The Use of Simulation for Undergraduate Surgical Education in Sub-Saharan Africa: A Scoping Review

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Abstract

Background

The implementation of simulation-based learning for surgical training in sub-Saharan Africa can help prepare trainees to address surgical burden. The current status of simulation for surgical skills training in undergraduate medical education in Africa South of the Sahara needs to be better defined. In this scoping review we aimed to identify gaps in the application of simulation to undergraduate surgical education in sub-Saharan Africa.

Methods

We conducted a scoping literature search using PubMed, Embase, and African Index Medicus in August 2021. Studies reporting data on the use of simulation-based learning for undergraduate or internship surgical training in SSA specific to surgical clerkships, programs or procedures were included in the analysis. There were no language or date restrictions.

Results

We identified 119 studies and included 19 in the final analysis. Most simulation-based learning for undergraduate surgical training in sub-Saharan Africa began recently (2017–2021), and were reported from Eastern Africa (78%). Half were planned as recurring, sustained simulation programs, and only 25% of programs applied simulation to early undergraduate training. Up to 44% of primary care and 32% of first-level hospital essential surgical procedures, as defined by the Disease Control Priority Program (DCP3), are reported as taught by simulation. Only 15% of programs taught non-technical skills and 14% had engineering collaborations.

Conclusions

We found a lack of published simulation-based learning for undergraduate medical education in sub-Saharan Africa for 65% of World Health Organization/World Bank Disease Control Priorities 3-defined essential operations. There is need to expand the range and depth of content, and participant spread. Interdisciplinary, trans-sectoral collaboration will enrich simulation program quality, and assist with expansion to other African regions.

Background

The 2015 Lancet Commission on Global Surgery highlighted a massive shortfall in global surgical capacity particularly concentrated in Low- and Middle-Income Countries (LMICs), with 5 billion people lacking access to surgical care. Despite a large burden of surgical disease in sub-Saharan Africa (SSA), there is a grossly inadequate number of surgery, anaesthesia, and obstetric (SAO) providers which is more marked in rural areas.(1) Unlike their counterparts in high-income countries (HICs) who need to undertake residency training before engaging in independent surgical practice, medical school graduates in SSA perform essential surgical procedures within their first year after graduation (Fig. 1).

Figure 1

Pathways to independent surgical practice in selected countries.

At the district hospital level, these general practitioners perform caesarean sections, laparotomies, and reduction of open fractures.(2) For example, in rural Rwanda, up to 90% of caesarean sections and 50% of abdominal emergencies are performed by general practitioners.(3, 4) This raises the need for surgically competent and entrustable medical school graduates. Building this competence is challenging, in view of the insufficient number of trainers, the relatively large number of medical students, prioritization of postgraduate surgical trainees at the expense of medical students, and the heavy workload of surgeons who might find it difficult to dedicate intraoperative time to teaching.(5) In addition, ethical dilemmas arise around permitting students to perform surgery, especially under often inadequate levels of senior supervision. Simulation-based surgical training may present a solution for some of these challenges.(6) Exploration of how surgical simulation has been used, and the description of types of World Bank essential surgical procedures taught using surgical simulation in undergraduate education may guide the process of contextualising the use of effective low-cost, high-impact simulation in Sub-Saharan Africa.

In simulation, real-life surgical encounters are modelled in a controlled setting in order to help students achieve specific clinical educational goals. These are being increasingly utilized in medical training in HICs. The spectrum of realism or authenticity varies along a simulation “fidelity” continuum, which is a subject of recent debate, as perceptions of fidelity vary widely based on its mediation of sensory perceptions, the task demands, learning objectives, the environment and factors suspending disbelief.(7) Its use ranges from low- to high-fidelity, based upon the degree to which the simulator attempts to replicate ‘real life’ situations or experiences for the learner. There is increasing evidence supporting the superiority of even low-fidelity SBL over historically utilised, more didactic teaching methods when undertaking training of procedural skills such as surgical suturing and central line insertion.(8–10) Furthermore there is also an expanding evidence base suggesting its value in developing rigorous, context specific, non-technical skills for surgery (11, 12) which have been shown to be important for improving the safety and quality of surgical care (13, 14).

