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Assessing the cost of laparotomy at a rural district hospital in Rwanda using time-driven activity-based costing

J. Ruhumuriza[1], J. Odhiambo[4], R. Riviello[2,5,6,7], Y. Lin[5,9], T. Nkurunziza[1], M. Shrime[5,8], R. Maine[10], J. M. Omondi[1,3], C. Mpirimbanyi[2], J. de la Paix Sebakarane[3], P. Hagugimana[3], C. Rusangwa[1] and B. Hedt-Gauthier[1,5]

[1]Partners In Health/Inshuti Mu Buzima and [2]College of Medicine and Health Sciences, University of Rwanda, Kigali, and [3]Ministry of Health, Butaro District Hospital, Burera, Rwanda, [4]Partners In Health, [5]Department of Global Health and Social Medicine and [6]Program in Global Surgery and Social Change, Harvard Medical School, [7]Center for Surgery and Public Health, Brigham and Women's Hospital, and [8]Office of Surgery and Health, Massachusetts Eye and Ear Infirmary, Boston, Massachusetts, [9]Department of Surgery, University of Colorado, Denver, Colorado, and [10]Department of Surgery, University of Washington, Seattle, Washington, USA

Correspondence to: Mr J. Ruhumuriza, PO Box 3432, KG 9 AV 46, Nyarutarama, Kigali, Rwanda (e-mail: john.ruhumuriza@gmail.com)

Background: **In low- and middle-income countries, the majority of patients lack access to surgical care due to limited personnel and infrastructure. The Lancet Commission on Global Surgery recommended laparotomy for district hospitals. However, little is known about the cost of laparotomy and associated clinical care in these settings.**

Methods: **This costing study included patients with acute abdominal conditions at three rural district hospitals in 2015 in Rwanda, and used a time-driven activity-based costing methodology. Capacity cost rates were calculated for personnel, location and hospital indirect costs, and multiplied by time estimates to obtain allocated costs. Costs of medications and supplies were based on purchase prices.**

Results: **Of 51 patients with an acute abdominal condition, 19 (37 per cent) had a laparotomy; full costing data were available for 17 of these patients, who were included in the costing analysis. The total cost of an entire care cycle for laparotomy was US$1023·40, which included intraoperative costs of US$427·15 (41·7 per cent) and preoperative and postoperative costs of US$596·25 (58·3 per cent). The cost of medicines was US$358·78 (35·1 per cent), supplies US$342·15 (33·4 per cent), personnel US$150·39 (14·7 per cent), location US$89·20 (8·7 per cent) and hospital indirect cost US$82·88 (8·1 per cent).**

Conclusion: **The intraoperative cost of laparotomy was similar to previous estimates, but any plan to scale-up laparotomy capacity at district hospitals should consider the sizeable preoperative and postoperative costs. Although lack of personnel and limited infrastructure are commonly cited surgical barriers at district hospitals, personnel and location costs were among the lowest cost contributors; similar location-related expenses at tertiary hospitals might be higher than at district hospitals, providing further support for decentralization of these services.**

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Introduction

Surgical care in low- and middle-income countries (LMICs) has suffered from insufficient prioritization, especially in rural settings[1–4]. Low-income countries struggle with an insufficient surgical workforce; the surgical specialist workforce density is 0·7 per 100 000 population[5], far below the recommendation[1] of 20 per 100 000 population. In addition, surgical facilities and equipment are often inadequate[6]. The combination of lack of trained personnel and equipment has resulted in a lack of safe and affordable access to surgical care for 90 per cent of patients who need it, contributing to high rates of surgical morbidity and mortality in LMICs[1].

It is now recognized that surgical care has a central role in the management of many medical conditions[1], but little is known about the cost of providing surgical care in LMICs.

Because of a history of patients with conditions that need surgical intervention being referred to higher-level hospitals and the perception that higher-level hospitals should provide surgery, surgical care is often viewed as expensive compared with the medical management of other diseases[2,3,7]. However, a systematic review[3] of the cost-effectiveness of surgical care showed that most essential surgical interventions, such as general surgery, caesarean sections and orthopaedic surgery, are cost-effective in LMICs.

