (39%)	34%
Rural	1128/1843 (61%)	66%†
Male household head	1253/1843 (68%)	78%
Mean household size (SD)	6·4 (5·3)	5·9
Individual data		
Respondents	3645/3686 (99%)	93%‡
Males	1677/3645 (46%)	49%
Females	1968/3645 (54%)	51%
Median age (range)	20 (0 to 100)	<19 (0 to >80)
Ethnic origin		
Mende	1309/3645 (36%)	33%§
Temne	1035/3645 (28%)	33%§
Other	1301/3645 (36%)	33%§

Data are n/N (%) unless otherwise specified. SOSAS=Surgeons OverSeas Assessment of Surgical need. DHS=Demographics and Health Surveys. *Data from 7284 households and 10 654 individuals, exact numbers for each measure are not available. †Calculated from tables 2.5.1 and 2.5.2 of the 2009 DHS. ‡Calculated on the basis of male and female response rates. §Approximate values.

Table 1: **Comparison of SOSAS and DHS (2009)[18] data**

	n (%)
Acquired deformity	443 (28%)
Mass (hard and soft)	423 (27%)
Abdominal distension or pain	190 (12%)
Wound (injury related)	179 (11%)
Wound (not injury related)	125 (8%)
Burn	86 (5%)
Congenital deformity	47 (3%)
Urological complaints	32 (2%)
Bleeding from rectum	24 (2%)
Obstructed delivery	22 (1%)
Recurrent discharge from arms, hands, legs, or feet	7 (<1%)
Missing	7 (<1%)
Total	1585

Percentages do not sum to 100 because of rounding.

Table 2: **Reported conditions in need of surgical care**

manual for enumerators. Data were collected with handheld tablets. The SOSAS survey (appendix) consists of two parts and has been previously described.[11] The first part is administered to a household representative to establish the number of household members, identify deaths in the household during the previous year, and establish whether any of the deceased household members had any of the following conditions in the week before their death: abdominal distension or pain; bleeding or illness during childbirth; injury; mass, growth, or swelling; acquired deformity; or a wound not due to injury or congenital deformity. The second section consists of structured interviews of two randomly selected household members who undergo a head-to-toe verbal examination covering six anatomical regions: face, head, and neck; chest and breast; abdomen; groin, genitals, and buttocks; back; and arms and hands and legs and feet.

The need for surgical care was recorded on the basis of an individual's response to whether they had a wound, burn, mass, deformity, or other condition needing surgical assessment or care—ie, the respondent decided whether or not they felt they needed surgical care. A surgical procedure was defined as: wound care, suturing, incision, excision, or other manipulation of tissue, in a safe and painless way.[18] Procedures were deemed major if they required regional or general anaesthesia and minor if they required local anesthetics or none. Although local enu- merators received a stipend, none of the researchers (local and international) received any payment and respondents were not paid.

Collected data were screened every day by the field supervisors and immediate feedback was given to the enumerators; RG gave overall feedback and supervision. Final assessment of the full database was done after data collection to identify inconsistencies and missing items. When clarification by the enumerators was not possible, inconsistent data were coded as missing.

The study was approved by the Sierra Leone Ministry of Health and Sanitation and ethics approval was obtained from the Ethics and Scientific Review Committee of Sierra Leone and the Research Ethics Committee of the Royal Tropical Institute in Amsterdam, Netherlands. Written informed consent was obtained from all respondents, but if the respondent was illiterate, a thumb-print with an additional signature from a literate witness was obtained. For individuals younger than 18 years, a parent or guardian provided written consent.

Statistical analysis

We analysed data with PROC survey logistic, with SAS (version 9.3). Univariate analyses were done and significant variables were included in a multivariable logistic regression model to predict present surgical need (yes or no). Univariate associations were analysed with χ^2 tests for contingency tables, t tests for normally distributed data, and the Mann-Whitney U test for skewed data. All tests were two-tailed.

Role of the funding source

All authors had access to the complete data file; RSG, MS, TBK, and ALK made the decision to submit for publication. The Thompson Family Foundation did not have any role in data collection or analysis, or writing of the manuscipt. Volunteers from Surgeons OverSeas wrote the study protocol, executed the study, and wrote the report, but did not receive any funds for this work.

Results

The figure shows the cluster distribution. 74 of the randomly selected clusters were located and confirmed by global positioning system coordinates. One cluster could not be located and was replaced with a village in the same chiefdom (Kenema district). Of the 1875 total targeted households, we analysed data for 1843 (98%). Data from 25 households were excluded because of inconsistencies, five households had too much missing information (ie, surveys that were not completed to the end of the form, or for which essential data for cluster number, age, and sex were missing), and two households refused to give consent.

In each household, we attempted to interview two household members; thus after the exclusions, the total expected number of interviews was 3686. However, in 41 households (1%), only one household member was interviewed, giving a total of 3645 respondents (table 1). Most (1696) household interviews were completed on the initial visit. 132 households needed two visits and 15 households needed three visits. Of selected household members, 149 (4%) were replaced because the individuals initially chosen were not available for interview even after several revisits. Table 1 shows household characteristics and demographic data for respondents.

Of the 3645 respondents, 1352 (37%; 95% CI 34·8–39·4) indicated that they had a wound, burn, mass, growth, deformity, or other surgical condition at the time of the interview and 896 (25%; 22·9–26·2) indicated that they were in need of surgical care. Because respondents could report having more than one surgical condition, a total of 1585 conditions were reported at the time of the interview (table 2). The anatomical regions with the greatest number of reported conditions were abdomen; head, face, and neck; and arms, hands, legs, and feet (table 3).

575 (31%) households reported at least one household member dying in the previous year, with 709 deaths overall. With the total household members (11 870) as denominator, the crude death rate was 59·7 per 1000 population per year. On the basis of conditions remembered as being present in the week before death, 237 (33%) deaths were associated with one of the seven conditions that we classified as those that might have benefited from surgical care (table 4). Abdominal distension and pain, problems during childbirth, and injury were the most common conditions recalled as occurring before death (table 4). However, of these 237 deaths, household representatives suggested that for 58 there was no need for a surgical intervention, resulting in 179 (25%; 95% CI 22·5–27·9) deaths for which the deceased individual might have benefited from surgical care.

For the multivariable analysis, urban residency was highly associated with literacy (data not shown), therefore we excluded literacy from the model. Female gender, age older than 45 years, illness in the past year, and urban residency were the reference populations for comparisons. Males were more likely to report a present need for surgical care than were females (appendix; odds ratio [OR] 1·48, 95% CI 1·3–1·7), and respondents in each age group younger than 45 years were significantly less likely to be in need of surgical care than were older respondents (appendix; <5 years OR 0·28, 95% CI 0·21–0·39; 5–15 years 0·38, 0·30–0·48; 15–45 years 0·66, 0·54–0·80). Individuals who reported not being ill in the previous year were also less likely to report a present surgical need than were those who had been ill (appendix; OR 0·37, 95% CI 0·31–0·44). Individuals living in a rural area were more likely to need surgical care than were urban residents (appendix; 2·29, 1·9–2·7).

	n (%)
Abdomen	392 (25%)
Head, face, neck	337 (21%)
Arms, hands, legs, and feet	335 (21%)
Groin, genitals, buttocks	227 (14%)
Chest, breast	157 (10%)
Back	137 (9%)
Total	1585

Table 3: **Anatomical location of conditions needing surgical care**

	n (%)
Abdominal distention or pain	98 (41%)
Bleeding or ill during childbirth	42 (18%)
Injury	41 (17%)
Mass, growth, or swelling	21 (9%)
Acquired deformity	18 (8%)
Wound not due to an injury	10 (4%)
Congenital deformity	7 (3%)
Total	237

Five participants had missing values.

Table 4: **Conditions of deceased household members that might have benefited from surgical care, recalled as occurring in the week before death**

Discussion

Administration of SOSAS in Sierra Leone shows a high prevalence of untreated surgical conditions. 25% of respondents had a condition possibly needing surgical attention and 25% of deaths in the previous year might have been averted with improved access to surgical services. An extrapolation to the entire population would equate to almost 1·5 million individuals needing—at minimum—a surgical consultation in Sierra Leone today. The major limitation of our study was that it relied solely on a verbal interview of self-reported conditions. Ideally, a physical examination would be done to corroborate responses; however, in view of the substantial ethical and logistical issues, with financial implications, such a survey could not be undertaken at this point. Surveys can be expensive; costs of training, personnel, transportation, and communication are all important considerations and are country-specific. The total cost of our study was less than US$35 000. The use of handheld

tablets reduced our overall costs substantially in terms of printouts and personnel needed for data entry, and the tablets could be sold after the study.

A second limitation is that the respondents' perception of a surgical condition might not be correct. For example, a head, face, or neck mass caused by Burkitt's lymphoma would need chemotherapy rather than a surgical procedure. Such conditions might cause an overestimation of the numbers recorded; however, they would still need to be assessed by a health-care professional so that a surgical intervention could be ruled out. The respondents' perception could likewise result in an underestimation of the prevalence of surgical conditions. However, an important factor is that the need was decided by the respondent; all conditions in which the respondent answered "not in need for surgical care" were excluded from the final analysis. This definition therefore eliminates all minor wounds and masses that the respondent does not judge to be important, and surgical problems that are not regarded as requiring care for cultural reasons (eg, umbilical hernias). This definition also excludes any condition reported by a respondent who had visited a health-care provider and who was assured that they did not need surgery or could not be treated surgically.

A third limitation is that the data collected about household deaths relied on recall from household representatives. Results of research into recall of injuries showed that periods up to 12 months can be safely used for important events.[19] To ensure that the SOSAS data were representative of Sierra Leone, the self-weighted clusters were randomly allocated and stratified for all districts and rural and urban populations.[15] Nevertheless our total crude death rate is of 59·7 per 1000 population per year is 3·1 times higher than WHO's offcial rate of 19 per 1000 population per year.[20] This finding might be attributable to the tendency to remember tragic events as being more recent than they actually were or underreporting of deaths in the WHO statistics and should be further investigated. Ideally, future studies will confirm or reject the high number of deaths that could have been prevented with surgery by use of a more detailed verbal autopsy method, such as that used in India to assess cancer deaths.[21]

Another limitation is that although Sierra Leone has 14 offcial languages, the survey was written in English but administered orally in the local language. Ideally the survey would have been translated into all the local languages; however, because this step was not considered practical, we followed the standard protocol for Sierra Leone's Demographic and Health Surveys.

Women generally need more operations in a lifetime than do men because of gynaecological disorders; however, our results show a higher prevalence of existing surgical conditions in male respondents than in females. This finding might be partly attributable to the study design, which by definition excluded healthy military personnel and other people not living in situations identifiable as households. Our sample contained more females than males, supporting the notion that men are more likely to work away from the household than are women, and thus are less likely to be captured with a household survey.

Whether surgical diseases are brought to the attention of a health-care professional depends on many variables. Mock and colleagues[22] reported that the severity of an injury is most likely to predict health-care seeking behaviour. Economic constraints and geographic location are also often thought to be important barriers to health care in general and specifically to surgical care.[23] Cultural beliefs and practices probably affect the decision whether or not to undergo surgery as advised by medical personnel.[24] Other medical interventions, such as vaccinations and treatment for epilepsy and tuberculosis, also have specific cultural and behavioural aspects related to health-care seeking behaviour.[25–27] In these instances, researchers have suggested that favourable outcomes can positively affect societal perceptions of care and can likewise affect timely presentation for an intervention. These points are important to consider when discussing strengthening of the health system and will require not only investment in surgical services, but also in investigations into existing perceptions and barriers to surgical care, and in assurance of safe surgical care with good outcomes.

Sierra Leone is one of the poorest countries in the world and studies have documented its profound lack of surgical capacity.[28,29] According to the Sierra Leone National Health Sector Strategic Plan 2010–15,[30] at least 20 surgeons should be trained to meet the unmet need; however, with fewer than 30 medical doctors graduating annually and few training opportunities, such goals are unlikely to be achieved soon. In addition to an increase in surgeons, theatres, equipment, and supplies, numbers of paramedic and anaesthesia personnel need to be increased to deliver safe surgical care. Currently most health care in rural areas is provided by community health offcers who have few surgical skills.

Panel: **Research in context**

Systematic review

We searched PubMed with the terms "surgery" and "household survey", or "burden of surgical disease". We identified no countrywide surveys of the prevalence of surgical conditions or surgical causes of death in low-income countries. Most existing data from low-income countries documenting the burden of surgical conditions are based on hospital assessments or extrapolations from high-income countries. In countries where medical records are often incomplete or absent, these data probably underestimate the true prevalence of surgical disease and surgically related deaths. Extrapolations based on high-income country data might lead to overestimations of need. We selected only reports published in English between 2000 and 2010, although we also included some older reports from the reference lists of these publications.

Interpretation

Our results suggest that a large proportion of the population in Sierra Leone is in need of surgical care. Therefore, when resources are allocated to assist in strengthening health systems, surgical capacity building should not be excluded.

Further investigations into the high prevalence of untreated surgical conditions are needed to confirm unmet need in other low-income and middle-income countries and to identify the causes. However, as Weiser and colleagues[5] have estimated, a large discrepancy exists in the number of surgical procedures done in high- income versus low-income and middle-income countries, with far more procedures in high-income countries (panel). The high number of untreated cases in low- income and middle-income countries might merely represent a backlog that could be reduced with the assistance of visiting teams; however, other causes such as environmental, genetic, cultural, or occupational factors might result in the large number of affected individuals.

Whatever the underlying cause for the high number of cases might be, these data provide valuable insight and provide a baseline for the health needs of the population, which should assist the Ministry of Health and Sanitation and non-governmental organisations wishing to start surgical programmes in Sierra Leone. Projects can be monitored and assessed against the baseline data. Ideally, data for surgically treatable conditions will be collected in future Demographic and Health Surveys in Sierra Leone to limit the necessity of repeating a full country implementation of SOSAS.

Contributors

RSG, ALK, and TPK researched the background of the study; RSG created the figure; SEY, RSG, MS, ALK, and TBK designed the study; MS, RSG, ALK, and K-AS collected the data; LDC and RSG analysed the data; LDC, RSG, ALK, and TBK interpreted the data; RSG, ALK, and LDC wrote the report; and all authors commented on and critically revised the report.

Conflicts of interest

We declare that we have no conflicts of interest.

Acknowledgments

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Chapter 3

Traumatic injuries in developing countries report from a nationwide cross-sectional survey of SierraLeone.

Stewart K-A, Groen RS, Kamara TB, Farahzad MM, Samai M, Cassidy LD, Kushner AL, Wren SM. *JAMA Surg. 2013 May;148(5):463-9.*

Abstract

Background To use a nationwide household survey tool to provide an estimate of injury prevalence, mechanisms of traumatic injuries, and number of injury related deaths in a low-income country.

Methods A randomized, cross-sectional nationwide survey using the Surgeons OverSeas Assessment of Surgical Need tool was conducted in 2012. Setting: Sierra Leone, Africa. Participants: Three thousand seven hundred fifty randomly selected participants throughout Sierra Leone. Main Outcome Measures: Mechanisms of injury based on age, sex, anatomic location, cause, and sociodemographic factors as well as mechanisms of injury-related deaths in the previous year were the primary outcome measures.

Results Data were collected and analyzed from 1843 households and 3645 respondents (98% response rate). Four hundred fifty-two respondents (12%) reported at least 1 traumatic injury in the preceding year. Falls were the most common cause of nonfatal injuries (40%). The extremities were the most common injury site regardless of age or sex. Traffic injuries were the leading cause of injury-related deaths (32% of fatal injuries).

Discussion This study provides baseline data on the mechanisms of traumatic injuries as well as the sociodemographic factors affecting injury prevalence in one of the world's poorest nations. It is anticipated that these data will provide an impetus for further studies to determine injury severity, associated disability, and barriers to accessing care in these resource-poor areas.

ORIGINAL ARTICLE

Traumatic Injuries in Developing Countries

Report From a Nationwide Cross-Sectional Survey of Sierra Leone

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Objective: To use a nationwide household survey tool to provide an estimate of injury prevalence, mechanisms of traumatic injuries, and number of injury-related deaths in a low-income country.

Design: A randomized, cross-sectional nationwide survey using the Surgeons OverSeas Assessment of Surgical Need tool was conducted in 2012.

Setting: Sierra Leone, Africa.

Participants: Three thousand seven hundred fifty randomly selected participants throughout Sierra Leone.

Main Outcome Measures: Mechanisms of injury based on age, sex, anatomic location, cause, and sociodemographic factors as well as mechanisms of injury-related deaths in the previous year were the primary outcome measures.

Results: Data were collected and analyzed from 1843 households and 3645 respondents (98% response rate). Four hundred fifty-two respondents (12%) reported at least 1 traumatic injury in the preceding year. Falls were the most common cause of nonfatal injuries (40%). The extremities were the most common injury site regardless of age or sex. Traffic injuries were the leading cause of injury-related deaths (32% of fatal injuries).

Conclusions: This study provides baseline data on the mechanisms of traumatic injuries as well as the sociodemographic factors affecting injury prevalence in one of the world's poorest nations. It is anticipated that these data will provide an impetus for further studies to determine injury severity, associated disability, and barriers to accessing care in these resource-poor areas.

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TRAUMATIC INJURIES account for a significant proportion of the global burden of disease, causing 9% of all deaths worldwide.[1] More than 90% of injury-related deaths occur in low- and middle-income countries.[1] Despite the overall impact, the burden and pattern of injuries in developing countries are not well known, and there have been a limited number of studies addressing this issue.[2-4] Most of the available data are extrapolated from hospital-based studies, which inherently have limited generalizability since many patients with injuries will not or cannot go to a hospital because of various factors such as availability, cost, transportation, and trained staff.[5,6] Thus, the use of hospitalization data, particularly in nations where surgical care is sparsely available, will exclude a significant proportion of patients with injuries and underestimate the incidence, prevalence, and morbidity of traumatic injuries.[7] This is in contrast to the majority of trauma literature, which primarily encompasses higher-income countries with established systems to track nationwide trauma care. Similar efforts to study injury in low-income countries, particularly in Sub-Saharan Africa, have been near impossible because of lack of resources; as such, an accurate nationwide characterization of trauma in developing countries does not exist at this time. The vast underrepresentation of the global burden of traumatic injury in the trauma literature likely impacts public health policies and resource allocations.[8]

Prior field work done by Mock et al[9] in 1999 demonstrated via a community-based survey that agricultural injuries, falls, and transport-related injuries were associated with a high burden of disability in urban and rural Ghana. More recently, population-based analyses of road traffic injuries in urban Tanzania[10] and urban

Ghana[11] have further demonstrated that these injuries are a major source of disability in these settings. Together, these studies have helped to quantify the morbidity and mortality associated with injuries in developing countries and highlight the need for data examining injury epidemiology on a larger scale.

Sierra Leone is a small West African country with a total population of 5.8 million people, of which 41.8% is pediatric (0-14 years); 54.5%, adult (15-64 years); and 3.7%, elderly (>65 years). The male to female ratio within the age groups is approximately equivalent, except for a predominance of women in the elderly group (almost one-third more women than men).[12] As one of the world's poorest nations, Sierra Leone currently ranks 180 of the 187 nations on the United Nations Development Index. Health indicators reflect the limited availability of health care: life expectancy at birth is 48 years, and 174 per 1000 children die before their fifth birthday.[13]

In an effort to document the surgical burden of disease in Sierra Leone, a nationwide survey was conducted using the Surgeons OverSeas Assessment of Surgical Need tool. Herein, we report the results of this study pertaining to injury epidemiology in Sierra Leone, with the goal of providing baseline data to further encourage development of injury prevention programs and devising immediate strategies to aid individuals who currently have traumatic injuries.

METHODS

The complete study methods have been previously described.[14] Briefly, baseline demographic information on the total population of Sierra Leone was obtained from Statistics Sierra Leone and used to divide the country into 9671 clusters. Seventy-five of these clusters were randomly selected, with stratification for urban and rural settings. Within each cluster, 25 households (of approximately 85) were randomly chosen. This sampling method has been extensively used in developing countries where accurate listings of households are unavailable.[9,15,16]

STUDY DESIGN AND PARTICIPANTS

The study was conducted using the previously reported and developed Surgeons Overseas Assessment of Surgical Need, which is a cross-sectional population-based household survey tool.[14,17] Data were gathered from January to February 2012. Briefly, a questionnaire eliciting socioeconomic and demographic information of all household members as well as information on deceased household members was administered to the head of each household. Regarding deceased household members, the heads of household were specifically asked whether they had an injury in the week prior to death and the mechanism of the injury. Two persons from each household (which could include the head of household) were randomly selected for an interview. These 2 individuals were asked whether they had any injury occurring in the previous year or more than 1 year ago. If they answered affirmatively, a verbal questionnaire eliciting the mechanism of injury and the body region involved was further administered. All interviews were conducted verbally in the appropriate local language.

Trained enumerators (Sierra Leonean nursing and medical students) used handheld tablets programmed with the survey for data collection. Field supervisors were available for queries and daily random data checks.

STATISTICAL ANALYSES

χ^2 Tests were used to assess statistically significant differences between groups. Logistic regression analysis using Proc SurveyLogistic (SAS Institute Inc) was conducted to identify associations between having sustained a traumatic injury in the last year and independent variables (sex, age, residency, occupation, and education). *P* values less than or equal to .05 were considered statistically significant. SAS OnDemand Enterprise Guide 4.3 was used to perform all statistical analyses.

ETHICAL CLEARANCE AND INFORMED CONSENT

The study was a collaborative effort between Surgeons OverSeas, Sierra Leone Ministry of Health and Sanitation, Connaught Hospital Department of Surgery, and Statistics Sierra Leone. Ethical approval was obtained from the Ethics and Scientific Review Committee of Sierra Leone, the Research Ethics Committee of the Royal Tropical Institute in Amsterdam, and the institutional review board of Stanford University. Written informed consent was obtained from all respondents. For individuals younger than 18 years, separate consents were obtained from the parent/guardian and the respondent. For respondents younger than 12 years, a parent/guardian either assisted with the interview or responded for the child.

RESULTS

DEMOGRAPHIC DATA AND DESCRIPTIVE EPIDEMIOLOGY

Data were collected and analyzed from 1867 households and 3645 respondents, yielding a response rate of 98.3%. The demographic composition of the study population was similar to the most recent reports from the Sierra Leone Demographic Health Survey (2008), indicating a representative sample.[14] The population structure shows a broad-based pyramid when plotted by age and sex and is characteristic of the population structure identified for developing countries (**Figure**). The mean (SD) age of respondents was 25 (19.7) years, with 36% younger than 15 years (children), 57.9% between 15 and 64 years old (adults), and 5.5% older than 65 years (elderly). Age information was missing for 22 respondents (0.6%). Females made up 54.2% of the study sample, with males accounting for the remaining 45.8%. More respondents resided in rural areas (61.2%) than in urban regions (38.8%).

INJURY PREVALENCE

A total of 873 individuals (24% of respondents) reported having at least 1 lifetime traumatic injury, with 452 (12.4%) reporting at least 1 traumatic injury in the previous year. There are overlaps in respondents providing data on injuries at the different points because each person could report more than 1 injury. In total, 1316 injuries were reported.

As shown in **Table 1**, females were less likely to have experienced a traumatic injury in the previous year compared with males (odds ratio [OR], 0.69; 95% CI, 0.57-0.83). The odds of having a traumatic injury were simi-

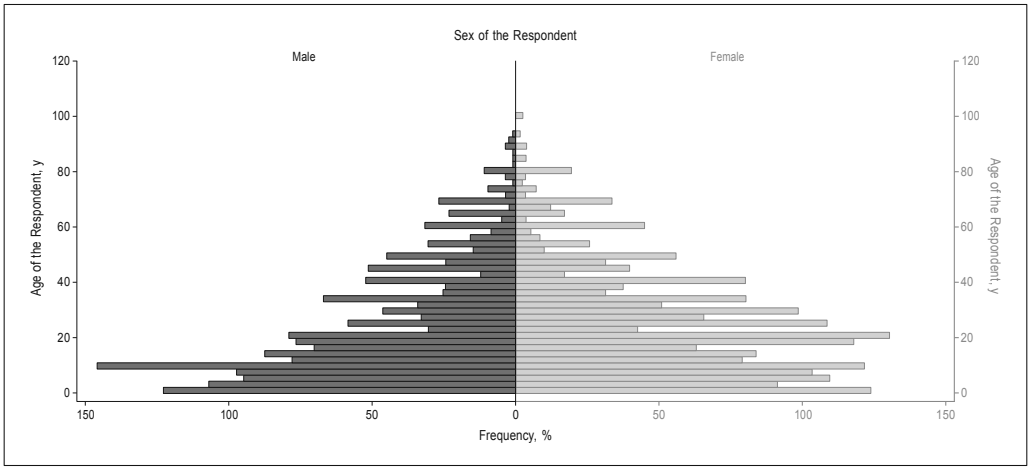

Figure. Demographic structure of the Sierra Leone Surgeons Overseas Assessment of Surgical Need study population (2012).

Table 1. Bivariate Analysis of Factors Associated With Having a Traumatic Injury in the Last Year

		Proportion Having at Least 1 Traumatic Injury in the Last Year		
	Sample Size	% (95% CI)	Crude OR (95% CI)	*P* Value
Sex				
M	244	14.6 (12.6-16.6)	1 [Reference]	<.001
F	208	10.5 (8.6-12.5)	0.69 (0.57-0.83)	
Age, y				
0-14	180	13.7 (11.5-15.9)	1 [Reference]	
15-64	256	12.1 (10.2-14.1)	0.87 (0.72-1.05)	.047
>65	15	7.4 (4.0-10.9)	0.51 (0.31-0.83)	
Missing	1	4.5 (0.0-13.4)		
Residency				
Rural	277	12.4	1 [Reference]	.97
Urban	175	12.4	1.00 (0.81-1.22)	
Occupation				
Unemployed	219	12.3 (10.2-14.4)	1 [Reference]	
Homemaker	15	13.9 (6.6-21.1)	1.15 (0.68-1.93)	
Domestic helper	42	15.9 (11.9-19.9)	1.35 (0.96-1.88)	
Farmer	108	12.8 (10.1-15.4)	1.04 (0.90-1.36)	.21
Self-employed	46	10.2 (7.1-13.4)	0.81 (0.58-1.14)	
Government employee	10	8.1 (2.8-13.3)	0.62 (0.31-1.26)	
Nongovernment employee	11	17.7 (10.7-24.8)	1.53 (1.00-2.36)	
Missing	1	6.3 (0.0-17.9)		
Education				
None	221	11.7 (9.6-13.8)	1 [Reference]	
Primary	103	12.7 (10.4-15.1)	1.10 (0.86-1.41)	.72
Secondary	111	13.7 (10.7-16.7)	1.20 (0.91-1.58)	
Tertiary or graduate degree	15	12.0 (6.6-17.4)	1.03 (0.62-1.71)	
Missing	2	20.0 (0.9-39.1)		
Total	452	12.4 (10.6-14.2)		

Abbreviation: OR, odds ratio.

lar for children and adults; however, elderly individuals were less likely to have experienced a traumatic injury in the previous year compared with children (OR, 0.51; 95% CI=0.31-0.83). The odds of having a traumatic injury in the previous year were not statistically different between groups when analyzed for residency location, occupation, or education level.