SBL is now very widely used in postgraduate surgical training, and its value in undergraduate medical training in high-income countries is also well recognized.(15) However the use of simulation for undergraduate training in surgery in SSA is yet to be explored, despite its potential to address challenges faced by essential surgical training in context. SBL has immense potential to prepare students for essential surgeries at the primary health centre and district hospital as identified by the World Bank Disease Control Priorities (16), such as caesarean section, reduction of fractures, and laparotomy. Collaborations between engineers and medical educators such as those highlighted by the American

College of Surgeons and the American Society of Engineers, have contributed to highlighting a "Three-Way Partnership between Physicians, Technology, and Information to Improve Patient Care" that contributes to conceptualization, design, and execution of SBL, largely in High-Income Countries.(17)

Identification of the training gap in essential surgical skills will enlighten the scope of collaboration needed for SSA to meet the pressing need for safe and effective scale up of surgical services in the world's most underserved populations. The aims of this scoping review were to identify geographical and educational gaps in simulation use in undergraduate medical training, and to highlight potential areas for collaboration between engineering and medical experts, ranging from the conception, design, improvisation, and promotion of SBL across SSA.

Methods

Eligibility criteria:

We performed a scoping review of the literature according to PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. Screening inclusion and exclusion criteria were agreed upon within the authorship team prior to title and abstract screening, full text review and extraction stages using a documented but unregistered scoping review protocol. Our inclusion criteria encompassed any original research or reviews reporting data on the use of SBL in undergraduate training and education specific to surgical clerkships, programs or procedures, or surgical internship training in SSA. We also included articles describing training for students studying primarily in SSA exposed to international training programs as part of their program. Our definition of undergraduate surgical training broadly encompassed training of nursing, medical, or dental students undertaking their first degree or its equivalent in the provision of operative, perioperative, or non-operative management of surgical and/or obstetric condition(s) including the provision of anaesthesia care.

We excluded studies concerning undergraduate simulation training programs not related to surgery and those focused on surgical training outside of SSA. Articles not connected with surgical training, focused on postgraduate residency or fellowship training, not utilizing simulation, from and those from High-Income settings were excluded. Opinion pieces or editorials were also excluded.

Search method:

Initial broad search terms including 'simulation', 'medical education', 'surgery' and 'Sub-Saharan Africa' were defined by the authors and in collaboration with a librarian. A comprehensive search strategy was developed. PubMed, Embase and African Index Medicus databases were searched systematically in August 2021 with no time or language restrictions. The full search strategy applied is provided in Additional file 1. The final literature search was performed on 30th August 2021.

We also identified additional relevant publications by citation reviews and through consultation with expert members of the authorship team who were immersed in undergraduate medical SBL in various

SSA contexts.

Selection of sources of evidence:

Covidence systematic review software (18) was used to facilitate paper screening at both title and abstract, and full text review stages, and Zotero reference manager (19) was used to remove duplicate texts. BA and CF performed title and abstract review. Three members of the research team (BA, FW, OM) used Microsoft Excel software to manually extract data. Full text review was undertaken by BA and PK. Extraction was undertaken by both BA and FW with any conflicts resolved through consensus with OM.

Data abstraction:

The criteria selected for abstraction was done via authorship consensus and the resulting data charting form was developed by BA, reviewed by RR, and fixed prior to commencing data extraction. Extracted data is provided below.

Data analysis and grading of evidence:

The Medical Education Research Study Quality Instrument (MERSQI) scores for each paper (possible total range 5–18) were assessed primarily to determine the quality of the educational research of papers included in this review (Table 1) (20, 21)

Results

This review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines (Figure 2).

Figure 2: Preferred Reporting Items for Systematic Reviews and Meta-Analyses 2020 flow diagram

Initial database searches returned 116 articles of which 10 were duplicates. Eighty-eight articles were excluded through both title and abstract screening, and full text review. One additional paper was identified through expert consultation which resulted in a total of 19 papers being exported for review. All 19 papers have been included in the final data extraction, analysis, and reporting process (Table 1).(22–40)

Table 1: Summary of 19 studies included in the scoping review

Across 17 studies evaluating published research on SBL in undergraduate surgical education, the median Medical Education Research Study Quality Instrument score was 11.25 (range 5.5 – 15.5, out of possible 18).

Studies that met the inclusion criteria were conducted across a range of 10 countries in SSA. Based on African Union regions, East Africa hosted 77.8% (n=14) of the referenced programs in contrast to Central Africa, which had no documented undergraduate surgical SBL programs (Figure 3). West and Southern Africa hosted only 11.1% (n=2) each. In one study, simulation education for undergraduate surgical education was held in Canada for students of a Rwandan medical school as part of a multi-country educational program. Most of these simulation programs (78.9%, n=15) were only recently introduced (from 2017 through 2021).

