A Comparison of Prospective and Retrospective Methods to Measure Surgical Volume and In-Hospital Post-Operative Mortality in Uganda

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Scholarly Report submitted in partial fulfillment of the MD Degree at Harvard Medical School

Date: March 1, 2017
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A Comparison of Prospective and Retrospective Methods to Measure Surgical Volume and In-Hospital Post-Operative Mortality in Uganda.

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ABSTRACT

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Purpose: Surgery is increasingly accepted as a necessary part of a functioning health system. In 2015, the Lancet Commission on Global Surgery (LCoGS) recommended that every country report its surgical volume and post-operative mortality rate (POMR) as part of six indicators on the strength of a surgical system. The LCoGS did not make recommendations on the best method to collect these data. This study aimed to collect these metrics at a regional referral hospital in Uganda, and to compare observational prospective data collection with retrospective review of patient charts and ward logbooks. We hypothesized that logbooks would be an efficient method, whereas prospective data collection and patient charts would be too time-consuming for large-scale data collection.

Methods: For one month, basic information was taken about every patient who had an operation at a regional referral hospital in Western Uganda. These patients were followed up through daily ward observation and their outcomes were followed until discharge or death. Prospective data were compared with data obtained from logbooks and patient charts to determine the validity of using retrospective methods for collecting these metrics.

Results: Surgical volume at this regional hospital in Uganda was projected to be 8,515 operations/year. The POMR at this hospital is 2.4%. Finding patient files in the medical records department was time consuming and yielded only 62% of the files. Furthermore, a comparison of missing versus found charts revealed that the missing charts are significantly different from the found charts. Logbooks, on the other hand, captured 99% of the operations and 94% of the deaths.

Conclusion: This regional referral hospital has a large volume of surgery, with a POMR that is equivalent to that reported from similar settings. Logbooks, which are ubiquitous in low-resource settings, represent a good source of data for measuring simple metrics such as POMR and surgical volume.
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Surgical Volume and Post-Operative Mortality Rate at a Referral Hospital in Western Uganda: Measuring the Lancet Commission on Global Surgery Indicators in Low-Resource Settings,

accepted by Surgery for publication on Jan 13, 2017. Published online March 1, 2017.

DOI: http://dx.doi.org/10.1016/j.surg.2017.01.009
Glossary of Abbreviations:

ASA – American Society of Anesthesiologists
C-section – cesarean section
DCP-3 – Disease Control Priorities 3rd Edition
HICs – High Income Countries
HIV/AIDS – human immunodeficiency virus/ acquired immunodeficiency syndrome
ICU – Intensive Care Unit
IRB – Institutional Review Board
LCoGS – Lancet Commission on Global Surgery
LICs – Low Income Countries
LMICs – Low and Middle Income Countries
MRRH – Mbarara Regional Referral Hospital
MSF – Médicins Sans Frontières
MUST – Mbarara University of Science and Technology
OBGYN – Obstetrics and Gynecology
PACU – Post-anesthesia care unit
POMR – Post-Operative Mortality Rate
TB – tuberculosis
WDI – World Development Index
WHA – World Health Assembly
WHO – World Health Organization
Section 1: Introduction

For most of its history, the field of international or global health was associated with infectious diseases. As it existed for the first several decades of its existence, the World Health Organization (WHO) was primarily focused on preventing the spread of communicable disease by quarantine, antibiotic dispersal and vaccines. While this led to great gains such as the eradication of smallpox, it also led to disease-specific vertical interventions (1). Throughout this time, the role of surgery (and of surgeons) was largely ignored. Even today, surgery is often thought of as too expensive or too resource intense for low and middle-income countries (LMICs) (2). However, when one thinks about surgical interventions as an integral part of a health system – for example, necessary to treat appendicitis, to provide timely C-sections for obstructed labor, to treat bowel perforations from typhoid, or remove (and sometimes cure) cancer – one realizes that surgery is an indivisible indispensable component of health care (3).

It has recently been estimated that up to 30% of the world’s disease burden would benefit from surgical care (care by a surgeon, anesthesiologist or obstetrician/gynecologist) (4); and that diseases that could be treated or ameliorated by surgery cause over 16.9 million deaths per year (3,5). This contrasts sharply with the 3.83 million deaths per year due to the traditional global health triumvirate of HIV/AIDS, TB and malaria (5). This also does not account for the millions of people who suffer disability from surgically treated causes such as road traffic injuries (6). Furthermore, providing surgical care is not significantly more expensive than interventions that form the basis of many global health strategies. Several common procedures such as hernia and cleft palate repairs are as cost-effective as the treatment of HIV/AIDS, TB or the full cadre of childhood vaccines (7,8).

In 2015, the publication of three entities led to the labelling of 2015 as a “landmark year” for global surgery. These publications highlighted the importance of surgery in global health (9), and included the Disease Control Priorities-volume3 (DCP-3) (10), the Lancet Commission on Global Surgery (3), and the World Health Assembly Resolution on Global Surgery (11). These publications highlighted the importance of developing health systems capable of providing both medical and surgical care for populations around the world. Each included recommendations (3) that are necessary for the advancement of surgery in LMICs. These recommendations include the scale up of the most cost effective procedures (10), the development of emergent surgical capacity (11), the creation of national surgical plans and nationwide collection of indicators for monitoring.
The Lancet Commission on Global Surgery (LCoGS) was first convened in September 2013; over the next 18 months the 25 commissioners met with collaborators from more than 100 countries to discuss the state of surgery across the globe (12). This culminated in the publication of its report in 2015 (3), along with over 100 supporting papers (13). The report had five key messages and two major recommendations supporting its vision of “universal access to safe and affordable surgical and anesthetic care when needed.” These recommendations were that every country develop a national surgical plan; and that all countries collect data on six surgical indicators. The indicators were created to assess the strength of the entire surgical system, and with repeat measurement, can gauge improvement. Meant to be used as a group, together they describe the safety, affordability and accessibility of surgery in each country. These indicators are as follows (3):

