Surgical volume and postoperative 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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Background. *The Lancet Commission on Global Surgery recommends that every country report its surgical volume and postoperative mortality rate. Little is known, however, about the numbers of operations performed and the associated postoperative mortality rate in low-income countries 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/y, compared to 4,000 operations/y reported in the only other published data. The postoperative mortality rate at this hospital is 2.4%, similar to other hospitals in low-income countries. 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 were 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 Lancet Commission on Global Surgery variables using logbooks that already exist in most hospitals in low-income countries. While some have suggested using risk-adjusted postoperative mortality rate as a more equitable variable, our data suggest that only a limited amount of risk adjustment is possible given the limited available data. (Surgery 2017;■:■-■.)*

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In APRIL 2015, the Lancet Commission on Global Surgery (LCoGS) published its findings. Included in its 56 pages were 2 major recommendations: one, that all countries develop a national surgical plan; and two, that all countries measure 6 indicators to describe the state of a country's surgical system. The 6 indicators are (1) the percent of the population with 2-hour access to a hospital that

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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) postoperative 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, 4 of the 6 LCoGS indicators were included in the World Bank's World Development Indicators.[2] The 2 that were not added were 2-hour access and postoperative mortality. Difficulty in collecting these 2 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[4] was able to find published reports on surgical volume from just 66 of the 194 WHO member states. 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 postoperative mortality rate (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 postoperative 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 5 sites for surgical postgraduate medical education in Uganda. The hospital has 4 operating theaters, 6 anesthesiologists, 12 obstetricians, and 11 surgeons, including surgical subspecialists.

Prospective data collection. A team of investigators spent 12 weeks (2, 2-week periods of new patient enrollment with 30-day follow-up after each period) in the operating theaters 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 postnatal obstetric and gynecologic wards. Special trips were also made daily to the private, medical, and pediatric wards to find any postoperative patients admitted to those services. All patients were then followed until death, discharge, reoperation, 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, postoperative mortality rate as well as variables that have been suggested to calculate a risk-adjusted POMR[13] (Table I). 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 theater logbooks were examined for the same 2, 2-week periods to collect data about all patients who had an operation during those time periods. Data elements potentially available from logbooks included: name, age, sex, date of operation, postoperative 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 intensive care unit and all wards were examined. The emergency ward also serves as the postanesthesia care unit, so that logbook was examined.

Table I. Variables collected for surgical volume and POMR

Variable	*Format*
Age	Continuous (nearest y)
Sex	Dichotomous (M versus F)
Preoperative diagnosis	Recorded then categorized
Postoperative diagnosis	Recorded then categorized
Operation	Recorded then categorized
Operative date	Day/mo/y
ASA class	Ordinal (1–5)
Urgency of operation	Dichotomous (emergency versus elective)
Functional status	Dichotomous (fully independent versus not at baseline)
Disposition	Dichotomous (alive or dead at departure from hospital)
Date of disposition	Day/mo/y

To examine another means of retrospective collection, a list of names of patients that had an operation during the same 2, 2-week periods was obtained from the operating theater 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 2 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 I.

Study population. All patients who had an operation at MRRH during 2, 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 theater for an operation but did not have one (eg, mothers who went for cesarean section but delivered in theater 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 prospectively and found 649 operations in logbooks and 404 charts from operative patients. 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 the Mbarara district only) and the maximum population (population of the 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. All statistical procedures were performed using Stata software (version 14; StataCorp, College Station, TX).

Ethical approval. Ethical approval for this study was obtained 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 operative care at MRRH were women (74%) with a mean age of 26.6 years. Although 70.2% of the procedures were considered emergency, 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 II). The distribution of age among the categories, however, was statistically different between prospective data and that found in charts ($P < .001$). The percent of women undergoing operative care and those undergoing emergency procedures were statistically different between prospective data and that found in charts, with more women (82.0% vs 74.1%, $P = .006$) and more emergency procedures

Table II. Demographics, different methodologies

	Prospective	*Logbooks*	*Found charts*	P *value**
# of patients	655	649	404	
Age (mean)	26.6	26.8	28.0	.388
less than 1	42 (6.4%)	43 (6.6%)	9 (2.2%)	
1–17	100 (15.3%)	96 (14.8%)	33 (8.2%)	
18–64	480 (73.3%)	477 (73.5%)	347 (85.89%)	
65 or older	33 (5.0%)	33 (5.1%)	15 (3.7%)	
Women (%)	485 (74.1)	471 (73.3)	331 (82.0)	.003
ASA (median)	1	1	1	
I	319 (53.5%)	302 (55.9%)	226 (61.4%)	.055
II	193 (32.4%)	166 (30.7%)	102 (27.7%)	.312
III	63 (10.6%)	58 (10.7%)	30 (8.2%)	.381
IV	18 (3.0%)	10 (1.9%)	7 (1.9%)	.352
V	3 (0.5%)	4 (0.7%)	3 (0.8%)	.815
Emergency procedures (%)	456 (70.2)	428 (72.7)	335 (84.4)	<.001