Figure 3: Geographical Distribution of Studies on Undergraduate Surgical Simulation-based Learning in Sub-Saharan Africa

Programs targeted various undergraduate learners, including medical students (63.2%, n=12), nursing students (21.1%, n=4), dental students (5.2%, n=1), pre-interns (10.5%, n=2), emergency medical care students (5.2%, n=1), and undergraduate anaesthesia students (5.2%, n=1). Up to one-fifth (n=4) of the simulation use could be considered multi-disciplinary, including both medical, nursing and/or dental school students within the same program. Most surgical SBL was targeted at senior clinical students - only one in four programs documented its use within the first half of undergraduate training. Up to 57.1% (n=8/14) of the documented simulation programs were newly introduced at the time they were being studied. Only 36.8% (n=7) were planned as sustained, recurring programs.

Over half (57.9%, n=11) of the included programs explicitly utilized low-fidelity models. 26.3% (n=5) utilized high-fidelity models only for training, and a minority (15.8%, n=3) utilized a combination of both high- and low-fidelity modalities within the same program. Fidelity was largely reported by the programs, but were also classified by authors in the absence of fidelity self-reports.

Simulation programs were predominantly directed by general surgery teams (57.9%, n=11). The most commonly taught technical skills were acute resuscitation including cardiopulmonary resuscitation (31.6%, n=6), airway management (26.3%, n=5), suturing of lacerations (26.3%, n=5), surgical knot tying (21.1%, n=4), chest tube insertion (21.1%, n=4) and orthopaedic casting (21.1%, n=4) (Table 2). Whilst all programs included at least some aspect of surgical technical skills training, 15.8% also formally addressed non-technical skills, including teamwork, inter-professional communication skills, decision making, and time management.

Next, we mapped the surgical skills taught via simulation onto the list of essential surgical procedure for the Primary Health Centre (PHC) and First-Level (i.e. district general/rural) Hospital, as defined by World Bank Disease Control Priority Program (DCP3) (Table 3).(16) Simulation was utilized in the training for five (55.6%) of the nine essential surgical procedures identified at PHC level. Only nine (32.1%) of the 28 procedures required at First-Level Hospitals, were taught using SBL. Only three of the nineteen programs (15.8%) had specific collaborations between engineers and physicians for the conception, design, or execution of SBL.

Table 2: Topics covered in SSA simulation programs

Table 3: Overlap between essential surgical procedures and simulation-based learning for undergraduate learners in Sub-Saharan Africa

Discussion

There is a limited body of evidence available to guide the curricula of this modality of training for undergraduate medical education in SSA. Therefore, it is important to document, for the first time, the gaps and potential as identified in literature. Despite the recognized benefits of SBL in medical education, reports documenting its effectiveness in SSA are rare. There appears to be a skew in documentation towards Eastern Africa, with no reports from Central Africa, and limited use in Western and Southern Africa. A higher prevalence of HIC/LMIC partnerships (with the associated funding and expertise) in Eastern Africa were evident in this review.(23, 24, 26, 28–31) There is potential for a more widespread impact of simulation on training of surgical personnel to meet the needs of SSA by leveraging relationships between academic, medical, and engineering institutions with medical and other health professional schools in LMICs. Emphasis should be on expanding partnerships to Central, West, and Southern Africa for more equitable exposure of learners to the opportunities of hands-on SBL in a safe space. However, it is possible that programs are being run, but reports are not being published in literature for multiple reasons, including insufficient funding, inequitable access to publication options, and language barriers.

Recently graduated doctors in SSA perform basic surgical procedures earlier in their careers compared to many HIC trained doctors. These procedures are often performed independently or with minimal supervision in their role as district hospital general practitioners (Fig. 1). The WHO DCP3 lists 44 essential surgical procedures as a baseline for meeting the currently unmet needs of communities across LMICs.

This list is further broken down into procedures that should be performed in tertiary hospitals (n = 44), level 1 or district / general hospitals (n = 37) and primary health centres (n = 9). Only a small proportion of these essential procedures are being taught using SBL, and this highlights untapped potential for improving the breadth and quality of surgical training of medical and nursing graduates in SSA. Surgical simulation training should be expanded in order to increase the efficiency of healthcare training in essential procedures.

A reliable barometer of a healthcare systems' ability to provide safe and effective access to surgical care is measured through the 3 'Bellwether' procedures (caesarean section, emergency laparotomy, and open fracture reduction and fixation). In rural Rwanda, up to 97% of caesarean sections are performed independently by general practitioners.(41) The shortfall in SOA specialist providers, large burden of surgical disease, as well as inequity in rural-urban distribution of surgical professionals raises the need to produce 'surgery-ready' medical graduates in SSA. However, from our review, no medical schools provided documented simulation training in emergency caesarean sections. Only a few identified programs simulated open fracture management and emergency laparotomy. This highlights a missed training opportunity in undergraduate medical education in SSA. Using SBL to train doctors in the Bellwether procedures can help scale access to essential surgical services in the region.

