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ORIGINAL SCIENTIFIC REPORT

General Thoracic Surgery in Rwanda: An Assessment of Surgical Volume and of Workforce and Material Resource Deficits

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Abstract

Background Benchmarking operative volume and resources is necessary to understand current efforts addressing thoracic surgical need. Our objective was to examine the impact on thoracic surgery volume and patient access in Rwanda following a comprehensive capacity building program, the Human Resources for Health (HRH) Program, and thoracic simulation training.

Methods A retrospective cohort study was conducted of operating room registries between 2011 and 2016 at three Rwandan referral centers: University Teaching Hospital of Kigali, University Teaching Hospital of Butare, and King Faisal Hospital. A facility-based needs assessment of essential surgical and thoracic resources was performed concurrently using modified World Health Organization forms. Baseline patient characteristics at each site were compared using a Pearson Chi-squared test or Kruskal–Wallis test. Comparisons of operative volume were performed using paired parametric statistical methods.

Results Of 14,130 observed general surgery procedures, 248 (1.76%) major thoracic cases were identified. The most common indications were infection (45.9%), anatomic abnormalities (34.4%), masses (13.7%), and trauma (6%). The proportion of thoracic cases did not increase during the HRH program (2.07 vs 1.78%, respectively, $p = 0.22$) or following thoracic simulation training (1.95 2013 vs 1.44% 2015; $p = 0.15$). Both university hospitals suffer from inadequate thoracic surgery supplies and essential anesthetic equipment. The private hospital performed the highest percentage of major thoracic procedures consistent with greater workforce and thoracic-specific material resources (0.89% CHUK, 0.67% CHUB, and 5.42% KFH; $p < 0.01$).

Conclusions and relevance Lack of specialist providers and material resources limits thoracic surgical volume in Rwanda despite current interventions. A targeted approach addressing barriers described is necessary for sustainable progress in thoracic surgical care.

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Introduction

The global burden of surgical disease has received increasing attention since the call to action by Paul Farmer and Jim Kim, who described surgery as the "neglected step-child of global health" [1]. The Lancet Commission on Global Surgery estimates that five billion people do not have access to basic and safe surgical care [2] and recommends a minimum of 5000 cases per 100,000 persons annually, focused on a tiered system of prioritized procedures [3, 4]. Capacity building efforts have seen a worldwide increase in surgical procedures performed annually, from 234.2 million in 2004 to 312.9 million in 2012 [5, 6]. Current efforts, based on disease epidemiology, place priority on essential obstetric and emergency surgery [6, 7]. Despite recommendations from both the World Health Organization and the Lancet Commission on Global Surgery that thoracic surgical care be available at tertiary centers, surgical services requiring more specialized training and intensive perioperative management have received little attention [2, 8].

Over the last 6 years, Rwanda implemented a multi-level approach to strengthen its healthcare system [8] and also recognized the concomitant need to expand its surgical capacity. It has benefited from national leadership support with international programs such as the Human Resources for Health (HRH) Program and academic partnerships [9, 10]. These efforts have resulted in the expansion of the Rwandan surgical residency program, recruitment of foreign specialists, creation of a simulation center, and stimulation of research [10–13]. Within this context, visiting thoracic surgical faculty providing clinical support has also delivered dedicated thoracic simulation workshops created to improve local capacity to perform basic thoracic procedures.

We believe characterizing Rwanda's national thoracic operative volume is crucial to understanding how current efforts are addressing patients' needs. Our objective was to evaluate the impact of simulation and capacity building efforts on patient access to thoracic surgery, as indicated by surgical volumes. In conjunction, we conducted a needs assessment of tertiary hospitals performing thoracic procedures to identify ongoing challenges to scaling up thoracic surgery provision.