The Lancet Commission on Global Surgery recommended that caesarean section, laparotomy and open fracture treatment, collectively referred to as the ‘bellwether procedures’, be available to patients at district hospitals[1]. The bellwether procedures are important to provide timely access to these procedures at district hospitals, but their availability also correlates with a facility’s ability to perform a broad array of other essential surgical services[1]. However, in sub-Saharan Africa few district hospitals provide laparotomy[8], and even fewer estimate its costs[9]. In Rwanda, the majority (82·5 per cent) of surgical interventions are performed at district hospitals, and over half of these interventions are caesarean sections[10]. Patients needing a laparotomy or open fracture treatment, however, are commonly referred to tertiary hospitals[11].

Over the past several years, Rwanda has been intensively training surgical specialists via the Rwanda Human Resources for Health Program[12]. In addition, the Rwandan Ministry of Health is decentralizing the provision of essential surgical care by establishing provincial hospitals as newly appointed rural referral hospitals[13]. As the pipeline of trained surgical providers expands to these rural hospitals where surgical infrastructure already exists, the next two procedures to be included in the surgical package are laparotomy and open fracture treatment. Knowing the cost of these procedures at rural African district hospitals is essential for planning for availability of laparotomy and determining the reimbursement package for treatment. The aim of this study was to examine the cost of laparotomy for patients with acute abdominal conditions at a rural district hospital in Rwanda.

Methods

Study setting

This study was conducted at three rural district hospitals (Butaro, Kirehe and Rwinkwavu) in the northern and eastern provinces of Rwanda. The three district hospitals are managed by the Rwandan Ministry of Health and receive additional clinical and operational support from Partners In Health, a Boston-based non-governmental organization. Rwanda has a decentralized healthcare system, which includes health centres, district hospitals, provincial hospitals and tertiary referral hospitals. Health centres provide basic services, whereas district hospitals provide minor and some major surgical services, primarily caesarean sections. Some hospitals might have clinicians who can provide laparotomy, but most patients who require a laparotomy are referred to a higher level of care. All three hospitals had clinicians on staff performing some surgical procedures, but only Butaro District Hospital had a surgeon on staff during the study period.

Study design and data collection

This costing study included patients treated for an acute abdominal condition at the three district hospitals between 1 January and 31 December 2015. Total costs were estimated using time-driven activity-based costing (TDABC)[14,15], including details of patients who underwent laparotomy, which was conducted only at Butaro District Hospital. With TDABC, the entire care cycle is broken down into its different activities and components from patient admission to discharge. Each activity or component is assigned a cost per minute or a purchase cost from which a total cost is derived, based on duration or consumption respectively.

Extensive chart review at all three hospitals identified patients with non-traumatic, non-obstetric emergency surgical conditions. From these, patients presenting with an acute abdominal condition were identified and data were collected on specific diagnoses, whether or not they received surgery at the district hospital, the type of surgery received and patient outcome. For patients who underwent laparotomy, patient charts, interviews of medical staff, observation and hospital records were used to obtain costing data. From patient charts, information about the type and frequency of laboratory tests done, imaging performed, medications given including dosages and duration of intake, supplies used, and duration of surgery and hospital stay were obtained.

A structured questionnaire was used to interview the head of surgery to develop a process map. The process map documented each patient activity, location of the activity, the type of personnel involved, and time estimates for personnel involved. In addition, all consenting personnel involved were interviewed to confirm time estimates for each activity, the probability of their involvement with each activity, and annual clinical availability.

Using observation and logistics records, data were collected on type and quantity of different equipment available

Table 1 Summary of costing categories and data sources

Cost category	Variable	Data sources
Personnel	Staff type and salary, activity involved in and duration of involvement	Human resources records Interview of medical staff
Location		
Equipment	All minor and major equipment in spaces used in service delivery	Equipment questionnaire filled through observation and logistics records Prices from logistics records
Fuel, electricity and water	Total cost of fuel, electricity and water per year	Expenditure report
Space	Area of spaces used in service delivery; construction cost per square metre, useful life-years	Space questionnaire filled through observation Interview of medical staff Prices from logistics records
Medicine	Antibiotics, anaesthesia and analgesia, fluids, relaxants, vasoconstrictors, resuscitation medicines, opiate analgesics, benzodiazepines (includes unit dose, daily frequency of intake, duration and mode of intake)	Patient charts Interview of medical staff Prices from local pharmacy
Supplies	Sutures, oxygen, catheters (intravenous, urinary), injection water, gloves (sterile and non-sterile), masks, urine bag, tubes (nasogastric, endotracheal, aspiration), scalpel, syringe and needle, disinfectants (includes number used)	Patient charts Interview of medical staff Prices from local pharmacy
Hospital indirect costs	Cleaning supplies, office supplies, building renovation costs, operational costs, telecommunication, internet, repairs and maintenance and administration costs Total outpatients and hospital beds in 2015	Hospital expenditure report for 2015

in each location where activities occurred, and the area of each space was measured. From human resources records, data on staff salaries and annual clinical availability were accessed. The annual financial expenditure report, hospital purchase records for equipment as well as purchase price list for medicines and supplies were obtained.