MECHANISM OF INJURIES

Falls were the most common cause of injuries overall, accounting for more than 40% of lifetime injuries in both urban and rural areas (**Table 2**). Wounds due to lacerations/blunt trauma were the next most common, accounting for 27% of injuries in urban regions and 31%

Table 2. Mechanism of Lifetime Injuries According to Urban vs Rural Residency

	No. (%)		
	Urban Injuries	Rural Injuries	Rural/Urban, OR (95% CI)
Fall	198 (41)	365 (44)	1.17 (0.94-1.47)
Stab/slash/cut/crush	134 (27)	249 (31)	1.15 (0.90-1.48)
Burn			
Hot liquid/hot object	64 (13)	77 (9)	0.68 (0.48-0.98)
Open fire/explosion	11 (2)	9 (1)	0.48 (0.20-1.17)
Traffic related			
Motorcycle crash	26 (6)	36 (4)	0.81 (0.49-1.37)
Car, truck, bus crash	25 (5)	32 (4)	0.75 (0.44-1.29)
Pedestrian, bicycle crash	11 (2)	9 (1)	0.48 (0.20-1.17)
Bite or animal attack	11 (2)	24 (3)	1.30 (0.63-2.69)
Gunshot	6 (1)	18 (2)	1.80 (0.71-4.57)
Missing	5 (1)	6 (1)	
Total	**491**	**825**	

Abbreviations: OR, odds ratio, CI, Confidence Interval.

Table 3. Mechanism of Lifetime Injuries by Age Group

	% (95% CI)		
Mechanism of Injury	Age 0-14 (n = 1313)	Age 15-64 (n = 2109)	Age >65 (n = 201)
	Urban		
Fall	11.4 (6.9-15.8)	12.0 (8.7-15.4)	9.1 (6.0-12.2)
Stab/slash/cut/crush	5.7 (3.6-7.7)	9.5 (5.9-13.1)	3.6 (0.0-7.4)
Burn	4.8 (3.0-6.6)	4.8 (2.8-6.8)	1.8 (0.0-5.7)
Motorcycle crash	0.4 (0.4-0.5)	2.5 (1.4-3.6)	. . .
Car, truck, bus crash	0.4 (0.0-0.9)	1.8 (0.7-2.8)	5.5 (0.0-14.1)
Pedestrian, bicycle crash	0.2 (0.0-0.7)	1.0 (0.0-2.0)	. . .
Bite or animal attack	0.9 (0.0-1.8)	0.8 (0.0-1.6)	. . .
Gunshot	. . .	0.7 (0.2-1.1)	. . .
Total	19.7 (13.4-25.9)	27.3 (19.3-35.3)	20.0 (10.8-29.2)
	Rural		
Fall	10.5 (7.9-13.2)	13.4 (10.7-16.1)	24.0 (17.0-30.9)
Stab/slash/cut/crush	5.5 (3.7-7.3)	10.8 (8.6-13.0)	8.2 (3.8-12.6)
Burn	4.4 (3.0-5.9)	3.1 (1.9-4.4)	2.1 (0.0-4.4)
Motorcycle crash	0.6 (0.2-1.0)	1.9 (1.2-2.7)	1.4 (0.0-3.3)
Car, truck, bus crash	. . .	1.8 (1.1-2.5)	1.4 (0.0-3.3)
Bite or animal attack	1.3 (0.7-1.9)	0.7 (0.1-1.1)	2.1 (0.0-4.4)
Gunshot	0.1 (0.0-0.4)	0.9 (0.3-1.5)	2.1 (0.0-4.2)
Pedestrian, bicycle crash	0.1 (0.0-0.4)	0.5 (0.1-0.9)	1.4 (0.0-3.4)
Total	17.1 (14.6-19.5)	26.6 (22.9-30.3)	35.6 (28.7-42.5)

in rural areas. Burns were the third most common cause of injury and mostly involved hot liquids or objects. Urban residency was significantly associated with decreased odds of having a burn from a hot liquid or object (OR, 0.68; 95% CI, 0.48-0.98). Traffic-related injuries, ie, motor vehicle, motorcycle, bicycle, or pedestrian crash, accounted for 13% of urban injuries and 9% of rural injuries. Bites and/or animal attacks and gunshot wounds were the least common causes of injury, accounting for 3% and 2% of all injuries, respectively.

When comparing age groups in urban areas, gunshot wounds were only reported in individuals aged 15 to 64 years (**Table 3**). Additionally, this group reported a higher rate of injuries due to motorcycle crashes compared with children and elderly individuals (2.5% vs 1.4% in children and 0% in elderly respondents). In rural areas, falls were more often reported in elderly individuals compared with younger age groups (24% vs 13.4% in adults and 10.5% in children). Adults reported more injuries due to motorcycle crashes, motor vehicle crashes, and lacerations/blunt trauma compared with children (1.9% vs 0.6%, 1.8 vs 0%, and 10.8% vs 5.5%, respectively).

There were no significant differences in the mechanisms of injury between male and female respondents in urban areas. In contrast, males in rural areas had a significantly higher percentage of injuries due to falls (15.3% vs 10.7%), motorcycle crashes (2.1% vs 0.7%), and gunshot wounds (1.3% vs 0.1%) compared with females.

Table 4. Body Region Involved in Lifetime Injuries by Age and Sex

	No. of Injuries (% of Respondents)[a,b]				No. of Injuries (% of Respondents)		
	Age 0-14 (n = 1313)	Age 15-64 (n = 2109)	Age >65 (n = 201)	*P* Value	Male (n = 1669)	Female (n =1976)	*P* Value
Body region							
Face/head/neck	67 (28.3)	133 (23.3)	12 (19.0)	.34	129 (27.2)	83 (20.8)	<.001
Chest/breast	19 (8.0)	65 (11.4)	6 (9.5)	.01	61 (12.9)	29 (7.2)	<.001
Back	27 (11.4)	111 (19.4)	16 (25.4)	<.001	88 (18.6)	66 (16.5)	.002
Abdomen	33 (13.9)	41 (7.2)	3 (4.8)	.44	35 (7.4)	44 (11.0)	.76
Groin/buttocks	12 (5.1)	37 (6.5)	7 (11.1)	.008	33 (7.0)	23 (5.8)	.004
Extremities	167 (70.5)	396 (69.4)	42 (66.7)	<.001	320 (67.5)	286 (71.7)	<.001
Total No. of respondents with injuries (% of total No.)	237 (18.0)	571 (27.0)	63 (31.3)		474 (28.4)	399 (20.2)	
Total No. of injuries	325	783	86		666	531	

[a] Values in parentheses represent the percentage of respondents in that column reporting an injury, except where otherwise indicated.
[b] Age data were missing for 22 respondents, who were therefore excluded from the analysis by age.

BODY REGIONS AFFECTED BY INJURIES

The extremities were the most commonly injured regions across all age groups and in both males and females, with 34% of injuries occurring on the lower extremities and 21% on the upper extremities (**Table 4**). Injuries to the face/head/neck were the second most common, accounting for 16% of all injuries. Back injuries accounted for 12%, followed by 7% on the chest/breast, 6% on the abdomen, and 4% on the groin/buttocks.

The percentage of reported injuries to the groin/buttocks and back over an individual's lifetime increased significantly with age. Injuries to the groin/buttocks were the least common site of injuries in children younger than 15 years (5.1%), compared with 6.5% in adults and 11.1% in elderly individuals ($P = .008$). Similarly, in children younger than 15 years, 11.4% of injuries were to the back, compared with 19.4% in adults and 25.4% in elderly individuals ($P < .001$).

Twenty-eight percent of males reported at least 1 lifetime injury, compared with 20% of females. Males were significantly more likely to have injuries to the face/head/neck (27.2% vs 20.8%), chest/breast (12.9% vs 7.2%), and groin/buttocks (7.0% vs 5.8%) compared with females. Conversely, a significantly higher proportion of females reported injuries to the extremities compared with males (71.7% vs 67.5%).

INJURY-RELATED DEATHS

Of the total 709 reported deaths, 41 deceased household members had an injury in the week prior to death (5.6%). Traffic injuries were the most common, accounting for 31.7% of fatal injuries. Falls accounted for 29.3%; bite or animal attacks, for 19.5%; lacerations/crush injuries, for 7.3%; and burns, 7.3%. About 5% of injuries did not have a reported cause (**Table 5**).

Table 5. Injuries in Deceased Household Members During the Week Before Death as Reported by the Head of the Household

Cause of Injury	Total Fatal Injuries, No. (%)
Traffic related	
Car, truck, bus crash	8 (19.5)
Motorcycle crash	5 (12.2)
Fall	12 (29.3)
Bite or animal attack	8 (19.5)
Stab/slash/cut/crush	3 (7.3)
Burn	3 (7.3)
Unreported cause of injury	2 (4.9)
Total	**41 (100)**

COMMENT

Traumatic injury epidemiology in low- and middle-income countries remains an underresearched and relatively neglected subject area. This report highlights the burden of disease due to traumatic injury in Sierra Leone, with a yearly nonfatal injury prevalence of 12.4% and fatal injury prevalence of 5.6% in the study sample. Extrapolating the sample prevalence to the entire population of 5.8 million results in a total of 719 000 nonfatal traumatic injuries and 325 000 injury-related deaths in Sierra Leone in the past year.

Interestingly, there were no significant differences in the overall mechanisms of injuries in urban and rural areas. Falls were the single most common cause of nonfatal injuries, consistent with studies in Iran,[18] Sri Lanka,[19] and China.[20] Falls from trees have been reported as a leading cause of injury in rural areas of developing countries such as Nigeria[21,22] and Papua New Guinea,[23] where the products of tall trees are important sources of food and income.[24] In our study, elderly individuals in rural areas were more susceptible to fall injuries compared with other age groups. Falls in elderly individuals likely have different etiology and may be associated with decreased daily physical activity.[25,26] Public health measures are needed to decrease the frequency and impact of falls, particularly in high-risk groups.

Lacerations/crush injuries were the second most common cause of injury in this study, with adults having the highest percentage of these injuries. Studies in rural Ghana[9] and Tanzania[27] have found lacerations to

be the leading cause of injuries, with the majority of these injuries sustained during agricultural work. In Tanzania, most cuts and stabs were caused by instruments such as axes and machetes being used by rural residents engaging in agricultural activities without protective equipment.

Although motor vehicle–related injuries were less common (fourth most common cause of injury overall), they were the most common cause of injury-related deaths, accounting for 32% of injuries during the week prior to death. Extrapolation to the population of Sierra Leone results in an estimated 104 000 traffic-related deaths in the previous year. Similarly, Mock et al[28] reported that in rural and urban Ghana, transport-related injuries were more severe than other types of injuries in terms of length of mortality, disability, and economic consequences. A possible explanation for the high mortality of traffic injuries in Sierra Leone may be the unavailability, underuse, and/or incorrect use of appropriate safety equipment such as helmets and seatbelts. Additionally, there may be a delay in accessing care after traffic accidents because of the poor road networks and the limited availability of rapid response vehicles.

Injuries due to gunshot wounds were uncommon in this series and were only seen in the adult population. Studies in rural Ghana[29] and Pakistan[30] showed that assault was an infrequent mechanism of injury in these areas, and in the Ghanaian series, none of the firearm injuries were due to assault. Further qualitative studies are needed to elucidate the circumstances surrounding firearm injuries.

In urban areas, there were no differences in the mechanisms of injuries when analyzed by sex. However, in rural areas, a higher proportion of males had injuries due to falls, motorcycle crashes, and gunshot wounds, compared with females. This may be a reflection of the relative similarity of activities performed by males and females in urban areas, compared with more distinct roles of males and females in rural areas.

There is a relative paucity of studies addressing the body regions most commonly injured in developing countries. However, this is an important consideration to determine appropriate treatment strategies. For instance, injuries to the extremities were most common regardless of age or sex, suggesting that orthopedic or reconstructive surgical approaches may be necessary for managing these injuries. Similarly, the high prevalence of face/head/neck injuries suggests that the services of otolaryngologists, ophthalmologists, dentists, plastic and reconstructive surgeons, or other individuals trained in these skill sets are likely needed to help address the current cases.

It is unclear why the number of reported injuries to the groin/buttocks and back increased with age. One possible explanation may be that given the high number of falls, the reported groin injuries may be related to hip fractures. Another possibility is that given the high prevalence of inguinal hernias,[31] it may be that respondents considered inguinal hernias as the result of traumatic injuries. Similarly, respondents may have also considered back pain related to field labor as a form of traumatic injury. Qualitative research would be useful for clarification. Regardless, this finding is important as it demonstrates specific body regions that are more likely to be injured in different age groups and thus can influence future studies to determine treatment strategies and resource allocation.

There are a few limitations to this study. First, the study relied on self-reporting by the respondents. It is likely that there was underreporting and hence underestimation of the prevalence of injuries associated with a social stigma, such as domestic violence, female genital mutation, or suicide. Additionally, there may also be underreporting due to recall bias, which was not evaluated in this study. In the absence of a physical examination, we were unable to explore the extent of probable underreporting. Even so, we believe that the estimates of this study are less prone to underestimation compared with hospital-based studies.[5,6] Second, the survey was primarily designed to capture the prevalence of surgical treatable conditions; as such, detailed information on the circumstances of injuries such as intentional vs unintentional or whether safety precautions were in place at the time of the injury was not elicited. Third, although efforts were made to generate a representative sample of Sierra Leone's population, the higher female proportion in our sample likely confirms that the household survey by nature excludes individuals who are away from the home, such as those who are institutionalized, military personnel, or miners.

In conclusion, the results of this nationwide survey provide population-based estimates of the prevalence of traumatic injuries in Sierra Leone, the mechanism of these injuries, and the sociodemographic factors affecting injury occurrence. It is hoped that this evidence will serve as a stimulus for future studies to elucidate injury severity, injury-related disability, and access-to-care challenges in these developing regions.

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Chapter 4

Household survey in Sierra Leone reveals high prevalence of surgical conditions in children. Groen RS, Samai M, Petroze RT, Kamara TB, Cassidy LD, Joharifard S, Yambasu S, Nwomeh BC, Kushner AL. *World J Surg. 2013;37(6):1220-6.*

Abstract

Background Although great efforts are being undertaken to reduce child morbidity and mortality globally, there is limited knowledge about the need for pediatric surgical care. Some data on surgical need is available from hospital registries, but it is difficult to interpret for countries with limited surgical capacity.

Methods A cross-sectional two-stage cluster-based sample survey was undertaken in Sierra Leone, using the Surgeons OverSeas Assessment of Surgical Need tool. Data were collected and analyzed on numbers of children needing surgical care and pediatric deaths that may have been averted if surgical care had been available.

Results A total of 1,583 children out of 3,645 individuals (43.3 %) were interviewed. Most (64.0 %, n = 1,013) participants lived in rural areas. At the time of interview, 279 (17.6; 95 % confidence interval (95 % CI): 15.7–19.5 %) had a possible surgical condition in need of a consultation. Children in the northern and eastern provinces of Sierra Leone were much more likely to report a surgical problem than those in the urban-west.

Discussion There is a high need for surgical care in the pediatric population of Sierra Leone. While additional resources should be allocated to address that need, more research is needed. Ideally, questions on surgically treatable conditions should be added to the frequently performed health care surveys on the pediatric population.

Household Survey in Sierra Leone Reveals High Prevalence of Surgical Conditions in Children

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Introduction

Although the needs of children have been on the global health agenda for many years and most prominently include Millennium Development Goal number 4 (MDG4) [1], only recently have the surgical needs of pediatric populations in low and middle income countries (LMIC) received attention [2, 3]. Very few studies have assessed the overall surgical needs of pediatric populations in LMIC, and most epidemiological data on pediatric surgical diseases focus on single conditions such as cleft lip/palate and club foot [4, 5]. More recently, the burden of injuries, particularly road traffic accidents, has been studied as an important and growing contributor to global childhood death and disability [6–8].

At present the most comprehensive epidemiological data on surgical need in the pediatric population are from hospital-based surveys [9, 10]. Data from a cross-sectional survey in Uganda estimated an annual rate of surgery for children aged 14 years and below to be 180 operations per 100,000 population per year. While an appropriate target number remains unknown, this figure is way below the surgical interventions in the pediatric population in the United Kingdom [10] or the 529 operations per 100,000 children in the United States [11, 12]. To further highlight the challenges for providing surgery for pediatric populations, capacity surveys conducted in sub-Saharan Africa document the lack of appropriate infrastructure, supplies, and personnel [13–15].

In Sierra Leone, in a bid to reduce the high maternal and child mortality, an initiative was introduced to provide free health care for pregnant and lactating women and children under 5 years [16]. This program has led to a surge of hospital visits by children with surgical conditions and a significant increase in the number of children undergoing surgical procedures [2]. While data from hospital visits can give insight into the epidemiology of surgical disease [9–11], these data provide a limited picture. Thus, to uncover the true surgical need of the population a detailed epidemiologic survey was required.

The objectives of this study were to determine the prevalence of pediatric surgical disease among Sierra Leonean children and to identify those children whose death could have potentially been averted by timely surgical care.

Methods

This study used the Surgeons OverSeas Assessment of Surgical Need (SOSAS) survey tool, the overall results of which are published elsewhere [17]. The subset on the pediatric population of the full database is presented in this study.

Setting

Sierra Leone, a small West African country (area: 72,000 km^2) with an estimated population of 5.8 million [18], is one of the poorest countries in the world and ranks 180 of 187 on the 2012 United Nations Development Index [19]. Administratively, Sierra Leone is divided into four regions: North, South, East, and West. These regions are divided into 14 districts, which are further subdivided into 9,671 enumeration areas (EA), which were used for cluster designation [20]. In 2010, the infant mortality rate was 114 per 1,000 and the under-5 mortality rate was 174 per 1,000 [21]. Sierra Leone was chosen as a location for the implementation of SOSAS because of the longstanding relationship between Surgeons OverSeas (SOS), the local surgeons and the Ministry of Health and Sanitation (MoHS) [22].

Study design

The overall study design was a cross-sectional, two-staged cluster-based household survey. Using probability proportional to size cluster sampling methodology, 75 clusters were randomly chosen from the 9,671 EA in Sierra Leone (Fig. 1). The clusters were stratified to get a representative sample of the Sierra Leonean population from the 14 administrative districts and a representative distribution of the rural and urban population. In order to obtain a self-weighted sample, we randomly selected 25 households in each cluster, with two individuals in each household being randomly assigned for the interview. For random assignment of households and individuals a listing was made, and with the help of a random calculator the household/individual was assigned. The total sample size of 3,745 individuals was calculated based on prevalence data gathered during a pilot study [23]. Via OpenEpi (openepi.com) a sample size of minimal 375 was calculated for the pediatric subsection of the database to get a prevalence of 25 %, with 5 % range with a 95 % CI, including a design-effect of 1.3.

Survey design

The SOSAS survey tool has been described in detail elsewhere [24, 25] and is available as an open-source document at www.surgeonsoverseas.com. Briefly, we interviewed both adults and children. Subjects were sequentially asked about the presence of potential surgical conditions in the head/face/neck (including eye/nose/ear), chest, back, abdomen, groin, and extremities. A potential surgical condition was categorized in: wound, injury, masses, acquired and congenital deformity, with some specific symptoms in need for surgical evaluation per body part.

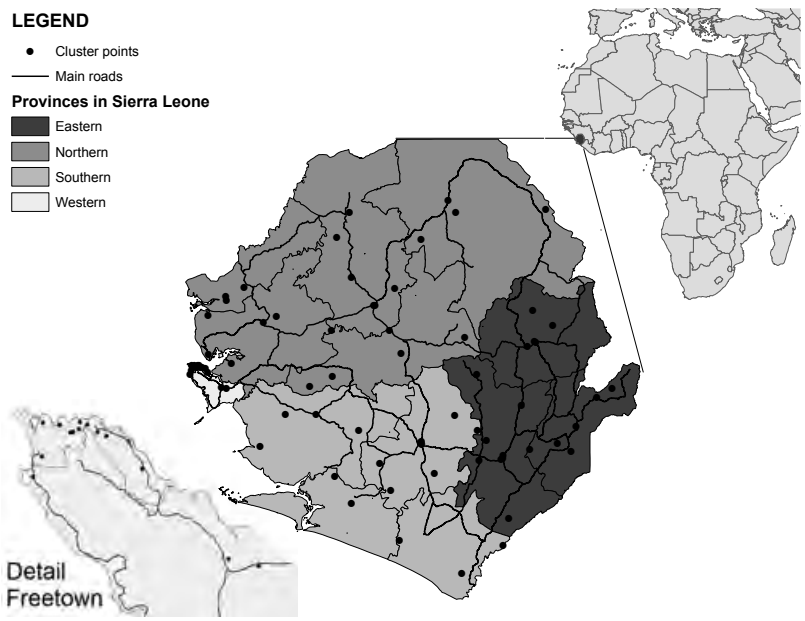

Fig. 1 Cluster points of SOSAS [map by R.S.G.]

For the purposes of the study, surgical care was defined as treatment of an injury or disorder through incision, excision, or manipulation of a body part. Minor procedures were defined as those done under local anesthesia, and major procedures were defined as those conducted under general anesthesia. Inclusion criteria for this sub-analysis of the pediatric portion was age below 18. For subjects under the age of 12, a parent or guardian was asked to help answer the questions.

Data collection, handling, and analysis

The survey was digitized using FileMaker Pro 11.0 v2 (FileMaker Inc., Santa Clara, CA, USA). Sixteen (16) trained enumerators collected data via direct computer entry on 3G iPad devices (Apple Inc., Cupertino, CA, USA) loaded with the survey in FileMaker Go 1.1 (FileMaker Inc.). Field supervisors (4) monitored data fidelity during data collection. Statistical analysis was performed with SAS 9.3 and the PROC surveyfreq and Proc surveylogistic procedures because this was a population-based sample. Contingency table data were analyzed with the v^2 test with a p value B 0.05 considered statistically significant. Children with and without a surgical problem(s) were compared in a multivariate logistic regression model with reported odds ratios and 95 % confidence intervals (95 % CI). Confidence intervals that did not include 1.0 were considered statistically significant.

Ethical considerations

The Sierra Leone MoHS approved the study, and ethical clearance was obtained from the Ethics and Scientific Review Committee of Sierra Leone and the Research Ethics Committee of the Royal Tropical Institute in Amsterdam, the Netherlands. Written consent was obtained from the parent or guardian of all minor subjects, and assent was obtained from subjects themselves. The total cost of the study was less than US$ 35,000.

Results

Demographic data: age gender, geographic region

A total of 3,645 individuals were interviewed (response rate of 98 %), of which 1,583 (43.4 %) were children under the age of 18. Table 1 shows the demographic frequencies of surveyed children, including the age, gender, urban/rural residency, and province distributions. Approximately half the children surveyed (50.8 %; n = 804) were male and the majority (66.7 %; n = 1,056) were under 11 years old. Most (64.0 %; n = 1,013) participants lived in rural areas, consistent with the last Demographic Health Survey (2008) in Sierra Leone [19].

Table 1 General frequencies of the researched pediatric population

		Number	%	95 % CI
Age, years	0–4	447	28.2	25.8–30.7
	5–10	609	38.5	36.2–40.8
	11–14	278	17.6	15.9–19.2
	15–17	249	15.7	14.0–17.5
Gender	Male	804	50.8	48.0–53.5
	Female	779	49.2	46.5–52.0
Residency	Rural	1,013	64.0	53.2–74.7
	Urban	570	36.0	25.3–46.8
Province	North	549	34.7	32.8–36.5
	East	410	25.9	23.7–28.1
	South	386	24.4	22.6–26.1
	West	238	15.0	13.6–16.5

Surgically treatable conditions

A total of 587 surgical problems were reported for 372 individual children; this figure includes previously treated surgical problems. At the time of interview, 279 (17.6 %; 95 % CI: 15.7–19.5 %) had a surgical condition in need of an intervention or consultation. Results of a multivariate logistic regression analysis are shown in Table 2. Respondents were 1.5 times more likely to report a surgical condition in male children (95 % CI 1.2–2.0), and 2.2 times more likely in rural children (95 % CI 1.7–3.0); both were statistically significant. The percentage of children with a surgical condition increased with increasing age. When compared to the oldest age group, the odds ratio for having a surgical condition was less than one for all three of the youngest groups and it was statistically significant for the 0–4 and 5–10 year age groups.

The region of residence was not included in the multivariate model because it was associated with rural and urban residence. Therefore it was evaluated univariately (Table 3). Those living in the northern or eastern provinces were much more likely to report a child with a surgical problem than those in the west (OR 3.5, 95 % CI 2.1–5.6 and OR 2.7, 95 % CI 1.6–4.4, respectively).

As stated above, respondents were asked to delineate the anatomic location of each surgical condition. Of 587 reported conditions children had encountered in their lives, 200 (34.1 %) were located in the abdomen, 134 (22.8 %) in the extremities, and 120 (20.4 %) in the head/face/neck (Fig. 2).

Figure 3 shows a breakdown of the types of surgical conditions reported. Of the total 587 surgical problems encountered during the lives of the children, 144 (24.5 %) of the surgical conditions were wounds, 138 (23.5 %) masses, 137 (23.3 %) other deformities, 129 (22.0 %) abdominal distention or pain, and 24 (4.1 %) burns. The abdominal and groin masses were further classified as either soft or solid in order to help identify hernias. Of the 45 groin masses, 38 (84.4 %) were soft and seven were solid. Of the 57 abdominal masses, 50 (87.7 %) were soft and seven were solid. Deformities were further classified as either acquired (103, 75.3 %) or congenital (34, 24.8 %). Of the congenital deformities 16 (47.1 %) were in the face/head/neck area and 12 (35.3 %) were reported to be in the extremities.

Number of procedures performed in the pediatric population

A total of 295 procedures were reportedly done in this population, of which the majority 272 (91.5 %) were described as minor procedures. No statistically significant difference was noted in the number of procedures performed between age groups and gender.

Discussion

The results of this study show that 17.6 % of the interviewed pediatric population of Sierra Leone had a potential surgically treatable condition at the time of the interview. Until this study, few data were available on the burden of surgical disease in LMIC, and even less was known about surgical needs in neonates, infants, and children [22]. Children constitute a significant portion (46 %) of the population in Africa, and so the need for pediatric surgical services may be greater than in other parts of the world [25]. Furthermore the burden of congenital anomalies would be expected to be higher based on the higher fertility rate, more likelihood of micro deficiencies, and less prenatal screening [26]. In our sample we found 34 cases (2.1 %) with reported congenital deformities with the main affected area the head/face/neck, which probably calls for specialized (reconstructive) surgery.

The similar distribution of gender in children who reported having undergone a surgical procedure was an unexpected result and contradicts another observation in which male children were more likely to present for surgical care before the free healthcare initiative [27]. The fact that the rural areas, as well as the northern and eastern provinces of Sierra Leone, have more untreated conditions is not surprising, as the surgical capacity in those areas is even more sparse than in the rest of the country [14].

In our study a large proportion of soft abdominal masses were found (n = 50), most likely representing umbilical hernias (UH). Umbilical hernias have the potential to resolve in the first years of life and are therefore not in need of immediate repair as long as they are asymptomatic. A large review of UH repairs in the

Table 2 Multivariate logistic regression analysis demographics comparing pediatric respondents with and without a current surgical problem

	Children in SOSAS without any surgical problem identified		Children with at least one current identified surgical problem		Odds ratio	95 % CI
	N	%	n	%		
Male	637	79.2	167	20.8	1.5	1.2–2.0*
Female	667	85.6	112	14.4		
Rural	797	78.7	216	21.3	2.2	1.7–3.0*
Urban	507	88.9	63	11.1		
0–4 years	382	85.5	65	14.5	0.53	0.35–0.78*
5–10 years	508	83.4	101	16.6	0.63	0.43–0.92*
11–14 years	221	79.5	57	20.5	0.84	0.55–1.3
15–17 years	193	77.5	56	22.5		
Total	1,304	82.4	279	17.6		

*Statistically significant

Table 3 Univariate analysis of region comparing pediatric respondents with and without a current surgical problem identified

	Children in SOSAS without any surgical problem identified		Children with at least one current identified surgical problem		Odds ratio	95 % CI
	n	%	N	%		
North	406	73.9	143	26.1	3.5	2.1–5.6*
East	322	78.5	88	21.5	2.7	1.6–4.4*
South	360	93.3	26	6.7	0.79	0.39–1.28
West	216	90.8	22	9.2		

* Statistically significant

United States revealed that most were repaired around 4 years of age [28], indicating that the UH found in this survey might overestimate the current surgical need. In the mentioned study, 7 % (34 cases) UH were emergent repairs because of (recurrent) incarceration, enteric fistula, strangulation, and evisceration [28]. Cohort studies to determine the ideal age of UH repair are unknown to the authors. For the groin masses, the majority were soft and likely to be inguinal hernias. Therapy for inguinal hernias is mandatory, as incarceration is likely [29]; therefore the 38 cases with a soft inguinal mass likely indicate a definite surgical need.