Very few programs (15.8%) included in this review had interdisciplinary Engineering-Medical teams working together to produce simulation programs. This could be because most simulations were on established, basic simulators. Limitations of local engineering capacity, a disconnect between medicine and engineering, or funding shortfalls among other factors may have also contributed. Taking the simulation agenda forward in SSA, the intersectoral and transdisciplinary nature of simulation has to be emphasized. The advantages of grassroots trans-sectoral engagement include the availability of more professional expertise for the design, maintenance, and deployment of simulation education. The emphasis of this engagement however should not be to shift the simulation modes to high-fidelity, high-cost simulation models which are non-sustainable for the SSA context, but to find creative ways to produce high-yield, low-cost simulation that will improve practice.

The sustainability of simulation programs in SSA is a concern that must be carefully considered with these partnerships. Most SBL documented at this level of medical training was captured at the start of the program. The programs appeared to be largely initiated for research, and were predominantly new or starting at the time of documentation. Creative funding, local ownership, concerted capacity building, and equitable partnerships will encourage these programs to continue beyond available grant funding. Follow-up studies may be in order to track the progress of these programs and assess their current state.

Effective non-technical skills (NTS) amongst both medical and nursing staff, is increasingly recognised as a vital aspect of the provision of safe surgery. It has been shown that errors in surgical decision-making contribute to almost half of errors made in the operating room. (42) Despite this, only 15.8% of identified programs taught NTS alongside technical skills. Incorporating this can potentially help reduce errors in the operating theatre.(43, 44) Whilst the importance of NTS in surgery is increasingly reflected in the provision of specific training courses in SSA, these courses are generally provided to qualified and practicing operating theatre staff.(45) There is also limited published evidence regarding the use of simulation in teaching NTS, with a recent systematic review of NTS training in LMICs identifying only 2 of 21 publications that discussed the use of simulation programs for NTS training.(46) SBL lends itself well to combining both technical skills and NTS training in a variable resource contexts such as SSA, where it has been argued that non-technical skills play a more significant role in the provision of safe and effective surgical care.(47) We believe it would be valuable to utilize a combined approach during the early stages of medical education. Expanding the use of SBL in SSA to teach and train undergraduate medical and nursing students will undoubtedly be a valuable future endeavour in the attempt to effectively scale up access to safe surgery. Furthermore, given the value of low-fidelity simulation in providing effective NTS training this would be a potentially low-cost, easily scalable measure to be explored.

Conclusions

The use of SBL in undergraduate surgical training is not widespread in the literature. Although simulation remains an effective tool to enhance both technical and non-technical skills for surgical care globally, less than 35% of WHO essential surgical procedures are taught to undergraduates in SSA utilizing simulation and less than 16% of programs focused on NTS training. Most documentation of surgical SBL identified in this review was focused on East Africa. As engineering and educational partnerships appear to drive the use of simulation in this region, training institutions in West, Central and Southern Africa could identify such opportunities. In addition, many reports characterized initial stages of program development and implementation. This review highlights an opportunity to improve the scope and quality of surgical care in Africa without the risk of learning potentially risky procedures on clinical patients. Long-term follow up of feasibility, affordability, and efficacy of these efforts should be considered and assessing the sustainability of indigenous simulation programs can help cement adoption of SBL in SSA.

Abbreviations

DCP3- Disease Control Priority Program

HICs- High-Income Countries

LMICs- Low- and Middle-Income Countries

MERSQI- Medical Education Research Study Quality Instrument

PRISMA- Preferred Reporting Items for Systematic Reviews and Meta-Analyses

SAO- Surgery, anesthesia, and obstetric

SBL- Simulation-based learning

SSA- Sub-Saharan Africa

Declarations

Ethics approval and consent to participate

Not applicable

Consent for publication

Not applicable

Availability of data and materials

All data generated or analysed during this review are included in this published article [and its additional information file].

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

Contributions of authors using the CRediT author statement- BA: Conceptualization, Methodology, Formal analysis, Investigation, Validation, Writing - Original Draft, Writing - Review & Editing, Visualization, Project administration; CF: Formal analysis, Investigation, Validation, Resources, Writing - Original Draft, Visualization, Writing - Review & Editing; OM: Formal analysis, Investigation, Writing - Review & Editing; PK: Formal analysis, Investigation, Validation, Writing - Review & Editing, Project administration; NS: Writing - Review & Editing; FW: Validation, Writing - Review & Editing; MH: Writing - Review & Editing, Project administration; GP: Writing - Review & Editing; EA- Methodology, Writing - Review & Editing, Supervision; JR: Conceptualization, Writing - Review & Editing, Supervision; SY: Conceptualization, Writing - Review & Editing, Supervision; RR: Conceptualization, Validation, Writing - Review & Editing, Supervision; AB: Conceptualization, Validation, Writing - Review & Editing, Supervision. All authors read and approved the final manuscript.