1. Percentage of the population that is 2 hours from a facility that can perform the 3 bellwether procedures – caesarean section, management of open fracture and laparotomy.
2. Number of surgeons, anesthesiologists and obstetricians (SAO’s) per 100,000 population
3. Number of surgical procedures performed per 100,000 population
4. Unadjusted, in-hospital postoperative mortality rate
5. Percentage of the population at risk for the development of an impoverishing expenditure should they need to undergo a surgical procedure
6. Percentage of the population at risk for the development of a catastrophic expenditure should they need to undergo a surgical procedure

Several of these indicators were also recently added to the World Bank’s World Development Index (14).

While the Lancet Commission, and supporting papers provided ample evidence for the use of these indicators (15–19), there was no guidance on the best way to measure these indicators. Electronic databases like those used in the high-income countries (HICs) to track such metrics are often too expensive to implement and maintain in many low-income countries (LICs) (20). Instead an efficient, easily reproducible method is needed to collect these data with
information that is currently available. This study aimed to look at two of these indicators in a LIC (Uganda), and to compare the results and process of obtaining these data in several ways.

This study occurred in Uganda, a country of just over 38 million located in Central East Africa. With one of the highest birth rates (5.8/woman), multiple civil wars prior to the rise of President Museveni (now in his 5th term), and early death rate (average life expectancy ~58), approximately half the population is under 15 (21). It continues to have a high HIV prevalence (7.1%), and lifetime risk of maternal mortality of 2.1% (14). These metrics continue to improve slowly; the public health system is chronically underfunded and most people are required to pay out of pocket for some portion of their care (22).

Post-operative mortality (POMR) and surgical volume are two indicators meant to assess quality and access to surgery in developing countries (3). However, little data has been published on these indicators, especially in Uganda. For the Lancet Commission, surgical volume was estimated to be 241/100,000 (17). There are no nationwide estimates of mortality. Most studies of surgical volume are based on few district hospitals (often district) (23–25), and from these samples national statistics are estimated (17). This runs the risk of drastically underestimating the amount of surgery occurring in developing countries; as many district hospitals refer their patients for operations.

Volume data complicated by many factors, including the definition of a surgical procedure itself. The Lancet commission provides a definition for use, “a procedure is defined as the incision, excision, or manipulation of tissue that needs regional or general anesthesia, or profound sedation to control pain” (3). However, it is not always clear from existing papers which procedures included meet these criteria. Estimating surgical volume is further complicated by difficulty in reporting catchment area, which can be affected by seasons, availability of staff and the referral chain. Thus the only other paper from a regional referral hospital merely reports a projected annual volume of 8511 surgical procedures (3950 excluding dental extractions), but does not estimate volume (26). In contrast, a paper reporting surgical volume from two district level hospitals in the same are reported a major case rate of 225/100,000 persons. This is extrapolated from 1051 major cases over four months and 1666
minor cases over three months from two hospitals, which would annualize to 9817 total surgical cases per year (25).

Data on post-operative mortality rate (POMR) is even more scarce. Most papers address only a single type of operation (eg, open heart surgery (27) or neurosurgical procedures (28)) or address a specific conditions such as deaths due to uterine rupture (29) or neonatal deaths (30)). Prior to the development of this study, only one recent paper was found that looked at all-cause mortality at two Ugandan district hospitals, with 16 deaths and an overall reported POMR of 0.6%. 14 of these deaths occurred after major surgery (1.6% , and 2 after minor procedures (0.5%) (25). The paper published from another regional referral hospital during the data collection phase of this study reported 77 deaths in patients with surgical disease in a nine month period, but does not delineate whether these patients actually underwent surgery, nor the number of procedures in the same time period (26). There is some data from surrounding countries, most notably a paper on all-cause mortality at a national teaching hospital in neighboring Rwanda had a POMR of 6% (31), as well as a summary of surgical care at several MSF-associated hospitals estimating POMR at 2.03% (32).

One of the major issues with comparing published POMRs are the types of surgeries being performed and whether surgeries are undertaken on sick patients. Thus, there is an ongoing debate about the utility of unadjusted POMR (as recommended by the Lancet Commission) (3,15) versus use of risk-adjusted POMR (33). This study additionally looked at the feasibility of measuring basic metrics (34) for risk-adjustment, as it is not well understood the ease with which these data can be collected. While it is generally agreed upon that risk adjustment can add value to comparisons, the issue is further complicated by a lack of standardized methodology. As of now there is no standard way to risk adjust for variables such as case mix, associated diseases or urgency of operation.

Knowledge of surgical volume and post-operative mortality rate assist understanding the quantity and quality of surgical care. By developing a reliable, rapid and accurate method for assessing these LCoGS indicators in LMICs, more representative data can be collected. In turn, nationally representative data can inform the development of national surgical plans. This is critical as developing countries begin to increase delivery of surgical care to their citizens to
assure equitable access to life-saving procedures. These data can also assist global players as the focus shifts from disease specific interventions to the development of health care systems (35).