This population-based data for the need for surgical care in LMIC is important for clinicians, policy makers, and donors. It provides the basis for planning training, logistics, and interventions and assists with monitoring and evaluating programs. However, next to the burden of surgical disease, other components of health interventions need to be considered, like effectiveness and safety of interventions, as well as cost. Nevertheless, data on the epidemiology of diseases might establish the need for surgical capability in LMIC, in effect, advocating for improvement by influencing political and donor agendas.

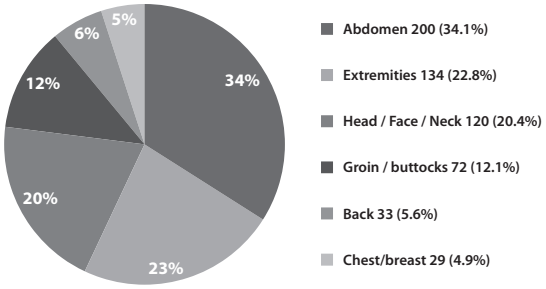

Fig. 2 Anatomic location of lifetime surgical conditions reported in the pediatric study population of Sierra Leone

Limitations

There are several limitations to this study. First, based on ethical and logistical limitations, the survey was administered as a verbal inventory of self-reported symptoms and medical history. Ideally, a physical examination component would be used to confirm responses. Second, the survey is designed so that respondents make the determination whether they need surgical care or not. There is the possibility

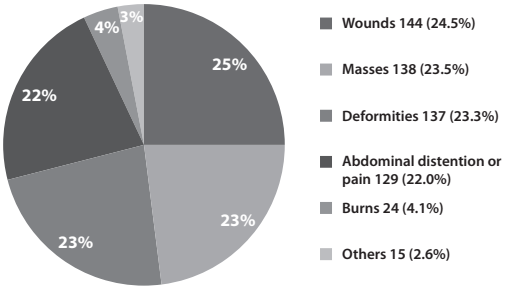

Fig. 3 Types of lifetime surgical conditions in the pediatric study population

that respondents overestimate the need for surgery to include deformities which cannot be surgically corrected. Conversely, surgical need could also be underestimated because of the presence of abdominal tumors that may not be clinically apparent. Third, for children under age 12, information was obtained from the parent or guardian, which may have led to some inaccuracies in the reporting of conditions.

Conclusions

When working on improving healthcare for the pediatric population globally and attaining MDG 4, surgically treatable conditions will have to be addressed. Based on the findings of the present study, we estimated that 17.6 % of the pediatric population of Sierra Leone may need a surgical consultation today. While additional resources should be allocated to address the surgical need, more research is needed. National health registries and accurate mortality registries should be institutionalized for longitudinal data collection. Ideally, questions regarding surgically treatable conditions should be added to the frequently executed health care surveys on the pediatric population of Sierra Leone.

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Conflict of interest The authors have no conflicts of interest relevant to this article to disclose.

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Chapter 5

Female health and family planning in Sierra Leone: Results of a nationwide household survey. Groen RS, Solomon J, Samai M, Kamara TB, Cassidi LD, Blok L, Kushner AL, Dhanaraj M, Stekelenburg J. *Obstetrics and Gynecology. 2013;122(3):525-31.*

Abstract

Background To describe the current status of access to maternal care, family planning utilization, and place of delivery in Sierra Leone, remains one of the poorest countries in the world, with one of the highest maternal mortality rates. As data from hospital statistics do not likely represent the needs of the population, surveys are an important source of information.

Methods Data from the Surgeons OverSeas Assessment of Surgical need (SOSAS), a cross-sectional two-stage cluster-based household survey conducted in Sierra Leone in 2012, were analyzed to determine access to maternal care, family planning usage, and location of delivery.

Results Of 3,318 females of reproductive age, data were collected on 1,205 women participants of reproductive age were interviewed in depth. Twenty percent (95% CI 17.9–22.5) of respondents reported using family-planning methods; injectables were the most frequently used method. Fifty-nine percent (95% CI 54.0–63.0) of the recalled deliveries took place outside of a health facility. Of the total births 1.9% (95% CI 1.3–2.5) were reportedly done delivered by cesarean section and 0.4% (9/2,316) with instrumental delivery. There were 53 reported maternal deaths in the 12 months prior to the survey, giving resulting in a maternal mortality rate of 1,600/100,000 females per year. Of the maternal deaths, 30 females, thirty (56.6%) did not receive any type of modern health care with 53% (16/30) of families noting citing financial constraints.

Discussion This study reaffirms a low family planning uptake and very low instrument deliveries and cesarean section rates in Sierra Leone. Additionally, financial barriers hinder access to health care and indicate that the free health care initiative for pregnant females is not yet fully covering the reproductive needs of the females of Sierra Leone.

Original Research

Female Health and Family Planning in Sierra Leone

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OBJECTIVE: To describe the current status of access to maternal care, family planning use, and place of delivery in Sierra Leone, one of the poorest countries in the world with one of the highest maternal mortality rates.

METHODS: Data from the Surgeons OverSeas Assessment of Surgical Need, a cross-sectional two-stage cluster-based household survey conducted in Sierra Leone in 2012, were analyzed to determine access to maternal care, family planning use, and location of delivery.

RESULTS: Of 3,318 females of reproductive age (12–50 years of age), 1,205 participants were interviewed in depth. Twenty percent (95% confidence interval [CI] 17.9–22.5) of respondents reported using family planning methods; injectables were the most frequently used method. Fifty-nine percent (95% CI 54.0–63.0) of the recalled deliveries took place outside of a health facility. Of the total births, 1.9% (95% CI 1.3–2.5) were reportedly delivered by cesarean and 0.4% (9/2,316) with instrumental delivery. There were 53 reported maternal deaths in the 12 months before the survey, resulting in a maternal mortality rate of 1,600 per 100,000 females per year. Of the maternal deaths, 30 females (56.6%) did not receive any type of modern health care with 53% (16/30) of families citing financial constraints.

CONCLUSION: This study reaffirms a low family planning uptake and very low instrument deliveries and cesarean delivery rates in Sierra Leone. Additionally, financial barriers hinder access to health care and indicate that the free health care initiative for pregnant females is not yet fully covering the reproductive needs of the females of Sierra Leone.

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LEVEL OF EVIDENCE: III

Sierra Leone, a small coastal West African country, is one of the world's poorest countries and has an average life expectancy of 50 years for the female population.[1] There are only five gynecologists for the six million people of Sierra Leone. Sixty-three percent of the population lives in rural areas with a limited road network and often no personal means of transportation. Sierra Leone has a Gross National Income of $340 U.S. per person per year and a poverty ratio of over 70% (as measured by the Multidimensional Poverty Index, which accounts for deprivations in education, health, and standard of living) and was recently ranked 180 out of 187 countries by the Human Development Index.[2–5] It is not on track to attain the Millennium Development Goals, particularly the reduction of maternal mortality. In 1990 Sierra Leone had a maternal mortality ratio of 1,300 per 100,000 live births, but this figure has only decreased by 25% to the current estimate of 970 per 100,000 live births.[6]

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Surveys are an important source of health statistics in countries like Sierra Leone where access to health care is very scarce, where it is assumed that many deaths occur outside of hospital settings, and death certificates either do not reveal sufficient information on the causes of death or do not exist. In an effort to document the surgical and women's health needs in Sierra Leone, a collaborative nationwide survey was undertaken by the Ministry of Health and Sanitation, the College of Medicine and Allied Health Sciences, Statistics Sierra Leone, and the nongovernmental organization, Surgeons OverSeas.[7]

In this article the findings of the females' health sections of the Surgeons OverSeas Assessment of Surgical Need in Sierra Leone are presented with the aim to inform and discuss the current status of access to maternal care, family planning use, and place of delivery.

PATIENTS AND METHODS

This study reports the results from a cross-sectional, two-stage cluster-based self-weighted household survey. The sample size was primarily calculated to assess the surgical need as explained elsewhere.[7] Using this sample size with a total of 3,750 individuals, we expected to capture at least 732 females of reproductive age (12–50 years of age), needed to confirm the proportion of females using contraception in Sierra Leone as is currently estimated by the World Health Organization at 8.2%[1] with a binomial distribution and 2% precision.

Guided by Statistics Sierra Leone, 75 clusters, defined as "enumeration areas," the smallest administrative units in Sierra Leone, were randomly chosen with a chance proportionate to population size. Each district as well as the rural and urban areas was stratified to achieve a representative sample of the population. In each cluster, 25 households were randomly selected, aiming for a self-weighted sample of 1,875 households. In each household, two household members were randomly selected using a random calculator after an instant listing of household members was made. Maps, randomization protocols, and supervision were provided by Statistics Sierra Leone, which also provided field supervision of the enumerators to follow the Demographic Health Survey guidelines and protocols.

Surgeons OverSeas Assessment of Surgical Need is a survey tool developed by a collaborative effort of various universities and clinicians from over 36 countries. Pretesting, cognitive interviewing, and a pilot test were part of the development and previously described.[8] The survey tool is comprised of two parts: 1) the household portion in which the head of a household or his or her representative was interviewed about the household denominator (household members) and household members who had died in the previous 12 months. The deaths were categorized based on conditions in need for surgical expertise; the interviewers recorded the cause of death as given by the head of household or his or her representative. Information was also obtained on the health care-seeking behavior of the families who experienced a household death in the previous year; and 2) two household members were then randomly selected from the list of household members for a verbal head-to-toe examination for the existence of surgically treatable conditions. The female respondents older than 12 years of age were also interviewed on their menstrual cycle and, as applicable, delivery modes as well as their current family planning methods. For this article, use of family planning methods and mode of delivery as well as access to care for the reported maternal deaths were analyzed to describe the current status regarding specific indicators for females' health in Sierra Leone.

Data were collected in January and February 2012 by 16 enumerators from Statistics Sierra Leone and College of Medicine and Allied Health Sciences. The enumerators were trained in interview skills and techniques, household sampling, and were given thorough instructions on the survey tool, tablet use as well as specific translational and privacy aspects of some of the survey questions. The Surgeons OverSeas Assessment of Surgical Need execution followed the protocols of the Demographic Health Survey of Sierra Leone regarding household definition, household selection, and onsite translations into the 14 languages of Sierra Leone.[4] Enumerators were assigned to the areas based on their language skills and the protocols included to return to household at least three times before marking unavailability to complete the survey. The full research execution protocol is available at www.surgeonsoverseas.org in the resource section.

All data were collected with 3G-enabled tablets, which included the programmed Surgeons OverSeas Assessment of Surgical Need with FileMaker Pro 11.0v2 for computer-assisted data collection. The only data collected on paper were the written consents and global positioning coordinates for verification of the random selected enumerating areas. Collected data were screened on a daily basis by the field supervisors and immediate feedback was given to the enumerators. A final data assessment was performed by the principal investigator (R.G.) to identify inconsistencies and missing items. Data were analyzed using SPSS statistical software. A 95% confidence interval (CI) is given for the relevant proportions in the analysis using CI=proportion (p) x 1.96 x standard error and the standard error = root of p(1-p/n).

The study was approved by the Sierra Leone Ministry of Health and Sanitation and ethical approval was obtained from the Ethics and Scientific Review Committee of Sierra Leone and the Research Ethics Committee of the Royal Tropical Institute in Amsterdam, The Netherlands.

RESULTS

Data were collected from 1,843 households giving a response rate of 98%.[7] The households had a total of 3,318 females of reproductive age (aged 12–50 years), of whom 1,205 (36%) were randomly assigned to be interviewed in depth. The social and economic characteristics of these 1,205 females are shown in Table 1. Fifty-seven percent lived in rural areas and half of them had no formal education. With regard to their employment status, 31.0% of these females reported being farmers, 28.5% were unemployed, and 22.2% were self-employed (Table 1).

At the time of the interview 8.5% (103/1,205, 95% CI 6.9–10.1) of the participants were reportedly pregnant, and 12.5% (151/1,205, 95% CI 10.6–14.4) were breastfeeding. Of the 103 pregnant participants, 18.4% reported to be in the first trimester, 46.6% in the second trimester, and 33.0% in the third trimester of pregnancy (Table 2). Thirteen of the 103 pregnant participants (12.6%) indicated bleeding in their pregnancy.

Table 1. Current Social and Economic Status Of Survey Participants

Variable	n	%
Residency		
Urban	520	43.2
Rural	685	56.8
Total	1,205	
Education		
None	612	50.8
Primary school	176	14.6
Secondary and higher	414	34.4
Total	1,205	
Illiteracy		
Not able to read or write	654	54.3
Self-reported health		
Not feeling totally healthy	487	40.4
Occupation		
Farmer	374	31.0
Unemployed	344	28.5
Self-employed	268	22.2
Home worker or domestic helper	175	14.5
Employee	42	3.5
Total	1,205	

Eighty-two percent of the total females interviewed (990/1,205, 95% CI 80.0–84.4) indicated that they menstruated at least once in the previous year. Of the 990 menstruating females, 12.8% reportedly had an irregular cycle, 10% reported spotting, and 45.1% mentioned pain, which interfered with their daily activities. Twelve percent of these females indicated the need for medical care for their menstrual problems (116/990, 95% CI 9.7–13.7) and 6.4% (77/116) sought traditional care for their menstrual problems. Financial constraints were reported by 50% of these females as the major barrier to obtain health care (Table 2).

Twenty percent of the interviewed females (95% CI 17.9–22.5) reported using family planning methods at the time of the interview. Injectable was most frequently mentioned as the method of contraception (118/244 [48.4%]) followed by oral contraceptive pills (89/244 [36.4%]) and implants (20/244 [8.2%]). Less frequently mentioned were intrauterine devices or condoms as well as breastfeeding (Table 2).

A total of 2,645 pregnancies, resulting in a total of 2,316 births, were recalled by the 990 females who were still menstruating (Table 3). Fifty-nine percent (1,355/2,316, 95% CI 54.0–63.0%) of the recalled deliveries took place outside a health facility. Of the

Table 2. Current Reproductive Health Characteristics of Survey Participants

	n	%	95% CI
Reproductive health			
Reported pregnancies	103/1,205	8.5	6.9–10.1
First trimester	19	18.4	
Second trimester	48	46.6	
Third trimester	34	33.0	
Unknown	2	1.9	
Currently menstruating	990/1,205	82.2	80.0–84.4
Irregular cycle	127	12.8	
Spotting	99	10.0	
Pain	466	45.1	
Use of family planning	244/1,205	20.2	17.9–22.5
Injectable	118	48.4	
OCPs	89	36.4	
Implant	20	8.2	
Breastfeeding*	7	2.9*	
Intrauterine device	4	1.6	
Condom	3	1.2	
Other	3	1.2	
Reproductive health care barriers			
Financial constraints	58	50.0	
Not available	5	4.3	
No time	3	2.6	
Transportation	1	0.9	
Total	116		

CI, confidence interval; OCP, oral contraceptive pill.
* Used as method of contraception.

Table 3. Recalled Pregnancies and Delivery Modes for Survey Participants With at Least One Menstruation in the Previous Year

	n	%	SE	95% CI	Range	Mean
Total no. of pregnancies in lifetime	2,645	100			0–12	2.7
No. of deliveries	2,316	100			0–11	2.3
No. of home deliveries*	1,355	58.5	2.3	54.0–63.0	0–11	
No. of health facility deliveries	957	41.3			0–9	
No. of cesarean deliveries	44	1.9	0.3	1.3–2.5	0–2	
No. of instrumental deliveries	9	0.4			0–1	

SE, standard error; CI, confidence interval.
* Location of delivery missing for four (0.2%) participants.

total births, 1.9% (44/2,316, 95% CI 1.3–2.5%) were reportedly delivered by cesarean and 0.4% (9/2,316) with instrumental delivery (Table 3).

There were a total of 709 household deaths reported; of these deaths, 32.7% (232/709) were females of reproductive age. Fifty-three females (53/232 [22.8%]) who died during reproductive age were at the time of death reportedly pregnant or within 6 weeks after their delivery. These reported deaths came from 40.0% (30/75) of the clusters, ranging from zero to six maternal deaths per cluster in the previous year. The clusters that were affected by a maternal death in the previous year are spread over the entire country (Fig. 1). Because maternal mortality rate is calculated by the number of maternal deaths divided by the total number of females in the sample aged 15–49 years,[9] our maternal mortality rate was computed as 53 of 3,318 or 0.01597 or 1,600 of 100,000 females per year.

Causes of maternal death were categorized 75.5% (40/53) as "bleeding or ill around childbirth" and 3.8% (2/53) as abdominal distention or pain. Other causes that were mentioned by the household representative were malaria, hypertension, chest pain, heart failure, and in 13.2% (7/53) of participants, the cause of death was unknown (Table 4).

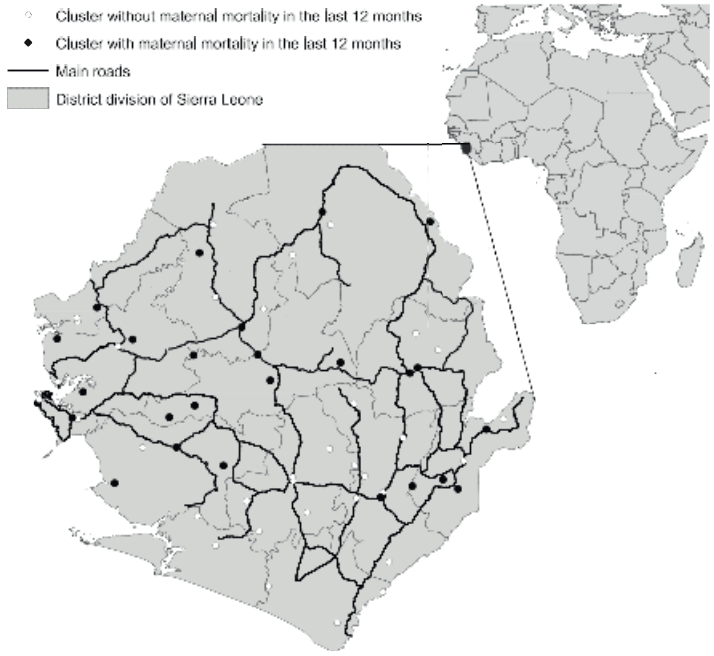

Fig. 1. The 75 clusters visited and indication of the reported maternal deaths.

Groen. Female Health in Sierra Leone. Obstet Gynecol 2013.

Table 4. Information Regarding Maternal Mortality as Reported by the Household Representatives

Mentioned Cause	n	%
Bleeding or ill around childbirth	40	75.4
Abdominal distention or pain	2	3.8
Malaria in pregnancy	1	1.9
Hypertension in pregnancy	1	1.9
Chest pain in pregnancy	1	1.9
Heart failure in pregnancy	1	1.9
Unknown	7	13.2
Total	53	100
Health care–seeking behavior		
Modern health care	31	58.5
Traditional health care	3	26.4
Both modern and traditional health care	14	5.7
None	5	9.4
Total	53	100
Type of care given		
No attempt to find modern care	8	15.1
No care at all	22	41.5
No need for surgery	11	20.8
Minor procedure	7	13.2
Major procedure	4	7.5
Missing value	1	1.9
Total	53	100

With regard to health-seeking behaviors for sick females before death, 84.9% (45/53) sought modern health care. Fifty percent of the families (22/45) who reportedly sought modern health care did not receive this care at all. Thus, a total of 30 participants (56.6%) did not receive any modern care (ie, 22 who sought but did not receive and eight who did not seek at all). Fifty-three percent (16/30) of their families reported that financial constraints were the main reason for not accessing modern care, 26.7% (8/30) had no time, and 6.5% (2/30) reportedly had difficulty with organizing transportation (Table 5).

In 47.2% of the cases, the place of death was reported to be the home, 45.3% in health facilities, and 7.5% elsewhere.

Table 5. Reasons Given by Family For Lack of Modern Care Before the Maternal Death

Reason	n	%
Financial constraints	16	53.3
No time	8	26.7
Care not available	3	0.1
No possibilities for transportation	2	6.7
Missing value	1	3.3
Total	30	100

DISCUSSION

Measuring maternal mortality is a complicated entity, especially without adequate public records, which is the case in many resource-poor countries. In a place such as Sierra Leone, where the majority of births (59% in this study) and deaths (55% in this study) take place outside of health care facilities, it is difficult to have comprehensive national level records of birth and death rates. And therefor surveys take an important place in the health statistics. This current survey was not specifically developed for maternal mortality and did not follow the sisterhood method.[10,11] Therefore, we calculated a maternal mortality rate instead of ratio. It is thought that our figure is an underestimation because deaths resulting from ectopic pregnancies or deaths from spontaneous or induced abortions might not have been accounted for. On the other hand, recall for a tragic event like a maternal death will probably be a significant memory and therefore prone to telescoping. Telescoping of events might make them seem closer to the current date than when it actually happened and might therefore lead to overreporting of an event in a year because the actual event was before the year of interest. Nevertheless, these data suggest that maternal mortality remains a crucial health concern throughout the nation of Sierra Leone and support the need for regional and national health strengthening.

Gabrysch and Campbell [12] found in their review that maternal age, ethnicity, mother's education, multiparity, inability to pay, and rural location are the most important factors influencing the absence of a skilled birth attendant at the time of delivery. Economic accessibility was thought to be a significant factor as well, which is consistent with our findings. Sierra Leone instituted free health care for all pregnant females in April 2010; thus, it is very concerning that the predominant reason reported by families for failure to seek care, resulting in a maternal death, was self-report of financial constraints.[13] Financial concerns were followed by not having enough time and difficulty arranging transportation. These last two reasons may indicate a lack of preparedness on the household level in general. Further research is needed to understand current preparedness in pregnancy by the pregnant woman as well as her family. Access to some of the randomly chosen cluster sites was difficult, requiring the use of boats, long hikes, and rough driving paths. This illustrates the likely difficulty for females in need of emergency obstetric care. Maternal waiting homes might be a possible solution to overcome these geographic barriers to care.[9]

One way to reduce the absolute number of pregnancy-related deaths is to improve access to and

use of contraception.[14–16] According to our study, 20% of females used family planning methods at the time of the interview, the majority of which were injectable hormonal contraceptives. This seems an improvement compared with other studies that reported 5% and 10% overall use rate.[3,17] However, caution has to be exercised when comparing different survey methods to estimate trends. Furthermore, the current survey did not explore in depth the correct use of contraception (eg, "When was the last injectable given?" or "What percentage of intercourse was with condoms?"). Our study did not explore the distribution or clustering of the mentioned contraception use either. This could be useful to address preferences across the country and in differences among the tribes of Sierra Leone or could reveal lack of local availability or skilled health care providers. Nevertheless, increasing contraceptive use in developing countries will not only reduce maternal mortality,[18] but also improve perinatal outcomes and child survival.[19]

Although maternal mortality and access to family planning are prominent in global health discussions, the gynecologic burden is infrequently mentioned. Our survey also documents part of the gynecologic burden in the population. Almost 12% of the females who were menstruating reported a need for medical attention based on prolonged, excessive, or painful menstrual periods. Although free care for pregnant and lactating females is made available,[13] females with leiomyomas, ovarian masses, and endometrial or cervical cancers are currently left with limited medical attention.

Survey limitations were related to the fact that the survey was primarily designed to measure the need for surgical care and only secondarily included questions related to reproductive health. To make the survey workable for the enumerators, elaborate questioning of the females on each individual childbearing period was therefore not included but could have given useful insight. Despite close supervision and a thorough training before the survey execution, we cannot exclude an interviewer's bias. The enumerators reported in the feedback session that some of the most difficult questions to ask were related to the menstrual cycle, which is considered a private condition in Sierra Leone.

In summary, our study documents family planning use by reproductive-aged females in Sierra Leone at 20%, which is substantially higher than the 8.2% reported by the World Health Organization for Sierra Leone[1] and therefore encouraging. However, our study also documented that only 1.4% of the recalled deliveries were by cesarean and less than 1% by instrumental delivery, far below the expected need.[20] Furthermore, financial constraints were mentioned by half of the families as the reason they were not able to access modern care. We therefore conclude that the free health care initiative for pregnant females is not yet fully covering the reproductive needs of the females of Sierra Leone.

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Chapter 6

Estimating operative disease prevalence in a low-income country: Results of a nationwide population survey in Rwanda.

Petroze RT, Groen RS, Niyonkuru F, Mallory M, Ntaganda E, Joharifard S, Guterbock TM, Kushner AL, Kyamanywa P, Calland JF. *Surgery. 2013;153(4):457-64.*

Abstract

Background Operative disease is estimated to contribute to 11% of the global burden of disease, but no studies have correlated this figure to operative burden at the community level. We describe a survey tool that evaluates population-based prevalence of operative conditions and its first full-country implementation in Rwanda.

Methods The Surgeons OverSeas Assessment of Surgical Need (SOSAS) survey tool is a cross-sectional, cluster-based population survey designed to measure conditions that may necessitate an operative consultation or intervention. Household surveys in Rwanda were conducted in October 2011 in 52 clusters nationwide. Data were population-weighted and analyzed with the use of descriptive statistics.

Results A total of 1626 households (3175 individuals) were sampled with a 99% response rate. 41.2% (95% confidence interval [95 CI%] 38.8–43.6%) of the population has had at least one operative condition during their lifetime, 14.8% (95% CI 13.3– 16.5%) had an operative condition during the previous 12 months, and 6.4% (95% CI 5.6–7.3%) of the population were determined to have a current operative condition. A total of 55.3% of the current operative need was found in female respondents and 40.3% in children younger than 15 years of age. A total of 32.9% of household deaths in the previous year may have been related to operative conditions, and 55.0% of responding households lacked funds for transport to the nearest hospital providing general practitioner operative services.

Discussion The SOSAS survey tool provides important insight into the burden of operative disease in the community. Our results show a high need for operative care, which has important implications for the global operative community as well as for local health system strengthening in Rwanda.

Estimating operative disease prevalence in a low-income country: Results of a nationwide population survey in Rwanda

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Surgeons OverSeas (SOS) provided the survey tool, technical assistance, and funding for the logistical execution of the data collection, including the salaries of the interviewers and field supervisor. The UVA Department of Surgery provided funding for statistical analysis and consultative assistance with study design.