Costing analysis

The following cost categories were included in the study and are summarized in *Table 1*: personnel, location (which included equipment, fuel, electricity, water and space), medicines, supplies and hospital indirect costs. All costs were stratified into three intervention phases: preoperative, intraoperative and postoperative.

Personnel

To obtain allocated costs for personnel, capacity cost rates (CCRs) were calculated, defined as the cost per minute for personnel equal to the position salary divided by the total minutes of clinical availability in 1 year. The CCR was then multiplied by the probability-weighted time – the estimated time allocated to a specific activity multiplied by the probability that it was that specific type of personnel that completed the activity. Percentage total cost for each type of personnel was calculated to identify personnel cost drivers.

Location: equipment, fuel, electricity, water and space

The CCR for a location was calculated with the assumption that each component of the location was available for 24 h a day, 365 days a year, as laparotomy was provided for inpatients and could occur at any time, and accounting for location bed capacity. For equipment and space, purchase price and cost of construction per square metre were used respectively, accounting for the yearly depreciation rate to obtain CCRs. In-kind equipment was assigned a cost based on purchase records at the hospital. For laboratory equipment in which tests were batched, batching was accounted for by dividing total time by batch volume. Flat fuel, electricity and water costs were assigned for each room based on its area (square metres), with the assumption that all rooms used generator *versus* grid electricity and water equally, except for the laboratory. Given equipment inventory and energy needs, it was assumed that the laboratory consumed 25 per cent of total hospital energy and the remaining 75 per cent was distributed equally to non-laboratory facilities. To obtain total cost, the CCR was multiplied by patient time in each location as well as patient activity time in locations, such as the laboratory, where the patient may not be present physically.

Medicines and supplies

Only medicines and supplies consumed by at least 10 per cent of the patients were included in cost calculations. If a medicine or supply was consumed by at least 10 per

Table 2 Management and outcome of patients with acute abdominal conditions

	Kirehe (*n* = 12)	Rwinkwavu (*n* = 9)	Butaro (*n* = 30)	Total (*n* = 51)
Acute abdominal condition				
Obstruction	9 (75)	2 (22)	12 (40)	23 (45)
Cholecystitis	0 (0)	1 (11)	0 (0)	1 (2.0)
Perforation	0 (0)	1 (11)	5 (17)	6 (12)
Sigmoid volvulus	0 (0)	1 (11)	9 (30)	10 (20)
Peritonitis	3 (25)	1 (11)	2 (7)	6 (12)
Appendicitis	0 (0)	3 (33)	2 (7)	5 (10)
Surgery and outcome				
Received surgery at DH	1 (8)	0 (0)	19 (63)	20 (39)
Laparotomy*	0 (0)	0 (0)	19 (100)	19 (95)
Surgery type unknown	1 (100)	0 (0)	0 (0)	1 (5)
Did not receive surgery at DH	11 (92)	9 (100)	11 (37)	31 (61)
Transferred to tertiary hospital	6 (55)	6 (67)	9 (82)	21 (68)
Discharged to home	5 (45)	0 (0)	0 (0)	5 (16)
Died	0 (0)	0 (0)	2 (18)	2 (6)
Unknown	0 (0)	3 (33)	0 (0)	3 (10)

Values in parentheses are percentages. *Seventeen of the 19 patients had full costing data and were included in cost estimates. DH, district hospital.

cent, the unit cost for the medicine or supply based on the purchase price was obtained. The allocated cost was the product of the unit cost of a medicine or supply multiplied by the expected number of units consumed per patient (the probability that a patient received the medicine or supply × the total number of units dispensed for patients who received the medicine or supply). For medicines, the phase of use (preoperative, intraoperative or postoperative) was indicated in data collection. For supplies, materials that were used throughout hospital stay were weighted by the duration of each operative phase.