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Methods and materials

Three referral hospitals were visited between May and July 2016: University Teaching Hospital of Kigali (CHUK), University Teaching Hospital of Butare (CHUB), and King Faisal Hospital (KFH). IRB approval was obtained from the University of Virginia (#2016-0105-00), CHUK (#EC/CHUK/0101/2016), CHUB (Ref#:CHUB/DG/SA/6/845/2016), and KFH Ethics-Research Committee. CHUK, a 650-bed hospital with six operating rooms, is the main public referral hospital in Kigali and serves as the principle training facility for Rwandan surgical residents. CHUB is a 365-bed public hospital with four operating rooms and functions as a regional referral center and key resident rotation site. KFH, a 200-bed private hospital in Kigali with six operating rooms, is the Rwanda site for the College of Surgeons of East, Central, and Southern Africa (COSECSA) surgical residents. These sites represent three of the four main referral hospitals in Rwanda and the only sites performing thoracic surgical procedures.

Operative volume calculation

Surgical procedures listed in operating room registries were reviewed. Information abstracted included patient demographics, operative team, diagnoses, and procedures performed. We excluded non-general surgery cases: neurosurgery, cardiac, otolaryngology, urology, orthopedics, and obstetrics/gynecology. Thoracic cases were defined as procedures involving the esophagus, mediastinum, pleural space, chest wall, and lung parenchyma. Tube thoracostomy was considered a minor thoracic procedure; otherwise, surgery requiring access to the chest via anterior or posterolateral thoracotomy was considered a major thoracic case. No sternotomies or video-assisted thoracoscopic surgeries were recorded in this series. Procedures involving resection of soft tissue only and not requiring entrance into the thoracic cavity were also not included. Postoperative diagnoses were classified as: inflammatory/infectious, tumor/mass, trauma, or anatomic/functional processes. Anatomic location was categorized into: lung/pleural space, esophagus, mediastinum, diaphragm via a transthoracic approach, cardiac via a thoracic approach, or other. Cases for which the operative region of the chest was not recorded were excluded.

Needs assessment

We conducted a comprehensive needs assessment of each facility, comprised of the minimum requirements for essential emergency surgical care and modified to include anesthetic care at a tertiary referral facility and

considerations specific to thoracic surgery. Facility infrastructure was captured using the World Health Organization (WHO) form for Needs Assessment and Evaluation for Resource Limited Health Care Facility [14]. An additional 137-item checklist was constructed from the following resources: WHO training manual "Surgical Care at the District Hospital," WHO Emergency Relief Items: Compendium of Basic Specifications, WHO/UNFPA Essential Drugs and other Commodities for Reproductive Health Services, WHO Essential Trauma Care Guidelines, and the WHO Guide to Anesthetic Infrastructure and Supplies at Various Levels of Health Care Facilities [15–18]. Thoracic surgery and anesthesiology experts were consulted for checklist refinement and addition of dedicated thoracic equipment items. (Electronic Supplement Material).

At each facility, staff interviews and on-site inspections were conducted with the operating theater manager, general surgery resident, and/or surgical faculty. Maintenance personnel, hospital administrator, and anesthesiology technicians were interviewed as needed. The field team directly visualized essential equipment, surgical trays, protocol manuals, and staffing schedules.

Responses from the needs assessments were grouped into seven categories: surgical capital outlays, surgical disposable items, anesthesiology capital outlays, anesthesiology disposable items, anesthetic drugs, thoracic-specific items, and communal equipment. Absolute availability was defined as the presence (or absence) of the item. Relative availability considers the quantity of the item into three groups: partial availability, requiring sharing between operating rooms or providers; sufficient supply for all operating room needs; and robust supply of materials necessitating additional on-site storage. Inadequate supply was defined as less than 60% relative availability of items within a category while adequate supply was 60–75% relative availability, and robust supply greater than 75% relative availability.

Statistical analysis

Descriptive and analytic statistics were used to compare patient characteristics, operative details, and year-to-year differences. Pearson Chi-square was used to test for association, or Fisher's exact test based on number of observations. When used as a continuous variable, age was compared to referral sites using the Kruskal–Wallis test due to non-normal distribution. Statistical analyses were performed in Stata (v15, StataCorp LLC, Texas, USA).