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ALTHOUGH OPERATIVE CARE is an essential component of health care, the global health community traditionally has not seen it as a priority. This may be attributable to the unfamiliarity of operative care within public health, concerns about cost-effectiveness, and the absence of the surgeon's involvement in health care planning.[1] Operative disease is estimated crudely to contribute to at least 11% of the global burden of disease, but no studies have correlated this figure to operative burden at the community level; current figures delineating operative burden are made on the basis of extrapolation of limited global data and estimations of disease incidence on the basis of hospital-level data.[2-4]

Rwanda is a land-locked country in sub-Saharan Africa with a population of 10.7 million.[5] The 1994 genocide decimated the socioeconomic, educational, and health care infrastructure of the country, exacerbating the country's existing problems with poverty and poor health care. However, Rwanda's subsequent aggressive development and health policies during the past decade have stimulated broad progress in both the economic and the health sectors.[6]

The Demographic and Health Surveys (DHS) are the most comprehensive sources in developing countries for population-based health statistics.[7] The 2010 DHS survey in Rwanda noted significant decreases in maternal and infant rates of mortality as compared with previous surveys, as well as an increase in the use of antenatal care and childhood immunizations.[5] The Maternal Mortality Ratio (maternal deaths per 100,000 live births) in Rwanda, for example, decreased to 340 in 2010 from 750 in 2005; to compare with more-developed countries, the 2010 Maternal Mortality Ratio for the United States was 21.[8] The DHS does not, however, include questions on operatively treatable conditions, which is not surprising because funding for operative development is severely lacking among international funding agencies.[9,10]

In a comprehensive national assessment of hospital-level capacity for emergency and essential operative care in Rwanda, researchers found deficiencies in operative infrastructure, personnel, and training, with numbers of available operating theatres and surgeons well below international standards.[11] Given these scarcities, the true burden of operative disease can likely only be assessed by extending evaluations beyond the hospital level to the community level.

The Surgeons OverSeas Assessment of Surgical Need (SOSAS) survey tool was developed to provide the missing data on operative need in low- and middle-income countries by establishing a standardized, duplicable survey tool to quantify the prevalence of operatively treatable conditions in resource-limited settings.[12] It is hoped that the data arising from SOSAS surveys will oblige global funds, nongovernmental organizations, and local health ministries to allocate increased resources to providing operative care, thereby strengthening health systems, saving lives, and reducing the burden of human suffering as the result of untreated operative disease. The SOSAS survey tool was developed for open-source access and is available at www.surgeonsoverseas.org.[13] Our study in Rwanda represents the first full-country survey to be conducted.

METHODS

Survey design. The SOSAS survey tool is modeled on DHS surveys as well as the WHO Guidelines for Conducting Community Surveys for Injuries and Violence. A research group comprising 46 international surgeons and public health experts provided input during the SOSAS development project. Designed for direct computer-based entry, a functional pilot of the study evaluating the ease and utility of use on iPad tablets was conducted in Sierra Leone in August 2011.[13] Local adaptations were made on the basis of population-based surveys of musculoskeletal impairment in Rwanda.[14,15]

The first section of the survey gathers household demographics, including a listing of all members of the household and information regarding timing and distance to health facilities, from a household representative. Household representatives also are asked to report the total number of deaths occurring in the household within the previous 12 months as well as the proximal cause of each death.

The second section of the SOSAS questionnaire is organized by anatomic area to measure a wide spectrum of proxy conditions that may necessitate operative consultation or intervention. The individuals who complete this section respond only regarding their own health. These conditions are meant to serve as representative of common conditions that can be easily described in the common language and identified by a nonmedical provider. For the purposes of this study, an operative condition is defined as a self-reported wound, burn, mass, congenital or acquired physical deformity, or operation in the anatomic areas defined in the survey: face/head/neck, chest/breast, back, abdomen, groin/genitalia, or extremities. For each anatomic area, survey questions seek to identify congenital, acquired, malignant, or injury-related conditions. Further questions investigate the timing of conditions and perceived barriers to care.

SOSAS was designed in English, translated to the local language of Kinyarwanda, and back-translated into English to ensure fidelity; French and English translations were available to interviewers for cross-referencing purposes during interviewing. Before we began to collect data, cognitive interviewing of the tool in English and Kinyarwanda occurred with nonmedical subjects.

Sampling. SOSAS is a cross-sectional, cluster-based population survey.[16,17] Because a nationwide population census has not been performed since the restructuring of administrative units in Rwanda

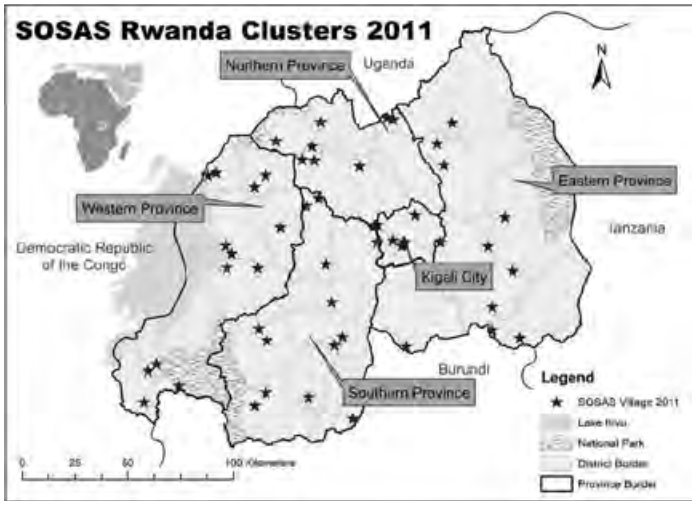

Fig 1. SOSAS Rwanda clusters, October 2011. (Color version of figure is available online)

in 2006, our sample design used the 2012 census preparatory frame, as used for the 2010 Rwanda DHS. Each of the nation's 30 officially defined districts formed a sampling stratum. Two-stage sampling to select 50 clusters, as defined at the village level, was done such that the probability of cluster choice was proportional to the district population size.[16-18] For each cluster, a village was chosen at random from the census list of villages within a district. One alternate village per district was also identified. Three alternate villages (1 substitute and 2 additional due to inadequate available households in a given cluster) were used for a total of 52 sampled clusters. In each sampled village, interviewers began at a centralized location and sampled every third household with the goal of sampling 30 households per village. At each household, they interviewed a household representative regarding overall demographics of the household, access to care, and household deaths. With the household representative, the interviewer created a listing of the ages and sexes of all members of the household. To select the individuals who would complete the full survey regarding specific operative conditions, a random number generator was used to select a maximum of 2 individuals per household.

Study population. Household members were defined as anyone who was a usual resident of the household or who slept in the household the night before the survey. All sexes and ages were eligible for inclusion with information provided by a parent/guardian for children. Informed consent was obtained from all participants. Participants were excluded if they were absent from the sampled household after three documented visits from the interviewer.

Data collection. Ten interviewers were competitively recruited and trained during a 5-day period. Data collection took place during a 1-month period (October 2011) in 52 clusters nationwide. Interviewers were assigned across regions so that interviewer effects in the final result would be minimized. District medical officers, district administrators, and village chiefs were contacted before initiating household visits in each cluster. Surveys were programmed in FileMaker Pro 11.0v2 (FileMaker Inc, Santa Clara, CA) and uploaded to 3G iPads (iPad 1, Apple Inc., Cupertino, CA) equipped with FileMaker Go 1.1 (FileMaker Inc).

During the first week of data collection, interviewers submitted their iPads to the principal investigator and data supervisor for daily data download with biweekly or weekly download for each of the sampling periods thereafter. Embedded time stamps in the program and geographic tracking of interviewers in the field using the "Find my iPad app" were used to monitor for fraud. Interviewers underwent direct observation in the field, and a field supervisor revisited 12 of 52 clusters to validate data collection at approximately 5% of households.

Statistical analysis. The collected data were analyzed using Statistical Package for Social Sciences, version 19 (IBM Corp, Armonk, NY). Variance estimation took into account the stratification of the sample at the district level, the clustered sampling of households in 52 clusters, and the selection of only two individuals per household regardless of household size. Design weights were applied to adjust each district to its correct proportion of the population, and to correctly represent the percentage of individuals residing in households of different sizes (from 1-person to 13-person households). The design weights were scaled to bring the case count up to 10.7 million persons, matching the 2011 population projection.[19]

Analysis of the weighted data revealed that younger adults, especially younger males, were underrepresented among those who were interviewed (or interviewed by proxy); elders and children were correspondingly overrepresented in the interviews. These patterns probably reflect which persons were at home during the field period in each village. Poststratification weights were applied that bring the distribution by age and sex for the results on the basis of individuals into full alignment with the national results of the 2010 DHS. No poststratification weights were needed for household-level results.

The percentages and population-count estimates presented here were derived from the complex sampling frequencies and crosstabulation procedures in SPSS, which provide estimates of sampling errors, confidence intervals, and tests of independence that are corrected for the design effects from the stratified, clustered design, and from weighting.

Ethical considerations. Ethical approval was provided by the University of Virginia Institutional Review Board and the Rwandan National Ethics Committee. The hospital director at the nearest hospital was contacted before survey implementation in each cluster to facilitate referral of serious health problems that were detected by interviewers. Approval to engage in a nationwide household survey was obtained from the Rwandan National Institute of Statistics, which also provided critical input in sample selection. Results were presented to the Rwandan Ministry of Health, the Rwandan National Institute of Statistics, and the Rwanda Surgical Society before publication.

RESULTS

Demographics. Figure 1 shows the location of the 52 sampled clusters based upon GPS coordinates taken at the index household. A total of 1626 households were sampled with a 99% response rate. A household representative completed the first section of the survey regarding overall household demographics, access to medical care, and household deaths. Table I summarizes the demographics of the survey. The mean household size was 4.67 individuals with 59.9% having a female household representative. Each household listed the age and sex of all household members; this included a total of 7547 individuals, representing a population breakdown of 52.7% female and 44.0% younger than 15 years of age.

Table I. Demographics, SOSAS Rwanda

Demographics	Estimate (SE)
Household	
Mean household size	4.67 (0.04)
Sex of household representative	
Male	40.1% (1.1%)
Female	59.9% (1.1%)
Mean age of household members	21.9 (0.18)
Sex of household members	
Male	47.0% (0.7%)
Female	53.0% (0.7%)
Village location*	
Rural	93.1% (2.7%)
Urban	6.9% (2.1%)
Individual demographics (for adults 15–59 y)y	
Education level	
None	23.2% (1.2%)
Primary school	62.0% (1.5%)
Secondary school	13.1% (1.7%)
Literacy	71.3% (1.7%)
Occupation	
Agriculture	68.8% (2.9%)
Student	12.6% (1.4%)
Unemployed	9.2% (1.0%)
Skilled employee	3.8% (0.7%)
Unskilled employee	3.4% (0.5%)
Self-employed/small business	1.9% (0.6%)

*Rural/urban differentiation not available from NISR as administrative restructuring since 2002 census; report here by consensus of local PI and interviewers.
yIndividual demographics are taken from the individual response section of the SOSAS questionnaire.
NISR, National Institute of Statistics of Rwanda; PI, principal investigator; SOSAS, Surgeons OverSeas Assessment of Surgical Need.

Access to operative care was found to be a consistent challenge, with 55.0% of responding households lacking the funds required for transport to the closest district hospital (general practitioner operative services) and 77.0% lacking funds for travel to referral hospitals (specialist operative services). A total of 70.4% of responding households reported greater than 2 hours' travel time for transport to the nearest operative services.

Table II. Prevalence of operative conditions at the community level

	Estimate, %	95% confidence interval, %	Estimate (no. people)	95% confidence interval (no. people)
Operative condition now	6.4	5.6–7.3	675,456	583,016–767,897
Operative condition in previous 12 months	14.8	13.3–16.5	1,568,268	1,393,707–1,742,829
Lifetime operative condition	41.2	38.8–43.6	4,359,980	4,081,975–4,637,984

Prevalence of operative conditions in the community. A total of 3175 individuals were randomly assigned from the household list (maximum 2 per household) to complete the full survey regarding their own health conditions. Table II details the overall prevalence of operative conditions in the community. If an interviewee identified a condition, we asked if he or she had sought or would like to seek medical care. If the answer was no, we asked why. Those individuals who responded "no need" were excluded from the calculations of operative need. A total of 41.2% of the population has had at least one operative condition during their lifetime, 14.8% had an operative condition during the previous 12 months, and 6.4% of the population was determined to have a current operative condition. For all identified potential operative conditions, 5.9% underwent a major operation. Of these 155 operations, 48 were cesarean deliveries.

The 2 main reasons cited by interview subjects for not seeking care were (1) no skilled doctor or nurse available and (2) no money available for health care. A condition was defined to be disabling if the interviewee reported significant shame, inability to work as they had previously, needing help with daily activities, or needing help with transportation. For all operative conditions reported, 34.3% were associated with a disability, and 58.0% of individuals with at least one identified condition had some type of disability.

Table III illustrates in greater detail the current operative need. The prevalence figures reported here are percentages of the total population. Univariate v^2 analysis showed significant differences in current operative need by age and geographic region. Not unexpectedly, older individuals were more likely to report current operative problems. However, the prevalence in the young population, particularly in the student and young adult working population was greater than 6%. Regionally, the Southern Province evinced the greatest level of current operative need. Supplementary Table I further details the anatomic breakdown of the current operative need.

Figure 2 describes the characteristics of the 6.4% of the population currently in need of operative care, broken down by sex, age, location, and geographic region. A total of 55.3% of the current operative need is in female patients, with 40.3% of the need being in children younger than 15 years of age. In fact, greater than 80% of the current operative conditions in Rwanda occur in individuals younger than 45 years of age. The need is primarily rural with the Southern Province comprising the greatest-need region. Similar results are seen on evaluating the previous year and lifetime operative need by sex, age group, location, and province (Supplementary Figs 1 and 2).

Figure 3 shows the breakdown by anatomic location of the identified operative conditions currently in need of care. Extremity conditions were the most prevalent (36%), closely followed by conditions of the face, head, and neck (which includes eye conditions; 28%).

Household deaths. Household representatives reported a total of 77 household deaths within the previous year, with 49.4% of reported household deaths occurring in children younger than 5 years of age. A total of 32.9% of the total deaths may have come as a result of operatively treatable conditions, as detailed in Figure 4. Of these, abdominal pain/distention (10%) and mass/growth (10%) were the most common causes of death.

DISCUSSION

This study represents the first implementation of a nationwide survey to document the prevalence of operative conditions at the community level. A total of 6.4% of the study sample---corresponding to an estimated 675,000 Rwandans---were determined to currently need operative care, with nearly 15%---an estimated 1.6 million Rwandans---reporting an operative condition within the previous year.

The results of this survey have important implications for the global operative community, and, more importantly, to health system strengthening in Rwanda. Regional differences seen in this study can be further analyzed in conjunction with hospital-level epidemiologic data to develop

Table III. Characteristics of current operative need

Characteristic	Prevalence (SE)	P value
Age		
0–4 y	4.9% (0.6%)	.050*
5–14 y	6.3% (0.5%)	
15–29 y	6.9% (0.7%)	
30–44 y	5.2% (1.4%)	
45–59 y	9.6% (0.8%)	
60 + y	7.1% (1.0%)	
Gender		
Male	6.1% (0.6%)	.444
Female	6.6% (0.5%)	
Location		
Rural	6.6% (0.4%)	.339
Urban	4.0% (2.0%)	
Region		
Kigali	4.6% (1.1%)	.001*
South	9.5% (0.6%)	
West	5.1% (0.8%)	
North	7.6% (1.6%)	
East	4.2% (0.5%)	

*Significance indicated at P#.05.

interventions to improve access to operative care. The current estimate of operative need---6.4% of the population---is twice the HIV prevalence in Rwanda, estimated at 3.0% by DHS 2010.[1] In fact, the overall HIV prevalence in Rwanda has not changed since the previous DHS survey, perhaps highlighting effective public health initiatives and a shift towards noncommunicable disease burden in the community. Because the majority of funding for public health initiatives is directed at communicable diseases, with an increasing focus on chronic, noncommunicable diseases, it is imperative to channel funding and attention for initiatives to address the operative burden. A small proportion of the identified operative conditions (5.9%) underwent operative intervention. At the individual level, interview subjects identified several barriers to accessing care for their specific conditions, with a lack of providers and lack of money predominating. The challenges to accessing operative care identified at the household level, with 55% of households stating they did not have funds to travel to the nearest facility that offers operative services, provide further insight into issues of operative access and highlights potential areas for health system strengthening.

Operative conditions lead to substantial morbidity and mortality in the Rwandan community, with 41.2% of the sample population reporting an operative condition in their lifetime, which extrapolates to more than 4.5 million current Rwandan citizens. Our findings demonstrate the possibility that >30% of household deaths in the previous year may have been attributable to operatively treatable conditions. Alarmingly, the population represented in these estimates is relatively young, with nearly 80% of the lifetime operative conditions (and well >80% of the operative conditions in the previous year) noted in individuals younger than 45 years of age. A student and working population afflicted with operative disease and disability in the face of insufficient access to care carries significant economic implications as the country strives to move beyond poverty. The young population carrying this operative burden differs from the older population in the Western/Northern world; this may further hint at a future health care crisis as the Rwandan population ages and noncommunicable diseases, including potential operative conditions such as cancer, overtake the infectious disease burden.[20-22]

This study further demonstrates the usability of the SOSAS survey instrument in the field. The organization of the survey script by anatomic area anecdotally seemed to assist respondents in recalling previous operative conditions. The challenge in relying on operative recall in a population with limited access to operative care, however, is that, although recall bias may affect reported time frame of incidents, we believe it likely underestimates the true operative need to a significant degree due to poor access and information about operative conditions. On the other hand, results derived from recall can certainly provide a baseline with regard to breadth of conditions and barriers to accessing care when conditions are identified.

The benefits and drawbacks of using iPads for computer-assisted personal interview have been previously documented during the functional pilot of the SOSAS survey.[13] Our survey had similar findings: interviewers had little trouble familiarizing themselves with the technology and found the iPads easy to use in the field. Direct data entry limited errors in recording data and allowed for early analysis. We further believe that the use of embedded time stamps and tracking of interviewer movements through the 3G network helped to limit fraud during data collection.

The main limitation of this survey is in the definition of operative conditions and case-finding at the household level. Thus, the identified conditions serve as proxies in estimating operative disease prevalence. All operative conditions identified in our study were self-reported by respondents (who have inadequate access to operative care) to interviewers with medical knowledge but without operative expertise or

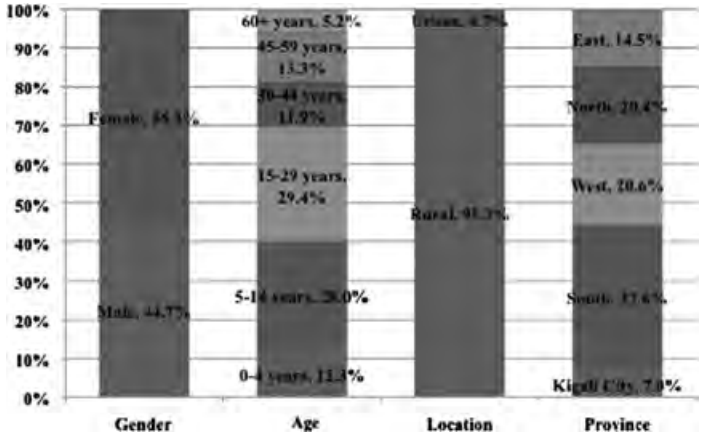

Fig 2. Breakdown of current operative need. (Color version of figure is available online.)

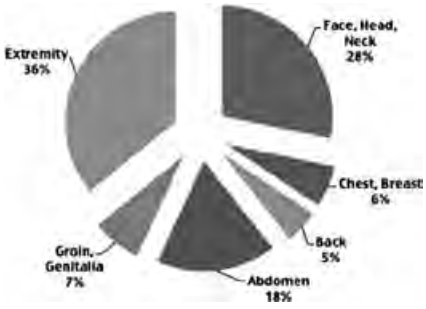

Fig 3. Anatomic breakdown of current operative need. (Color version of figure is available online.)

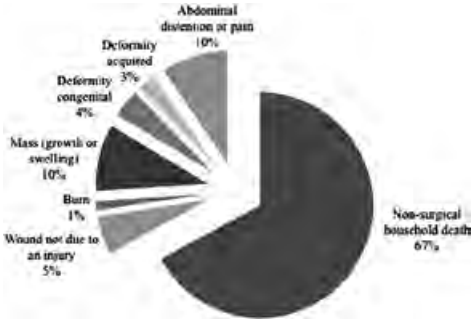

Fig 4. Potentially operatively treatable household deaths.

sophistication. This may overestimate some conditions such as a neck mass that could be a Burkitt's lymphoma requiring chemotherapy, not operative intervention, but we would argue that an operative consultation may still be warranted in this case. Alternatively, this survey does not identify such conditions as intra-abdominal cancers or early breast cancers that could be amenable to operation. For this reason, we believe our estimates of operative need in Rwanda are likely an underestimation of the true prevalence of operative conditions. Furthermore, the suspected prevalence of operative conditions before death (32.9%) highlights that the 6.4% estimate of current operative need does not adequately represent severe operative conditions truly in need of care now such as severe injuries, cancers, and abdominal emergencies.

A further limitation is that we did not validate our results in the community with physical examinations by trained surgeons or additional diagnostics such as one might see in similar projects that address the incidence and prevalence of infectious diseases such as HIV or malaria. This may limit the universality of the SOSAS findings. Although the validation of the survey tool with physical examination, laboratory, and/or radiographic diagnostics may provide insight, validation is limited by surgeon shortage in the community, funding for operative research in resource-limited settings, and ethical considerations in performing physical examinations in a community-members' household. Furthermore, the benefit of this study is to provide community-level estimates---to identify reasonable proxies for operative disease. Ideally, as operative capacity and access improves, operative

conditions can be reliably assessed and treated at health facilities, providing more accurate numbers of the prevalence of operative disease.

We think that the SOSAS survey tool provides important insight into the burden of operative disease and that the results should serve as a guide to highlight needs and stimulate further research. What is clear from these results is that operative conditions are a significant burden in the community and in a relatively young population. The results further highlight the issue of access---the operative needs of the community are simply not being met by the current operative capacity in the country.

In Conclusion, the results of SOSAS Rwanda can hopefully be used in Rwanda to geographically characterize specific categories of operative need at the community level, so as to plan hospital-level care. There is no gold standard for evaluation of operative need at the community level, but we would recommend the use of SOSAS widely to create a baseline in low- and middle-income countries. By providing a deeper representation of operative need than is currently available through hospital-based surveys and statistical modeling, these results can ultimately lead to improvements in operative services worldwide by highlighting the importance of operative capacity building through infrastructure and training and emphasizing the need to improve operative access in horizontal health system–strengthening approaches.

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PART II – SURGICAL CAPACITY

Chapter 7

A tool and index to assess surgical capacity in low income countries: an initial implementation in Sierra Leone.
Groen RS, Kamara TB, Dixon-Cole R, Kwon S, Kingham TP, Kushner AL. *World J Surg. 2012;36(8):1970-7.*

Abstract

Background A first step toward improving surgical care in many low and middle income countries is to document the need. To facilitate the collection and analysis of surgical capacity data and measure changes over time, Surgeons OverSeas (SOS) developed a tool and index based on personnel, infrastructure, procedures, equipment, and supplies (PIPES).

Methods A follow-up assessment of 10 government hospitals in Sierra Leone was completed 42 months after an initial survey in 2008 using the PIPES tool. An index based on number of operating rooms, personnel, infrastructure, procedures, equipment, and supplies was calculated. An index was also calculated, using the 2008 data for comparison.

Results Most hospitals demonstrated an increased index that correlated with site visits that verified improved conditions. Connaught Hospital in Sierra Leone had the highest score (9.2), consistent with its being the best equipped and staffed Ministry of Health and Sanitation facility. Makeni District Hospital had the greatest increase, from 3.8 to 7.5, consistent with a newly constructed facility.

Discussion The PIPES tool was easily administered at hospitals in Sierra Leone and an index was found useful. Surgical capacity in Sierra Leone improved between 2008 and 2011, as demonstrated by an increase in the overall PIPES indices.

A Tool and Index to Assess Surgical Capacity in Low Income Countries: An Initial Implementation in Sierra Leone

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Introduction

With surgery increasingly recognized as an important component of public health [1], there is a need to characterize conditions at the health facilities where surgical care is provided in low and middle income countries. Such information will allow clinicians, policy makers, health care planners and donors to more easily identify gaps and evaluate interventions.

In 2008, the World Health Organization (WHO) developed a Tool for the Situational Analysis of Emergency and Essential Surgical Care (WHO tool) to measure surgical capacity [2]. To date nine individual country reports have been published using the WHO tool [3–11] despite limitations, which include collected data sets that are difficult to analyze and sections that are ambiguous or difficult for respondents to clearly answer. Osen et al. [12] validated the WHO tool and stated that questions related to process of care had poor reliability and should be revised. Unfortunately, to date despite repeated requests no revision of the WHO tool has been done.

In addition to only documenting the surgical capacity of a facility or multiple facilities in a country, an index to more easily compare facilities with each other and over time would be useful. Kwon et al. [13] recently published a technique for calculating an index using the WHO tool. However, given the limitations of the WHO tool, the index is also relatively cumbersome to apply.

In light of the limitations of the WHO tool, the inability to easily calculate an index, and the lack of accessibility to the database holding the data collected by WHO, a decision was made to develop a novel tool.

The aim of this article is to highlight a novel surgical capacity survey based on personnel, infrastructure, procedures, equipment and supplies (PIPES). This new PIPES tool was designed to be easy to administer, to allow simple data analysis, to permit comparison between facilities, and to document changes in the surgical capacity of facilities over time.

Methods

The PIPES tool was developed by modifying the WHO tool and including the absolute numbers of hospital beds and operating rooms; a binary system of measurement to enable easier counting of available items; omitting reasons for not performing procedures; and restructuring and streamlining individual questions.

The final PIPES tool has 105 total data items, compared to the 256 of the WHO tool. The 105 data items are divided into five sections: Personnel, Infrastructure, Procedures, Equipment, and Supplies. Individual scores for each section are calculated by adding 1 point for each item that is present, functioning, and always available in sufficient quantities.

The PIPES tool is available on the Surgeons OverSeas (SOS) website www.surgeonsoverseas.org and as Appendix 1 to this article.

Survey site

For the purposes of this study, the PIPES tool was used in Sierra Leone, a small West African country with a population of 6 million, with a documented lack of surgical capacity [3]. Sierra Leone was chosen due to an earlier assessment and the longstanding relationship between local surgeons and the Ministry of Health and Sanitation (MOHS) and Surgeons OverSeas (SOS) [14].

The PIPES tool was used at 10 MOHS hospitals in August 2011, 42 months after an initial survey that documented the limited surgical capacity [2]. During the site visits, key administrative personnel and clinicians were interviewed and a survey form was completed for each facility.

The 10 hospitals assessed included five facilities in the Sierra Leone capital, Freetown, and five facilities outside of Freetown (Table 1). These 10 facilities are the main MOHS hospitals providing surgery to the majority of the population (Fig. 1).

