



A needs assessment for simulation in African surgical education

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Received: 22 August 2023 / Accepted: 28 December 2023 / Published online: 7 February 2024
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Abstract

Introduction There is a critical need for comprehensive surgical training in African countries given the unmet surgical burden of disease in this region. Collaborative and progressive initiatives in global surgical education will have the greatest impact on trainees. Little is known about surgical education needs from the perspective of practicing surgeons and trainees in low-middle-income countries (LMICs). Even less is known about the potential role for simulation to augment training.

Methods A modified Delphi methodology with 2 rounds of responses was employed to survey program directors (PD) and associate program directors (APD) of Pan-African Association of Christian Surgeons (PAACS) general surgery residency programs across eight low-middle-income countries in Africa. 3 PD/APDs and 2 surgical residents participated in semi-structured interviews centered around the role of simulation in training. Descriptive analysis was performed to elicit key themes and illustrative examples.

Results The survey of program directors revealed that teaching residents the psychomotor skills need to perform intracorporeal suturing was both high priority and desired in multiple training sites. Other high priority skills were laparoscopic camera driving and medial visceral rotation. The interviews revealed a specific desire to perform laparoscopic surgery and a need for a simulation curriculum to familiarize staff and trainees with laparoscopic techniques. Several barriers to laparoscopic surgery exist, such as lack of staff familiarity with the equipment, lack of public buy in, and lack of generalizable and adaptable educational modules. Trainees saw utility in the use of simulation to optimize time in the operating room and sought opportunities to improve their laparoscopic skills.

Conclusion Faculty and surgical trainees in LMICs have interest in learning advanced surgical techniques, such as laparoscopy. Developing a simulation curriculum tailored to the trainees' local context has the potential to fill this need.

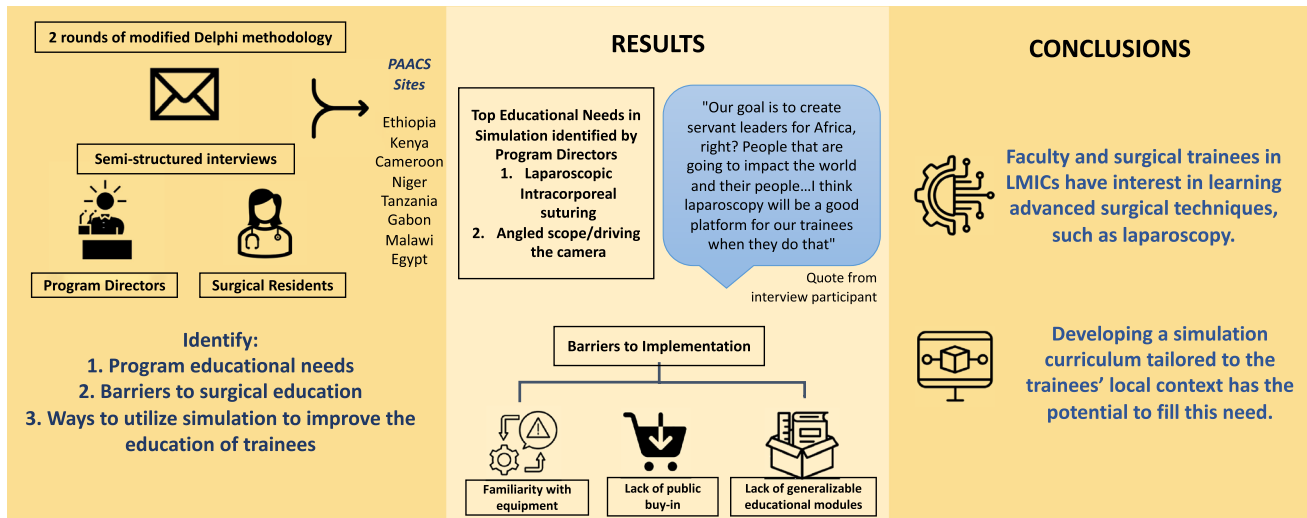
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Graphical abstract



LMIC = Lower and Middle Income Countries

@JoytotheOR
@PAACS_

Keywords Global surgery · Laparoscopic · Surgical education · Needs

It is estimated that over 90% of individuals in Sub-Saharan Africa lack access to safe and affordable surgical care [1]. The high and largely unmet surgical burden of disease in the region drives the critical need for comprehensive surgical training in African countries [2]. The Lancet Commission on Global Surgery previously highlighted the role of the workforce shortage in exacerbating this high burden [3]. Low and middle-income countries (LMICs) therefore have an urgent need to develop training programs that produce competent and highly skilled surgeons. This is especially true in low-resource environments where the surgeon to population ratio has been found to be exceptionally low [1].