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Tables

Table 1: Summary of 19 studies included in review

[wide table, attached separately so as not to insert a page break- not an additional file]

Table 2: Topics covered in SSA simulation programs

Simulation Topics (N=78)	n	References	%
Resuscitation and Airway Management			
Airway Management (Basics of airway management, intubation, Cricothyroidotomy)	5	23, 31, 32, 33, 39	6.4
Resuscitation (Primary, secondary, tertiary survey, BLS, CPR)	6	22, 26, 31, 33, 37, 39	7.7
Surgical Procedures			
Surgical Preparation			
Surgical equipment sterilisation	1	36	1.3
Scrubbing	1	32	1.3
Gowning	1	32	1.3
Gloving	1	32	1.3
Surgical instrument identification	1	23	1.3
Surgical knot tying	4	23, 24, 35, 36	5.1
Patient skin preparation	1	32	1.3
General Surgical Procedures			
Suturing of skin lacerations	5	22, 23, 24, 35, 36	6.4
Incision and drainage of abscesses	1	22	1.3
Laparotomy/Abdominal access and closure	2	23, 32	2.6
Intestinal perforation repair/anastomosis	3	23, 32, 33	3.8
Haemorrhage control	3	29, 35, 37	3.8
Management of epistaxis	1	35	1.3
Neurosurgery Procedures			
Burr hole	1	39	1.3
Cardiothoracic Surgery Procedures			
Chest tube insertion	4	23, 31, 32, 39	5.1
Anaesthesia Procedures			
Inferior dental regional nerve block	1	22	1.3
Orthopaedics Procedures			
Orthopaedic casting	4	23, 35, 37, 39	5.1
Orthopaedic splinting	1	24	1.3
Dental/Oro-maxillofacial surgery procedures			
Reduction of temporomandibular joint dislocation	1	22	1.3
Eyelet jaw wiring	1	22	1.3
Obstetric-Gynaecologic Procedures			
Vacuum assisted vaginal delivery	1	32	1.3
Insertions of subcutaneous contraceptive implants	1	38	1.3
Trauma			
Management of Polytrauma	1	35	1.3
Extended- Focused Assessment Sonography for Trauma	1	31	1.3
Venous Access			
Venous cutdown	2	32, 39	2.6
Interosseus insertion	1	33	1.3
IV placement	2	31, 33	2.6

Surgical Safety and Checklists (Quality Improvement)			
WHO surgical safety checklist	1	36	1.3
Simulation for Nursing procedures			
Bladder Catheterization (Foley's)	2	23, 24	2.6
Wound care	2	27, 35	2.6
Nasogastric tube insertion	1	24	1.3
General nursing interventions	1	24	1.3
Post operative care	1	24	1.3
Clinical Examinations			
Clinical breast examination	1	28	1.3
Clinical Scenarios			
Closed head injury requiring intubation	1	31	1.3
Blunt abdominal trauma in a pregnant woman	1	31	1.3
Gunshot wound to the right chest	1	31	1.3
Thematic Simulation			
Traumatology	1	37	1.3
Emergency surgery	1	37	1.3
Non-technical Skills			
Team work	1	26	1.3
Inter-professional communication skills	1	33	1.3
Decision making	1	33	1.3
Time management	1	33	1.3
Patient safety and prescribing	1	33	1.3
Others			
Surgical instrument identification	1	23	1.3

Table 3: Overlap between essential surgical procedures and simulation-based learning for undergraduate learners in Sub-Saharan Africa