Use of PIPES and calculation of the index

From the data collected, a Personnel score was calculated by adding 1 point for each full time staff member recorded

Table 1 Sierra Leone Ministry of Health and Sanitation Hospitals (MOHS) 2008 and 2011: facility type, number of operating rooms, surgery, and anesthesia staff

Hospital name	Facility type	Hospital patient beds 2011 (2008)	Operating rooms 2011 (2008)	Surgery staff 2011 (2008)	Anesthesia staff 2011 (2008)
Capital city (Freetown) hospitals					
Rokupa	Secondary	58 (30)	1 (1)	1 (1)	2 (1)
Lumley	District	37 (35)	1 (1)	2 (2)	4 (1)
Kingharman	Secondary	30 (20)	1 (1)	4 (6)	3 (2)
PCMH	Maternity	147 (120)	3 (1)	8 (4)	8 (6)
Connaught	Tertiary	327 (267)	3 (2)	5 (7)	6 (7)
District hospitals					
Margburka	District	154 (146)	1 (1)	1 (1)	1 (1)
Port Loko	District	85 (200)	1 (1)	2 (1)	2 (2)
Moyamba	District	82 (30)	2(1)	1 (1)	1 (1)
Makeni	Regional	250 (50)	1 (1)	2 (1)	2 (1)
Bo	Regional	320 (450)	3 (2)	4 (3)	3 (1)
Total		1,490 (1,348)	17 (12)	30 (27)	32 (23)

PCMH Princess Christian Maternity Hospital

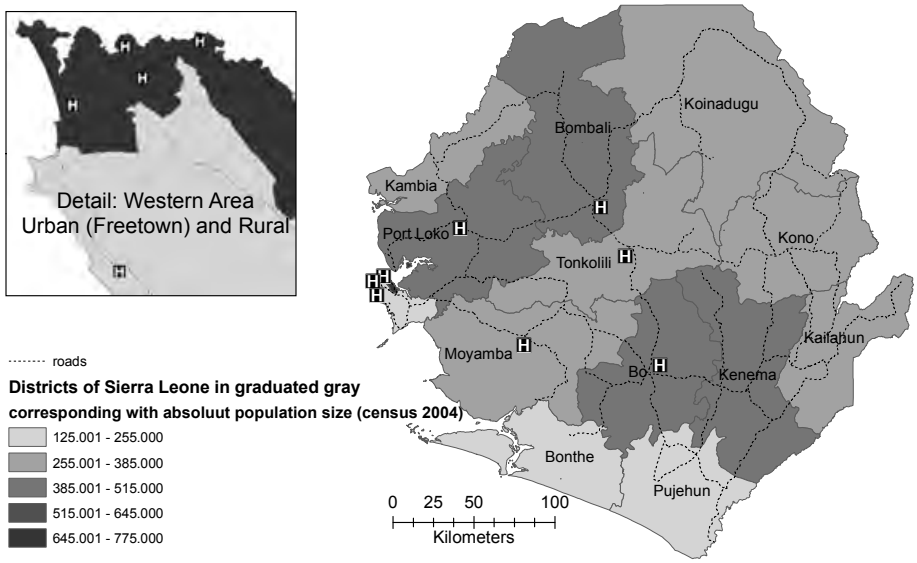

Fig. 1 Map of Sierra Leone with Ministry of Health and Sanitation (MOHS) hospitals surveyed

for each of four data items: surgical specialists, doctors with surgical skills, anesthesiologists (MD), or nurse anesthetists. Staff members who were only available on a part time basis were not included. There was no limit to the Personnel score.

An Infrastructure score was calculated by adding the number of operating rooms and 1 point for each data item that was always available or functioning from a list of 13 additional items that included: 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.

A procedure score was calculated by adding 1 point for each of the 40 data item procedures that were undertaken at the facility. For a maternity hospital that does not routinely perform many general surgery or other specialty procedures, a reduced procedure score was calculated using only 19 data items.

An Equipment score was calculated by adding 1 point for each of the 22 equipment items; a supplies score was calculated by adding 1 point for each of the 25 supply items; and the number of operating rooms was added separately.

A PIPES Index for a hospital was calculated by summing the number of operating rooms and the Personnel, Infrastructure, Procedure, Equipment, and Supplies scores. This number was then divided by the total number of data items (105) and multiplied by 10 to create the PIPES index. For a maternity hospital with a lower possible procedure score, the total was divided by 84, in order to have a comparable index. There is no maximum number for the PIPES index, based on the fact that there is no limit on number of personnel and operating rooms.

Use of 2008 data

To enable comparison of the 2008 survey data and the 2011 survey results, a 2008 PIPES index was also calculated. To do this, the data were first re-recorded in binary form as either "always available" or "not always available" instead of "absent," "available with frequent shortages," or "fully available for all the patients all the time." Items that were always available were given 1 point. If a data item was not recorded or blank, "0" was used in the calculation. Part-time personnel were not included in the sum of the Personnel score.

For the 2008 PIPES Index, a total of 64 data items were included. For a Procedure score, total number of personnel was calculated from four data items: surgical specialist, doctor with surgical skills, anesthesiologist (MD), and nurse anesthetist.

An Infrastructure score was calculated from six data items: running water, electricity, generator, medical records, emergency room, and recovery room. The Procedure score was calculated from 33 data items (11 for a maternity hospital); for Equipment we used 13 data items and for supplies, seven.

The 2008 PIPES index was then calculated by summing the number of operating rooms, Personnel score, Infrastructure score, Procedure score, Equipment score, and Supplies score. The total was divided by 64 (total number of data items) and multiplied by 10. For a maternity hospital, the total score was divided by 42.

Results

The PIPES tool and index showed an overall increase in surgical capacity in Sierra Leone between the first survey in 2008 and the repeated survey in 2011. The number of hospital patient beds in each facility in 2011 ranged from 30 beds to 327 beds, with a total of 1,490, compared to 1,398 in 2008. All facilities gained beds except for Port Loko and Bo, where the number of beds decreased over this 3 year period, from 200 to 85, and from 450 to 320. Most facilities still had only one operating room, although Connaught and Moyamba increased from 1 to 2; PCMH increased from 1 to 3, and Bo, from 2 to 3. Most facilities either gained staff or stayed the same in the comparison of 2011 data with the older numbers from 2008. Of note was Connaught Hospital, where the number of surgeons decreased by two and anesthesia staff decreased by one; and Kingharman, where surgeons also decreased by two. In 2011 the survey found an overall facilities total of 17 operating rooms, 30 surgical staff, and 32 anesthesia staff (Table 1).

The PIPES indices formulated for the 10 hospitals in 2011 and in 2008 are shown in Fig. 2. Connaught Hospital, the main tertiary referral center, had the highest index increase, from 7.2 to 9.2, which correlated well with its being the best staffed and equipped MOHS hospital providing surgical care in Sierra Leone. The increase in the index also reflected the improvements that have been seen since 2008, which now include running water, full electricity, full generators, compressed oxygen in cylinders, endoscopes, an intensive care unit, and a CT scanner.

Makeni Regional Hospital showed a large increase in PIPES Index, from 3.8 to 7.5, and this was reflected by the newly built and equipped facility which, despite improvements, still faces many issues: there is only one functioning operating room, and there is no compressed oxygen and no running water. Moyamba District Hospital also improved greatly, with its score increasing from 3.4 in 2008 (the lowest) to 5.7 in 2011.

The other facilities, with the exception of Magburaka District Hospital and Bo Regional Hospital, showed some increase in indices, which probably indicates some slight improvements. The Margburka District Hospital had a lower index in 2011, from 3.8 down to 3.7. It was noted to be the hospital with the greatest deficiencies in 2008, and during the 2011 visit it was being renovated and therefore the care provided was limited. The Bo Regional Hospital index also decreased, from 5.8 to 5.5.

Although many of the facilities had improved, there were still great deficiencies in basic infrastructure elements, such as running water or electricity. Staffing shortages were common at all facilities, and most hospitals could not undertake complex operations such as open fracture management or specialized cases such as pediatric and plastic surgery. Many facilities also lacked many of the items needed to provide safe and appropriate surgery, with limited numbers of anesthesia machines, oximeters, instrument sets, gowns, drapes, sutures, and eye protection.

Surgical capacity within Freetown was much greater than in the district hospitals, and this is illustrated by the differences in PIPES Index between the two areas (Fig. 2).

Discussion

Recently published studies have documented the surgical capacity of a number of low and middle income countries. While the majority of these studies have used the WHO tool [3–11], studies from Rwanda [15] and Malawi [16] used other survey tools. The WHO tool has a number of significant limitations, which we felt warranted development of a novel tool. The limitations include difficulty in data analysis, length of the survey, poor reliability of process methods sections, and limited access to data collected by WHO.

To address these limitations, the PIPES tool was developed as a simpler, easier to administer survey. The use of the PIPES tool in Sierra Leone confirmed that it could be administered easily, and showed that data analysis was simplified and that a useful index could be calculated.

This study was done with the support of the Sierra Leone MOHS, which assisted with personnel and transport, and the data collected will be used to help plan interventions. The data will also be used to direct SOS programs, which in the past have included supporting salaries of surgical health care workers at Connaught Hospital, providing containers of equipment and supplies, and assisting with training workshops [14].

There are multiple limitations to this study. First is that the repeat assessment did not use the WHO tool. Though the use of the WHO tool was initially considered, it was finally decided that doing a repeat assessment with that tool would not be ideal, given the length of the survey, difficultly in administering it, and the difficulty in analyzing the data and calculating an index. The grouped response totals for data in the WHO tool for items such as number of operating rooms and patient beds, and the lack of a definitive measure of whether supplies were “always

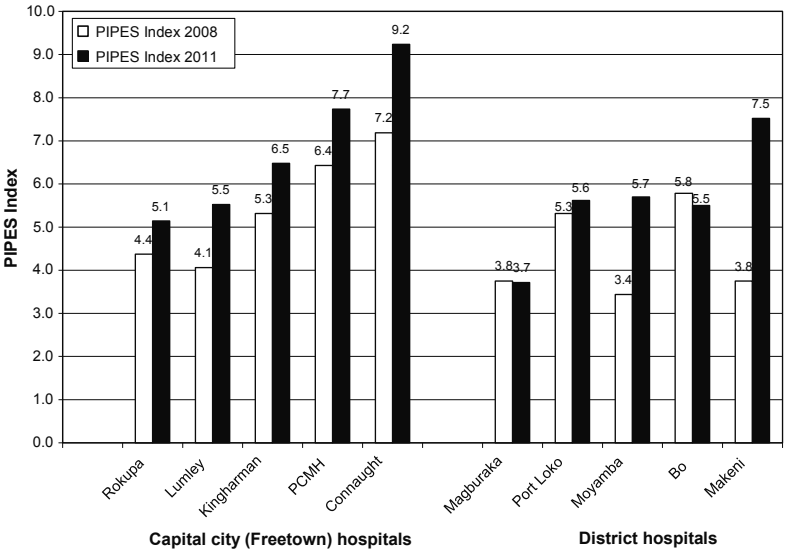

Fig. 2 Comparison of PIPES index 2008 versus 2011: MOHS hospitals in Freetown and outside of Freetown. PCMH Princess Christian Maternity Hospital

available" or "not always available" make the WHO tool data difficult to analyze. A second limitation is that to compare PIPES Indices and show change over time, the 2008 survey data had to be reanalyzed and converted into a PIPES index. As this conversion used the method of Kwon et al. [13] we felt that it was suitable for showing changes over time. In addition, the results of the changes in PIPES indices correlated well with what was known to have occurred with improvements at the various facilities.

Another limitation is that there are no outcome measures provided in this survey. While measuring morbidity, mortality, length of stay, or number of operations is important, the data collection surrounding these factors often requires significant time and effort. As the aim of the PIPES tool was to provide a quick snapshot that could be repeated easily, these other items were not included.

As stated, this study provides only a snapshot in time, and it is important to consider that conditions are often fluid. Staff begin and leave postings; skills are developed and new procedures undertaken; supplies are available or not; and equipment is replaced or breaks down. However, a survey tool that is easy to administer and that provides data simple to analyze is vital in planning interventions and evaluating programs. Also of primary importance is the realization that not many resources are needed to undertake a PIPES survey. Unlike the WHO tool, the PIPES survey is easy to administer and analyze. However, whichever tool is used, it is hoped that organizations and ministries of health will incorporate such surveys into their yearly planning so as to assess baseline conditions and track changes over time.

This is the first time the PIPES tool has been used in a research study, but plans are underway to use it to assess the surgical capacity in health facilities in other low income countries in Africa and middle income countries in South America. Plans are also underway to undertake a validation study whereby surveys will be emailed to hospital personnel or filled in by phone interviews, after which the facilities will be reassessed during follow-up on-site visits.

For this study, only the 10 MOHS hospitals assessed in 2008 that provide most of the surgical care in Sierra Leone were evaluated. Although surgical care is provided by other private and non-governmental hospitals in Sierra Leone, those facilities were not surveyed for this study as the main focus was to test the PIPES tool and index and to provide a comparison over time. In addition, these other facilities are supported by outside funding and resources and are beyond the control of the MOHS.

The PIPES index was created based on the work by Kwon et al. [13] to develop a surgical capacity index. In creating the PIPES index, we decided not to limit the number of operating rooms or personnel, as this would allow these items to carry heavier statistical weight. It is thought that as a health system improves, a plateau of the assessed infrastructure, supplies, and equipment will be reached. Eventually, the surveyed items will always be available and all procedures should be performed. However, it will be the number of operating rooms and numbers of full time staff that will make the difference in the care provided.

Conclusions

As interest in surgery increases within the global health community, and as donors and policy makers begin to look at surgical projects, a clear, concise way of evaluating surgical capacity is needed. The PIPES tool was found to be useful in Sierra Leone to re-evaluate 10 MOHS hospitals, and a PIPES index was calculated which facilitated comparing hospitals with each other and over time.

Conflict of interest None

Appendix 1

This survey is made to assess the gaps in availability of surgical care at resource-limited health facilities. This tool has105 total data items divided into five sections: personnel, infrastructure, procedures, equipment, and supplies (PIPES).

Form for completing the PIPES tool

Country:	
Interviewer: Name/contact info	
Health care facility: Name/address	
Phone interview or site visit:	
Respondent: Name/contact info	
Type of Healthcare Facility: (Health Center, District, Tertiary, Univ, Private, NGO, Mission)	
Hospital beds (total numbers)	

Personnel (4)	Total number
General surgeons	
Anesthesiologists (MD)	
Medical doctors (doing surgery)	
Nurse anesthetists	
Total P score: (add all the numbers of Personnel)	

Infrastructure (14)	Always available (1)	Not always available (0)
Running water?		
External electricity?		
Functioning back-up generator?		
Incinerator?		
Medical records?		
Emergency department?		
Postoperative care area?		
Intensive Care Unit?		
Pretested blood available (blood bank)?		

Appendix continued

Country:	
Lab to test blood and urine?	
Functioning x-ray machine?	
Functioning ultrasound machine?	
Functioning CT scanner?	
Sub Total I score: (give 1 point to each available item)	
Number of functioning operating rooms:	
Total I score: (add subtotal ? No. of operating rooms)	

Procedures (40)	Done (1)	Not done (0)
Resuscitation		
Suturing		
Wound debridement		
Incision & drainage of abscess		
Laparotomy		
Cricothyroidotomy		
Tracheostomy		
Chest tube insertion		
Burn management		
Cesarean section		
Dilatation and curettage		
Tubal ligation		
Hysterectomy		
Obstetric fistula repair		
Appendectomy		
Hernia repair—elective		
Hernia repair—strangulated		
Hydrocele		
Bowel resection and anastomosis		
Male circumcision		
Biopsy (lymph node, mass, other)		
Cholecystectomy		
Skin grafting		
Pediatric hernia repair		
Pediatric abdominal wall defects		
Repair imperforate anus		
Splinting		
Casting		
Traction (closed fracture)		
Open treatment of fracture		
Management of osteomyelitis		
Amputation		
Clubfoot repair		
Cleft lip repair		

Procedures (40)	Done (1)	Not done (0)
Contracture release		
Laparoscopic surgery		
Regional anesthesia blocks		
Spinal anesthesia		
Ketamine anesthesia		
General anesthesia		
Total Pr score: (add all procedures done)		

Equipment (22)	Always available (1)	Not always available (0)
Oxygen: compressed (cylinder)		
Oxygen: concentrator		
Resuscitator bag valve and mask (adult)		
Resuscitator bag valve and mask (paediatric)		
Oropharyngeal airway (adult size)		
Oropharyngeal airway (paediatric)		
Endotrachael tubes (adult)		
Endotrachael tubes (pediatric)		
Anesthesia machine		
Pulse oxyimeter		
Oxygen mask and tubing		
Stethoscope		
Blood pressure measuring equipment		
Thermometer		
Instrument sets (abdominal, c-section)		
Kidney dish, stainless-steel		
Sterilizer (autoclave)		
Suction pump (manual or electric)		
Electrocautery machine		
Vaginal speculum		
Endoscopes (gastro, colon, broch)		
Operating room lights		
Total E score: (add all Equipment available)		

Supplies (25)	Always available/ sufficient (1)	Not always available/ sufficient (0)
Gloves (sterile)		
Gloves (examination)		
Nasogastric tubes		
Intravenous fluid infusion sets		

Supplies (25)	Always available/ sufficient (1)	Not always available/sufficient (0)
IV cannulas		
Syringes		
Disposable needles		
Tourniquet		
Sterile gauze		
Bandages, sterile		
Adhesive tape		
Suture (absorbable)		
Suture (non-absorbable)		
Urinary catheters		
Sharps disposal container		
Scalpel blades		
Face masks		
Eye protection (goggles, safety glasses)		
Apron		
Boots (operating room shoes)		
Gowns (for surgeon/scrub nurse)		
Drapes (for operations)		
Chest tubes		
Trach tubes		
Laparoscopic supplies		
Total S score: (add all supplies sufficient available)		

A total PIPES index is calculated by summing the number of the Personnel, Infrastructure and number of operating rooms, Procedure, Equipment, and Supplies scores. This number is then divided by the total number of data items (105) and multiplied by 10 to create the PIPES index. For a maternity hospital or otherwise categorical hospital with a lower possible Procedure score, the number of reduced data items is used. There is no maximum number for the PIPES index.

P score:	(no maximum)
I score:	(maximum 13 plus numbers of functioning operating rooms)
Pr score:	(maximum of 40)
E score:	(maximum of 22)
S score:	(maximum of 25)
Total PIPES score:	

Divide the total score by 105 and multiply by 10 for the PIPES index:

(Total PIPES score/105) x 10 =

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

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Chapter 8

Assessment of pediatric surgery capacity at government hospitals in Sierra Leone.

Kushner AL, Groen RS, Kamara TB, Dixon-Cole R, Daoh KS, Kingham TP, Nwomeh BC.

World J Surg. 2012;36(11):2554-8.

Abstract

Background Traditionally, efforts to reduce child mortality in low- and middle-income countries (LMICs) have focused on infectious diseases. However, surgical care is increasingly seen as an important component of primary health care. To understand the baseline surgical capacity in LMICs, a number of studies have recently been published, but none has focused on pediatric surgery.

Methods The Surgeons OverSeas (SOS) Personnel, Infrastructure, Procedures, Equipment and Supplies (PIPES) survey was used to collect surgical capacity data from government hospitals in Sierra Leone. The data were analyzed specifically to identify baseline needs for pediatric surgery.

Results Nine hospitals were assessed, and all had a functioning laboratory to test blood and urine and were capable of undertaking resuscitation, suturing, wound debridement, incision and drainage of an abscess, appendectomy, and male circumcision. However, in only 67 % could a pediatric hernia repair be performed, and in none were more complex procedures such as cleft lip and clubfoot repairs performed. Fewer than 50 % of facilities had sufficient gloves, nasogastric tubes, intravenous cannulas, syringes, needles, sutures, urinary catheters, infusion sets, anesthesia machines, or compressed oxygen.

Conclusion Using the standard PIPES tool, we found severe deficiencies in the pediatric surgical capacity at government hospitals in Sierra Leone. However, a pediatric-specific tool is required to understand more accurately the pediatric surgical situation.

Assessment of Pediatric Surgery Capacity at Government Hospitals in Sierra Leone

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Conclusions Using the standard PIPES tool, we found severe deficiencies in the pediatric surgical capacity at government hospitals in Sierra Leone. However, a pediatric-specific tool is required to understand more accurately the pediatric surgical situation.

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Introduction

Traditionally, health care for pediatric populations in low- and middle-income countries (LMICs) has concentrated on infectious diseases. However, surgical care is increasingly recognized as an important component of public health [1]. In an effort to highlight the deficiencies in surgical care in LMICs, a number of studies documenting conditions have been published [2–11]. These studies examined factors such as personnel, infrastructure, procedures performed, and equipment and supplies in general, but they did not focus specifically on pediatric surgery.

In April 2010, Sierra Leone's Ministry of Health and Sanitation (MoHS) initiated a program to provide free health care to all children under 5 years old and to pregnant

and lactating women in an effort to reduce the high childhood and maternal mortality rates in the country. The program successfully increased access to health care for many children [12]. It has also, however, led to an increase in the number of pediatric surgery cases at Connaught Hospital, the main tertiary care referral center in the capital city, Freetown [13].

The goal of this study was to document pediatric surgery capacity in Sierra Leone. It was aimed at helping Connaught Hospital and the MoHS identify needs and plan for the increase in pediatric surgery cases.

Methods

Setting

Sierra Leone is a small West African country (area: 72,000 sq km) with an estimated population of 5.8 million. It is one of the poorest countries in the world and ranks 180 of 187 on the 2012 United Nations Development Index [14]. It is estimated that in 2012 the infant mortality rate was 76.64 per 1000 live births—ranking it among the bottom 12 countries [15]. Sierra Leone has one of the lowest physician densities, with a total of only 95 physicians in 2008—0.16 physicians per 10,000 population [16]. It is one of the few countries without a trained pediatric subspecialist surgeon. With the exception of the handful of cases performed by visiting humanitarian surgeons, all procedures in children are performed by local surgeons whose patients are usually adults.

Design

The Surgeons OverSeas (SOS) Personnel, Infrastructure, Procedures, Equipment, and Supplies (PIPES) tool was developed as an easy to administer surgical capacity survey. PIPES consist of 105 items and was designed to be administered rapidly to provide a quick snapshot of surgical capacity at LMIC health facilities. In addition to documenting individual items, an index can be calculated to show changes in capacity over time and differences among facilities. The PIPES tool was first used in Sierra Leone in August 2011 to reevaluate 10 MoHS hospitals initially assessed in 2008. A description of the PIPES tool and results of the changes in PIPES indices was recently published [17].

For this study, unpublished data previously collected during site visits and from interviews of key administrative hospital staff using the PIPES tool were analyzed regarding personnel specifically trained in pediatric procedures, infrastructure, pediatric surgery-specific procedures performed, and supplies and equipment relating to pediatric surgery capacity.

As previously described by Kingham et al., there are only 17 MoHS hospitals in Sierra Leone [2]. Of these government hospitals, one is a pediatric hospital with no surgical services, and six are in rural locations and provide minimal surgical care (limited to minor procedures). Therefore, only 10 hospitals were included in the 2008 assessment and it was data from these 10 hospitals that were reassessed in 2011. As one of these hospitals is a maternity hospital (Princess Christian Maternity Hospital) where no pediatric or general surgery is performed, data collected from this facility were excluded for this study.

Statistics

The data were analyzed using descriptive statistics.

Results

The nine MoHS hospitals assessed include four in Freetown (Connaught, Kingharman, and Rokupa Hospitals and Lumley Health Center) and five in the districts (Bo Regional, Makeni Regional, Port Loko District, Magburka District, and Moyamba District Hospitals). Connaught Hospital is the country's largest health care facility, with 327 beds. It is also the only MoHS tertiary care referral center for medical and surgical conditions.

Personnel

None of the facilities surveyed had a pediatric surgeon or other personnel specifically trained to perform pediatric surgical procedures. General surgeons or other adult-specialty surgeons performed all the procedures in children. Nurse anesthetists administered most of the anesthesia.

Infrastructure

The assessed facilities had between 30 and 327 beds. Six facilities had only one functioning operating room. Connaught and Bo Hospitals each had three functioning operating rooms, and Moyamba District Hospital had two. All facilities had a laboratory to test blood and urine, and seven (78 %) had a generator to provide power. Only five (56 %) had a recovery room, ultrasonography machine, and blood bank. Plain radiography was available in three (33 %) hospitals. Only one hospital (Connaught) offered computed tomography and had an intensive care unit (Table 1).

Procedures

From the 2011 assessment, it was noted that all facilities could perform resuscitation, suturing, incision and drainage

Table 1 Percentage of selected Sierra Leone government hospitals with available infrastructure (n = 9)

Infrastructure items	%
Laboratory (blood and urine)	100
Generator	78
Recovery room	56
Ultrasonography	56
Blood bank	56
Running water	44
Plain radiography	33
Electricity	22
Computed tomography	11
Intensive care unit	11

Table 2 Percentage of selected Sierra Leone government hospitals that had performed procedures at least once (n = 9)

Procedure	%
Resuscitation	100
Suturing	100
Wound débridement	100
Incision and drainage of abscess	100
Appendectomy	100
Male circumcision	100
Splinting fracture	89
Burn management	78
Casting a fracture	78
Bowel resection and anastomosis	67
Pediatric hernia repair	67
Traction fracture	44
Contracture release	33
Open treatment of fracture	33
Management of osteomyelitis	22
Pediatric abdominal wall defects	11
Clubfoot repair	0
Cleft lip repair	0
Imperforate anus repair	0

of abscesses, débridement, appendectomy, and male circumcision. Splinting of a fracture was done in eight facilities (89 %), burn management and casting of fractures in seven (78 %), bowel resection and anastomosis and pediatric hernia repair in six (67 %), traction for fractures in four (44 %), contracture release and open fracture management in three (33 %), and management of osteomyelitis in two (22 %). Only Connaught Hospital attempted repair of pediatric abdominal wall defects. No facility performed cleft lip, clubfoot, or imperforate anus repairs (Table 2).

Table 3 Percentage of selected Sierra Leone government hospitals with equipment and supplies always available (n = 9)

Equipment and supplies	%
Bag-valve mask (pediatric)	89
Oxygen concentrator	78
Pulse oximeter	78
Oropharyngeal airway (pediatric)	78
Endotrachael tubes (pediatric)	78
Scalpel blades	67
Gauze (sterile)	67
Bandages (sterile)	56
Gloves (examination)	44
Nasogastric tubes	44
Intravenous cannulas	44
Syringes	44
Disposable needles	44
Gloves (sterile)	44
Suture	
Absorbable	44
Nonabsorbable	44
Urinary catheters	44
Anesthesia machine	33
Intravenous infusion sets	33
Compressed oxygen in cylinder	22

Equipment and supplies

Equipment and supplies related to pediatric surgery that were sufficiently available at the hospitals included pediatric bag valve masks in eight (89 %) hospitals; oxygen concentrators, pulse oximeters, pediatric oropharyngeal airways, and pediatric endotracheal tubes in seven (78 %); scalpel blades and sterile gauze in six (67 %); sterile bandages in five (56 %); examination gloves, nasogastric tubes, intravenous cannulas, syringes, disposable needles, sterile gloves, absorbable and nonabsorbable sutures, and urinary catheters in four (44 %); intravenous infusion sets in three (33 %); and compressed oxygen in only two (22 %) hospitals (Table 3).

Discussion

Although surgical care is increasingly recognized as an important component of public health [1] and a number of studies have documented the overall lack of surgical capacity in LMICs [2–11], little is known about the capacity of these countries to provide surgical care to children, who constitute nearly half of the population. In fact, data extrapolated from a study in The Gambia by Bickler and Sanno-Duanda estimated that 85 % of children

in LIMCs need some form of surgical care before their 15th birthday [18]. There are no comprehensive surveys of pediatric surgical disease burden, although needed. However, several reports provide an insight into the number of children undergoing surgery and the types of cases treated. A cross-sectional survey in 29 hospitals in south-western Uganda estimated an annual rate of surgery for children \15 years of age to be 180 operations per 100,000 population [10]. In Rwanda, a representative survey of district and regional hospitals across the country found that pediatric surgical cases constituted only 1 % of the 45,759 cases performed each year [19].

Other reports in the literature documenting pediatric surgery from sub-Saharan Africa are mostly from single institutions, and they report only procedures, providing little information on facility and personnel [18, 20, 21] More information on overall personnel has been provided by Chirdan et al. in a survey of eight African countries representing 402 million people, approximately one-third of the population of the continent. In these countries, there were a total of 231 pediatric surgeons—only a fraction of the estimated 1006 needed for their populations. Compared to Europe and North America, which have two to three pediatric surgeons per million people, Nigeria, the most populous country in Africa, has 0.43 per million and Malawi only 0.06 per million. Some countries, such as Sierra Leone, do not have a single pediatric surgeon [22].