**Section 2: Student Role**

I joined this project just after its initial conception. The basic plan regarding a comparison of prospective and retrospective methods had been made, however many of the details of the study were still under discussion. I helped clarify these details and assisted Dr. Geoffrey A Anderson (surgical resident at MGH) in writing the research proposals and ethics forms for both the US and Ugandan IRBs.

While we waited for final approval of the projects in country, I worked with our collaborators to get to know the various departments (I was primarily based in the obstetrics and gynecology ward, but also worked with the surgery and anesthesia departments). It was crucial that we develop a data collection flow that allowed for accurate data collection without impeding the daily work flow of our colleagues. The months spent shadowing our Ugandan collaborators gave me a better understanding for the daily difficulties they face in providing clinical care. I was also able to appreciate the shifts in disease epidemiology.

Once we had the requisite ethics approvals, I became one of three primary data collectors. I completed much of the prospective data collection in the operating rooms for surgical volume; and split the daily observation for discharges and deaths with the other data collectors so we could attend rounds in all three locations. I collected paper data collection sheets from the other researchers and completed all the primary data entry, including coding of diagnoses and procedures into ICD codes where appropriate. I also completed all the logbook and patient chart reviews for retrospective data collection.

After data collection and entry were complete; I worked under the guidance of Dr. Anderson and Dr. Shrime to analyze our data with appropriate statistical methods. From this I helped our Ugandan colleagues present our initial data to their departments, as well as create posters for a university wide research symposium. I also created the various tables and figures for our publication.

Dr. Anderson was the primary author of this paper. In addition to the above-mentioned data analysis/presentation, I helped with the literature review required for the introduction and discussion. I also worked closely with him to edit the paper to prepare it for submission. Once
we received feedback, I prepared the first draft of our response to the reviewers and made appropriate changes to the manuscript.

During this project (along with the others I completed during my time in Uganda), I learned a great deal about the development and execution of research in global surgery. The most important lesson was that of the need for strong partnerships to improve research capacity for both parties. I also learned a lot about data management, analysis and staying organized through the months-long process of designing and publishing a study.
Section 3: Acknowledgements

This study would not have been possible without the generous support of the Doris Duke Charitable Foundation’s International Clinical Research Fellowship. On a personal note, thank you to my family, for letting me move to Uganda for nine months, and for supporting me throughout my medical training. I also can’t thank my mentors, Dr. Shrime and Dr. Anderson, enough; I learned a tremendous amount and wouldn’t have made it through the year without them. I also want to thank our collaborators in Uganda, especially Dr. Peter Kayima, Dr. Lenard Abesiga and Dr. Ronald Mayanja who welcomed us to their country and hospital. Without their guidance, willingness to teach us about their system and assistance in completing these projects this research would not have been possible.
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Appendix 1:

DOI: http://dx.doi.org/10.1016/j.surg.2017.01.009

Surgical Volume and Post-Operative Mortality Rate at a Referral Hospital in Western Uganda: Measuring the Lancet Commission on Global Surgery Indicators in Low-Resource Settings

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Sources of funding: Massachusetts General Hospital Center for Global Health, Doris Duke Foundation, GE Foundation Safe Surgery 2020 Initiative, Kletjian Foundation

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Word Count: 3811
ABSTRACT

Background: The Lancet Commission on Global Surgery (LCoGS) recommends that every country report its surgical volume and post-operative mortality rate (POMR). Little is known, however, about the numbers of operations performed and the associated POMR in low-income countries (LICs) or how to best collect these data.

Methods: For one month, every patient who underwent an operation at a referral hospital in Western Uganda was observed. These patients and their outcomes were followed until discharge. Prospective data were compared with data obtained from logbooks and patient charts to determine the validity of using retrospective methods for collecting these metrics.

Results: Surgical volume at this regional hospital in Uganda is 8,515 operations/year, compared to 4,000 operations/year reported in the only other published data. The POMR at this hospital is 2.4%, similar to other hospitals in LICs. Finding patient files in the medical records department was time consuming and yielded only 62% of the files. Furthermore, a comparison of missing versus found charts revealed that the missing charts are significantly different from the found charts. Logbooks, on the other hand, captured 99% of the operations and 94% of the deaths.

Conclusion: Our results describe a simple, reproducible, accurate and inexpensive method for collection of the LCoGS variables using logbooks that already exist in most hospitals in LICs. While some have suggested using risk-adjusted POMR as a more equitable variable, our data suggest that only a limited amount of risk adjustment is possible given the limited available data.
INTRODUCTION

In April of 2015, the Lancet Commission on Global Surgery (LCoGS) published its findings. Included in its 56 pages were two major recommendations: one, that all countries develop a national surgical plan; and two, that all countries measure six indicators to describe the state of a country’s surgical system. The six indicators are: 1. the percent of the population with two-hour access to a hospital that can provide a cesarean section, manage an open fracture and perform an exploratory laparotomy; 2. the number of surgeons, anesthesiologists and obstetricians/100,000 people; 3. the number of surgical procedures performed/100,000 people; 4. post-operative mortality; 5. impoverishing expenditure due to accessing surgical care; and 6. catastrophic expenditure due to accessing surgical care (1). These metrics together give an estimate of the strength of a country’s surgical system.

Recently four of the six LCoGS indicators were included in the World Bank’s World Development Indicators (WDI) (2). The two that were not added were two-hour access and post-operative mortality. Difficulty in collecting these two indicators, even from high-resource settings, was one of the primary reasons for their exclusion (3). Currently, few country-level data exist on these indicators. Much of the data produced for the Lancet report came from modeling studies. For example, Weiser et al. was able to find published reports on surgical volume from just 66 of the 194 WHO member states (4). While this was an improvement on previous attempts (5) the authors acknowledge the dearth of data on surgical metrics.