Hospital indirect costs

For the unit hospital indirect costs per day, where it was assumed that the outpatient cost per day was the same as that for an inpatient, the indirect cost per day was the total indirect cost divided by the sum of total hospital bed-days (number of inpatient beds × 365 hospital bed-days) and the number of outpatients seen in 2015. Indirect costs per minute were then estimated. The allocated cost was the product of the unit cost and total time.

Total cost of laparotomy per patient

For the total cost of laparotomy, the total costs of personnel, location, medicines, supplies and hospital indirect costs in each phase were summed. The cost of laparotomy was the total intraoperative cost. The total cost of providing care was the sum of preoperative, intraoperative and postoperative costs.

Summary of assumptions

The primary costing adhered to the assumptions detailed in *Table S1* (supporting information). In summary, the median values of observed laparotomy cases were used for length of hospital stay, duration from admission to surgery start, and duration of surgery. It was assumed that the laboratory consumed 25 per cent of total hospital energy, based on projections from the hospital maintenance team accounting for equipment inventory and laboratory volume. The remaining 75 per cent of energy was distributed based on space area for the rest of the hospital. The hospital indirect cost per min was the same for outpatients and inpatients. Medications, supplies and laboratory tests used by at least 10 per cent of the patients were included, assuming that use in less than 10 per cent represented rare cases and did not reflect a typical cost.

Sensitivity analysis

Sensitivity analysis was conducted, looking at a plausible range for particular assumptions to obtain lower and upper bounds for the total cost of laparotomy per patient. The modified assumptions included hospital duration of stay, duration from admission to start of surgery, duration of surgery, energy use and hospital indirect costs. In the sensitivity analyses, the assumptions for lower-bound estimates included 25th percentile data for duration of hospital stay and duration of surgery, and 75th percentile data for admission to surgery start. Energy use distribution was 15 per cent for laboratory and 85 per cent for non-laboratory spaces, and hospital indirect cost per min was the same for outpatients and inpatients. For upper-bound estimates, assumptions included 75th percentile data for duration of hospital stay and duration of surgery, and 25th percentile data for duration from admission to surgery start. Energy use distribution was 35 per cent for laboratory