**P* values represent an analysis of variance between all categories.

Table III. Comparison of patient's whose charts were missing versus those found

	Found charts	*Missing charts*	P *value*
# of patients	404 (62.2%)	245 (37.8%)	
Age (mean)	28.0	24.8	.02
less than 1	9 (2.2%)	34 (13.9%)	
1–17	33 (8.2%)	63 (25.7%)	
18–64	347 (85.89%)	131 (53.5%)	
65 or older	15 (3.7%)	17 (6.9%)	
% Women	331 (81.9)	143 (58.9)	<.001
ASA (median)	1	2	<.001
I	226 (61.4%)	84 (42.0%)	<.001
II	102 (27.7%)	78 (39.0%)	.006
III	30 (8.2%)	32 (16.0%)	<.001
IV	7 (1.9%)	5 (2.5%)	.636
V	3 (0.8%)	1 (0.5%)	.668
Emergency procedure (%)	335 (84.4)	106 (50.0)	<.001
POMR	1.50%	3.70%	.07

(84.4% vs 70.2%, $P < .001$) 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 III). Only 62.2% of the requested charts were obtainable from the medical records department despite a 2-week daily search. Patients with missing charts were significantly younger (mean age 28 vs 24.8, $P = .02$) and more likely to be male (18.1% vs 42.1%). The age distribution was also significantly different ($P < .001$). Median ASA was slightly higher in the patients with missing charts, and patients with missing charts 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 ($P < .001$).

Surgical volume. During the 4 weeks of operating room observation, 655 operations were recorded. This annualizes to 8,515 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 operation, representing 47% of all operations. The OBGYN department contributed 61.3% of all operations, while 24.4% were either general or pediatric operative procedures. The remaining 14.7% of operations were subspecialty in nature.

The operating room logbooks provided a very accurate measure of surgical volume, capturing 99% of the prospective collected operations. The distribution of types of operations was also nearly

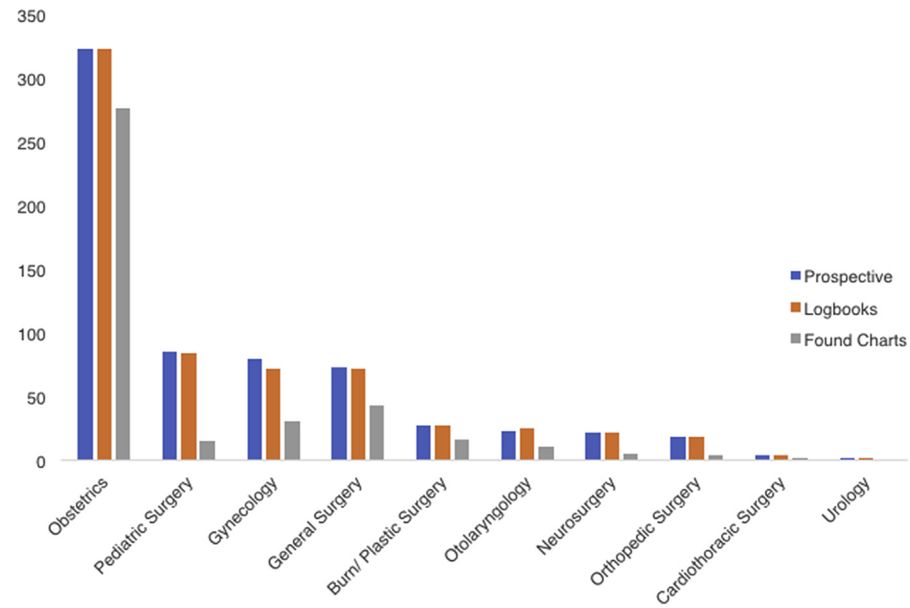

Fig 1. Surgical volume by surgical specialty. The distribution of broad surgical categories was identical between prospective and logbook extraction ($P = 1.0$); however, found charts represented a statistically different surgical distribution ($P < .001$). (Color version of this figure is available online.)