Results

A total of 14,130 general surgery procedures were performed between January 2011 and July 2016. Of these, 460 (3.26%) were thoracic procedures and 248 (1.76%) were considered major thoracic cases after eliminating tube thoracostomy (212 procedures, 1.50%) for uncomplicated pneumothorax, or evacuation of hemothorax or pyothorax. The distribution of major thoracic cases was significantly different between referral hospitals: 78 (31.4%) at CHUK, 17 (6.9%) at CHUB, and 153 (61.7%) at KFH ($p < 0.001$). Relative to general surgical procedures performed at each site, KFH had the highest proportion of major thoracic procedures, 153/2821 (5.4%), while CHUK and CHUB were similar, 78/8770 (0.89%) and 17/2539 (0.67%), respectively; $p < 0.0001$. The proportion of major thoracic cases to all thoracic cases also differed by site (CHUK 32.6%, CHUB 47.2%, KFH 82.7%; $p < 0.0001$). Despite performing the majority of general surgery procedures, only 31.4% of major thoracic cases were completed at CHUK. Meanwhile, KFH accounted for 20% of general surgery volume but performed 61.7% of the major thoracic cases (Table 1).

Major thoracic cases increased from 29 cases in 2011 to an average of 48 cases following the HRH program. There was no difference in the proportion of major thoracic cases relative to other general surgery cases during the study period, $p = 0.22$ (Fig. 1). Regarding simulation training, there was no significant difference in thoracic cases performed in the year before and the year after training (53 vs 43, $p = 0.15$).

Table 1 summarizes the demographic characteristics and operative details of patients undergoing major thoracic surgery in Rwanda by site. Average patient age was 29.8 years. 102/247 (41.3%) were female, and of the 148 patients with known insurance status, 91 (61.5%) had private insurance, versus Mutuelle de Santé (MS), a community-based public health insurance. Patients with MS health insurance more often obtained care at CHUK (92.7% MS vs 7.3% private), while those with private insurance more frequently attended KFH (17.8% MS vs 82.2% private, $p < 0.0001$).

Thoracic procedures were most commonly performed for inflammatory or infectious indications (45.9%), followed by anatomic or functional abnormalities (34.4%), tumor excision or mass biopsies (13.7%), and trauma (6%). The indication for thoracic surgery did not vary significantly by site ($p = 0.213$). Most thoracotomies performed were for lung parenchyma and pleural space disease (62.6%), followed by esophagus (16.4%), cardiac by thoracic approach (11.3%), mediastinum (3%), diaphragm (2.5%), and other (4.2%). The university hospitals

Table 1 Overall, and by hospital, patient and operative characteristics of thoracic surgery in Rwanda