Thus, an increase in resources is needed to address the shortfalls in personnel, infrastructure, procedures, equipment, and supplies pediatric surgical care in LMICs is to provided. However, before policymakers and donors will fund and support such programs, the baseline conditions must be sufficiently documented and an assessment of the community's needs undertaken. Only by understanding the magnitude of the problem will it be possible to begin to develop programs and measure the effects of interventions.

A high proportion of the population in LMICs are infants and children, with nearly 50 % of the population in Sierra Leone \15 years of age [23]. With increasing recognition of the importance of noncommunicable diseases—congenital malformations, malignant diseases, injuries—surgery plays an increasingly important role. Common conditions for which surgical interventions can offer a cure, palliate, or reduce disability include traumatic injuries, cancer, and congenital malformations such as cleft lip and clubfoot [24]. Despite the increasing evidence, improving surgical care in general and especially for children is rarely a priority for policymakers.

In Sierra Leone, where there are no trained pediatric surgeons, local general surgeons perform the operations done in children, and nurse anesthetists give most of the anesthesia. The surgery performed is mostly limited to hernia repairs, orchiopexies, burns, and fracture repair, although these surgeons also perform more complex operations (e.g., Wilms tumor resection, major abdominal operations for conditions such as typhoid perforation). These cases are not specifically documented in the current version of the PIPES tool [17]. PIPES was developed as a modification of the World Health Organization (WHO) Tool for the Situational Analysis of Emergency and Essential Surgical Care that was originally introduced in 2008 [2]. PIPES is more concise (105 items vs. 256 for the WHO tool), has a binary system of measurement for ease of data collection, and permits easier calculation of an index to compare facilities or follow longitudinal trends. The differences between PIPES and the WHO tool have been discussed in detail elsewhere [17]. Although neither tool was specifically designed for pediatric use, we found it easier to select items from PIPES that could provide a snapshot of pediatric surgical capacity. However, once we had removed the "adult-specific" items, it was not possible to determine a true PIPES index. We suggest that a pediatric version of PIPES be created and include more procedures commonly found in pediatric populations.

Congenital anomalies contribute to childhood death and disability in LMICs. In this study, however, we documented only the congenital conditions that require specialized surgical expertise, such as cleft lip, clubfoot, and imperforate anus. Currently, these conditions cannot be treated at the government hospitals. More complex anomalies, such as tracheoesophageal fistula repairs, congenital diaphragmatic hernia, and congenital cardiac abnormalities, are even less likely to be treated in LMICs such as Sierra Leone. These conditions, although treatable in competent hands and with sufficient resources, are beyond the scope of most surgeons and anesthetists in LMICs and are therefore not included as data points in the current version of the PIPES tool.

On a positive note, all of the government hospitals assessed in this study were capable of providing resuscitation, suturing, wound débridement, incision and drainage of abscesses, appendectomy, and male circumcision; and six facilities undertook pediatric hernia repair.

There are a number of limitations in this study. First, it is only a snapshot of the MoHS hospitals where surgery is performed. It does not take into account that at different times supplies are available or not or that infrastructure improves or deteriorates. It is therefore important that such assessments be repeated over time and that trends be documented. Second, this study did not document the capacity of the limited number of nongovernmental organization, mission, or private hospitals or the short-term medical missions that periodically provide care for children with congenital anomalies. Third, the PIPES survey is not specifically designed to assess pediatric surgery needs, so it likely overestimates the availability of items such as

intravenous and urinary catheters if adult sizes are in sufficient supply but pediatric sizes are not. As such, even though the results of this survey were useful to Connaught Hospital and to the MoHS in identifying deficiencies, it would be preferable to have a tool that could specifically measure pediatric surgery capacity. In light of the findings of this study, such a survey is being developed that will include documenting the number of pediatric surgeons if there are any, recording if a greater array of pediatric surgical procedures are performed, and documenting more pediatric surgery-specific equipment and supplies such as nasogastric tubes (B14F), intravenous cannulas (C22 gauge), and sutures (4/0 and higher). Ideally, such a pediatric PIPES survey would also be undertaken in conjunction with a review of the operating room logbook and physical inspection of the stock.

Conclusions

Surgical care is increasingly recognized as an important part of public health. This study documents the great deficiencies in the infrastructure, procedures, equipment, and supplies for pediatric surgery identified during an assessment of government hospitals in Sierra Leone. It is hoped that the results of this survey will help direct policymakers and donors to provide additional resources for improving the surgical care of the pediatric population in LMICs and help plan interventions. We recommend that such surveys be undertaken in other countries and be repeated over time. We also recommend that a survey be developed that specifically documents pediatric surgery capacity.

Conflict of interest None.

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Chapter 9

Free health care for under-fives increases access to surgical care in Sierra Leone: an analysis of case-load and patients characteristics.

Groen RS, Kamara TB, Nwomeh BC, Daoh KS, Kushner AL.

World J Surg. 2013;37(6):1216-9.

Abstract

Background In April 2010 Sierra Leone launched a nationwide program that provides free health care to all pregnant and lactating women and children under 5 years old. This study evaluates the effect that the free health-care program had on pediatric surgical activities of Connaught Hospital.

Methods The study period was defined as the 20 months before and after April 27, 2010, the start date of the free health-care program. Data on age, gender, diagnosis, and procedure for patients under 5 years of age and the total number of operations were collected from the Connaught Hospital operating room logbook.

Results The number of operations on children under 5 increased by 500 %, from 42 to 210 cases. This increase was significantly larger than the 17 % increase of 1,393–1,630 seen with operations for patients 5 years and older ($p<0.01$).

Discussion The decision by the Sierra Leone President to institute a program of free health care for children under 5 has resulted in an increased number of pediatric surgical cases at Connaught Hospital. Efforts should be undertaken to provide additional supplies and equipment and to develop training programs for surgeons and support staff to care for the children in need of surgical care.

Free Health Care for Under 5 Year Olds Increases Access to Surgical Care in Sierra Leone: An Analysis of Case Load and Patient Characteristics

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Abstract
Background In April 2010 Sierra Leone launched a nationwide program that provides free health care to all pregnant and lactating women and children under 5 years old. This study evaluates the effect that the free health-care program had on pediatric surgical activities of Connaught Hospital.
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Conclusion The decision by the Sierra Leone President to institute a program of free health care for children under 5 has resulted in an increased number of pediatric surgical cases at Connaught Hospital. Efforts should be undertaken to provide additional supplies and equipment and to develop training programs for surgeons and support staff to care for the children in need of surgical care.

Introduction

In an effort to improve the lives of the world's poorest populations, the United Nations created the millennium development goals (MDGs). The MDGs, introduced in 1991, comprise a set of ten targets aimed at reducing poverty, improving education, and providing access to clean water and health care. The aims of MDGs 4 and 5 are to reduce the under 5 mortality rate by two-thirds and the

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maternal mortality rate by 75 %, respectively, between 1990 and 2015 [1].

Although no MDG specifically mentions surgery, a case has been made that without improvements in the capacity to provide surgical care, the targets for MDGs 4 and 5 will not be reached [2, 3]. With respect to MDG 4, although most childhood deaths in low- and middle-income countries are caused by infections, there are also a significant number of deaths that result from trauma, malignancies, and congenital conditions, many of which can be diagnosed, treated, or palliated with surgical care [4].

As one of the world's least developed countries, Sierra Leone was ranked 180/187 on the UN Development Index for 2011 [5]. With an estimated per capita GDP of US$734 and an average life expectancy of 47.8 years, the country also has one of the world's highest under 5 (174/1,000) and infant mortality rates (114/1,000) [6]. In April 2010, in an effort to improve the health of the population of 6 million, the President of Sierra Leone launched a nationwide program that provides free health care to all pregnant and lactating women and children under 5.

This program was heralded as a great success [7], and in a preliminary analysis, it appeared to have led to an increase in pediatric surgical cases at Connaught Hospital, the main tertiary-care referral center in the country [8]. For this study we sought to further analyze the volume and characteristics of the pediatric surgical cases undertaken specifically for under 5 children and assess changes that occurred following the implementation of the free health-care program. The data collected would be useful in planning interventions and defining resource needs.

Methods

This retrospective observational study evaluated pediatric surgical activities in the main operating rooms of Connaught Hospital. The study period was defined as the 20 months before and after April 27, 2010, the start date of the free health-care program.

Setting

Connaught Hospital, in the Sierra Leone capital city Freetown, is the country's largest health-care facility, with 327 beds. It is also the ministry of health and sanitation (MOHS) tertiary-care referral center for medical and surgical conditions. Although a pediatric hospital is present in Freetown, no procedures are undertaken there and all pediatric surgical cases are referred to either Connaught Hospital or a nongovernmental hospital, which also provides free surgical care.

Inclusion criteria and analysis

All patients under 5 years of age who were operated on in the main operating rooms of Connaught Hospital were included in the study. Data on age, gender, diagnosis, and procedure for patients under 5 years of age and the total number of operations performed were collected from the handwritten entries in the surgical logbook kept outside the operating rooms. Age was recorded in whole numbers. The number of procedures performed by visiting international surgeons was also recorded. A v^2 test was used to assess the significance of the increased number of under-5 cases.

Results

The total number of all operations performed at Connaught Hospital in the 20 months before and after the start of the free health-care program increased by 28 %, from 1,435 to 1,840. During this same time period, the number of operations on children under 5 increased by 500 %, from 42 to 210. This increase was significantly larger than the 17 % increase (from 1,393 to 1,630) seen in operations on patients 5 years old and older ($p < 0.01$). Additionally, the percentage of under-5 cases compared to total cases rose from 2.9 to 11.4 % (Table 1).

The average age of patients under 5 who underwent surgery was 1.8 years before the program and 2.1 years after the program started. Overall, males outnumbered females before the program at 20:1, but this decreased to 6.5:1 after the start of the program (Table 1).

When comparing the types of cases, those categorized as congenital formed the majority, with 73.8 % (n = 31)

Table 1 Comparison of operations on children under 5, 5 and above, and total, and average age and sex distributions for the 20 months before and 20 months after start of free health-care program, Connaught Hospital, Freetown, Sierra Leone

	Before free health care (%)	After free health care (%)	
Under-5 operations	42 (2.9)	210 (11.4)	$p < 0.01$
Five-and-above operations	1,393 (97.1)	1,630 (88.6)	
Total operations	1,435	1,840	
Operations by international teams (under 5)	11 (26.2)	30 (14.2)	
Average age (under 5)	1.8	2.1	
Total males (under 5)	40	182	
Total females (under 5)	2	28	
M:F	20:1	6.5:1	

before and 68 % (n = 144) after the start of the program. No gastrointestinal cases were recorded before the free health-care program, while 8.1 % (n = 17) were recorded as gastrointestinal after the program began (Table 2).

When examining specific procedures, inguinal hernia repair was the most common: 26 (61.9 %) before and 128 (60.9 %) after. After the start of the free health-care program, a larger number of foreign body removals (n = 14), umbilical hernias (n = 10), sequestrectomies (n = 8), incision and drainage of abscesses (n = 6), and post-burn contracture releases (n = 6) were undertaken.

Prior to the free health care for the under 5 year olds, international visiting surgeons performed 11 operations (26.2 %) in this surgical patient population at Connaught Hospital, including insertion of three VP shunts; after the start of free health care, visiting teams performed 30 operations (14.2 %).

Discussion

This study highlights the increase in the volume of pediatric surgery at Connaught Hospital in Sierra Leone that was observed after the initiation of a nationwide program to provide free health care for children under 5 years old and pregnant and lactating women. The results show that the total number of operations for patients 5 years old and above increased by 17 % between the two 20-month study periods, while the number of operations performed on children under 5 increased by 500 %.

Although the data represent an absolute increase of only 168 cases, it is important to view this increase in the context of how surgical care is delivered in Sierra Leone.

Table 2 Comparison of the number of surgical cases on under 5 year olds by diagnostic category before and after the start of the free health-care program at Connaught Hospital, Freetown, Sierra Leone

Diagnosis	Before free health care (%)	After free health care (%)
Congenital[a]	31 (73.8)	144 (68.6)
Surgical infection[b]	1 (2.4)	20 (9.5)
Gastrointestinal[c]	0	17 (8.1)
Trauma	2 (4.8)	8 (3.8)
Urology	3 (7.1)	7 (3.3)
Neoplasm	1 (2.4)	7 (3.3)
Ears, nose, and throat	1 (2.4)	4 (1.9)
Neurosurgical	3 (7.1)	3 (1.4)
Total	42 (100)	210 (100)

[a] Hernia repairs

[b] Sequestrectomies, incision, and drainage of abscess

[c] Appendectomies and removal of foreign body from esophagus

Prior to the institution of the free health-care initiative, under-5 surgical procedures were conducted in a manner similar to that of other procedures. Patients arrived with a problem and were seen by a clinician. If it was determined that a surgical procedure was needed, a prescription was written for supplies such as sterile gloves, suture, gauze, and antibiotics. The patient or relatives were then responsible for buying these supplies from an outside pharmacy; once they returned with the supplies, the procedure was undertaken.

After the initiation of the free health-care program, Connaught Hospital and more commonly the surgeons were obligated to provide the material necessary to undertake the procedure: both elective and emergency cases. As Kingham et al. [9] documented in 2009, there is a massive deficiency of surgical capacity in Sierra Leone with its limited supplies, equipment, and surgical specialists.

One observation of this study is that while some procedures were performed by international visiting surgeons who brought their own supplies, the majority of the increased caseload was undertaken by local Sierra Leone surgeons who were obligated to provide the necessary supplies. During the study period, the absolute number of pediatric cases performed by visiting surgeons increased from 11 to 30; however, the percentage of under-5 cases done by visiting surgeons decreased from 26.2 to 14.2 %.

After the start of the free health-care program, a large number of inguinal hernia repairs were performed. Before the program there were no hernia repairs or operations to remove a foreign body; however, after the start of the program these procedures were common. It is unclear what happened with these cases earlier; however, it is unlikely that the increase in number indicates an increase in the prevalence. It might suggest a backlog of cases, which is supported by the change of average age from 1.8 to 2.1 years.

The relatively high number of urology cases possibly reflects the presence of a urologist at Connaught Hospital, resulting in clinicians referring these types of cases. The urologist was present in the 20 months before and after the introduction of the free health-care program and therefore is unlikely to be a confounder. Relatively few pediatric trauma cases were undertaken and this may reflect the presence of a nongovernmental hospital that specializes in emergency surgical care located near Freetown. This hospital often has international surgeons and also offers free health care.

Limitations of the study include the retrospective nature of the study design, the limited variables, and no means of verifying missing registration of cases. The simplistic medical records system of a handwritten operating room logbook limits the ability to thoroughly analyze patients

under 5 year of age, specific procedure details, and postoperative morbidity and mortality. The need to improve data collection and the hospital's medical records system has been identified as a priority. Ideally, international donors will recognize the benefits to patient care and research and assist with such projects.

With the increasing number of pediatric surgical cases in Sierra Leone, there should be an effort to train local surgeons to perform many of the more technically challenging procedures like the insertion of VP shunts and congenital atresias. In our data, these procedures were performed by visiting international surgeons; however, in other low-income countries local hydrocephalus programs have been initiated [10]. These types of initiatives should be accompanied by training of the anesthesia and nursing staffs for specific pediatric needs. Surgery will be a success only if training is integrated with adequate, uninterrupted pediatric supplies and equipment. Although gradual improvements have been seen at Connaught Hospital [11], there is still a lack of sufficient functioning operating theatres, supplies, and postoperative management, and, therefore, the hospital has difficulties providing free health care to those under 5 from a logistical and financial standpoint.

Conclusion

The decision by the Sierra Leone President to institute a program of free health care for children under 5 years old and pregnant and lactating women has been heralded as a success; however, it has also resulted in an increased number of pediatric surgical cases at Connaught Hospital. Efforts should be undertaken to provide additional supplies and equipment and to develop training programs for surgeons and support staff to care for the children in need of surgical care.

Conflict of interest The authors have no conflicts of interest to disclose.

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Chapter 10

Scarcity of healthcare worker protection in eight low- and middle-income countries: surgery and the risk of HIV and other bloodborne pathogens.

Leow JJ, Groen RS, Bae JY, Adisa CA, Kingham TP, Kushner AL.

Trop Med Int Health. 2012 Mar;17(3):397-401.

Abstract

Background In view of the substantial incidence of bloodborne diseases and risk to surgical healthcare workers in low- and middle-income countries (LMICs), we evaluated the availability of eye protection, aprons, sterile gloves, sterilizers and suction pumps.

Methods Review of studies using the WHO Tool for the Situational Analysis of Access to Emergency and Essential Surgical Care.

Results Eight papers documented data from 164 hospitals: Afghanistan (17), Gambia (18), Ghana (17), Liberia (16), Mongolia (44), Sierra Leone (12), Solomon Islands (9) and Sri Lanka (31). No country had a 100% supply of any item. Eye protection was available in only one hospital in Sri Lanka (4%) and most abundant in Liberia (56%). The availability of sterile gloves ranged from 24% in Afghanistan to 94% in Ghana.

Discussion Substantial deficiencies of basic protective supplies exist in low- and middle-income countries.

Scarcity of healthcare worker protection in eight low- and middle-income countries: surgery and the risk of HIV and other bloodborne pathogens

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Abstract

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conclusion Substantial deficiencies of basic protective supplies exist in low- and middle-income countries.

keywords bloodborne diseases, HIV/AIDS, surgery, occupational health

Introduction

In sub-Saharan Africa, HIV prevalence rates in the general population range from 1% to 2% in West Africa to more than 20% in parts of Southern Africa (UNAIDS 2010), and the rates among surgical patients are even greater (Kingham et al. 2009b). The percentage of the population with chronic hepatitis B virus infection exceeds 8% (Teshale 2011), and the estimated prevalence of hepatitis C virus infection ranges from 1.6% in Southern and East Africa to 6% in Central Africa (Madhava et al. 2002).

As part of their daily routine, surgical healthcare workers are frequently at risk for exposure to patients' blood and body fluids, and the risk to such personnel in low- and middle-income countries (LMICs) is even greater (Fry 2007; De Silva et al. 2009; Mohebati et al. 2010). This problem is compounded by the scarcity of resources in these countries that make it difficult for surgical healthcare workers to access protective gears (Consten et al. 1995; Kingham et al. 2009b). It is well established that precaution based on the adequate knowledge and utilization of appropriate protective gear is a key to protecting the healthcare workers from potential exposure to these contagions. Particularly important is the use of protective items such as gloves, aprons and eye protection (CDC 1988). Current evidence suggests that using such items significantly reduces the risk of infection and safeguards occupational health, with several studies showing splash rates of more than 40% onto protective masks and glasses during operations (Mast et al. 1993; Marasco & Woods 1998; Sharbaugh 1999; Calfee 2006; Olapade-Olaopa et al. 2006; Davies et al. 2007).

The aim of this study was to review recently published data from various LMIC hospitals and document the availability of equipment and supplies for the protection of healthcare workers. We hypothesized that the quantity of

protective items supplied to these hospitals was inadequate for such a high-risk population.

Methods

The WHO Tool for Situational Analysis for Access to Emergency and Essential Surgical Care (WHO 2008) was developed in 2008 to document the surgical capacity of health facilities in LMICs. The tool captures data on the availability of infrastructure, personnel and surgical procedures that can be performed as well as on supplies and equipment. Investigators are asked to categorize the availability of these items into one of the following three groups: always available, infrequently available, not available. The tool has been successfully used for surgical capacity assessment in several LMICs, and a number of articles documenting the needs of health facilities based on the tool have been published.

For this paper, we identified all published literature where the tool was used. We then collected data from each paper to investigate the number of hospitals in each country and the availability of the following five protection gears in each of those hospitals: eye protection, aprons, sterile gloves, sterilizers and suction pumps. The data on the availability of the protection gears were re-categorized into two rather than three categories, stating that facilities either have the equipment available 'all the time' or 'not all the time'.

Results

Eight studies that utilized the WHO survey tool for the surgical capacity assessment in individual countries have been published. The studies cover Afghanistan (Contini et al. 2010), the Gambia (Iddriss et al. 2011), Ghana (Choo et al. 2010), Liberia (Sherman et al. 2011), Mongolia (Spiegel et al. 2011), Sierra Leone (Kingham et al. 2009a), the Solomon Islands (Natuzzi et al. 2011) and Sri Lanka (Taira et al. 2010).

Table 1 Individual countries with published surgical capacity assessments and number of hospitals assessed

Country (reference)	Number of hospitals assessed
Afghanistan (Contini et al. 2010)	17
Gambia (Iddriss et al. 2011)	18
Ghana (Choo et al. 2010)	17
Liberia (Sherman et al. 2011)	16
Mongolia (Spiegel et al. 2011)	44
Sierra Leone (Kingham et al. 2009a)	12
Solomon Islands (Natuzzi et al. 2011)	9
Sri Lanka (Taira et al. 2010)	31
Total	164

In total, 164 hospitals were investigated: 17 in Afghanistan, 18 in Gambia, 17 in Ghana, 16 in Liberia, 44 in Mongolia, 12 in Sierra Leone, 9 in the Solomon Islands and 31 in Sri Lanka (Table 1). The investigators in the Gambia, Liberia, Sierra Leone and Solomon Islands conducted field assessment work in the majority of hospitals located in the countries, while those in Afghanistan, Ghana, Mongolia and Sri Lanka used a representative sample.

In Afghanistan, the availability was not reported for each individual item for each hospital; instead, the authors stated that equipment and supplies for basic surgical emergencies were uniformly available in four regional hospitals, incompletely or only occasionally available in six provincial and in five district hospitals. Thus, for the five protective items analysed here, we assumed that deducing from the author's report these items were 'always available' in only 24% of facilities surveyed.

In Ghana, 94% of facilities had consistent supplies of sterile gloves. Sterilizers were readily available in approximately 80% and suction pumps in 70%.

In Sri Lanka, where 31 hospitals were surveyed, some facilities failed to respond to all questions. Based on the reports of those who did responded to all questions relating to the five protective items, eye protection was always available in only 5% of facilities; sterile gloves were available in 55% and sterilizers in 65% of the 22 facilities that responded to the respective question.

In sum, none of the eight countries had a 100% supply of all five items (Table 2). Aprons were available in 24% of the hospitals surveyed in Afghanistan, in 33% in the Gambia and in 63% in Liberia. Eye protection was available in only one hospital in Sri Lanka (4%), and even in Liberia, which reported to have them available in the largest percentage of the facilities, only 56% responded that they had sufficient supplies. The availability of sterile gloves greatly varied, ranging from 24% in Afghanistan to 94% in Ghana. Likewise, the availability of sterilizers ranged from 24% in Afghanistan to 92% in Sierra Leone. Lastly, the availability of suction pumps was relatively low, with 24% in Afghanistan, 71% in Ghana, 9% in Mongolia and 44% in the Solomon Islands.

Discussion

Our study highlights the limited resources devoted to protecting healthcare workers from the occupational hazard of HIV infection in LMICs. Such deficiency is not confined to healthcare workers – patients can also potentially be exposed to HIV contagion during medical

Table 2 Number and percentage of hospitals which always have protective supplies and equipment by individual country

	Afghanistan (n = 17)	Gambia (n = 18)	Ghana (n = 17)	Liberia (n = 16)	Mongolia (n = 44)	Sierra Leone (n = 12)	Solomon Islands (n = 9)	Sri Lanka (n = 31)
Apron	4 (24)*	6 (33)		10 (63)				
Eye protection	4 (24)*	3 (17)		9 (56)	4 (9)	5 (42)		1 (5)t
Gloves (sterile)	4 (24)*	10 (56)	16 (94)	10 (63)	35 (80)	9 (75)	8 (89)	12 (55)t
Sterilizer	4 (24)*	9 (50)	14 (82)		18 (41)	11 (92)	7 (78)	14 (64)t
Suction pump	4 (24)*		12 (71)		4 (9)		4 (44)	

Data given in parenthesis are expressed as percentage.
*Equipment and supplies were only uniformly available at four regional hospitals.
tDenominator of 20 was used.
tDenominator of 22 was used.

procedures and are left without any means to protect themselves from such exposure.

Occupational risks related to bloodborne diseases for surgeons or surgical practitioners are well documented: Consten et al. (1995) reported that 22.3% of 1078 patients who underwent surgical procedures in Zambia were HIV positive and that there was a 1% rate of parenteral exposure in the course of 1161 procedures. Surgical patients are more likely to be HIV positive than the general population, and therefore healthcare workers treating surgical patients should be considered a high-risk population (Consten et al. 1995; Lewis et al. 2003; Mkony et al. 2003; Kedir 2008; Kingham et al. 2009b). Consten et al. (1995) estimated that if a surgeon were employed for 5 years in Zambia, the cumulative risk of contracting HIV would be 1.5%, assuming an average of three exposures per year.

Obi et al. (2005) surveyed 264 randomly selected surgical trainees or practicing surgeons at five facilities in Nigeria and found that in the previous 5 years, 40.2% (n = 106) of the surgical trainees and 26% (n = 70) of the practicing surgeons reported at least one needle-stick injury and at least one incident of blood splashes during surgery. Moreover, 89% of the 236 healthcare workers surveyed were engaged in the risky practice of routinely operating on patients with open hand wounds; these wounds were subsequently contaminated with blood in 5% of the cases. During surgical procedures, all respondents wore protective aprons, but only 65.2% were double-gloved and only 30.3% used protective goggles. A study in Australia examined 160 eye shields that were consecutively used by surgeons and surgical assistants in Melbourne (Marasco & Woods 1998). It found that 44% tested positive for blood, although the surgeons themselves were only aware of the occurrence of any spray episodes in 8% of cases.

Constant supplies of the protective items investigated in this study would likely greatly reduce the risk of exposure for surgical healthcare workers. A laboratory experiment based on animal testing demonstrated that the use of gloves reduces the volume of blood transmitted to the underlying skin by approximately 50% during a needle-stick injury (Mast et al. 1993). Wearing two pairs of latex gloves reduces the risk of exposure caused by glove defects from approximately 17% to 5% (Gerberding et al. 1990).

Nevertheless, these items are frequently not affordable in LMICs. Aisien and Ujah (2006) documented that 60% of respondents in Nigeria who did not use the protective items during surgical procedures cited the lack of supplies as their primary reason for not doing so, as did 85% of surgical trainees in Nigeria (Adebamowo et al. 2002).

While the availability of HIV protective equipment is essential to the delivery of safe surgical care and the protection of both patients and providers, ensuring that healthcare providers are properly trained in the use of surgical safety equipment and aseptic techniques is also important. The lack of surgical equipment alone cannot entirely account for the proper use of equipment and the importance of safety protocols in the event of an involuntary exposure. Primary preventive measures (training, protective equipment) as well as secondary prevention of possible infections with prophylactic post-exposure drugs are important.

One initiative that addresses the lack of surgical workforce protection is the Surgery and HIV Assessment and Response Program (S.H.A.R.P) of Surgeons OverSeas. This programme aims to provide local workers with protective gear to prevent the spread of HIV/AIDS, hepatitis and other bloodborne diseases, by locally procuring HIV protective equipment and providing it to government health facilities. An advocacy campaign is calling for legislation to provide such safety equipment for all healthcare workers, and recently, a seminar on health and safety in the surgical workplace was conducted in Freetown, Sierra Leone.

Each country will likely have a different mechanism of supply and distribution. There are no available data on whether supplies are provided through the government or privately, although from anecdotal experience we suspect it is a combination of both. It is not known whether the lack of protective surgical supplies limits the availability of surgical services.