Surgical training in low-resource settings has historically been focused on the need for cost-effective care with an emphasis on simplicity and the provision of quality care within the means of a limited healthcare infrastructure [2]. At the same time, advancements in technique, more nuanced understanding of surgical pathophysiology, and the widespread adoption of minimally invasive surgical techniques have transformed the landscape of surgical education in resource-rich settings. Despite perceived or existing infrastructural limitations, surgical trainees in low-resourced countries now require more advanced training to provide the standard of surgical care to their patients. Ensuring access to this standard of care promotes global surgical equity, an established goal of the Lancet and other international governing bodies of surgery [3]. One method of bringing this advanced training to surgical

residents with limited local resources is through surgical simulation.

Simulation has been a pivotal tool of surgical education for decades. Both wet lab techniques, animal models, and dry lab techniques, using box trainers and even household objects, have been described [4]. Simulation as a tool has become even more valuable as surgical training strives to be safer and more efficient in teaching learners the technical skills necessary for independent practice while providing optimal, high-value care for patients [5, 6]. Simulation allows trainees to practice nuanced technical maneuvers without threat of patient harm, to gain familiarity with new or advanced tools, and to practice troubleshooting surgical problems in real time [5]. In particular, box trainers, which have been used since the advent of laparoscopic surgery, are often portable and allow trainees to practice these specialized skills in the space and at the time of their choosing [7]. As it pertains to global surgery, simulation provides an opportunity to acquire technical skills in the absence of abundant, high-technology equipment [8]. It also allows for education through modules and pre-determined activities that do not require the physical presence of a surgical expert and can be performed in remote settings. The high potential impact of simulation on surgical education in the low-resource setting calls for expedited and intentional investment in this area.

It is critical that innovations in global surgical education be directed by the needs of practicing clinicians and trainees on the ground. There is a current paucity in the literature on

surgical education needs as it pertains to surgical simulation from the perspective of practicing surgical educators and trainees in LMICs. The goal of this study was to solicit the opinions of current program directors and surgical residents of African surgical training programs to identify the educational needs of their programs, the current barriers to surgical education that exist, and the ways in which simulation could be used to improve the education of trainees in this setting.

Methods

Survey data

A modified Delphi methodology with 2 rounds of responses was employed to survey program directors (PD) and associate program directors (APD) of the general surgery residency programs in the Pan-African Academy of Christian Surgeons (PAACS) across eight low-middle-income countries in Africa (Ethiopia, Kenya, Cameroon, Niger, Tanzania, Gabon, Malawi, and Egypt). In an open-ended email survey, APDs and PDs were initially asked to identify the psychomotor skills they felt would most benefit from surgical simulation in their respective programs. Initially submitted responses were then consolidated, categorized by specialty, and redistributed to the PDs to be ranked by priority. Descriptive analysis was then performed on the frequency of the skills listed by the faculty (round 1) and the priority assigned to them (round 2) using Microsoft Excel.

Interview data

PDs and APDs from this same cohort were asked to participate in semi-structured interviews. Of the 11 program directors, three volunteered to participate. Two surgical residents from these surgical residency programs were also identified by their program directors as key informants to participate in the interviews and offer their perspective on surgical training. All interview participants currently work as program directors or general surgical residents in one of the following countries: Ethiopia, Kenya, Cameroon, Niger, Tanzania, Gabon, Malawi, Egypt. To maintain anonymity among a small population of surgical clinicians, demographic information is limited to job title and year of training. The interview guide was developed by authors JO and GK with the goal of understanding the programs' educational strengths and needs as well as the utility of surgical simulation for their residents [Supplement 1]. This work is one part of a comprehensive needs assessment of surgical education in resource-poor settings; this study focuses solely on a subset of interview data that relates directly to the use of surgical simulation.