Table IV. Postoperative mortality rate

	Prospective	*Logbooks*	P *value**	*Found charts*	P *value*†
Total recorded deaths	16	15		6	
POMR	2.4%	2.3%	.88	1.5%	.29
Emergency operation POMR	3.1%	2.6%	.65	1.5%	.15
Noncesarean section POMR	4.6%	4.4%	.96	4.5%	.89
Emergency non-cesarean section Intra-abdominal POMR	10.8%	12.4%	.76	13.3%	.68
POMR by age category					
less than 1	7.1%	7.0%	.98	11.1%	.69
1–17	2.0%	1.0%	.58	0.0%	.50
18–64	1.5%	1.5%	.99	1.2%	.71
65 or older	12.1%	12.1%	1.0	6.7%	.57

*Representing the difference between logbook and prospective data.
†Representing the difference between found charts and prospective data.
C/S, XXX.

identical (Fig 1). In contrast, the charts found disproportionately represented obstetric operations (68.3% vs 49.2%, $P < .001$) and underrepresented charts from pediatric patients (3.7% vs 13.0%, $P < .001$).

Postoperative mortality rate. There were 16 deaths after the 655 observed operations, resulting in an overall postoperative mortality rate of 2.4% (Table IV). As expected, POMR varied widely by department. There were no postoperative deaths in patients undergoing cesarean section (Fig 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 ($P = .07$) and 12.1% in patients 65 and older ($P = .004$).

Ward logbooks recorded 15 of the 16 deaths observed prospectively. POMR as determined by retrospective logbook 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 IV).

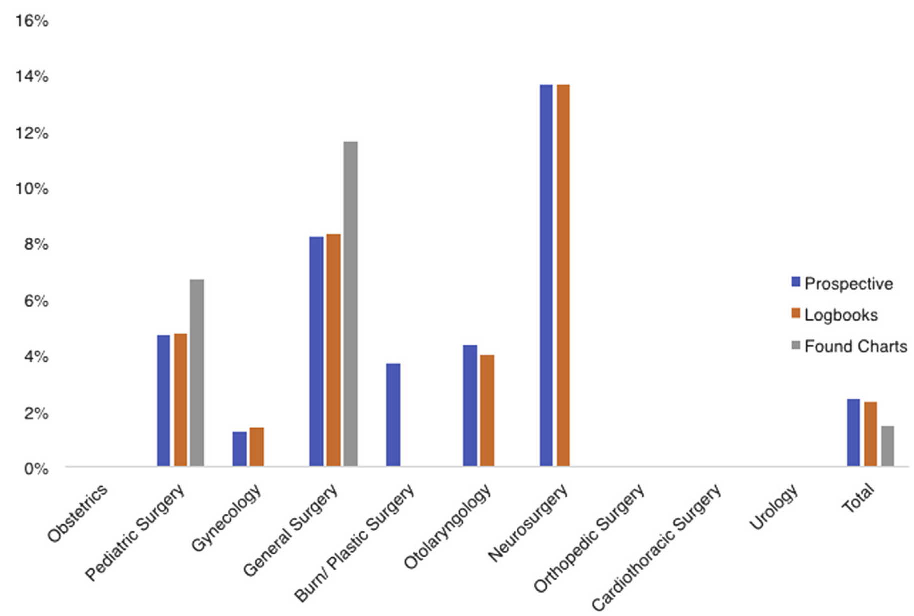

Fig 2. POMR per surgical specialty. Fifteen of the 16 prospectively observed deaths were recorded in ward logbooks. Only 6 deaths were found in charts. Differences in POMR did not reach statistical significance. Prospective represents actual measures of POMR for each specialty, logbooks represent what the POMR would have been had logbooks been the primary mechanism of investigating death. Likewise, found charts represent what the calculated POMR would have been in each specialty relying on charts for recording deaths. (Color version of this figure is available online.)

DISCUSSION

Surgical volume at this regional hospital in Uganda is 8,515 operations per year, significantly higher than the 4,000 operations/y 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, makes 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 2 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 were significantly different from the found charts.

For example, charts were more likely to be missing for younger patients, men, and elective cases and less likely for patients in ASA category 1. 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 do not 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.