Protection during surgical procedures is equally important to healthcare providers and the patients they are treating, because bloodborne pathogens can be transmitted either way. In a study of accidental blood exposures in three West African nations, healthcare providers only reported approximately 30% of all blood exposures (Tarantola et al. 2005). An even higher estimate of 40–70% for the underreporting of needle-stick injuries is proposed (Wilburn 2004). Stigma and hesitation may play a role in influencing a surgical healthcare provider's decision to report an exposure. The stigma among healthcare workers who acquired HIV through occupational exposure cannot be ignored, and HIV rates among healthcare workers are probably underreported. A survey of South African surgeons revealed mixed views on reporting HIV status to colleagues, patients and hospital administration, with most favouring non-disclosure (Szabo et al. 2009). Knowledge about exposure risks and formal reporting protocols and systems for post-exposure prophylaxis may be lacking. Several studies have indicated that providers require further education and training on protective and post-exposure prophylactic measures (Chogle et al. 2002; Nwankwo & Aniebue 2011). Providers who are not aware of their own HIV sero-status or exposure to other bloodborne infections may further increase the risk of infection of both patients and other healthcare providers.

Limitations

Our study has a number of limitations. Firstly, not all data were reported for all the items for all of the countries. Even though all surveys used the same assessment tool, because different investigators conducted them without consultation with each other, their reports lacked consistency. Owing to the missing or unreported data in some of the studies, some assumptions needed to be made. Notably, data from Ghana, Afghanistan, Mongolia and Sri Lanka came from a representative sample of hospitals, while data from the Gambia, Liberia, Sierra Leone and Solomon Islands were collected at all facilities. Secondly, the general descriptive nature of WHO survey tool may inadequately represent data. For instance, in facilities where supplies are not 'always available', it is difficult to quantify the frequency of availability. Supplies that were 'infrequently available', which we re-categorized together with the 'not available' into 'not always available' could refer to broad range of product availability not accounting for seasonal or temporal variations in supply. Therefore, in our presentation of the data into binary categories of 'always available' and 'not always available', we may have skewed the original data by over- or underestimation. Thirdly, the WHO survey tool only provides a snapshot of data and does not provide any information on the trend of rising or falling availability of supplies over time. Fourthly, there is no indication from each study as to whether all hospitals included in the assessment actually provide surgical care. This can introduce significant bias, as those hospitals that do not will naturally not stock as many surgical supplies, although some items such as sharps disposals and gloves are considered universal precaution items and should be available in every healthcare facility.

Conclusion

There is a substantial deficiency of basic supplies of protective gears in LMICs even though these items are essential for protecting surgical healthcare workers against bloodborne diseases. To ensure a sustainable supply of these items for the workers, governments as well as global donor agencies must establish a policy that requires provision of these items for health workers and secure funding to do so.

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GENERAL DISCUSSION

GENERAL DISCUSSION

Undertaking the research for this thesis was a complex project involving many colleagues in various countries and in various institutions who collaborated, assisted, advised, and criticized this work. They all agreed however, on its mission of defining the surgical disease burden and to work on the assessment of surgical capacity in order to focus attention on surgically treatable conditions at the level of local ministries of health as well as at the UN and WHO. We expected that this will assist in the allocation of donor funding as well as in the allocation of various necessary resources. Before surgical care is fully accepted as an important component of health care systems more countries need to do similar assessments and publicize their surgical needs and their current insufficient surgical capacity. Therefore, before going into a general discussion of our results and discussion of consequent recommendations, we wish to thank and commend the Sierra Leone Ministry of Health and Sanitation for their helpful participation in many of our studies and for their permission for me to use, distribute, and publish the collected data.
As noted in the introduction, the aim of the thesis was two-fold, to document the need for surgical care in Sierra Leone and to determine the surgical capacity, including safety measures for health care personnel. This discussion will be structured accordingly with the exception of some related-topics on pediatric surgical need and capacity. Although ideas and recommendations are generated throughout the discussion, general recommendations and ideas for further studies are briefly summarized in the last paragraph of the discussion.

Surgical need

The data presented in this thesis clearly show a high prevalence of untreated surgical conditions in Sierra Leone. In the final analysis of our survey we found that 25% of respondents had a condition that likely required a surgical intervention. The survey also showed that 25% of deaths identified in the previous year could likely have been prevented if there was adequate access to surgical services. If one was to extrapolate these findings to the entire population of Sierra Leone, the population at risk would be projected to be almost 1.5 million individuals who would have benefited from a surgical consultation in Sierra Leone at the time of the study [1]. Our survey tool, SOSAS, was also used for a national assessment of operative needs in Rwanda, a country with greater financial support and which is considered more advanced on the development scale than Sierra Leone. In Rwanda, 6.4% (95% CI 5.6–7.3%) of the population was found to have an active current need for a surgical evaluation [2]. Using a very rough metric, including the lower limit of the confidence interval for surgical need in Rwanda (which appears to be a major underestimation), it can be extrapolated to 56 million people in sub-Saharan Africa that are currently in need of minimal surgical evaluation and most likely will need an intervention.

I am not aware of any other study which has documented, as we have, the overall surgical need in a low income country in Africa. There have been several studies published on the surgical needs and inadequacies in the field of management of trauma in Africa. Using SOSAS we found a yearly nonfatal injury prevalence of 12.4% with a 5.6% incidence of mortality related to trauma [3]. The single most common cause of nonfatal injuries was due to falls; this is consistent with previous studies in Iran, Sri Lanka and in China [4-6]. Not unexpectedly, falls from trees have been reported as a leading cause of injury in rural areas of developing countries such as Nigeria and Papua New Guinea [7-9] where the products of tall trees are an important source of food and therefore, income. Studies in rural Ghana [10] and Tanzania [11] have described lacerations to be the leading cause of injuries, with the majority of such injuries sustained during agricultural work. In Tanzania, most cuts and stab wounds were due to injuries inflicted by instruments such as axes and machetes which were used by rural residents engaging in agricultural activities without the use of any protective equipment which is not available. Although motor vehicle–related non-fatal injuries were less common (fourth most common cause of injury overall), they were found to be the most common cause of injury-related deaths, accounting for 32% of injuries during the week prior to death. Similarly, Mock et al [12] reported that in rural and urban Ghana, transport-related injuries were more severe than other types of injuries in terms of duration, of disability, economic consequences, and death.

One of the best and most reliably investigated surgical conditions is diagnosis and management of inguinal hernia. This extremely common condition will affect 27% of males and 3% of females throughout their lifetime [13]. In the US there is an estimated 800,000 hernia operations per year making this one of the most common

procedures performed [14]. In contrast, in Sub-Saharan Africa (SSA), where there are an extremely large number of unrepaired inguinal hernias, patients often present late in the course of their disease with gangrenous bowel or with giant scrotal hernias [15, 16] which require immediate or well-planned surgical interventions depending on the bowel function and viability. Such patients, as well as others such as those with carcinoma of the breast, suffer from lack of access to timely surgical services, leading to frequent fatalities and enormous economic losses.

Using SOSAS data, 7% of the male population had a 'soft groin mass' [manuscript in preparation]. Although this does not translate directly to hernias, it is likely that most of the "soft groin masses" in the male respondents were unrepaired hernias and thereby represent a very large backlog of cases in Sierra Leone. A sub-analysis of pediatric population in the SOSAS survey in Sierra Leone revealed that children also had a large proportion of soft masses located in the groin (n=38) and abdominal wall (n = 50), in which the soft abdominal masses most likely represented umbilical hernias (UH) [17]. Umbilical hernias have the potential to resolve in the first 4-5 years of life and are therefore not in need of immediate repair as long as they are asymptomatic. A large review of UH repairs in the United States revealed that most were repaired around 4 years of age [18], indicating that the UH found in the younger children in this survey might overestimate the current surgical need. In the US study however, 7% (34 cases) of the total UH required emergent repairs because of (recurrent) incarceration, enteric fistula, strangulation, and evisceration [18], therefore indicating that all those with an UH should have access to immediate surgical care. The ideal age of UH repair remains uncertain since the timing of repairs in the Western countries is due more to social aspects (repairs are mostly done before starting school) than to the natural course of the disease. The soft groin masses in children are likely to be inguinal hernias. Therapy for inguinal hernias is mandatory, as incarceration is likely [19].

Based on hospital data from eastern Africa it was estimated that 175 per 100,000 individuals are in need of hernia repair each year [20]. A systematic review from sub-Saharan Africa estimated a higher total annual need for inguinal hernia repair at 205/100,000 population, with estimates of an unmet need of 175/100,000 population annually [21]. These figures compared to our data imply that there is indeed a major backlog of hernia cases in Sierra Leone. A second review on the same topic emphasizes the insufficiency of accurate information on the true burden of inguinal hernias in Africa, especially, in the sub-Saharan region [22]. Since published studies are predominantly extrapolations from hospital data, they significantly underestimate the true burden of the disease among the African population. According to the authors, there were no reported population-based studies that could provide accurate data on the epidemiology of inguinal hernias. The current SOSAS data on 'soft groin masses' partially fills this gap. We strongly recommend that relevant questions regarding surgical needs are included in all countrywide DHS. Even more so based on the suggestion by colleagues like Kingsnorth and others who advocated that hernia repair should be considered a public health priority [23]. Determination of the incidence of hernias is feasible when appropriate questions are added to the DHS. Other parameters of surgical need that can be measured by appropriate questions are related to open wounds, as well as disability related to sustained trauma. We have begun to obtain more precise data on the surgical burden in specific areas and countries and propose in this thesis that this is a necessary precedent to any eventual approach to these health problems and to their solutions.

Using the SOSAS Sierra Leone database we performed a focused analysis on female health since this should be a major component of the health delivery systems in sub-Sahara Africa based on the central role women play in the society and the fact that some funds are available to address maternal mortality (MDG5) in SSA. It was encouraging to find that family planning used by reproductive-aged females in Sierra Leone, was estimated to be at 20%, which is substantially higher than the 8.2% previously reported by WHO for Sierra Leone [24]. It has been previously shown that age-delay of childbearing as well as spacing of deliveries decreases maternal mortality [25-28] and improves perinatal outcomes and child survival [29]. The current analysis, however, documented that only 1.4% of the recalled deliveries were done by cesarean section while fewer than 1% were instrumental delivery (vacuum/forceps); these data were far below the predicted need for that population [30]. Financial constraints were mentioned by half of the families as the main reason for not being able to access modern obstetrical care. The conclusion therefore is that, despite the free health care initiative for pregnant females in

Sierra Leone, adequate access to modern obstetrical care does not meet the reproductive needs of the women of Sierra Leone [31]

The conclusions in this thesis are drawn from the original SOSAS data; we realize however, that the major limitation of SOSAS is that the findings rely solely on a verbal interview of self-reported conditions and are not confirmed by objective observations or any chart reviews. The respondents' perception of a surgical condition might not be correct. For example, a mass caused by Burkitt's lymphoma, which is endemic in certain SSA countries like Congo, with a prevalence of 7/100,000, would need rather chemotherapy than a surgical procedure [32]. Despite this reservation, our enumerators when debriefed found that generally the majority of interviewees were quite knowledgeable most of the time on what constitutes a surgical condition. This is consistent with what I found with qualitative research performed in Sierra Leone via focus group discussions [manuscript in preparation]. Despite this possible limitation of the survey tool, SOSAS, we feel that for the most part the recorded findings accurately reflected the actual need for surgical evaluation and for the most appropriate intervention.

It has been questioned by some whether the conduct of a survey that we describe is financially worth performing in an environment where health care budgets are so very limited and every penny should be dedicated to actual surgical care for the patients. It is well known that Health Care Surveys can be very expensive. Their budgets generally include costs of training, personnel, transportation, and communication which are all important considerations and are country-specific. We performed and highly recommend pilot-testing of SOSAS in the designated country to gain insight in how to use the questionnaire and also to develop appropriate community and national contacts, plan day to day execution along with the most effective logistics and staff selection to execute a full country survey [33]. Cognitive interviewing as well as pilot testing are essential steps for survey development [34-35]. We relied and modeled our study on the lessons firmly expressed by Sudman and Bradburn that 'If you don't have the resources to pilot-test your questionnaire, don't do the study' [36]. Ideally, our pilot-testing could have been accompanied by the performance of a physical examination which could serve as a validation method. However, in view of substantial ethical and logistical issues, as well as financial implications, such a combined survey could not be undertaken for this thesis. Development of a validation method for SOSAS is the logical next step in this research field. Such a study will help to further determine which questions and/or tests could be most effectively and reliably used to incorporate surgically treatable conditions in the national DHS.

The actual cost of executing our study was less than US$35 000 per country, with the primary investigators not being reimbursed for the investment of their time in the development, execution, and interpretation of the studies. The use of handheld tablets reduced our overall costs substantially in terms of printouts and personnel needed for data entry: the tablets could be sold after completion of the study. The execution of SOSAS in Rwanda demonstrated that the survey could be accurately reproduced by a different principal investigator (PI) with a different research team working in a different cultural and national environment in a country with a different level of development. The full country survey in Sierra Leone, as well as in Rwanda, confirmed that interviewers had little trouble familiarizing them-selves with the technology and found the iPads easy to use in the field, once they were properly instructed and trained by the research team and the PI. Direct data entry limited errors in recording data by avoiding transcriptions, and allowed for early, almost instantaneous, analysis which further added to the benefits of using this type of technology for the survey. Quick feedback was possible by the field supervisors, who reviewed the surveys on both a daily basis and before leaving the cluster (area). It was therefore, possible to promptly identify any missing data and collect the appropriate information in a second visit to the household before proceeding to the next cluster. Through our ability to conduct such immediate corrections, we were able through the SOSAS survey to create a very robust and comprehensive database with fewer than 4 % missing data-entry points. One of the most important contributions of this thesis has been the creation and characterization of the survey tool, SOSAS, which we have shown to be highly reliable and effective when used and supervised appropriately.

As we look towards the future and the most effective and practical methods of delivering surgical health care in

underserved countries, it has become clear to us on the basis of this thesis that each country must define its own burden of surgical disease profile. SOSAS, or surgical disease related questionnaire as we have used for Sierra Leone and for Rwanda should be incorporated in the investigation of the disease profile. We have also shown that these methods, appropriately modified, as necessary, can be applied to other countries as well. When results of similar studies from many countries in the SSA become available, it will be possible to correlate the results with development index or gross national income, and this may not only be highly informative, but may also permit development of corrective measures which will be variable from country to country. Identification of health care systems determinants (eg. governmental systems versus private systems) will also provide critical insights for the most effective and practical way of providing surgical care to majority of the population.

Surgical Capacity

Another important factor in redefining and restructuring a surgical health care system in an underserved country must include evaluation of the available surgical capacity of a country studied not only by total number but especially by regional and even individual hospital capacity. Realizing the importance of such an evaluation we explored the surgical capacity of Sierra Leone with PIPES (Personnel, Infrastructure, Procedures, Equipment, and Supplies) a new tool, developed by modifying the WHO (World Health Organization) tool. Given the limitations of the WHO tool, including difficulty in data analysis, duration of the survey, poor reliability of process methods sections, and limited access to data collected by WHO [37] a modification was indicated. The final survey tool had 105 total data items, as compared to 256 in the original WHO tool which makes it more malleable and practical to use. The 105 data items were divided into five sections: Personnel, Infrastructure, Procedures, Equipment, and Supplies (PIPES). Reassessment with this new tool revealed an apparent increase in surgical capacity in Sierra Leone [38]. The use of the PIPES tool in Sierra Leone confirmed that it could be easily administered, and that the data thus obtained could be analyzed in a more simplified fashion. We also showed that we could readily calculate a useful outcome index as was previously done with the WHO tool by Kwon et al [39], in a rather complex manner secondary to the more elaborate WHO-survey. Using the PIPES tool, projections can be made by matching of the surgical needs (SOSAS) with the PIPES index of surgical capacity for a country or a region, in order to develop data-driven plans for restructuring of a surgical care delivery system for that specific region or country.

In the same fashion that we looked at the surgical capacity for adults, we also investigated the pediatric surgical capacity in Sierra Leone and as expected, found deficiencies in aspects of Personnel, Procedures performed and Equipment and Supplies [40]. It became clear that any analysis of surgical needs and/or capacity requires a specific Pediatric PIPES survey for a more detailed evaluation which will differ from that found for the adult patient. Specific capacity assessment for the pediatric population are critical, since earlier estimates indicated that 85% of children in LIMCs need some form of surgical care before their 15th birthday [41]. The SOSAS sub-analysis of pediatric needs in Sierra Leone indicated that, 17.6% of pediatric population (under 18 years of age) had a possible surgical condition in need of a consultation at the time of interview [17]. A cross-sectional survey in 29 hospitals in south-western Uganda estimated an annual rate of surgery for children <15 years of age to be 180 operations per 100,000 population [42]. In Rwanda, a representative survey of district and regional hospitals across the country found that pediatric surgical cases constituted only 1% of the 45,759 cases performed each year [43]. Information on overall personnel involved in pediatric care has been provided by Chirdan et al. in a survey of eight African countries representing 402 million people. In these countries, there were a total of 231 pediatric surgeons—only a fraction of the estimated 1,006 needed for their populations [44]. Compared to Europe and North America, which have two to three pediatric surgeons per million people, Nigeria, the most populous country in Africa, has 0.43 pediatric surgeon per million and Malawi only 0.06 per million. Some countries, such as Sierra Leone, do not have a single pediatric surgeon. Such deficits appear at first look to be insurmountable. However, no effective health care planning can be activated without first defining in detail the deficits in surgical capacity, in a similar manner to the definition of surgical needs which we have emphasized in this thesis previously.

Despite the lack of even one pediatric surgeon in the whole country, pediatric surgery is performed effectively in Sierra Leone by skilled general surgeons [45]. It is unknown whether more pediatric lives could be saved if a fully

trained pediatric surgeon was available or whether more surgeons and more training in pediatric surgery for the general surgeons is sufficient.

In this study we were able to evaluate the pediatric procedures (under 5 year of age) actually performed only in Connaught Hospital, the only tertiary hospital in Sierra Leone (Chapter 9). The PIPES analysis, on the other hand, only indicated the possible surgeries that might be performed in all hospitals in Sierra Leone [40] (Chapter 8). Most cases that we analyzed were related to congenital abnormalities (including inguinal hernias). The study concluded that the number of operations on children under 5 years of age increased by 500 %, from 42 to 210, after the introduction of the free health care program. Interestingly, males outnumbered females at 20:1 before the establishment of the free health care program, but this unbalanced ratio decreased to 6.5:1 after the start of the program, indicating that free healthcare also promoted gender equity. Our data from SOSAS however, indicated a similar distribution of gender in children who reported having undergone a surgical procedure [17] (Chapter 4). These two findings, the observation in which male children were more likely to present for surgical care in the analysis of pediatric case load of Connaught hospital versus an almost equal sex distribution in children who underwent a procedure seem to contradict each other. More detailed analysis of the ages of children who underwent surgery according to the SOSAS database is currently being processed, and might provide an answer to the gender equity question. Another explanation might be found in the relatively high number of urology cases (predominantly male) given the presence of an urologist at Connaught Hospital, resulting in clinicians referring these types of cases which are more likely to be boys.

The exploration of the increase of surgical care for children under 5 after the exemption of the health care fees in Chapter 9, indicates that surgical care is not affordable for many people in Sierra Leone. Therefore introduction of a flexible payment schemes or seasonal reduction of payment, as well as cross-subsidizing from the wealthy patients to the poor (the Robin Hood approach) might be a partial solution to access to surgical care for children. Currently Connaught hospital has a private ward which is part of cross-subsidizing program for those who are not able to pay their bills and this approach awaits evaluation.

Recommendations

The surgical capacity assessment of Sierra Leone which we describe was a first step following identifying surgical needs. However the study did not include an assessment of the adequacy of the current surgical care and of surgical capacity. Since adequate surgical care includes safe performance of anesthesia and availability of well-trained surgical staff who can perform surgical procedures not only with adequate knowledge and skills, but also in adequate sterile conditions with protective equipment for the medical operating staff, we have included some summary comments on quality of surgical care. We explore the use of protective equipment for the staff which was initially sorely lacking when we began our studies in Sierra Leone and were recently corrected; this is explored in Chapter 10. Many other aspects of quality of care are not addressed in this thesis, but need to be more thoroughly explored and corrected in the future. Morbidity and mortality meetings as well as monitoring of the numbers of surgical procedures and complication rates in a national registry could help maintain quality of care and identify gaps of knowledge or skills both locally and regionally. Similar thorough root cause-analysis of morbidities and mortalities, along with more thorough descriptions of surgical capacities and deficiencies in equipment and supplies, we are convinced, will in the future lead to overall improvement in the surgical health care in LIMC's.

Since deficiencies are noted in many areas of surgical capacity, our recommendations are for the time being general in nature, rather than specific. Task-shifting of some surgical procedures to general medical doctors, or even assistants, should be further explored, to improve human resources for surgical interventions and especially to improve access to surgical care in rural areas and in regions with very poor road conditions [46-51]. Since training of new surgeons, as well as of surgical assistants and of surgical health care workers, is critical to implementing improvement of surgical care in Sierra Leone, there is an absolute need for the development of a surgical residency program in Sierra Leone where none exists at present. This must become a priority in order to address the surgical need of the population. Furthermore collaboration of the Ministry of Health and Sanitation together with NGOs or academia from high-income countries could lead to training-collaborations and

specialized surgical-camps to reduce the backlog of, for example, pediatric surgical cases, or hernia repairs. The success of all such interventions, idealistic though they seem, will rely on effective logistics for supplies and equipment, funding for instruments, sutures, drains etc, and on well controlled and efficient patient flow, as well as maintenance of equipment, and salaries for the needed staff. Evaluation of various programs for their surgical capacity should ideally be accompanied by research on the quality of care as well as evaluation of existing training, guidelines, supervision, and career opportunities and salaries for those who could be additionally trained to assist surgeons or substitute for them in minor cases, and thus enlarge the qualified personnel pool.

Surgical capacity (availability of services), adequacy (safety and quality of care) as well as affordability as are keystones in providing health care in general and surgical care specifically. However accessibility for those in the rural areas in a country such as Sierra Leone with limited road network, poses yet another hurdle in the provision of care, necessitating a referral system, which includes better communication, as well as upgrades of the ambulance system, which currently is hardly available for those outside of Freetown.

Lastly, the acceptability of surgical care by the community and its leaders is critical for the individual patient's timely presentation to the hospital and thereby having a better likelihood of a good surgical outcome. Cultural beliefs and practices probably affect the decision to seek surgical care and accepting the risks of a surgical procedure as advised by medical personnel [52-54]. Other medical interventions, such as vaccinations and treatment for epilepsy and tuberculosis, also have specific cultural and behavioral aspects related to health-care seeking behavior [54-56]. Favorable outcomes can positively affect societal perceptions of care and can likewise affect timely presentation for an intervention. It is very clear and must be thoroughly understood by all health care providers and planners that an increase in surgical capacity and services depends on much more than on the availability of personnel, facilities, equipment, and even government support. It depends on all that but in addition it must also include the public values and norms in addressing illnesses which can be positively affected by educational programs and in assurance of the quality of the delivered surgical services.

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APPENDICES

SUMMARY

The intent of this thesis is to lay a foundation for evidence-based methodology and approaches to the improvement of surgical health care delivery systems in underserved countries. The initial focus has been on the development of survey tools to evaluate the need for surgical care and to quantitate as best as possible the available resources in a country, using Sierra Leone as the main subject of our studies. To validate the methods we also examined the use of the survey in Rwanda and relied on available literature, scant as it is. The first part of this thesis discusses the surgical need in Sierra Leone as indicated by this newly developed survey tool, called Surgeons OverSeas Assessment of Surgical need (SOSAS), which has now been used in Sierra Leone and in Rwanda. For the available surgical resource quantification the PIPES survey (Personnel, Infrastructure, Procedures, Equipment and Supplies) was developed and used in Sierra Leone. This and related research on surgical capacity is explored in part two of this thesis.

In Chapter 1 I describe the initial pilot study of SOSAS in Sierra Leone. It quickly became clear that the employment of SOSAS using iPads was relatively straightforward and simple while at the same time facilitated data entry. Quick analysis of the collected data allowed for rapid feedback and appropriate adjustments. Although the survey has over 400 data entry points, the use of conditional formatting, permitted the enumerators to collect household demographics and interview two randomly selected household members in an average of 25 minutes. The survey methodology was acceptable, with a response rate of 96%. Five major sections/questions were amended to facilitate and refine further the use of this tool following the initial pilot use of the survey.

The results of the full country survey of Sierra Leone using SOSAS are outlined in Chapter 2. Of the 1875 targeted households, data were analyzed for 1843 (response rate: 98%). A total of 896 respondents (25%; 95% CI 22.9–26.2) reported a surgical condition needing attention at the time of the interview. We also concluded that 179 of 709 (25%; 95% CI 22.5–27.9) deaths of household members identified during the year prior to the survey might have been averted by appropriate timely surgical care. It is apparent from this part of the study that this large uncovered disease burden warrants more attention than is currently given. We conclude that demographic health surveys applied in any country should include surgically related questions in their questionnaires, as ours did, to obtain a fair and well balanced view of the health concerns.

As part of a special focus on most important surgical disease in the underserved countries and in the world, we describe in Chapter 3, the rate of injuries. Twelve percent of the population in Sierra Leone reported at least 1 traumatic injury in the year preceding the survey; falls were the most common cause of nonfatal injuries (40%) and traffic injuries were the leading cause of injury-related deaths (32% of fatal injuries). Women were less likely to experience a traumatic injury than men (odds ratio [OR], 0.69; 95% CI 0.57- 0.83) as determined by data obtained for the year previous to the survey. In urban areas, there were no differences in the mechanisms of injuries when analyzed by gender. However, in rural areas, a higher proportion of men as compared to women had injuries due to falls, motorcycle crashes, and gunshot wounds. This finding may reflect the relative similarity of activities performed by men and women in urban areas; which differs from more distinct roles that men and women assume in rural areas. The most common injury site was the extremity, regardless of age or gender. Our results complement those found by other focused surveys dealing with injury and trauma in low and middle income countries.

Chapter 4 is dedicated to another specialized surgical need, the pediatric surgical need. Pediatric health needs, especially for those under the age of 5, have been high on the global health agenda following emphasis by Millennium's development of goal number 4, which targets the mortality rate in those patients under 5 years of age. A total of 1,583 children out of 3,645 individuals (43.3%) were interviewed with the assistance of their guardians. Most individuals under the age of 18 (64.0%, n = 1,013) lived in rural areas. At the time of the interview, 279 children (17.6%; 95% CI 15.7–19.5) had a possible surgical condition which needed treatment and/or a consultation. Children in the northern and eastern provinces of Sierra Leone were much more likely to report a surgical problem than those in the urban-west.

Broadening the category of specialized needs to an area of great deficiency and my special interest, I focus in Chapter 5 on surgical needs for obstetrical problems. Of 3,318 women of reproductive age in the households visited, data were collected on randomly selected 1,205 female participants of reproductive age. Twenty percent (95% CI 17.9-22.5) of respondents reported using family-planning methods; injectables (Depoprovera) were the most frequently used method. Fifty-nine percent (95% CI 54.0-63.0) of the recalled deliveries occurred outside of a health facility. Of the total births, 1.9% (95% CI 1.3-2.5) were reportedly delivered by a cesarean section while only 0.4% were performed with instrumental delivery. The interviews with the household representatives revealed 53 maternal deaths in the 12 months prior to the survey, resulting in a maternal mortality rate of 1,600/100,000 females per/year. Of the maternal deaths, 30 women (56.6%) did not receive any type of modern health care, 53% (16/30) of whose families cited financial constraints as a major limiting factor. These results of maternal deaths, a low percentage of instrumental deliveries, and a low rate of cesarean sections found through our survey in Sierra Leone, combined with the reported financial constraints, indicate that the free health care initiative planned for pregnant women does not yet fully cover the reproductive needs of women in Sierra Leone.