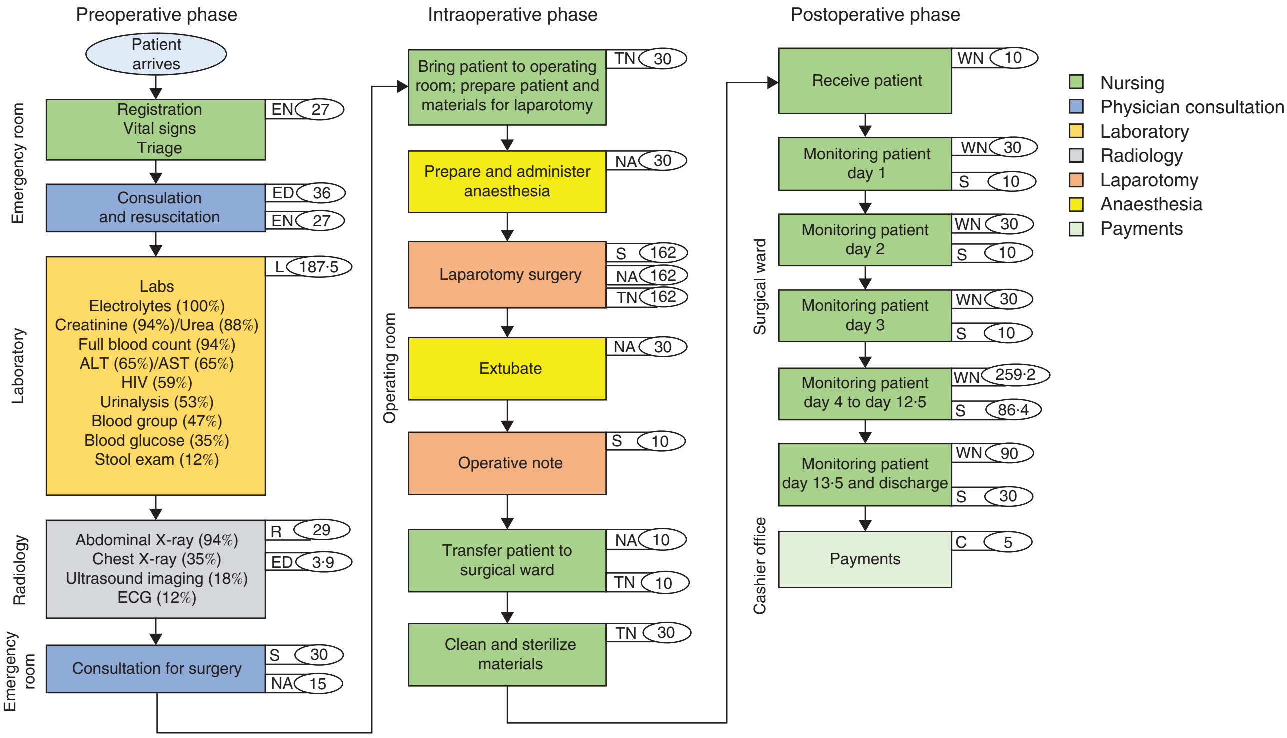

Fig. 1 Process map for patients with acute abdominal conditions who received laparotomy. Large boxes show activities, arrows show the direction of events, small boxes show the type of personnel involved in the activity, and small ovals show probability-weighted personnel time in minutes for every activity. ALT, alanine aminotransferase; AST, aspartate aminotransferase; HIV, human immunodeficiency virus; EN, emergency nurse; ED, emergency doctor; L, laboratory technician; R, radiologist; S, surgeon; NA, nurse anaesthetist; TN, theatre nurse; WN, ward nurse; C, cashier

and 65 per cent for non-laboratory spaces, and the total hospital indirect cost per inpatient was twice that per outpatient.

Ethics

A confidential file that linked patient identifiers to a unique study identifier was kept. The confidential file was accessible to approved study staff and destroyed after data validation. The study received scientific approval from Partners In Health/Rwanda Research Committee and the National Health Research Committee in Rwanda. The Rwanda National Ethics Committee (IRB 00001497) and Harvard Medical School Institutional Review Board (IRB 15-3818) provided ethical review and approval. Approval was also received from the Ministry of Health and health facility leadership for data collection.

Results

From 1 January to 31 December 2015, 51 patients with an acute abdominal condition presented to the three hospitals. Nineteen patients underwent laparotomy, all at Butaro District Hospital, and 17 with files available were included in the costing analysis. One further patient had surgery, but the type of operation was not recorded. Of the 31 patients who did not undergo surgery at a district hospital, 21 were transferred to tertiary hospitals, five were discharged home, two died, and for three no outcome was recorded (*Table 2*). For patients who had a laparotomy, the median time from admission to start of surgery was 17·9 (i.q.r. 9·6–33·4) h, median duration of surgery was 162 (3·0–210·0) min and median length of hospital stay was 13·5 (9·0–17·0) days.

In the preoperative phase, laboratory technicians spent the most time on patient activities, with an estimated 187·5 min for a mean of seven laboratory tests per patient (*Fig. 1* and *Table 3*). In the intraoperative phase, the nurse anaesthetist and theatre nurse both provided care for 232 min and the surgeon spent 172 min providing patient care. In the postoperative phase, the ward nurse and surgeon were the main care providers, spending 449·3 and 146·4 min respectively. Overall, the ward nurse

Table 3 Capacity cost rates and total costs in US dollars for personnel supporting laparotomy at a rural district hospital in Rwanda

		Preoperative phase		Intraoperative phase		Postoperative phase		Total	
	CCR ($)	Time (min)†	Allocated cost ($)	Time (min)†	Allocated cost ($)	Time (min)†	Allocated cost ($)	Time (min)†	Allocated cost ($)*
Surgeon	0·255	30·00	7·65	172·00	43·85	146·42	37·32	348·42	88·82 (59·1)
Emergency doctor‡	0·080	39·92	3·19	0	0·00	0	0·00	39·92	3·19 (2·1)
Emergency nurse‡	0·049	54·00	2·63	0	0·00	0	0·00	54·00	2·63 (1·7)
Theatre nurse	0·049	0	0·00	232·00	11·31	0	0·00	232·00	11·31 (7·5)
Nurse anaesthetist	0·044	15·00	0·66	232·00	10·25	0	0·00	247·00	10·91 (7·3)
Ward nurse	0·049	0	0·00	0	0·00	449·25	21·91	449·25	21·91 (14·6)
Laboratory technician	0·054	187·52	10·05	0	0·00	0	0·00	187·52	10·05 (6·7)
Radiology technician	0·048	29·00	1·38	0	0·00	0	0·00	29·00	1·38 (0·9)
Cashier	0·036	0	0·00	0	0·00	5·00	0·18	5·00	0·18 (0·1)
Total			25·56		65·41		59·41		150·38

*Values in parentheses are percentages. †Probability weighted time: total time allocated to a specific activity weighted by the probability that personnel type completed the activity. ‡The emergency nurse performed activities 90 per cent of the time with the other 10 per cent performed by emergency doctor. Their time involvement was weighted by these probabilities. All other staff performed their activities 100 per cent of the time. CCR, capacity cost rate (cost of personnel on a specific activity per min).