	All Sites	CHUK	CHUB	KFH	*P* value[b]
Total, no. (%)	14,130	8770 (62)	2539 (18)	2821 (20)	–
All thoracic, no. (%)	460	239 (52)	36 (7.8)	185 (40.2)	–
Major thoracic, no. (%)	248	78 (31.4)	17 (6.9)	153 (61.7)	–
Major thoracic compared to all procedures (%)	1.76	0.89	0.67	5.42	< 0.0001
Major thoracic compared to all thoracic (%)	53.9	32.6	47.2	82.7	< 0.0001
Average age (range)[a]	29.6 (0–84)	27.3 (0–75)	48.2 (22–78)	28.7 (0–84)	0.0009
< 1 years old, no. (%)	18 (7.3)	6 (7.7)	–	12 (7.8)	0.729
1–18 years old, no. (%)	55 (22.2)	20 (25.6)	–	35 (22.9)	0.040
> 18 years old, no. (%)	175 (70.5)	52 (66.7)	17 (100)	106 (69.3)	0.009
Sex[a]					0.184
Female, no. (%)	102 (41.3)	26 (33.3)	6 (37.5)	70 (45.8)	
Male, no. (%)	145 (58.7)	52 (66.7)	10 (62.5)	83 (54.2)	
Insurance info (missing %)[a]	148 (40.3)	41 (47.4)	–	107 (30)	< 0.0001
Mutuelle de Sante, no. (%)	57 (38.5)	38 (92.7)	–	19 (17.8)	
Other insurance, no. (%)	91 (61.5)	3 (7.3)	–	88 (82.2)	
Postoperative diagnosis (missing %)[a]	218 (12.1)	74 (5.1)	16 (5.9)	128 (16.3)	0.213
Inflammatory/infectious, no. (%)	100 (45.9)	34 (45.9)	8 (50)	58 (45.3)	0.939
Tumor/mass, no. (%)	30 (13.7)	9 (12.2)	–	21 (16.4)	0.196
Trauma, no. (%)	13 (6)	7 (9.5)	2 (12.5)	4 (3.1)	0.061
Anatomic/functional, no. (%)	75 (34.4)	24 (32.4)	6 (37.5)	45 (35.2)	0.893
Anatomic location (missing %)[a]	238 (4)	75 (3.8)	17 (0)	146 (4.6)	0.016
Lung/pleural space, no. (%)	149 (62.6)	48 (64)	9 (52.9)	92 (63)	0.678
Esophagus, no. (%)	39 (16.4)	17 (22.7)	5 (29.4)	17 (11.6)	0.029
Mediastinum, no. (%)	7 (3)	4 (5.3)	1 (5.9)	2 (1.4)	0.169
Diaphragm, no. (%)	6 (2.5)	2 (2.7)	–	4 (2.7)	1.000
Cardiac (thoracic approach), no. (%)	27 (11.3)	4 (5.3)	2 (11.8)	21 (14.4)	0.105
Other, no. (%)	10 (4.2)	–	–	10 (6.9)	0.037
Foreign faculty presence (missing %)[a]					0.001
Yes, no. (%)	208 (83.9)	56 (71.8)	13 (76.5)	139 (90.9)	
No, no. (%)	40 (16.1)	22 (28.2)	4 (23.5)	14 (9.1)	

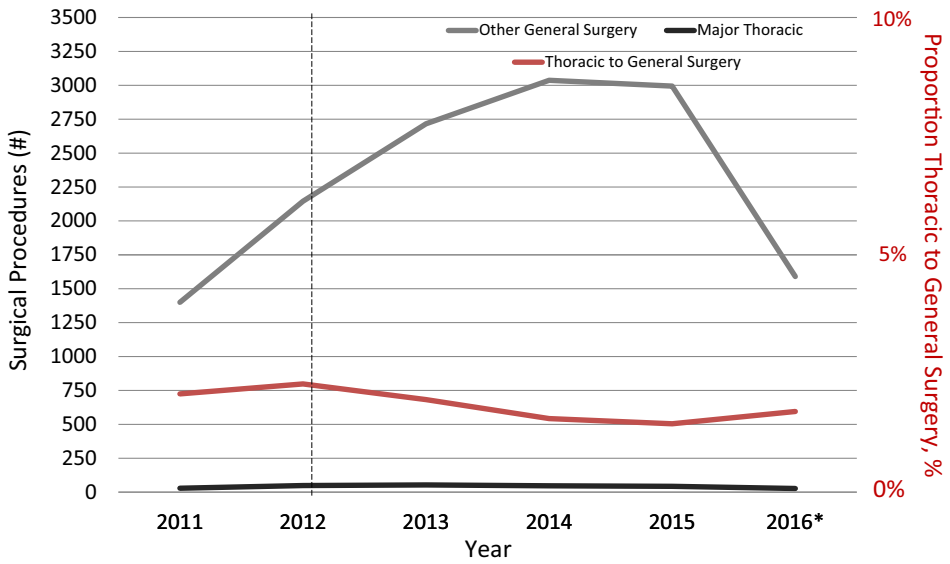
Statistical comparison is between hospital sites and does not include average of sites. CHUK: University Teaching Hospital of Kigali, major public referral hospital. CHUB: University Teaching Hospital of Butare, regional public referral hospital. *KFH* King Faisal Hospital, tertiary private referral hospital