Interviews were performed by JO, a surgical trainee with expertise in the social sciences, between October 2021 and April 2022 over a secure video platform. JO had no pre-existing relationships with the interview subjects. The interview subjects gave their verbal consent for a 30–60-min interview with audio recording. The transcripts of these interviews were obtained via a third-party transcriptionist with review by JO for accuracy. Transcripts were manually coded by JO using description and essentialism as the primary analytical strategies [9, 10]. Emergent codes driven by participant responses were organized into themes that captured the thoughts and lived experiences of participants. Descriptive themes were discussed and finalized with input from the entire research team.

This research was granted exemption status by the University of Michigan Institutional Review Board (HUM00188880). This research is reported in accordance with the Standard for Reporting Qualitative Research (SRQR) [11].

Results

Survey data

When asked about the psychomotor skills that would most benefit from surgical simulation, 19 individual responses were received from 8 out of 11 programs in round 1 of the surveys. Round two of the surveys asked participants to rank the skills by priority. This round received responses from 8 of the 8 programs that responded to round 1. A variety of skills were identified by residency program leadership, including ultrasound skills for trauma, the use of staplers for bowel resections, visualization of ureters on cystoscopy, and others. The highest priorities were identified in laparoscopic skills, specifically the use of an angled laparoscope and advanced laparoscopic skills such as intracorporeal suturing (See Fig. 1). 6 of the 8 PDs specifically ranked intracorporeal suturing as a top simulation priority (Table 1).

Interview data

Analysis of interview transcripts revealed recurrent themes regarding the educational needs of the programs, such as (1) the desire to be able to perform laparoscopic surgery, (2) the need for high-quality simulation as a tool to teach laparoscopic skills, (3) the infrastructural and logistical obstacles to advanced surgical techniques, and (4) the lack of generalizability of current educational modules.

Educational Needs in Simulation Identified by Surgical Program Directors in Low-Middle Income Countries

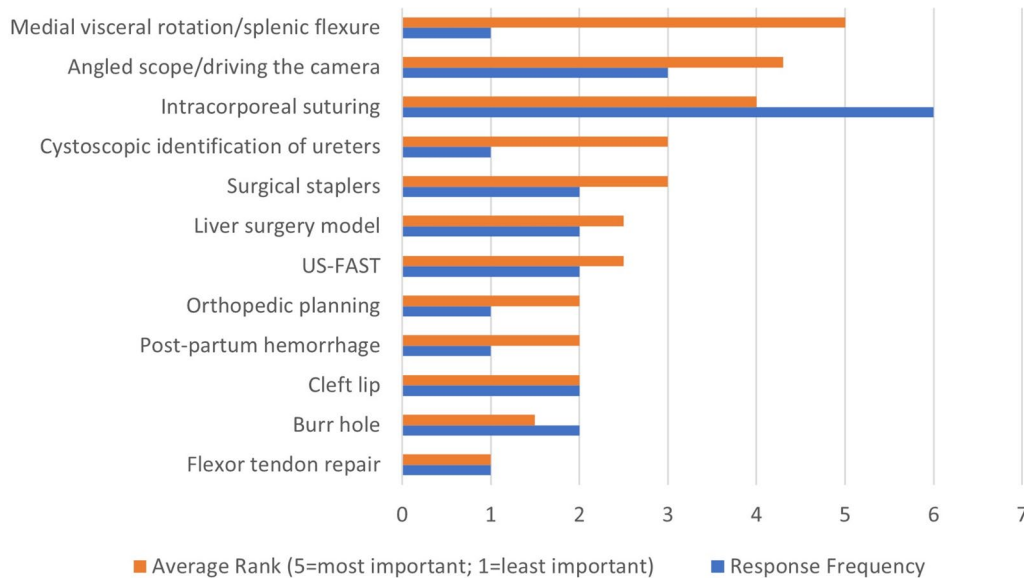


Fig. 1 Bar graph of psychomotor skill needs and priorities

Table 1 Demographic table of interview subjects

Interview subject	Role
Subject 1	Program Director
Subject 2	Surgical Resident (PGY1)
Subject 3	Assistant Program Director
Subject 4	Program Director
Subject 5	Program Director
Subject 6	Surgical Resident (PGY3)