As part of testing the reproducibility of the SOSAS survey tool, the same survey with local adaptations, was also used in a national assessment of surgical needs in Rwanda. This country has more funds in general and for health care than Sierra Leone and is therefore listed much higher on the development scale. The results of this survey are presented in Chapter 6. With a 99% response rate the final analysis included a total of 1626 households (3175 individuals) and it resulted that 41.2% (95 CI% 38.8–43.6%) of the population has had at least one surgical condition during their lifetime; 14.8% (95% CI 13.3–16.5%) had a surgical problem during the year preceding the survey while 6.4% (95% CI 5.6–7.3%) of the population were found to have a current surgical problem that required attention. Of that last group 55.3% were women and 40.3% were children younger than 15 years of age. A total of 32.9% of household deaths in the year prior to the survey may have been related to surgical conditions, with 55.0% of responding households reporting lacking funds to transport the patient to the nearest hospital which could provide personnel, be it a general practitioner, to perform an operation.

We concluded in our discussion that using a very rough metric, including the lower limit of the confidence interval for surgical need in Rwanda (which appears to be a major underestimation when compared to Sierra Leone with a much higher need), our findings can be extrapolated to 56 million people in sub-Saharan Africa that are currently in need of minimal a surgical evaluation and most likely will need an intervention.

In light of this newly documented, but most likely long standing, epidemic of surgically treatable conditions, efforts must be made to identify the causes and determinants that can be addressed to solve this problem. It is possible that the high number of conditions which need immediate surgical care in Sierra Leone is solely due to a backlog of cases and may not be reflective of conditions in other Low or Middle Income Countries or even in Sierra Leone once the “backlog” is taken care of. There might also be local environmental, genetic, cultural or occupational reasons for such a great need for surgical care. As was pointed out by the enumerators’ feedback sessions, most people don’t see an umbilical hernia as a surgical problem. Whatever the underlying cause may be for the large number of cases that we describe, the data provide valuable insight and baseline statistics to develop an understanding of the health needs of the population on the basis of data, collected with great emphasis on reliability. These data can also assist the MoHS and non-governmental organizations in effective planning for health care delivery to the population in need and for initiation of surgical programs where and when they are needed. By documenting a baseline denominator, projects can be properly monitored and evaluated. It is hoped that the type of survey that we describe will be also used in the future not only to initiate new programs, but also to evaluate the effectiveness of those that are ongoing or which are completed. Ideally, data concerning surgically treatable conditions will be collected in future demographic health surveys so as to limit the necessity of repeated implementations of SOSAS for many other countries.

In Chapter 7 is the start of Part two of this thesis, in this chapter we switch gears from surgical needs to surgical capacity. The newly developed PIPES survey (Personnel, Infrastructure, Procedures, Equipment and Supplies – assessment) is explained and used to evaluate the available health resources for surgery, in Sierra Leone. We

were also able to compare our findings from 2011 with those which existed from a similar survey done in 2008. Not unexpectedly many facilities lacked most of the items needed to provide safe and appropriate surgical care, with limited numbers of anesthesia machines, oximeters, instrument sets, gowns, drapes, sutures, and eye protection, as well as anesthesiologist, surgeons, and even qualified general practitioners. Most facilities either gained staff or stayed the same in the comparison of 2011 and 2008 data. The total number of hospital beds increased overall, in each facility in 2011 the number of hospital beds ranged from 30 beds to 327 beds per hospital, with a total of 1,490, compared to 1,398 in 2008. Most facilities still had only one operating room, although 4 hospitals had 2 or more functional operating rooms. Although many of the facilities had improved as indicated by the PIPES-index, staffing shortages were still common at all facilities in 2011.

A specific assessment of surgical capacity for the pediatric population is presented in Chapter 8, and indicated that a pediatric hernia could be repaired in 67 % of hospitals while none of the more complex procedures, such as cleft lip and clubfoot repairs could be performed in entire Sierra Leone. It is unfortunate that the congenital deformities of the face/head/neck area (n=16) and of the extremities (n=12) which the surgical needs assessment of the pediatric population showed to be a significant health burden to the children and their families (Chapter 4), currently cannot be repaired in Sierra Leone in the governmental health care system, unless it relies on (international) specialist teams working with the local surgeons and teaching them while working together on the backlog as well as timely repair for new cases.

This does not negate in any way the pediatric surgery practiced successfully with care by local general surgeons as is described in Chapter 9. This Chapter looks specifically at the relation between the increase in pediatric surgeries performed following the announcement of the Sierra Leone Ministries of Health and Sanitation of free health care for all children under the age of 5. The total number of all operations performed at Connaught Hospital in the 20 months before and after the start of the free health-care program increased by 28 %, from 1,435 to 1,840. During this same time period, the number of operations on children under 5 increased by 500 %, from 42 to 210. This increase was significantly larger than the 17 % increase (from 1,393 to 1,630) seen in operations on patients 5 years old and older ($p<0.01$). Additionally, the percentage of patients under 5 years of age compared to the total number of cases rose from 2.9 to 11.4 %.

There was an obvious connection between our findings through our pediatric data in SOSAS which indicated that pediatric hernias (soft swellings in the groin area) were the most frequently mentioned surgical abnormality in need for repair and the actual number of pediatric hernias repaired in this review of cases. The average age of patients under 5 who underwent surgery was 1.8 years before the program and 2.1 years after the program was started. Overall, males outnumbered females before the start of the program at a ratio of 20:1, but this decreased to a ratio of 6.5:1 after the start of the program. This suggests that this increase in health care for children under five might be associated with a reduction of gender inequity to health care access. Although the free health care initiative was heralded as a success, the reimbursement of the surgeons, the cost of the equipment and materials to the hospital, as well as hospital costs per se, were not taken into account in maintaining this effort and should be reconsidered.

Finally in Chapter 10 we provide a secondary analysis using the WHO Tool for the Situational Analysis of Access to Emergency and Essential Surgical Care to evaluate safety of surgery performed in relation to infectious diseases. In this Chapter we list the availability of daily needs for health care protection equipment including gloves, aprons and eye protections. At the time of our review there were eight publications that documented such data from 164 hospitals: Afghanistan (17), Gambia (18), Ghana (17), Liberia (16), Mongolia (44), Sierra Leone (12), Solomon Islands (9) and Sri Lanka (31). No country had a 100% supply of any item. Eye protection was available in only one hospital in Sri Lanka (4%) and was most readily available in Liberia being still only 56% of the times when the equipment was needed. The availability of sterile gloves ranged from 24% in Afghanistan to 94% in Ghana. Surgical patients in HIV-endemic areas are more likely to have HIV than the general population, and this study highlights the limited resources devoted to protecting healthcare workers from the occupational hazard of HIV infection or other blood borne diseases. Increasing surgical care without special attention to the safety and quality of care would not only be unwise but would also be unethical from the perspective of both the patient

and the health care provider.

It has been clear to us throughout this study that close collaboration with local and international health care workers, non-governmental organization as well as academic institutions and the local governments are needed to analyze and improve surgical health care in LMIC's. Both need and capacity assessments are part of the foundation needed to build a good surgical network. Through my thesis, I have tried to begin to lay such a foundation by analyzing how these assessments can be developed and applied in a methodical and effective manner, not only in Sierra Leone, but also in a broader sense in other countries which have similar needs.

Samenvatting

Dit proefschrift heeft de behoefte aan chirurgie en chirurgische capaciteit van de gezondheidszorg in Sierra Leone onderzocht. In dit land hebben momenteel grote delen van de bevolking geen toegang tot chirurgische zorg. Hiertoe zijn twee nieuwe vragenlijsten ontwikkeld. Het onderzoek werd uitgevoerd in Sierra Leone aangezien Surgeons OverSeas sinds 2008 samen met de locale chirurgen en het Ministerie van Volksgezondheid in Sierra Leone werkt. Bovendien was er veel enthousiastme om mee te doen in Sierra Leone.

Het eerste deel van dit proefschrift bespreekt de chirurgische behoefte in Sierra Leone, zoals geevalueerd met Surgeons OverSeas Assessment of Surgical need (SOSAS) uitgevoerd in het begin van 2012. Deze vragenlijst is gebaseerd op de schaars aanwezige literatuur en ontwikkeld in discussie met specialisten die als experts worden gezien als het gaat om chirurgische hulp verlening in ontwikkelingslanden en specialisten op het gebied van bevolkingsonderzoeken. Door hetzelfde onderzoek ook uit te voeren in Rwanda, met een ander onderzoeks team, is de methode geëvalueerd op reproduceerbaarheid. Het onderzoek over de chirurgische capaciteit van Sierra Leone wordt gepresenteerd in deel twee van dit proefschrift. De beschikbaarheid van chirurgische mogenlijkheden in de verschillende ziekenhuizen in Sierra Leone is gekwantificeerd met een andere survey (PIPES; Personel, Infrastructure, Procedures, Equipment and Supplies). Deze vragenlijst is gebaseerd op een eerder gebruikte vragenlijst van de Wereld Gezondheids Organizatie maar vereenvoudigd en verbeterd voor gebruik en vergelijking.

In hoofdstuk 1 beschrijf ik de pilot-studie van SOSAS in Sierra Leone. Het werd al snel duidelijk dat het gebruik van iPads voor de invoering van antwoorden relatief eenvoudig en simpel was voor de interviewers als ook de onderzoekers. Directe analyse van de verzamelde gegevens gaf de mogelijkheid voor de snelle feedback en de nodige aanpassingen. Hoewel de vragenlijst meer dan 400 vragen heeft, geeft de huidige opmaak in electronisch formaat de mogelijkheid om de volledige survey van een huishouden en een gedetailleerd interview met twee willekeurig geselecteerde leden van het huishouden in gemiddeld 25 minuten te voltooien. De pilot-studie gaf aan dat SOSAS in Sierra Leone acceptabel was, met een respons van 96%. Vijf hoofdsecties en vragen van SOSAS zijn gewijzigd voor verduidelijking, verbetering en vereenvoudiging.

De resultaten van SOSAS, na uitvoering in alle districten van Sierra Leone, worden beschreven in hoofdstuk 2. Van de 1875 beoogde huishoudens, werden de gegevens geanalyseerd van 1843 huishoudens (respons: 98%). In totaal rapporteerden 896 respondenten (25%; 95% BI 22,9-26,2) een mogelijk chirurgische aandoening op het moment van het onderzoek (prevalentie). Vervolgens bleek dat 179 van de 709 (25%; 95% BI 22,5-27,9) overleden familieleden in het jaar voorafgaand aan het onderzoek meest waarschijnlijk chirurgishe zorg nodig hadden gehad. De antwoorden zijn gebaseerd op wat de bevolking aangeeft als een chirurgisch probleem. Deze gezondheids problemen dienen uiteraard nader geevalueerd te worden door een dokter met chirurgische kennis en mogelijkheden en geven dan ook niet het uiteindelijk aantal benodigde operaties weer. Maar toch kunnen we concluderen dat de chirurgishe zorg in landen als Sierra Leone meer aandacht zou moeten krijgen dan momenteel wordt gegeven. We doe de aanbeveling dat chirurgisch gerelateerde vragen worden ingelast in de standaard demografische gezondheidsenquetes, alleen dan komt er een evenwichtige weergave van de gezondheidsproblemen in een land als Sierra Leone.

Een gedetailleerde analyse van verwondingen en traumata wordt gegeven in hoofdstuk 3. Twaalf procent van de bevolking in Sierra Leone vermeldde ten minste 1 traumatisch letsel in het jaar voorafgaand aan de enquête; de meest voorkomende oorzaak van niet-fatale verwondingen was vallen (40%). Verkeer gerelateerde verwondingen waren de belangrijkste oorzaak van dodelijke verwondingen (32%). Vrouwen hadden minder kans op een dodelijk traumatisch letsel dan mannen (odds ratio (OR), 0,69, 95% BI 0,57-0,83). Er was geen verschil in stedelijke gebieden in de oorzaak van verwonding en geslacht. Echter, op het platteland, had een groter aandeel van de mannen in vergelijking met de vrouwen een verwonding als gevolg van vallen, motorongevallen en schotwonden. Deze bevinding kan de relatieve gelijkheid van de activiteiten van mannen en vrouwen in stedelijke gebieden weerspiegelen. Deze verschilt mogenlijk van de meer onderscheiden rollen die mannen en vrouwen hebben op het platteland. De meest voorkomende blessure was aan de ledematen, ongeacht leeftijd of

geslacht. Onze resultaten zijn vergelijkbaar met en aanvullend op eerder gevonden resultaten van letsel en trauma specifieke enquêtes in ontwikkelings landen.

Hoofdstuk 4 is gewijd aan de behoefte aan gespecialiseerde kinderchirurgie. Er werden 1583 kinderen onder de leeftijd van 18 jaar geïnterviewd met de hulp van hun voogden. De meeste kinderen (n = 1013; 64,0%) woonden op het platteland. Een chirurgishe aandoening ten tijde van het interview werd gerapporteerd voor 279 kinderen (17,6%; 95% BI 15,7-19,5). Kinderen in de noordelijke en oostelijke provincies van Sierra Leone hadden meer kans op een chirurgische probleem, dan die in het zuiden en westen.

Hoofdstuk 5 gaat in op chirurgische behoeften voor vrouwen, met name verloskundige problemen, een gebied wat mijn speciale interesse heeft. De bezochte huishoudens omvatten 3318 vrouwen in de vruchtbare leeftijd. Gedetailleerde gegevens werden verzameld van 1.205 vrouwen, die willekeurig waren geselecteerd. Twintig procent (95% BI 17,9-22,5%) van deze vrouwen gebruikte een anti-conceptie methode; hormonale injecties (depoprovera) was de meest gebruikte methode.

Negenenvijftig procent (95% BI 54,0-63,0%) van de bevallingen vond plaats buiten een zorginstelling. Van het totaal aantal geboren kinderen, werd 1,9% (95% BI 1,3-2,5%) naar verluidt geboren via een keizersnede, terwijl slechts 0,4% werd geboren met een vacuum- of tang-verlossing. Door de interviews met de vertegenwoordigers van de huishoudens bleek dat er 53 gevallen van moedersterfte waren geweest in de 12 maanden voorafgaand aan het onderzoek. Dit resulteert in een schatting van moedersterfte van 1600 / 100.000 vrouwen per jaar. Dertig overleden vrouwen (n=30, 56,6%) hadden geen enkele vorm van moderne gezondheidszorg gekregen, in 53% (16/30) gaf de familie aan dat hun financiele situatie de belangrijkste beperkende factor was. Deze hoge moedersterfte, het lage percentage van vacuum- en tang-verlossingen en het lage percentage keizersneden in combinatie met de gerapporteerde financiële beperkingen, suggereren dat het initiatief om zwangere vrouwen gratis gezondheidszorg te geven in Sierra Leone nog onvoldoende dekking heeft bereikt.

Als onderdeel van het testen van de reproduceerbaarheid van de SOSAS survey, werd dezelfde vragenlijstmet lokale aanpassingen, ook gebruikt in een nationale evaluatie van chirurgische behoeften in Rwanda. Dit land heeft meer financiele mogelijkheden en een beter gestructureerd gezondheidszorgsysteem dan Sierra Leone, en wordt derhalve veel hoger op de ontwikkelingschaal geplaatst. De resultaten van dit onderzoek worden gepresenteerd in hoofdstuk 6. Dit onderzoek omvatte interviews met 1.626 huishoudens, met twee interviews per huishouden gaf dit informatie over 3175 personen. De analyse liet zien dat 41,2% (95% BI 38,8-43,6%) van de bevolking ten minste eenmaal een chirurgische aandoening heeft gehad tijdens hun leven; 14,8% (95% BI 13,3-16,5%) had een chirurgische probleem tijdens het jaar voorafgaand aan het onderzoek, terwijl 6,4% (95% BI 5,6-7,3%) van de bevolking een huidig probleem had dat een chirurgishe evaluatie vereiste. In vergelijking met de resultaten in hoofdstuk twee, blijkt dat er minder directe behoefte aan een chirurgische evaluatie is in Rwanda, dan in Sierra Leone. Een totaal van 32,9% van de sterfgevallen in de huishoudens, in het jaar voorafgaand aan het onderzoek, kon worden toegeschreven aan een gezondheids probleem wat in de westerse wereld wordt benadered door chirurgische hulp. Het ontbreken van middelen om een patient te vervoeren naar het dichtsbijzijnde ziekenhuis was in 55,0% van de sterftegevallen problematisch.

Wij concludeerden dat met een zeer grove schatting, door het gebruik van de ondergrens van het betrouwbaarheidsinterval (BI) voor chirurgische behoefte in Rwanda, dat tenminste 56 miljoen mensen in sub-Sahara Afrika momenteel de behoefte hebben aan een chirurgische evaluatie en meest waarschijnlijk een operatie nodig hebben.

Het is meest waarschijnlijk dat deze nieuw gedocumenteerde, maar waarschijnlijk reeds lang bestaande, epidemie van chirurgisch behandelbare aandoeningen, wordt bepaald door de minimale chirurgische capaciteit van Sierra Leone. Achterstand van zaken, als ook lokale milieu-, genetische, culturele of beroepsmatige redenen kunnen meespelen in zo'n grote behoefte aan chirurgische zorg. Zoals werd opgemerkt door de evaluatie sessies met de interviewers waren de meeste mensen op de hoogte van veel voorkomende chirurgische problematiek. Dit geeft aan dat het werken aan chirurgische capaciteit een politieke prioriteit zou moeten zijn. Deel twee van

dit proefschrift gaat verder in op de chirurgische capaciteit van Sierra Leone en gebruikt een methode welke ook in andere landen is toegepast.

De nieuw ontwikkelde PIPES enquête (Personeel, Infrastructure, Procedures, Infrastructure and Supplies) wordt uitgelegd in hoofdstuk 7, en toegepast om de beschikbare middelen voor chirurgische capaciteit in Sierra Leone te evalueren. We waren ook in staat om onze bevindingen uit 2011 te vergelijken met die van een vergelijkbaar onderzoek in 2008. Niet onverwachts heeft Sierra Leone minimale chirurgische capaciteit, een groot deel van de middelen die nodig zijn om veilig chirurgische zorg te bieden ontbreekt. Hoewel veel van de voorzieningen in het algemeen waren verbeterd, zoals aangegeven door de PIPES-index, waren er nog steeds veel personeels tekorten in 2011. De vragenlijst identificeerde ook een beperkt aantal anesthesieapparaten, zuurstof-meters, chirurgische instrumentaria, steriele kleding en doeken als ook een tekort aan hechtingen en oogbescherming voor het personeel. Ook was er een tekort aan anesthesisten en chirurgen, en zelfs gekwalificeerde basisartsen. Het totale aantal ziekenhuisbedden en personeel was gestegen. De meeste ziekenhuizen hadden 1 operatiekamer, terwijl 4 ziekenhuizen 2 of meer functionele operatiekamers hadden.

Een specifieke beoordeling van capaciteit op het gebied van kinderchirurgie wordt gepresenteerd in hoofdstuk 8. Dit geeft aan dat een liesbreuk bij kinderen in 67% van de ziekenhuizen kon worden hersteld, terwijl geen van de meer gecompliceerde procedures, zoals correctie van een hazenlip of klompvoet kon worden uitgevoerd in een staats-ziekenhuis in Sierra Leone. Het is betreurenswaardig dat aangeboren misvormingen van het gezicht, hoofd en halsgebied (n = 16) en van de extremiteiten (n = 12), waarvan het bevolkingsonderzoek had aangetoond dat deze een aanzienlijke gezondheidslast representeerden bij kinderen (hoofdstuk 4), niet konden worden gecorrigeerd in de gezondheidszorg van de overheid van Sierra Leone. Een tijdelijke oplossing kan zijn om gespecialiseerde (internationale) teams samen te laten werken met de lokale chirurgen, zodat tijdens de operaties niet alleen de patient geholpen wordt, maar ook gewerkt wordt aan locale capaciteitsversterking.

Alhoewel er de nodige gebreken zijn in de mogelijkheid voor kinderchirurgie, de locale algemeen chirurgen operen kinderen, zoals beschreven in hoofdstuk 9. Dit hoofdstuk kijkt specifiek naar de relatie tussen de toename van de operaties uitgevoerd na de aankondiging door het Ministerie van Volksgezondheid van Sierra Leone met een programma dat gratis gezondheidszorg biedt aan kinderen onder de leeftijd van 5 jaar.

Het totaal aantal operaties uitgevoerd in Connaught Hospital in de 20 maanden vóór en na de start van het vrije gezondheidszorgprogramma was toegenomen met 28% (van 1.435 tot 1.840), meest waarschijnlijk doordat er een aantal verbeteringen waren ingevoerd in het ziekenhuis. In dezelfde periode steeg het aantal operaties voor kinderen onder 5 jaar met 500%, van 42 tot 210. Deze stijging was aanzienlijk groter dan de stijging van 17% (van 1393 tot 1630) gezien bij operaties op patiënten van 5 jaar en ouder ($p < 0,01$). Onze bevinding uit het bevolkinsonderzoek met SOSAS gaf aan dat een pediatrische hernia (zachte zwellingen in de liesstreek) de meest genoemde chirurgische abnormaliteit was, dit kwam overeen met het feit dat de meest uitgevoerde operatie bij kinderen een voor een hernia was. De verhouding van meisjes:jonges die een operatie ondergingen was 1:20 voor de start van vrije gezondheidszorg; dit daalde tot een verhouding van 1:6,5. Dit laatste suggereert dat gratis gezondheidszorg voor kinderen onder vijf jaar kan bijdragen aan een vermindering van geslachtsongelijkheid in toegang tot gezondheidszorg. Hoewel het gratis gezondheidszorg initiatief voor kinderen onder 5 werd aangekondigd als een succes, de betaling voor een operatie (de chirurgen, apparatuur en materialen), komen momenteel niet in aanmerking voor vergoeding door het Ministerie van Volksgezondheid en wordt momenteel door het ziekenhuis en de chirurgen betaald. Uiteraard moet dit heroverwogen worden in de wetenschap dat er veel chirurgische aandoeningen zijn zoals aangetoond met SOSAS in het eerste deel van dit proefschrift.

Tenslotte, in hoofdstuk 10, geven we de resultaten weer van een systematische review van artikelen met resultaten van de 'WHO Tool for the Situational Analysis of Access to Emergency and Essential Surgical Care' om de veiligheid van de operaties uitgevoerd in verband met besmettelijke ziekten te evalueren. In dit hoofdstuk geven we een overzicht van de beschikbaarheid van beschermingsmiddelen zoals sterile handschoenen, schorten en oog bescherming, die dagelijkse nodig zijn om gezondheidswerkers te beschermen tegen besmettelijke ziekten. Er waren acht publicaties op het moment van onze analyse, die gegevens documenteren van 164

ziekenhuizen: Afghanistan (17), Gambia (18), Ghana (17), Liberia (16), Mongolië (44), Sierra Leone (12), Solomon eilanden (9) en Sri Lanka (31). In geen enkel land waren alle items aanwezig. Oogbescherming was slechts aanwezig in 1 ziekenhuis in Sri Lanka (4%) en het was het meest beschikbaar in Liberia, maar nog steeds slechts in 56% van de ziekenhuizen. De beschikbaarheid van steriele handschoenen varieerde van 24% in Afghanistan tot 94% in Ghana. Chirurgische patiënten in HIV-endemische gebieden hebben meer kans om een HIV-infectie te hebben dan de algemene bevolking, en deze studie wijst op de beperkte middelen die beschikbaar zijn voor de bescherming van werknemers in de gezondheidszorg. Deze beroepsgroep heeft een hoog beroepsrisico op HIV/AIDS of andere aandoeningen die via bloed overdraagzaam zijn. Ontwikkelings programma's in gezondheidzorg moeten speciale aandacht geven aan de veiligheid en kwaliteit van de zorg. Het niet in acht nemen van de genoemde beschermende middelen voor aandoeningen die via bloed overdraagbaar zijn, zou niet alleen onverstandig zijn, maar zou ook onethisch zijn vanuit het perspectief van zowel de patiënt als de zorgverlener.

Op basis van de ervaring met ons onderzoek zijn wij van mening dat er een nauwe samenwerking moet zijn tussen lokale en internationale gezondheidswerkers, niet-gouvernementele organisaties , academische instellingen en lokale overheden. Dit is nodig om de chirurgische gezondheidszorg te analyseren en te verbeteren. Het inventariseren van de behoefte aan chirurgie en chirurgische capaciteit, vormt de basis die nodig is om een goed chirurgische netwerk op te bouwen. Door mijn proefschrift heb ik geprobeerd om een basis te leggen voor een methodologie als ook een eerste schatting van de chirurgische epidemiologie. Ik heb aangetoond dat het mogelijk is om een bevolkings onderzoek naar chirurgische aandoeningen te doen, dat de behoefte aan chirurgie hoog is, en dat een evaluatie van de chirurgische capaciteit inzicht geeft in de specifieke tekortkomingen, niet alleen in Sierra Leone, maar ook in andere landen die vergelijkbare behoeften hebben.

LIST OF ABBREVIATIONS

CAPI	Computer-Assisted Personal Interviewing
COMAHS	College of Medicine and Allied Health Sciences (in Freetown, Sierra Leone)
CPD	Cephalo-Pelvic Disproportion
DALY(s)	Disability Adjusted Life Year(s)
DHS	Demographic Health Survey
EA	Enumeration Area, the smallest geographic area chosen as clusters
GIEESC	Global Initiative of Emergency and Essential Surgical Care
GNI	Gross National Income
HDI	Human Development Index
HIC	High Income Countries
HIV	Human Immunodeficiency Virus
KIT	Royal Tropical Institute in Amsterdam
LMIC(s)	Low and Middle Income Country/Countries
MDG(s)	Millennium Development Goal(s)
MoHS	Ministries of Health and Sanitation
NGO(s)	Non-Governmental Organization(s)
PI	Principle Investigator
PIPES	Personnel, Infrastructure, Procedures, Equipment and Supplies; a tool for surgical capacity assessment
SOS	Surgeons OverSeas, A NGO with a mission to save lives in developing countries by improving surgical care.
SOSAS	Surgeons OverSeas Assessment of Surgical need (available via www.surgeonsoverseas.org)
SSA	Sub-Saharan Africa
SSL	Statistics Sierra Leone, the National Statistics Bureau of Sierra Leone
UH	Umbilical Hernia
UN	United Nations
US	United States of America
WHO	World Health Organization

BIOGRAPHY and PUBLICATIONS

Reinou S. Groen, MD, was born in Gramsbergen (NL) and was traveling since she was 16 years old, starting with a visit to family in Australia, organizing school-exchange programs with Sweden and building an orphanage in Croatia. She worked in Ghana, Nigeria and Tanzania during her medical studies and thereafter became a Dutch Tropical Doctor (surgical & obstetrical profile), with a Master in International Health from the Royal Tropical Institute in Amsterdam. During her time as Surgeons OverSeas International Fellow she was engaged with the United Nations and the World Health Organization and she developed a population based survey to assess surgical needs. This was implemented in Sierra Leone and resulted in the presented research. Furthermore she has experience in providing and teaching emergency obstetric care for Doctors Without Borders and Surgeons OverSeas in Democratic Republic of Congo, Niger and Sierra Leone. She is a graduate of Groningen University Hospital in the Netherlands and is currently specializing in Gynecology and Obstetrics at Johns Hopkins Hospital (USA). She is married to Adam L. Kushner.

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