[a]Calculated including only major thoracic cases

[b]*P* value refers to an association between the dependent variables and choice of referral site

performed proportionately more esophageal cases (22.7% CHUK and 29.4% CHUB vs 11.6% KFH, $p = 0.029$). Most major thoracic cases were performed alongside a foreign faculty member (83.9%), with variation between hospitals (71.8% CHUK, 76.5% CHUB, and 90.9% KFH; $p = 0.001$).

Inadequate supplies were found in three of seven categories at CHUB and four of seven at CHUK. In contrast, KFH had an adequate or robust supply of all equipment categories. We found an adequate or robust supply of surgical capital outlays and disposable items for essential surgery at all referral centers. Despite the presence of necessary items for anesthesia capacity, the relative availability of these items was inadequate at the university hospitals. The supply of thoracic-specific surgical and anesthetic equipment was also inadequate at the university hospitals (Fig. 2). Specifically, there were no reliable presence of bronchial blockers or double-lumen endotracheal tubes, operative room availability of bronchoscopy, long instruments, rib cutters, water seal drainage systems, and Y tube connectors for chest tubes. Thoracostomy tubes measuring 28 French or greater were not present at any referral center at the time of data collection.



Major Thoracic	29	49	53	47	43	27	
General	1400	2145	2716	3037	2994	1590	
Proportion (%)	*2.07*	*2.28*	*1.95*	*1.55*	*1.44*	*1.70*	*P=0.22*

* Data abstraction was completed on June 31, 2016. 2016 numbers are reflective of the first half of the year.

Fig. 1 Number of general surgery cases compared to major thoracic procedures per year, 2011–2016. Dashed line indicates initiation of the Rwanda HRH program