Table 4 Total cost and cost drivers of laparotomy by operative stage, including lower and upper bound estimates at a rural district hospital in Rwanda

	Allocated cost (US$)					
	Preoperative costs	Intraoperative costs	Postoperative costs	Total primary costs	Lower-bound estimates*	Upper-bound estimates†
Personnel	25·56 (11·5)	65·41 (15·3)	59·42 (15·9)	150·39 (14·7)	105·93 (11·4)	182·38 (16·4)
Location‡	29·38 (13·2)	11·21 (2·6)	48·61 (13·0)	89·20 (8·7)	72·76 (7·9)	103·80 (9·4)
Medicines	160·21 (71·9)	121·24 (28·4)	77·33 (20·7)	358·78 (35·1)	358·79 (38·8)	358·79 (32·4)
Supplies	3·02 (1·4)	228·00 (53·4)	111·13 (29·8)	342·15 (33·4)	332·66 (35·9)	345·19 (31·1)
Hospital indirect costs§	4·58 (2·1)	1·29 (0·3)	77·01 (20·6)	82·88 (8·1)	55·25 (6·0)	118·58 (10·7)
Total	222·75	427·15	373·50	1023·40	925·39	1108·74

Values in parentheses are percentages. *Assumptions include: duration of hospital stay of 9 days; duration from admission to surgery start of 33·4 h and duration of surgery of 93 min; energy use distribution was 15 per cent for laboratory and 85 per cent for non-laboratory spaces. †Assumptions include: duration of hospital stay of 17 days, duration from admission to surgery start of 9·6 h and duration of surgery of 210 min; energy use distribution was 35 per cent for laboratory and 65 per cent for non-laboratory spaces. ‡Includes cost of equipment, fuel, electricity, water and space. §The total hospital indirect cost per inpatient was twice that per outpatient.

(449·3 min) and surgeon (348·4 min) spent the most time providing care.

The most expensive type of personnel was the surgeon, with a CCR of US$0·255, followed by the emergency doctor with a CCR of US$0·080 (*Table 3*). The personnel cost was US$25·56 (17·0 per cent) for the preoperative phase, US$65·41 (43·5 per cent) for the intraoperative phase and US$59·41 (39·5 per cent) for the postoperative phase. The total personnel cost of US$150·38 was driven largely by the cost of the surgeon (US$88·82, 59·1 per cent of the total), followed by that of a ward nurse (US$21·91, 14·6 per cent).

The total cost of a laparotomy per patient was US$1023·40 (*Table 4*). The cost of medicines (US$358·78, 35·1 per cent) followed by the cost of supplies (US$342·15, 33·4 per cent) were the largest cost contributors. Personnel costs accounted for 14·7 per cent (US$150·39) of the overall costs, and the lowest contributors to overall cost were location (US$89·20, 8·7 per cent) and hospital indirect costs (US$82·88, 8·1 per cent). The intraoperative cost of laparotomy was US$427·15 (41·7 per cent), whereas the total preoperative and postoperative cost was US$596·25 (58·3 per cent). Supplies drove the intraoperative (US$228·00, 53·4 per cent) and postoperative (US$111·13, 29·8 per cent) costs, whereas medicines (US$160·21, 71·9 per cent) drove the preoperative costs.

In the sensitivity analysis, the total cost of a laparotomy ranged from US$925·39 to US$1108·74 (*Table 4*). For the lower-bound estimate, the highest cost contributors were medicines at 38·8 per cent (US$358·79) followed by supplies at 35·9 per cent (US$332·66). For upper-bound estimates the highest cost contributors remained the same, with medicines leading at 32·4 per cent (US$358·79) followed by supplies at 31·1 per cent (US$345·19). Duration of hospital stay produced the largest change in total cost, with a cost reduction of US$65·76 in lower-bound estimates and a cost increase of US$50·18 in upper-bound estimates (details of incremental contributions in sensitivity analysis are shown in *Table S2*, supporting information).