While the Lancet Commission provided sound justification for surgical volume and POMR as metrics, little guidance was provided on how best to collect these data (1). Documentation, data collection and management are well-recognized barriers to research in developing countries (6–10). Poor documentation and fragmented data sources pose a challenge to researchers
attempting to complete large-scale, accurate studies on these metrics. If these metrics are to be collected annually all over the world for reporting to the World Bank, a methodology for data collection that is simple, reproducible and inexpensive is needed. We set out to find such a methodology by comparing prospective, observational collection with multiple methods of retrospective data collection for LCoGS indicators 3 and 4 (surgical volume and post-operative mortality). Through this comparison we hoped to determine the accuracy of various retrospective methods and thereby define a methodology that can be used in low resource settings.

METHODS

Setting

Mbarara Regional Referral Hospital (MRRH) is a 600-bed, government referral hospital in southwest Uganda (11) and is associated with a university that has a nursing and medical school. It serves a catchment area of over 3 million people and is the specialty referral center for a region of 8 million (12). It is the largest referral hospital in the Ugandan public system and 1 of only five sites for surgical post-graduate medical education in Uganda. The hospital has four operating theatres, six anesthesiologists, twelve obstetricians and eleven surgeons, including surgical subspecialists.

Prospective Data Collection

A team of investigators spent 12 weeks (two, 2-week periods of new patient enrollment with 30 day follow up after each period) in the operating theatres directly observing every patient who had an operation at MRRH during daylight hours. Due to safety concerns, overnight operations were recorded by meeting with the on-call surgeons, obstetricians, nurses and anesthesiologists at the beginning and end of every night shift as well as by attending morning rounds where the
night's cases were reviewed. The investigators attended rounds daily in the emergency, male, female and pediatric surgical wards as well as the post-natal obstetrical and the gynecological wards. Special trips were also made daily to the private, medical and pediatric wards to find any post-operative patients admitted to those services. All patients were then followed until death, discharge, re-operation, elopement or transfer. If a patient was still admitted after 30 days of follow-up that patient was censored.

The team recorded variables for each patient that were needed to calculate surgical volume, post-operative mortality rate as well as variables that have been suggested to calculate a risk-adjusted POMR (Table 1). The collection of these variables was used to assess the feasibility of collection and accuracy from various sources.

Two Methods of Retrospective Data Collection

The team of investigators examined the same time period at MRRH retrospectively, first using logbooks and then using patient charts collected from medical records.

Anesthesia, obstetrics and gynecology (OBGYN) and surgical operating theatre logbooks were examined for the same two, 2-week periods to collect data about all patients who had an operation during those time periods. Data elements potentially available from logbooks include: name, age, gender, date of operation, post-operative diagnosis, type of operation, American Society of Anesthesiologists physical class score (ASA) and urgency of operation. To follow up on disposition of these patients, the logbooks from the ICU and all wards were examined. The emergency ward also serves as the post-anesthesia care unit (PACU) so that logbook was examined.
To examine another means of retrospective collection a list of names of patients that had an operation during the same two, 2-week periods was obtained from the operating theatre logbooks. This list was then taken to medical records and an attempt was made to pull these patients’ files. To allow time for records to be collected by medical records staff, this list was submitted to medical records at least two weeks after the last patient was censored. The recovered medical records were then examined to supplement the data available in the operating theater logbooks. If files were missing from medical records, then daily attempts over the subsequent 2 weeks were made to retrieve these files. Variables collected are shown in Table 1.

Study population
All patients who had an operation at MRRH during two, 2-week periods in 2016 were included. The LCoGS definition for an operation as, “any procedure occurring in an operating theatre,” was used (1). Patients who went to the operating theatre for an operation but did not have one (e.g. mothers who went for cesarean section but delivered in theatre prior to anesthesia) and patients who had an operation at another institution and were then transferred to MRRH were excluded. Procedures that occurred on the wards, in procedure rooms or in offices were not included.

Power calculation
One of the main outcomes of this project was to determine if logbooks or patient charts can be used to collect POMR. To this end we measured whether POMR differs between the gold standard of prospective data collection and the retrospective measurements using logbooks and charts. We witnessed 655 operations and found 649 operations in logbooks and 404 charts. The
prospective POMR was 2.4%. With 80% power and an alpha level of 0.05 we are powered to detect a 15.5% difference in POMR.

**Data Analysis**

Volume was reported as a simple count and as number of operations per 100,000 population. The catchment area for this referral hospital was determined by examining the home villages of the patients. Because some of the surrounding districts have hospitals that perform operations but also refer to MRRH, the catchment area is expressed as a range. The range is between the minimum population (population of Mbarara district only) and the maximum population (population of Mbarara district plus all the referring districts). The minimum number in this range will overestimate surgical volume and the maximum will underestimate it. Prospective surgical volume was compared to retrospective using a measure of inter-rater reliability, the kappa statistic.

POMR was calculated by dividing the number of deaths by the total number of procedures performed. Prospective POMR was also compared to retrospective using the kappa statistic.

**Software**

All statistical procedures were performed using STATA 14 (College Station, TX).

**Ethical approval**

Ethical approval for this study was obtain from the Institutional Review Committee at Mbarara University of Science and Technology, the Ugandan National Committee for Science and Technology and from the Institutional Review Board at Boston Children’s Hospital.
RESULTS

Demographics:

The majority of patients undergoing surgery at MRRH were female (74%) with a mean age of 26.6 years. Although 70.2% of the procedures were considered emergent, they were performed primarily on healthy patients, with a median ASA of 1.