Desired exposure to laparoscopic surgery

The residents interviewed expressed that exposure to laparoscopic surgery was a key factor in the selection of their training program (Table 2, Quote 1). Simulation was already found to be a key staple of the training in the residency programs affiliated with the interview subjects. However, most of these efforts appear to be focused on wet lab models, such as working with cow intestines or pig vasculature, as opposed to dry lab models (Table 2). In the same way that the principles of open surgery are carefully taught to trainees, respondents expressed a consistent desire for the means to teach the basic skills of camera driving, port placement, and tissue handling needed for laparoscopic surgery. The lack of transferability between open and laparoscopic skills is highlighted with the statement: “First you’re teaching how to use a scalpel, scissors, Bovie, and suturing... then you go

into the belly with a camera and instruments, and all of a sudden none of it makes sense anymore” (Subject 1). Both faculty and residents spoke of this desire to “get all of these residents up to speed” (Subject 1) as it pertains to laparoscopy when compared globally to other training programs (Table 2).

Simulation in laparoscopic surgery

With this desire established, the need for simulation as a specific means of obtaining these laparoscopic skills was expressed clearly by all interview subjects. In contrast to established wet lab simulation, respondents felt that there is currently very little opportunity for trainees to practice the skills needed for laparoscopy, such as camera driving and port insertion (Table 2, Sect. 2]. While some may have access to box trainers, this access is not consistent, does not come with a standardized curriculum, and is lacking in quality of the equipment. Faculty also felt that the increase in size of the residency programs created an environment in which simulation is key for trainees to develop specific technical skills independently and to maximize learning in the now limited time inside of the operating room (Table 2, Sect. 2, Quote 5). One resident describes the benefits of consistently working with laparoscopic simulation below:

Resident 2: “Well my first laparoscopy case, I had not had any training. My attending screamed the whole

Table 2 Illustrative quotes for surgical educational needs assessment in simulation*(1) Desire to Perform Laparoscopic Surgery*

“I was very excited about this program, and one of the reasons is because of the laparoscopic surgeries, and it’s probably one of the only hospitals in the country outside of the capital city that can do laparoscopic surgery, so I’m very excited to be here. And we have been doing laparoscopy simulation trainings and practices in a very small, very humble model, and we train, we do peg-transfers...but I don’t think that’s very adequate. I’m very excited that I’m enrolled in this surgery program which would lead to training using simulations. That’s going to help general surgeons in the future just like myself.” [Subject 2]

“There are certain things that we thought we would never see in Africa, and that’s just not coming to pass. We have ICUs, we have CT scanners, and now we’re doing laparoscopy, and so, at some point, they really need those skills as well. Depending on where they end up, they need to be able to continue that...they need to acquire those skills.” [Subject 3]

(2) Need for Surgical Simulation

“There is no real skills lab for them to work in and try to obtain their skills, and that’s one of the reasons why I was so interested in the simulation [question] because...especially in laparoscopy there are just certain things that time with the machine really helps.” [Subject 3]

“We need more laparoscopic simulation stuff, it’s trocar position decision-making, physiology of pneumoperitoneum and the complications that are associated with it, how do you get hemostasis in the belly. Your tricks and tips are going to be different than open surgery. The basics of driving a camera, a 30 degree and 0 degree. There’s a learning curve with that. We’re trying to get all these residents up to speed on being able to do it.” [Subject 1]

“It’s more the basic skills that I want them to get down through simulation. Camera following, port insertion, that sort of thing. I’m not so much keen on one operation itself, as them learning the skills and moving the instruments and finding the instruments even in the field of view. So they get the real basics down.” [Subject 3]

“We had a surgical skills day about 6 months ago...we had animal parts, intestines, so we did small bowel anastomosis and colon anastomosis, vascular anastomosis, suturing techniques using suture boards...But true simulation, besides using animal parts to practice anastomoses, the residents haven’t had much exposure to it. Like when I was a resident, we had an endoscopy simulator, so you can do a full colonoscopy, right? We don’t have that by any means.. Skills stations and places to practice your skills, we try to do that.” [Subject 1]