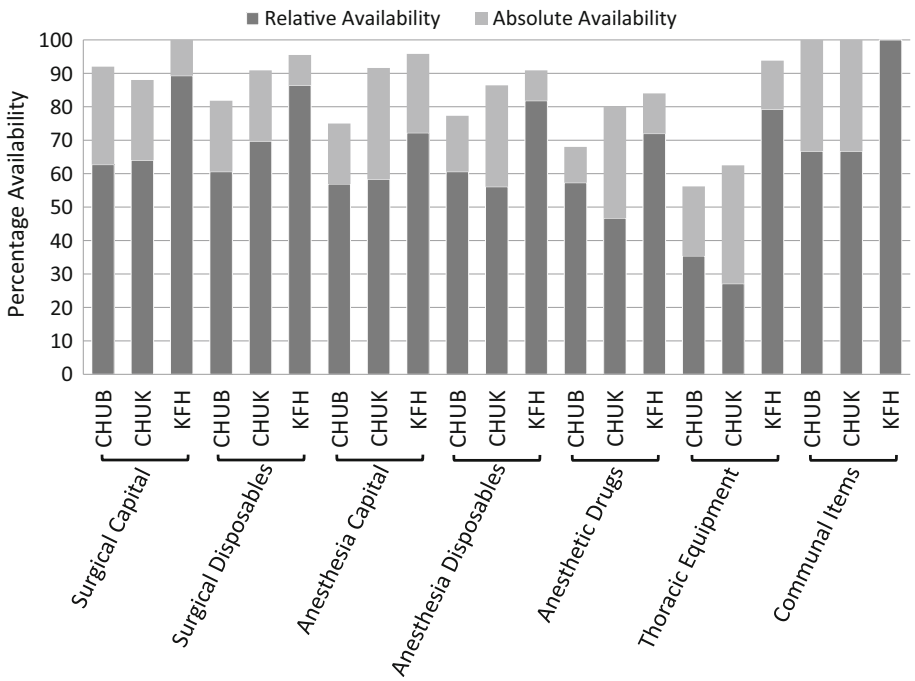


Fig. 2 Absolute and relative availability by needs assessment categories. The private hospital, KFH, has better supply in all categories on a relative and absolute basis in comparison with the university hospitals, CHUB and CHUK. KFH: King Faisal Hospital. CHUK: University Teaching Hospital of Kigali, major public referral hospital. CHUB: University Teaching Hospital of Butare, regional public referral hospital. KFH: King Faisal Hospital, tertiary private referral hospital

Between the three sites, there are a total of 17 adult ICU beds (four CHUB, seven CHUK, and six KFH). Review of the personnel roster noted two anesthesiologists at CHUB, one at CHUB, and 3.5 at KFH. As part of the HRH program, investment in the anesthesia program has occurred concurrently. Presently, the program includes 27 anesthesiology residents, which rotates at each included site and provides an additional level of ICU monitoring.

Discussion

This study represents the first attempt to describe general thoracic operative volumes in Rwanda, and to perform a targeted needs assessment in this area. While little is known about thoracic surgical conditions in Rwanda, or Africa more generally, a 2011 nationwide household survey [19] estimated that thoracic conditions comprise 11% (6% chest/breast, 5% back) of the country's unmet surgical need. This reflects findings in Sierra Leone of 7.5% chest/breast and 7.4% back pathology, using comparable methodology [20]. While the overly inclusive definitions employed preclude accurate estimates of thoracic disease and may be inflated, they are in clear excess of the current thoracic operative volume, which comprises only 1.76% of general surgical procedures. Findings from a study of 25 African countries, excluding Rwanda, confirm a similar rate of thoracic cases (1.3% of 11,422 operations), possibly indicating a continent-wide systemic issue [21].

The WHO recognizes that there are services that cannot be provided at the district-level hospital. However, it does recommend that referral hospitals ensure the provision of certain complex procedures, including thoracic surgery [22]. Our findings show a lack of training and experience in general thoracic procedures and a lack of resources in specific thoracic surgical equipment, even at the tertiary level. These results add to the complexity of our understanding for provision of specialized surgical conditions, as Petroze et al. [23] found that delay to surgical care at the Rwandan district hospital level was associated with a lack of training, rather than a lack of resources. Despite an influx of foreign-trained faculty, implementation of focused workshops, and doubling of the annual general surgery volume, the proportion of major thoracic cases has not changed in the past 5 years. Furthermore, while KFH was materially best equipped to provide thoracic surgical care and performs more thoracic operations than the other sites, the university hospitals serve the indigent population and provide the majority of surgical care overall.

Beyond material supplies, barriers to improved provision of thoracic surgery in Rwanda may include consistent on-site specialized providers. During this study period, we found that nearly all major thoracic surgery is performed in the presence of a visiting foreign faculty with formal trauma or thoracic training. As the HRH program funding cycle reaches completion and foreign faculty are present less frequently, we expect a decline in the provision of major thoracic surgery. Anticipating this, focused thoracic simulation workshops were implemented with the goal of equipping general surgeons to provide thoracic care at the completion of their training. However, we conclude that although educational initiatives can augment the operative training experience [24], they have not demonstrated adequacy in addressing the necessary substantial and sustained expansion of thoracic surgical care.