Comparing retrospective and prospective methods, differences in mean age and median ASA were not statistically significant for both logbook and patient chart review (Table 2). However, the distribution of age among the categories was statistically different between prospective data and that found in charts (p<0.001). The percent of females undergoing surgery and those undergoing emergent procedures were statistically different between prospective data and that found in charts, with more women (82.0% vs 74.1%, p = 0.006) and more emergent procedures (84.4% vs 70.2%, p<0.001) found when collecting data from charts.

Using the prospective data, we were able to compare data from missing charts to those we were able to collect from medical records. (Table 3.) Only 62.2% of the requested charts were obtainable from the medical records department despite a 2-week daily search. Missing patient charts were significantly younger (mean age 28 vs 24.8, p= 0.02) and more likely to be female, (81.9% vs 58.9%, p <0.001). The age distribution was also significantly different (p < 0.001). Median ASA was slightly higher in the missing patients, and missing patients were more likely to have an ASA of 2 or 3, and less likely to have an ASA of 1. Missing charts were also more likely to represent elective procedures (p < 0.001).

Surgical Volume:
During the four weeks of operating room observation, 655 surgeries were recorded. This annualizes to 8515 operations performed at MRRH this year. The projected surgical volume is between 98 and 292 operations per 100,000 people per year given the largest and smallest possible catchment populations for MRRH. Cesarean sections were the most common surgery, representing 47% of all operations. The obstetrics and gynecology department contributed 61.3% of all operations; while 24.4% were either general or pediatric surgical procedures. The remaining 14.7% of surgeries were sub-specialty in nature.

The operating room logbooks provided a very accurate measure of surgical volume, capturing 99% of the prospective collected surgeries. The distribution of types of surgeries was also nearly identical (See Figure 1). In contrast, the charts found disproportionately represented obstetric surgeries (68.3% vs 49.2%, p < 0.001), and underrepresented charts from pediatric patients (3.7% vs 13.0%, p<0.001).

Post-Operative Mortality Rate
There were 16 deaths after the 655 observed operations, resulting in an overall post-operative mortality rate of 2.4% (Table 4). As expected, POMR varied widely by department. There were no post-operative deaths in patients undergoing cesarean section (Figure 2). Neurosurgery had the highest mortality at 13.6%. General surgery had a mortality rate of 8.2%. There was also a noticeable difference in mortality by age, with a POMR of 7.1% in children less than 1 year (p = 0.07), and 12.1% in patients 65 and older (p = 0.004).

Ward logbooks recorded 15 of the 16 deaths observed prospectively. POMR as determined by retrospective log book review was 2.3%, with a distribution that closely matched that found
during the prospective collection. In contrast, only 6 deaths were found via chart review; implying a POMR of 1.5% (Table 4).

**DISCUSSION**

Surgical volume at this regional hospital in Uganda is 8,515 operations per year, significantly higher than the 4,000 operations/year reported in the only other paper on volume at a referral hospital in Uganda (10). The POMR at this hospital is 2.4%, and is 6% when OBGYN cases are excluded. This is similar to the overall 2.1% POMR reported from several Médicins Sans Frontières (MSF) hospitals (14), and the non-OBGYN POMR is nearly identical to the 6% reported at a referral hospital in Rwanda (15). The dearth of information on volume and POMR, however, make it difficult to draw broader conclusions that compare these data across countries, hospitals or time periods.

Our attempt to collect POMR retrospectively from medical records demonstrated the futility of this approach. Finding patient files in the medical records department was time consuming and ultimately yielded only 62.2% of the needed files, despite two weeks of dedicated daily work with the medical records department by staff and researchers. Furthermore, a comparison of missing versus found charts revealed that the missing charts are significantly different from the found charts. For example, charts were more likely to be missing for younger patients, males, and elective cases and less likely for patients in ASA category I, II or III. For these reasons, we do not recommend collection of patient charts as an effective method for data collection in low resource settings. This is unfortunate because many of the variables that have been suggested for risk stratification (16) for POMR are only available in patient charts and not from logbooks. This limitation also required us to use the logbooks as the only method of patient identification.
for surgical volume. The only alternative is to use medical records, which are frequently missing and prohibitively labor intensive to collect and search through.

Logbooks, alternatively, proved to be a rapid, simple, accurate and effective method for determining surgical volume and POMR. Logbooks recorded 99% of the operations and 94% of the deaths. These rates of capture are actually extraordinarily high given resource constraints. This speaks to the importance placed on the accuracy of these records by the responsible staff. For example, the ward logbooks we used for deaths are maintained by the nurses. These women and men face nurse-to-patient ratios of 1:40 (some of whom don’t speak their language) and a total lack of supplies and medications. They are tasked with everything from patient care to managing stockrooms and prepping supplies such as gauze. Give the accuracy, despite such barriers, we recommend using logbooks to collect surgical volume and POMR. For this method to be effective, however, an intimate knowledge of the different types of logbooks and the information contained in each is a requirement. A step-by-step approach to this is outlined in Figure 3.