st of WHO/World Bank Disease ntrol Priorities (DCP3) essential surgical care procedures	Procedures taught using simulation-based learning (SBL) in sub-Saharan Africa (SSA)*		Number of educational programmes identified using SBL
	Yes/No	n (%)	
ected essential procedures at nary Health Centre Level (N=9)			
1. Dental extraction	No	n=5/9 (55.6%) for essential procedures at primary care level	
2. Drainage of dental abscess	No		
3. Treatment of dental caries	No		
4. Normal (spontaneous vaginal) delivery	Yes		1
5. Drainage of a superficial abscess	Yes		1
6. Male circumcision	No		
7. Resuscitation with basic life support measures	Yes		6
8. Suturing laceration	Yes		5
9. Management of non-displaced fractures	Yes		1
ected essential procedures at t Level (District General) pital Level (N=9)		n=5/28 (32.1%) for essential procedures at first (district) care level	
1. Cesarean birth	No		
2. Vacuum extraction/ forceps delivery	Yes		1
3. Ectopic pregnancy	No		
4. Manual vacuum aspiration and dilatation and curettage	No		
5. Tubal ligation	No		
6. Vasectomy	No		
7. Hysterectomy for uterine rupture or intractable postpartum haemorrhage	No		
8. Visual inspection with acetic acid and cryotherapy for precancerous cervical lesions	No		
9. Repair of perforations: for example, perforated peptic ulcer, typhoid ileal perforation	Yes		3
10. Appendectomy	No		
11. Bowel obstruction	No		
12. Colostomy	No		
13. Gallbladder disease, including emergency surgery	No		
14. Hernia, including incarceration	No		
15. Hydrocelectomy	No		
16. Relief of urinary obstruction: catheterization or suprapubic cystostomy	Yes		2
17. Resuscitation with advanced life support measures, including surgical airway	Yes		11

18. Tube thoracostomy (chest drain)	Yes		4
19. Trauma laparotomy	Yes		2
20. Fracture reduction	Yes		4
21. Irrigation and debridement of open fractures	No		
22. Placement of external fixator; use of traction	Yes		1
23. Escharotomy/fasciotomy (cutting of constricting tissue to relieve pressure from swelling)	No		
24. Trauma-related amputations	No		
25. Skin grafting	No		
26. Burr hole	Yes		1
27. Drainage of septic arthritis	No		
28. Debridement of osteomyelitis	No		

procedures at second or third level hospitals (including repair of obstetric fistula, cleft lip, cleft palate, ectal malformations, Hirschsprung's Disease, and club foot, shunts for hydrocephalus, surgery for visual irment, cataract extraction and insertion of intraocular lens, and eyelid surgery for trachoma) were taught to cal undergraduates using simulation-based learning