Discussion

Less than half of patients presenting to rural district hospitals in Rwanda with an acute abdominal condition needing laparotomy received surgery locally, in part due to a lack of surgical personnel. These laparotomies were performed only at Butaro District Hospital, where there was a general surgeon on staff.

Limited surgical specialists are often cited as a barrier to accessing surgical care at district hospitals[11,16–19]. Although the cost of the surgeon's time contributed about 60 per cent of the total personnel costs, the overall cost of personnel was still lower than that of medicines or supplies. Personnel cost was the third lowest cost contributor overall and the third lowest for the intraoperative costs. Although this is markedly lower than other estimates of personnel-related costs relative to overall inpatient surgical costs[19], in this context the cost of the surgeon may not be the limiting factor as much as the deficit of available surgeons. Rwanda has only 0·15 general surgeons per 100 000 population[10], compared with six per 100 000 population in developed nations[20]. The country has invested in a Human Resources for Health Program to increase the number of surgical specialists[21], and the impact of this training programme should be assessed in the future. More effort is needed in sub-Saharan Africa to train and deploy surgeons to rural settings.

The intraoperative costs of laparotomy in the present study (US$427·15) are comparable to a modelling estimate in Ethiopia of US$393·81[9]. However, an additional US$596·25 was needed to provide the preoperative and postoperative hospital care associated with having a laparotomy. The results of this study bring into question whether surgical services are charging or planning for scale-up at a rate commensurate with the total cost of providing care. Decision-makers who set fee schedules for clinical services should consider these findings. In doing so, hospitals that provide these services will set more appropriate charges for the care they provide and will in turn be able to deliver more surgical care. Future studies should report on the costs of the entire cycle of care-giving, as this is necessary for budgeting and planning to scale-up laparotomy at district hospitals where the surgical infrastructure already exists.

Although the total costs in this study are higher than previous estimates that focused only on the intraoperative surgical delivery, the alternative, namely transferring patients to tertiary hospitals to receive care, is also costly. Given similar inpatient services, the cost per bed-day at tertiary hospitals is estimated to be two to five times higher than the equivalent at a district hospital[22]. In addition, the cost of patient transfers to tertiary hospitals can impoverish families[22] or lead to delays in reaching care[23] that can jeopardize patient outcomes. Although more expensive than anticipated, providing laparotomy at the district hospital is still likely to be the least costly option.

Limitations of this study include relying on certain assumptions for the calculation of costs, although these were minimized and, where possible, based on local data or interviews. Recall bias at interview was reduced by performing follow-up interviews with other staff members and by prioritizing chart data where available. The study included only patients who were admitted to the district hospitals, and therefore patients with an acute abdominal condition who never presented to care and those transferred to tertiary hospitals without admission at the district hospital were not captured. It is plausible that if laparotomy were to become more available at these facilities, the number of patients presenting for care would increase. In addition, the cost data covered only patient admission to discharge; thus information on prehospital costs as well as the cost of follow-up after laparotomy should be assessed in the future. A measure of cost-effectiveness is needed to inform planning further. As the district hospitals in this study were supported by a non-governmental organization and laparotomy costing data were available from only one hospital, generalizability to other district hospitals in Rwanda or in the region may be limited. However, surgical care practice for other procedures is similar between this district hospital and others in Rwanda. In addition, the unit costs for personnel, medicines and supplies used here are the same as those in other district hospitals in Rwanda, because the management of all of these is under the Ministry of Health.

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Supporting information

Additional supporting information can be found online in the supporting information tab for this article.

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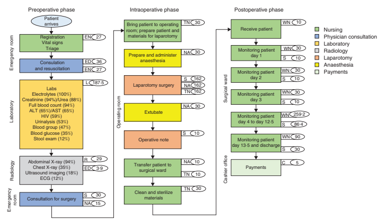

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The Lancet Commission on Global Surgery recommended that all district hospitals should be able to perform laparotomy, but little is known about the cost of performing laparotomy at a district hospital in sub-Saharan Africa. A time-driven activity-based costing method was used to estimate the overall hospital cost of laparotomy in rural Rwanda at US$1023, driven largely by the cost of medicines (US$358·79, 35·1%) and supplies (US$342·15 (33·4%). These findings advocate for decentralization of laparotomy because infrastructure (US$89·20, 8·7%) and personal costs (US$150·39, 14·7%) were not the barriers as previously hypothesized, and similar resources cost more at tertiary hospitals.