An alternative solution would be to create a registry to collect these data. While this has been a very effective approach in high-resource settings, and may be appropriate in middle-resourced settings, it would be difficult to create a multi-institution database capable of creating a nationally representative sample in low-resourced setting such as Uganda. Power and internet connectivity are frequent problems. Additional challenges include the cost of the equipment, maintenance and training, as well as preventing theft of valuable equipment. For countries with limited resources, these data show that utilization of a standardized log book across hospitals would suffice for the collection of the Lancet Indicators and would even allow for basic risk stratification.
Data on surgical volume from LICs are generally scarce. The data that do exist are typically drawn from studies of a single or a few hospitals (7–9). We were able, however, to find a few papers from Uganda that attempted to measure these metrics. These papers only report the numbers of a particular type of surgery or in surgical camps, or limit their analyses to the most frequent procedures. In Uganda, five papers were found from the last 15 years that described total surgical volume at various hospitals (10,17–20). A total of 18 hospitals (some hospitals were included in more than one study) were surveyed; 15 were district hospitals. Some papers examining surgical volume in Uganda reported numbers ranging from 5-225 operations/100,000 population (17,19). One paper reported a total of 3950 non-dental operations at a regional referral hospital, but it did not discuss the catchment area (10). While the numbers vary, all are well below the 5,000/100,000 operations recommended by the Lancet Commission (1). Our volume is estimated to be significantly higher than many of the previous reports. This is not surprising as MRRH is one of the busiest and best-staffed referral hospitals in the country. The other regional referral hospital represented has just three general surgeons; Mbarara has nine surgeons, as well as surgical residents and interns (10). The major paper used by the LCoGS to report surgical volume around the world did so in many low and middle income countries (LMICs) by extrapolating volume from a small number of hospitals (5). Many times, as in Uganda, the data were entirely from district hospitals. This is likely to result in an incomplete estimate, given that surgical care in many LMIC’s in countries is concentrated in large urban centers with higher surgical volumes than smaller district hospitals(5,21). The imprecision of the volume/population as calculated in this and other studies is representative of the fact that these are meant to be nationally collected metrics. With a nationally representative sample including all levels of hospitals, the catchment areas of individual hospitals (which are difficult to assess) would no longer be a barrier to accurate calculation.
Published research on post-operative mortality is even more limited, with most papers focusing on mortality from a single type or group of procedures (22–25). Only one paper was found that included all surgeries performed at a district hospital in Uganda, with a post-operative mortality rate of 0.6% for all surgeries (including minor procedures such as fracture reduction). The mortality rate for exploratory laparotomy was 8% and after cesarean section 0.8% (19). A single-site study of the surgical service at a large referral hospital in Rwanda had a post-operative mortality rate of 6% (15). A study of several MSF-associated hospitals in the Democratic Republic of Congo, the Central African Republic and South Sudan reported a post-operative mortality rate of 2.03% after major surgery (14). These examples show the wide range of POMR, depending the types of procedures included in the calculation as well as type of hospital and setting. A notable exception to the generally small studies on POMR is a paper just publish by the GlobalSurg group, reporting POMR over a 2 week period in over 350 locations from 58 countries around the world (26). This work represents a tremendous amount of work from over 1,000 authors. They found an emergency intra-abdominal POMR of 8.6% among the 53 participating LMIC hospitals. Our emergency intra-abdominal POMR was slightly higher at 10.8 (prospectively) or 12.4% (logbooks). One reason for this difference could be related to the fact that even the low-income countries included in the GlobalSurg paper were, on average, of higher GDP levels than Uganda and therefore higher on the resource scale. This difference further demonstrates the need for data collection across countries of all resource levels.

Recently, some have suggested that POMR could be improved through risk-adjustment (24). Unadjusted POMR is useful by itself on a national level and for comparing the same institutions or countries over time. Adjustment would be helpful when comparing among institutions. We found that risk adjustment is only feasible for the variables contained within logbooks, as other
variables cannot be accurately collected. These variables include age, gender, ASA, urgency status, diagnosis and operation type. Diagnosis and operation type, however, would need to be coded before analysis; and this would require a significant amount of resources, including manpower, coding knowledge and time. This is unlikely to be possible in most resource-limited settings outside of a research project. While data collection in high income countries is trending toward more and more detailed models for risk adjustment, Anderson et al researched the simplest models that still provided discriminatory power. They suggest the use of a four-variable model with ASA, wound classification, functional status prior to surgery and age to risk adjust (13). Unfortunately, only two of these were regularly collected in our logbooks (ASA and age). If further research can elucidate the most important variables, we would recommend adding these to the standardized logbooks for future data collection.

This study has some limitations. The conclusions come from examining one hospital in one LIC. The quality of logbooks and medical records might be different at other hospitals in Uganda or in other LICs. However, similar difficulty with medical records in LICs has been reported in other studies (8–10). In this hospital, very few procedures involving more than local anesthesia are completed outside of the operating room. At other hospitals, however, other procedures may be performed on the wards or in offices. As the Lancet Commission specifically defines operation as a procedure occurring in an operating room, this would not change surgical volume as defined. However, it may underestimate the true amount of surgical care. An additional limitation of these results is that we only performed three months of prospective data collection. We were able, therefore, to observe only a small number of deaths (16). This small sample size prevented us from making any definitive statements about the distribution of these deaths.
Now that the Lancet Commission on Global Surgery recommends annual reporting surgical volume and POMR by every country, and the World Bank is collecting these data, a standardized methodology for collecting these data is needed. Our results suggest that these data can be collected rapidly, inexpensively and reliably from examining the various logbooks that are ubiquitous in the operating theatres and surgical wards of LICs. In many LICs these logbooks are provided by ministry of health and, therefore, standardized at all government locations within those countries. For countries that do not yet have standardized logbooks and to assist with standardization across countries our data suggests a minimum variable set that should be included for data reporting as suggested by the LCoGS and now being requested by the World Bank. Furthermore, there are a small number of risk stratification factors included in the logbooks like age, gender, urgency status and ASA. This should be considered a starting point for a standardized set of variables collected in LICs for risk adjustment. Collection of additional risk-adjustment variables has been suggested (16) but collection of these variables is not logistically feasible with the current state of data management in most low resource settings.