Figures

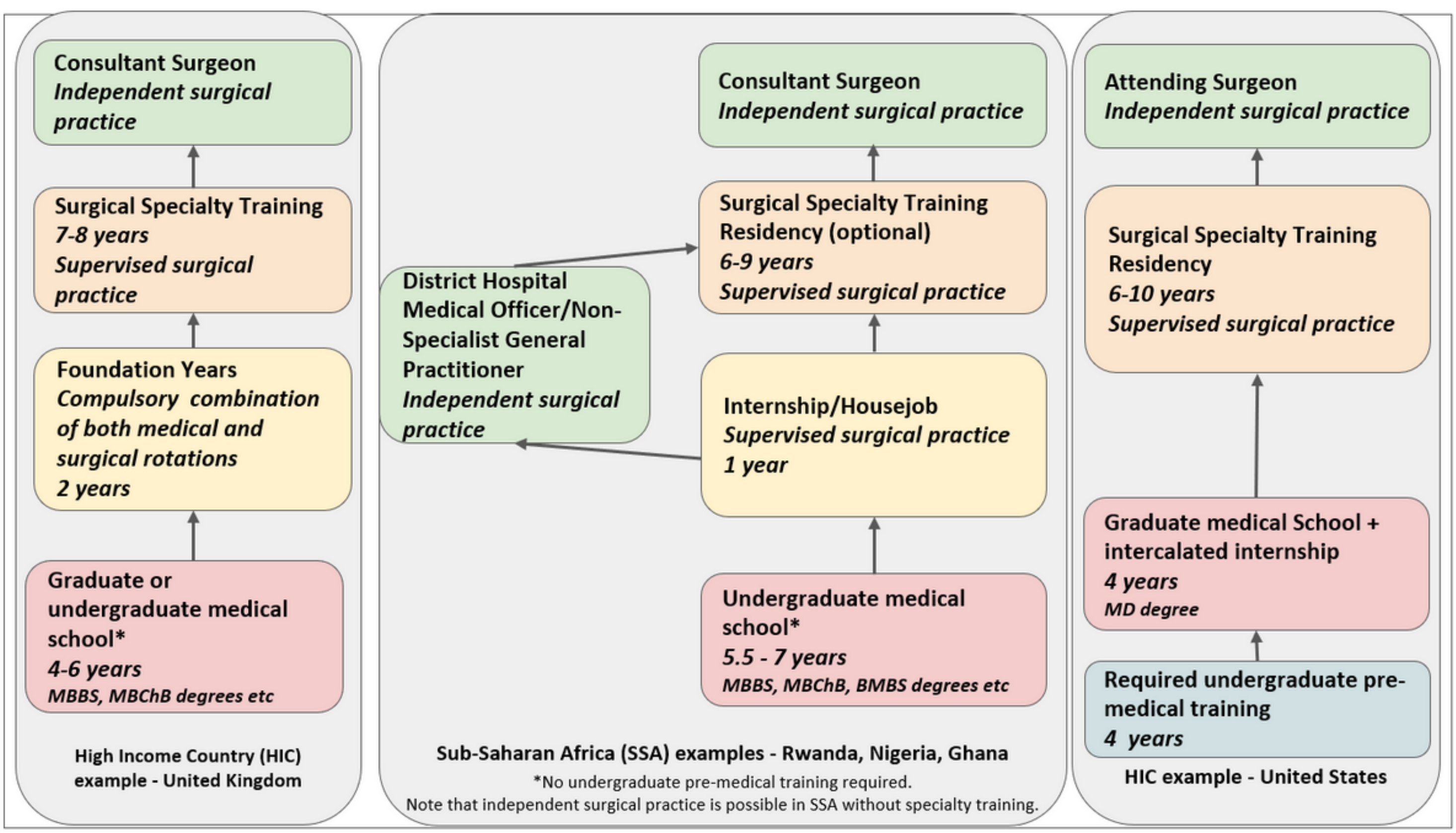

Figure 1

Pathways to independent surgical practice in selected countries.

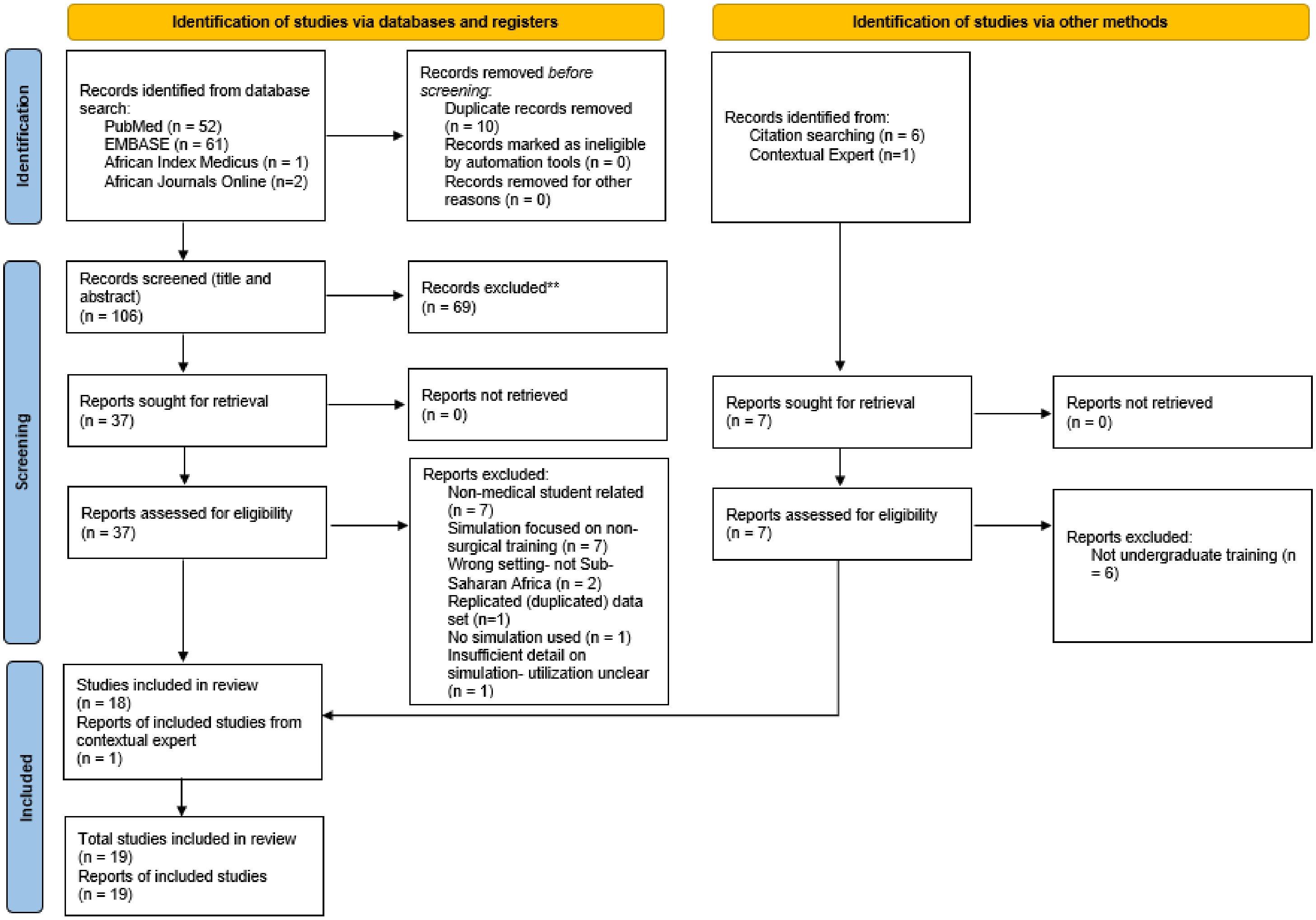

Figure 2

Preferred Reporting Items for Systematic Reviews and Meta-Analyses 2020 flow diagram