“When I did my residency, we didn’t have many residents. So I would not have seen a big role for simulation because I actually got to work a lot with patients. As the resident numbers have increased, then you find that there is a little more need for expertise aside from the direct interaction with patients. So it would give residents who are not being allowed to perform some procedures because maybe there is a senior resident and a consultant already [a chance to] perform them in a simulation lab. Then by the time they actually get to perform [in the OR], they would actually have some basic skills” [Subject 4]

(3) Infrastructural, Educational, and Logistical Barriers

“We have a tiny box of just a camera and some equipment, so you can practice peg transfer, cutting the circle...we’ve been practicing those things and sometimes having competitions. But I don’t feel like they’re adequate. We have a very small box. [...] It’s a very simplistic model and you can only do a few things in it. There is a camera clarity problem. We only have the Maryland forceps. It would be very good if we could practice laparoscopy, even holding the camera for the first time could be very confusing and being able to find that sense of position. [Subject 2]

“We have problems with even the knowledge level the population is at, you know. I recently heard that some people are saying they don’t want laparoscopic surgery because they say that maybe they use radiation for laparoscopy...So there’s a misconception in the community of what it is.” [Subject 2]

“What you find here in [Country 1] is that a lot of university hospitals have lap towers, but no one knows how to use them. It’s an equipment need...but it’s more of a knowledge gap, just people that understand how it all works, can set it up, and can troubleshoot it. I think we’re one of the few places training our residents actively where the residents actually get to do it, and not just watch a faculty member operate and say, wow that was great.” [Subject 1]

“For laparoscopy, I have to tell them [OR staff] each time how to set up over and over and over again.” [Subject 3]

“I get criticized by some folks in the US that say, why are you doing laparoscopic surgery in Africa? Like it’s not happening. But it’s happening. My graduates are asked a lot by other hospitals when they get out, like do you know anyone that knows how to do laparoscopic surgery, because they might have 3 or 4 towers and no one knows how to use them. Our goal is to create servant leaders for Africa, right? People that are going to impact the world and their people...I think laparoscopy will be a good platform for our trainees when they do that.”

(4) Generalizability of Educational Material

“The content is almost exactly like your ABSITE exam. So, while we don’t have radiation at all at our hospital, and nearly at all in the country, and there’s very limited chemotherapy options, the residents still have to know the Z11 trial, and sentinel lymph node mapping, and who gets radiation and who doesn’t, even though, practically, it’s not applicable.” [Subject 1]

“Related to the instrumentation, like for orthopedic surgery, if you try to do the latest, greatest, fancy deal they’ve got, it’s not applicable to Africa because it doesn’t exist. So, you ...have to be careful with the technological aspects of what is available versus what we have, that’s that’s the only hesitation [with simulation].” [Subject 3]

“There’s positives and negatives [to introducing foreign teaching modules]. The positive is that it’s mainly the tried and tested modules that have been used elsewhere, that have seemed to work, and...they give us a starting point. The bad side is that...it’s very difficult to copy/paste everything because the environment is different. What the residents here have to deal with...is different from what the residents have to deal with in the States. The patient populations, those are different, disease burden and all that.” [Subject 4]

Table 2 (continued)

The problem will be acquiring whatever [educational material] is made in the US. If it's low cost, if it's affordable. Right, maybe we'll be able to afford it, but if it's expensive you have only a small subset of people that can afford it [here]. And even then, some people choose the low cost, because there's really no difference in how much skills you acquire from the low cost or the very cumbersome expensive ones." [Subject 6]

case. 'No! The camera should be this way! Hold the camera like this! Turn the camera!' (laughs). So when I had that simulation, I thought... this is really nice. And every day I would go back there, I went back there almost every day. And there was a period where we didn't really have much to do because the crisis had escalated, our roads were blocked, we didn't have patients. So I would just sit there and every now and then work on it. So you just learn. Then with time; I have not mastered it but I'm better at coordinating myself. So I remember the last appendectomy we did in less than 20 minutes. The attending I did it with had never seen me do laparoscopy, and in no time we were out and the girl recovered without an abscess or without any complications. So after that I saw that the only reason why we were able to go that fast was because I had been practicing. And so far I don't have any other problems with 'Oh the camera! Oh follow me!' (laughs). Those problems are no longer there. Other people still have those problems, but it's because they have not been practicing."