Surgical volume and POMR represent just two of the six Lancet Commission indicators. When collected in coordination with the other four indicators, they can help guide efforts for national surgical planning. These data can be used by ministries of health and finance, hospital administrators and researchers for a variety of purposes, including highlighting the most common or dangerous procedures, disease surveillance, resource allocation, staffing and training in needs and budgetary planning. Collection of surgical volume and POMR will also allow for quality improvement, as much can be learned by comparing these indicators across and within settings over time.
CONCLUSION

The LCoGS recommends that every country begin annual reporting of surgical volume and POMR. Our results describe a simple, reproducible, accurate and inexpensive method for collection of these variables using logbooks that already exist in the operating theatres and on the wards of most hospitals in low resource settings. While some have suggested using risk-adjusted POMR as a more equitable variable, our data suggests that only a limited amount of risk adjustment is possible given the limited resources in hospitals such as MRRH.

ACKNOWLEDGEMENTS

Support for this project was graciously provided by the Departments of Surgery, Obstetrics and Gynecology, Otolaryngology and Anesthesia at Mbarara Regional Referral Hospital/Mbarara University of Science and Technology.

Disclosure of financial interests and potential conflicts of interest

Mark Shrime and has received money for talks produced by Ethicon.

Funding support

The salary support for Geoffrey Anderson was provided by the Massachusetts General Hospital, and he received a grant from the Partners Centers for Expertise. Lenka Ilcisin was funded by the Doris Duke Foundation. Mark Shrime was funded by the Kletjian Foundation and the GE Foundation Safe Surgery 2020 program.
REFERENCES


Figures and Tables

Table 1: Variables Collected for Surgical Volume and POMR

<table>
<thead>
<tr>
<th>Variable</th>
<th>Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>Continuous (nearest year)</td>
</tr>
<tr>
<td>Gender</td>
<td>Dichotomous (M vs F)</td>
</tr>
<tr>
<td>Pre-operative diagnosis</td>
<td>Recorded then categorized</td>
</tr>
<tr>
<td>Post-operative diagnosis</td>
<td>Recorded then categorized</td>
</tr>
<tr>
<td>Operation</td>
<td>Recorded then categorized</td>
</tr>
<tr>
<td>Operative date</td>
<td>Day/month/year</td>
</tr>
<tr>
<td>ASA class</td>
<td>Ordinal (1-5)</td>
</tr>
<tr>
<td>Urgency of operation</td>
<td>Dichotomous (emergent vs elective)</td>
</tr>
<tr>
<td>Functional Status</td>
<td>Dichotomous (fully independent vs not at baseline)</td>
</tr>
<tr>
<td>Disposition</td>
<td>Dichotomous (alive or dead at departure from hospital)</td>
</tr>
<tr>
<td>Date of disposition</td>
<td>Day/month/year</td>
</tr>
</tbody>
</table>

Table 2: Demographics, Different Methodologies

<table>
<thead>
<tr>
<th># of patients</th>
<th>Prospective</th>
<th>Logbooks</th>
<th>Found Charts</th>
<th>p*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (mean)</td>
<td>655</td>
<td>649</td>
<td>404</td>
<td>0.388</td>
</tr>
<tr>
<td>less than 1</td>
<td>26.6</td>
<td>26.8</td>
<td>28.0</td>
<td></td>
</tr>
<tr>
<td>1-17</td>
<td>100 (15.3%)</td>
<td>96 (14.8%)</td>
<td>33 (8.2%)</td>
<td></td>
</tr>
<tr>
<td>18-64</td>
<td>480 (73.3%)</td>
<td>477 (73.5%)</td>
<td>347 (85.89%)</td>
<td></td>
</tr>
<tr>
<td>65 or older</td>
<td>33 (5.0%)</td>
<td>33 (5.1%)</td>
<td>15 (3.7%)</td>
<td></td>
</tr>
<tr>
<td>Female (%)</td>
<td>485 (74.1%)</td>
<td>471 (73.3%)</td>
<td>331 (82.0%)</td>
<td>0.003</td>
</tr>
<tr>
<td>ASA (median)</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>319 (53.5%)</td>
<td>302 (55.9%)</td>
<td>226 (61.4%)</td>
<td>0.055</td>
</tr>
<tr>
<td>II</td>
<td>193 (32.4%)</td>
<td>166 (30.7%)</td>
<td>102 (27.7%)</td>
<td>0.312</td>
</tr>
<tr>
<td>III</td>
<td>63 (10.6%)</td>
<td>58 (10.7%)</td>
<td>30 (8.2%)</td>
<td>0.381</td>
</tr>
<tr>
<td>IV</td>
<td>18 (3.0%)</td>
<td>10 (1.9%)</td>
<td>7 (1.9%)</td>
<td>0.352</td>
</tr>
<tr>
<td>V</td>
<td>3 (0.5%)</td>
<td>4 (0.7%)</td>
<td>3 (0.8%)</td>
<td>0.815</td>
</tr>
<tr>
<td>Emergent Procedures (%)</td>
<td>456 (70.2%)</td>
<td>428 (72.7%)</td>
<td>335 (84.4%)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

*p-values represent an analysis of variance between all categories.
### Table 3: Comparison of patient’s whose charts were missing vs those found