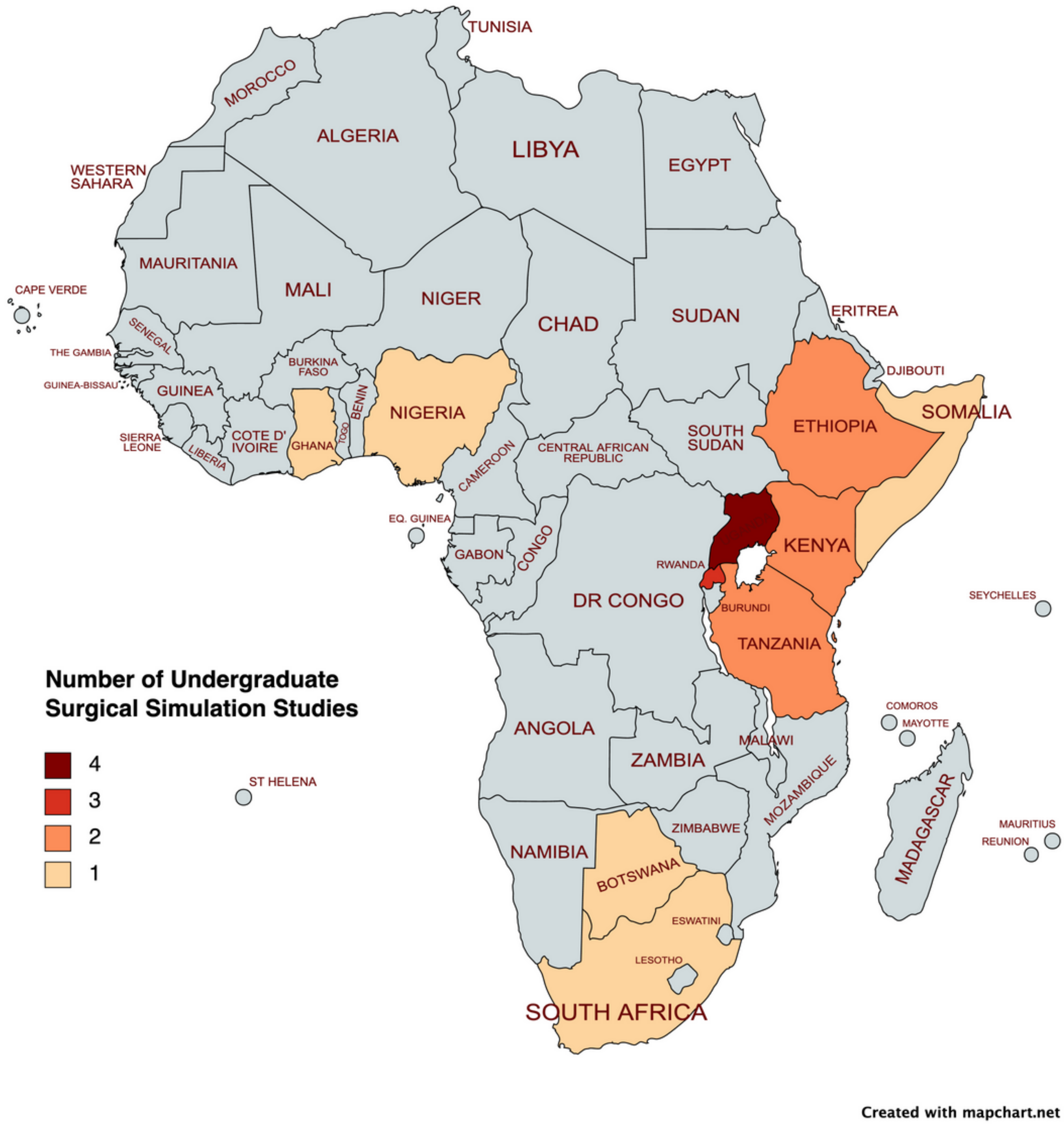

Figure 3

Geographical Distribution of Studies on Undergraduate Surgical Simulation-based Learning in Sub-Saharan Africa

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Table1.docx
- Additionalfile1.pdf