A survey of trainees following the workshops identified barriers to providing major thoracic surgery as: a lack of exposure to thoracic surgical training, absence of specialized faculty, and a lack of material resources specific for thoracic surgery [24]. We propose one means of addressing this multifaceted issue is a permanent Rwandan specialty-trained thoracic surgeon. Already this has been addressed within the anesthesia department. Investment from the Ministry of Health led to sponsored training of a cardiothoracic-specialized anesthetist, who is available full-time to facilitate these procedures and to augment training for anesthesia residents. Aside from the perioperative outcomes benefit to patients of having a dedicated thoracic surgeon [25], studies from similar developing contexts support the rationale and feasibility of this proposal. Tenwek Hospital in Western Kenya observed a dramatic and sustained increase in patient access to and volume of thoracic surgery following the addition of a cardiothoracic surgeon to their staff [26, 27]. Middle-income countries, such as India and South Africa, recognize the role of thoracic surgeons and relevant support systems as being central to respiratory care in these contexts, particularly as the incidence of lung cancer rises [28–30]. Burgeoning national cardiac surgery referral centers in Ghana and other LMICS have gained traction through a variety of means, all of them requiring an individual or group to carry the program until maturation [31–33].

Furthermore, we show that the epidemiology of thoracic surgical disease differs from that in high-income countries. Pulmonary malignancy is the most frequent indication for thoracic surgery in high-income settings [34], whereas thoracic procedures in Rwanda are primarily undertaken for infectious and inflammatory conditions. This difference in epidemiology is also reflected in data from South Africa [35]. Such conditions are of particular importance to be managed urgently, given the associated morbidity and mortality and the economic impact of infectious diseases (empyema, tuberculosis) that tend to affect younger individuals [28]. Based on our findings, we believe that the effort to improve thoracic surgical care in Rwanda would benefit from a local specialist who knows local disease patterns, is adequately equipped to address them, and can act as a champion for advancements in surgical training and infrastructure resourcing. Additionally, without a specialist thoracic surgeon to educate the next generation of surgical residents and medical students, limited knowledge of treatable operative thoracic conditions among health professionals may also be contributing to the persistently low number of procedures performed despite the HRH program interventions. This also has implications on

recognition of these conditions and referral of these conditions to appropriate providers.

Limitations

Preoperative diagnostic availability, ICU capacity, rehabilitation services, microbiology/pathology services, and other specialty follow-up care were not assessed separately. We acknowledge the importance of these elements in the decision-making process for operative intervention and evaluation of an adequate health-system infrastructure for performing thoracic surgery. Pre- and postoperative assessment such as spirometry, diffusion capacity, and advanced imaging remains challenging in much of Africa due to cost of personnel training and equipment [36]. Plain films and computed tomography are available on-site at each of the included hospitals while MRI is available only at KFH. Meanwhile, most pathology and microbiology can be performed in-house or sent to an outside facility for formal interpretation. Despite functioning ICUs with ventilator capacity and dedicated anesthesiology staff and trainees at each site, anecdotally capacity varied highly across institutions particularly with regard to availability of invasive monitoring and diagnostic testing.

Without prevalence data of thoracic conditions, we were unable to model the optimum volume of major thoracic cases or investment needed based on provider shortage and resources acquisition. However, our findings suggest a similarly large performance gap in thoracic operative volume when compared to other African countries [20, 21, 37, 38]. Finally, the aim of our study was limited to addressing operative volume, and separate consideration must be given to perioperative outcomes following thoracic surgery in this context.

In conclusion, benchmarking the current status of thoracic surgery and characterizing the barriers to care is the first step to constructing an investment case for expanding patient access to thoracic care in Rwanda. We found that the performance of major thoracic cases is critically low in Rwanda. The number of general surgery cases has more than doubled, yet the relative proportion of thoracic surgery has not changed. This reflects the impact of visiting faculty members and other educational interventions, but speaks to the unsustainability of this approach in thoracic surgical care. Few but important deficiencies remain in necessary equipment for thoracic procedures at the referral hospital level. To deliver the essential thoracic surgical care needed for the population, Rwanda, like many countries in similar states of healthcare development, will need to invest in dedicated thoracic surgical providers and trainers across multiple disciplines and in the equipment, consumables, and systems needed for this specialized service line to grow.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no competing interests.

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