This example powerfully illustrates the potential educational impact of a simulation curriculum that is embedded into the program.

Barriers to laparoscopic surgery

Themes were also raised regarding the current barriers to laparoscopic surgery, including infrastructural, educational, and logistical challenges (Table 2, Sect. 3). There was some variability in the degree that local infrastructure impacted surgical care. Subject 3 states: "You know, everything laparoscopy is dependent on power, and so when our power goes off, you're slowed down until the power comes back on. Until then, you can do nothing." Yet, Subject 4 states: "So from an institutional standpoint, the infrastructure is there ...there's no issues with the infrastructure. The theater is excellent, it's fine; I mean, it's just like any other theater that you can be in. Of course, there are a few differences, but, I mean, the facility, it's okay. We have electricity and all that." These statements illustrate the range of infrastructural development in different hospitals and in different countries on the continent of Africa.

Regarding education, it appears that both hospital staff and patients could benefit from understanding more about the details of laparoscopic surgery. The maintenance and

technical understanding needed by the operating room staff was described by all interview subjects, who spoke to the time it takes to assemble and troubleshoot any malfunctioning equipment in addition to performing the surgery. They felt that often the surgeons were the only individuals aware of how the equipment functions, having to guide operating room staff through every step of troubleshooting. Even among the programs that perform a significant amount of laparoscopic surgery, there was a limit to when they can perform these surgeries due to the limited knowledge of their assistants. Subject 1 stated: "Now we do no laparoscopy at night, because the nurses have no idea how to do it, and typically I'm not patient enough to go through and like be the surgeon and the circulator and the scrub, right? I just will do an open procedure." Regarding patient understanding, some subjects spoke of the misconceptions some patients have regarding the safety of newer surgical techniques, such as concerns that laparoscopy is a form of radiation or inherently dangerous to one's health (Table 2, Sect. 2, Quote 3).

Curricular limitations

Lastly, the limited generalizability of current international curriculum was also highlighted by interview subjects. They pointed out the differences between their countries and the United States in terms of disease burden and accessibility of advanced treatment regimens. However, many of these advance techniques and regimens are tested on the annual exams that these residents take in their programs, given that these exams are created by and designed for those practicing surgery in the Global North (Table 2, Sect. 4, Quote 1). The primary concern was that training modules would be too expensive to implement. While there was appreciation of "*tried and tested*" surgical curriculum reaching local trainees, many expressed skepticism that curriculum designed abroad would be financially practical or provide appreciable improvements to the educational initiatives already in place (Table 2, Sect. 4).

Discussion

Historically, surgical education in low-resourced African countries has focused on techniques that minimize the complexity and expense of surgical care. However, as resources become more available and the standard of care is persistently elevated in countries such as the United States, one

could argue that the global surgical community has a duty to widely disseminate the knowledge and practice of advanced surgical techniques. The survey data and the interview data presented here illustrate that there is both a need and interest in focusing educational initiatives on laparoscopic simulation. As the interview subjects attest, laparoscopic skills are now seen by many in these settings to be a fundamental part of the training of a competent general surgeon. This is especially true since many of these surgical trainees will go on to be one of only a handful of surgeons at a local hospital responsible for quality surgical care for a large population. Their ability to provide the standard of surgical care using a variety of modalities depends directly on the techniques that trainees are exposed to in training. Simulation can mitigate the impact of limited operating room exposure to laparoscopic surgery by allowing trainees to become comfortable with basic skills, such as directing the laparoscope, hand–eye coordination with laparoscopic instrument, and tissue handling, all prior to entering the operating room.