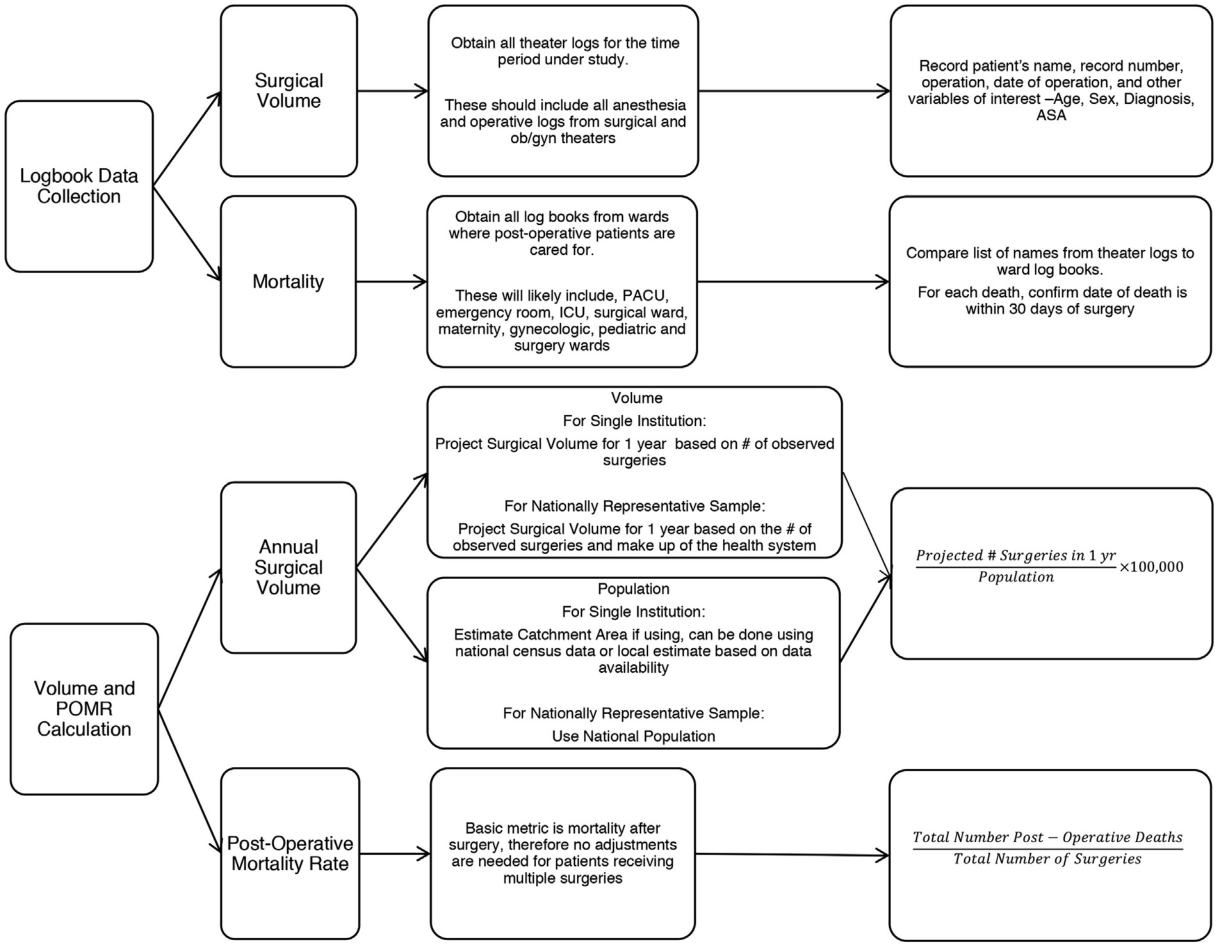

Fig 3. Step-by-step method for collection and calculation of volume and POMR using logbooks.

Given 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 Fig 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-resource settings, it would be difficult to create a multi-institution database capable of creating a nationally representative sample in a low-resource 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 logbook across hospitals would suffice for the collection of the Lancet Commission indicators and would even allow for basic risk stratification.

Data on surgical volume from low-income countries (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 operation, or in surgical camps, or limit their analyses to the most frequent procedures.

In Uganda, 5 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 to 225 operations/100,000 population.[17,19] One paper reported a total of 3,950 nondental 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, because MRRH is one of the busiest and best-staffed referral hospitals in the country. The other regional referral hospital represented has just 3 general surgeons; Mbarara has 9 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 operative care in many LMICs 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 postoperative 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 operations performed at a district hospital in Uganda, with a postoperative mortality rate of 0.6% for all operations (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 postoperative 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 postoperative mortality rate of 2.03% after major operations.[14] These examples show the wide range of POMR, depending on 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 published by the GlobalSurg group reporting POMR over a 2-week period in over 350 locations from 58 countries around the world.[26] This paper represents a tremendous amount of work from over 1,000 investigators. 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 LICs 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, because other variables cannot be accurately collected. These variables include age, sex, 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[13] researched the simplest models that still provided discriminatory power. They suggest the use of a 4-variable model with ASA, wound classification, functional status prior to operation, and age to risk adjust.[13] Unfortunately, only 2 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. Similar difficulty with medical records in LICs, however, 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. It may, however, underestimate the true amount of surgical care. An additional limitation of these results is that we only performed 3 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 of 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 theaters and surgical wards of LICs. In many LICs, these logbooks are provided by a 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 suggest 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, sex, 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 2 of the 6 Lancet Commission indicators. When collected in coordination with the other 4 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.

In 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 theaters 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 suggest that only a limited amount of risk adjustment is possible given the limited resources in hospitals such as MRRH.

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