<table>
<thead>
<tr>
<th></th>
<th>Found Charts</th>
<th>Missing Charts</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong># pts</strong></td>
<td>404 (62.2%)</td>
<td>245 (37.8%)</td>
<td>0.02</td>
</tr>
<tr>
<td><strong>Age (mean)</strong></td>
<td>28.0</td>
<td>24.8</td>
<td></td>
</tr>
<tr>
<td>less than 1</td>
<td>9 (2.2%)</td>
<td>34 (13.9%)</td>
<td></td>
</tr>
<tr>
<td>1-17</td>
<td>33 (8.2%)</td>
<td>63 (25.7%)</td>
<td></td>
</tr>
<tr>
<td>18-64</td>
<td>347 (85.89%)</td>
<td>131 (53.5%)</td>
<td></td>
</tr>
<tr>
<td>65 or older</td>
<td>15 (3.7%)</td>
<td>17 (6.9%)</td>
<td></td>
</tr>
<tr>
<td><strong>% Female</strong></td>
<td>331 (81.9%)</td>
<td>143 (58.9%)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td><strong>ASA (median)</strong></td>
<td>1</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>226 (61.4%)</td>
<td>84 (42.0%)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>II</td>
<td>102 (27.7%)</td>
<td>78 (39.0%)</td>
<td>0.006</td>
</tr>
<tr>
<td>III</td>
<td>30 (8.2%)</td>
<td>32 (16.0%)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>IV</td>
<td>7 (1.9%)</td>
<td>5 (2.5%)</td>
<td>0.636</td>
</tr>
<tr>
<td>V</td>
<td>3 (0.8%)</td>
<td>1 (0.5%)</td>
<td>0.668</td>
</tr>
<tr>
<td><strong>Emergent Procedure (%)</strong></td>
<td>335 (84.4%)</td>
<td>106 (50.0%)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td><strong>POMR</strong></td>
<td>1.50%</td>
<td>3.70%</td>
<td>0.07</td>
</tr>
</tbody>
</table>

*representing difference between logbook and prospective data
†representing difference between found charts and prospective data

### Table 4: Post-Operative Mortality Rate

<table>
<thead>
<tr>
<th>Total Recorded Deaths</th>
<th>Prospective</th>
<th>Logbooks</th>
<th>Found Charts</th>
</tr>
</thead>
<tbody>
<tr>
<td>POMR</td>
<td>2.4%</td>
<td>2.3%</td>
<td>1.5%</td>
</tr>
<tr>
<td>Emergent Operation POMR</td>
<td>3.1%</td>
<td>2.6%</td>
<td>1.5%</td>
</tr>
<tr>
<td>Non-Cesarean Section POMR</td>
<td>4.6%</td>
<td>4.4%</td>
<td>4.5%</td>
</tr>
<tr>
<td>Emergent Non-C/S POMR</td>
<td>10.8%</td>
<td>12.4%</td>
<td>13.3%</td>
</tr>
<tr>
<td>Intra-Abdominal POMR</td>
<td>7.1%</td>
<td>7.0%</td>
<td>11.1%</td>
</tr>
<tr>
<td>less than 1</td>
<td>2.0%</td>
<td>1.0%</td>
<td>0.0%</td>
</tr>
<tr>
<td>18-64</td>
<td>1.5%</td>
<td>1.5%</td>
<td>1.2%</td>
</tr>
<tr>
<td>65 or older</td>
<td>12.1%</td>
<td>12.1%</td>
<td>6.7%</td>
</tr>
</tbody>
</table>

*representing difference between logbook and prospective data
†representing difference between found charts and prospective data
**Figure 1: Surgical Volume by Surgical Specialty**

Fig. 1 The distribution of broad surgical categories was identical between prospective and logbook extraction (p = 1.0), however found charts represented a statistically different surgical distribution (p < 0.001).
Figure 2: POMR per Surgical Specialty

Fig 2. 15 of the 16 prospectively observed deaths were recorded in ward logbooks. Only 6 deaths were found in charts. Differences in POMR did not reach statistical significance. Prospective represents actual measures of POMR for each specialty, Logbooks represents what the POMR would have been had logbooks been the primary mechanism of investigating death. Likewise, found charts represents what the calculated POMR would have been in each specialty relying on charts for recording deaths.
Figure 3: Step-by-Step method for collection and calculation of volume & POMR using logbooks

Logbook Data Collection

Surgical Volume
- Obtain all theater logs for the time period under study.
  - These should include all anesthesia and operative logs from surgical and obstetric theaters

Mortality
- Obtain all log books from wards where post-operative patients are cared for.
  - These will likely include, PACU, emergency room, ICU, surgical ward, maternity, gynecologic, pediatric and surgery wards

Volume
- For Single Institution:
  - Project Surgical Volume for 1 year based on the # of observed surgeries
- For Nationally Representative Sample:
  - Project Surgical Volume for 1 year based on the # of observed surgeries and make up of the health system

Annual Surgical Volume
- For Single Institution:
  - Projected # Surgeries in 1 yr / Population
- For Nationally Representative Sample:
  - Use National Population

Population
- Estimate Catchment Area if using, can be done using national census data or local estimate based on data availability

Post-Operative Mortality Rate
- Basic metric is mortality after surgery, therefore no adjustments are needed for patients receiving multiple surgeries

Record patient’s name, record number, operation, date of operation, and other variables of interest – Age, Sex, Diagnosis, ASA

Compare list of names from theater logs to ward log books.
- For each death, confirm date of death is within 30 days of surgery