Furthermore, it is no longer accurate to assume that more advanced surgical modalities such as laparoscopy are not feasible in resource-limited environments. While some locations may have inconsistent access to electricity or basic infrastructure (as Subject 3 suggested) there are other spaces that have operating rooms comparable to the United States with few limitations (such as where Subject 4 practices). This illustrates a key tenet of global health: low and middle-income countries on the continent of Africa are not a monolith and thoughtful consideration of the specific local context is paramount prior to introducing any initiatives or interventions. The tools needed to perform laparoscopic surgery were first distributed among some LMICs in the 1970–1980s among tubal ligation campaigns at that time [12, 13]. As the benefits of laparoscopic surgery became common knowledge, including the decreased infection rate, decreased blood loss, reduced post-operative pain, decreased bed utilization, and rapid return of functional status, there were certainly some early adopters of the technology in countries such as India and Senegal [13–15]. It was even believed that diagnostic laparoscopy could take the place of magnetic resonance imaging (MRI), computed tomography (CT), and other cost-prohibitive imaging modalities to diagnose acute intra-abdominal pathology [13, 16]. In a recent survey of surgeons at the annual meeting of COSECSA (College of Surgeons of East, Central, and Southern Africa), roughly 50% of surgeons reported having access to laparoscopic surgery [16].

Though access to materials was previously a rate-limiting factor in adoption of laparoscopic techniques, many surgeons on the ground report that lack of technical training is now a prominent obstacle [17]. Surgeons who are interested in gaining these skills often require external funding to attend infrequent courses sponsored by surgeons from

HIC (high-income countries). Often these courses last short periods of time and are conducted with altered curricula that have not been formally validated, yielding mixed results and leaving trainees or faculty eager for more opportunities to hone their skills [13, 18]. A locally informed simulation curriculum designed around laparoscopic surgery that does not have the same physical constraints as a course would be an ideal setting to improve these technical skills for trainees.

In the literature, we see that surgical trainees from numerous African countries have previously reported lack of exposure to minimally invasive surgical techniques as a training deficit [19, 20]. Some work has been done in South Africa regarding trainee and faculty perspectives on laparoscopic surgery. On a Likert scale of 1 (strongly disagree) to 5 (strongly agree), trainees and faculty responded to the question of “Do you feel laparoscopic training is essential for South African general surgical registrars?” with average scores of 4.95 and 4.78, respectively [21]. Trainees and faculty largely felt that laparoscopic training at their institution was not adequate and listed “availability of a laparoscopic skills laboratory” as the factor most likely to encourage laparoscopic training [21].

A more recent assessment performed by COSECSA demonstrated that faculty and trainee surgeons are engaged in laparoscopic surgery across these regions of the continent [22]. A median of three surgeons per hospital performed a median of 10 laparoscopic operations per month with cholecystectomy being the most performed procedure [22]. Lack of skilled surgeons was found to be one of the top five barriers to performing laparoscopic surgery, further indicating that interventions targeted towards laparoscopic surgical education would improve capacity on the ground to perform minimally invasive surgical procedures [22].

The study presented here has several key limitations. Both the survey data and the interviews solicited information from a small number of individuals who certainly do not represent the views of the entire surgical workforce in all LMIC African countries or even all PAACS residency programs. However, 8 of the 11 programs surveyed responded to round 1 of the survey with psychomotor skills of interest. Though the total number of programs included was small, this still represents a 72% response rate. The interviews, though limited, were in-depth and representative of the experiences of surgeons at 4 different hospitals in 4 different countries. Their individual experiences may not be generalizable, but the themes they discuss likely bear key similarities to the general experiences of surgeons in these settings and offer insight worth considering.

There is no doubt that the poor adoption of laparoscopic surgery in LMICs is a complex and multifactorial problem. However, the literature and the data gathered here highlight that the time is ripe for investment in simulation to improve laparoscopic skills for the next generation of surgeons in

African LMICs. While there has been survey data reported, this is one of the few studies to assess the educational utility of surgical education among stakeholders in multiple countries with rich qualitative data. These data provide specific examples of how a trainee's experience can be enhanced with surgical simulation.

Supplementary Information The online version contains supplementary material available at <https://doi.org/10.1007/s00464-023-10665-y>.

Acknowledgements The authors would like to thank the members of the Pan-African Association of Christian Surgeons for their time responding to surveys and participating in these interviews.

Funding No funding source was used to conduct this research.

Declarations

Disclosures Joy Obayemi, John Donkersloot, Erin Kim, Keir Thelander, Mary Byrnes, and Grace Kim have no conflicts of interest or financial ties to disclose.

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