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Evaluation of Simulation Ophthalmic Surgery Training Courses in sub-Saharan Africa: What is the impact of this training on students and trainers?

Oliver Kemp

oliver.kemp@uhbw.nhs.uk

University of Cape Town https://orcid.org/0000-0002-3303-5993

Deon Minnies

William Dean

Gloucestershire Hospitals NHS Foundation Trust

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Abstract

Background:

Sub-Saharan Africa (SSA) faces the world's highest age-standardised prevalence of blindness (0.99%), nearly double the global average. The leading causes—cataract, glaucoma, and diabetic retinopathy—may require surgical interventions. Yet SSA suffers from a significant shortage of ophthalmologists (2.7 per million population) and a lack of access to quality surgical training. Simulated Ophthalmic Surgery (SOS) training provides a promising, safe, and scalable method for early-stage surgeons and trainers to develop critical surgical skills outside live theatre settings.

Methods:

A cross-sectional, anonymous electronic survey was distributed to 201 trainees and 22 trainers who attended UCT SOS training between 2017 and 2024, exploring demographics, training experiences, perceived impacts, and systemic barriers.

Results:

The survey received responses from 100 trainees (49.7%) and 18 trainers (81.8%). Trainee worked in 20 SSA countries, with 93% reporting improved confidence, 78% noting fewer complications, and 76% observing better postoperative outcomes. Trainers also benefited: 78% felt more confident in teaching, and 75% observed fewer complications among trainee they later supervised. 65% of trainee and 70% of SSA-based trainers reported inadequate resources for continued simulation practice. Only 50% of trainee could apply their training within one month.

Conclusion

UCT's SOS courses significantly enhance surgical and teaching confidence. Institutional barriers such as delayed application, inadequate infrastructure, and limited training time threaten the long-term impact. Simulation-based surgical training shows strong potential for building SSA's ophthalmic workforce and reducing avoidable blindness. Sustained investment in simulation training infrastructure, policy integration, and structured mentorship attachments is essential to unlock this potential.

INTRODUCTION

Sub-Saharan Africa (SSA) is home to approximately 15% of the global population.[1] The age-standardised prevalence of blindness (binocular visual acuity < 3/60) in SSA is 0.99%, the highest of the global subregions. This is nearly double the global average of 0.52%.[2,3] Ninety percent of all global visual impairment is avoidable, meaning it can be either treated or prevented.[3] Forty percent of blindness is caused by cataract in adults aged over 50 in SSA, with 18% caused by glaucoma.[4] SSA has also seen the highest increase globally in age-standardised prevalence of blindness from diabetic retinopathy over the past 30 years.[4] The treatment of visual impairment caused by these conditions often requires ophthalmic surgery, with cataract surgery regarded as the most cost-effective sight-restoring treatment in health care.[5]

Vision and eye health is important to every human being, meaning access to eye services is paramount. Outside of the personal benefits of good vision, the provision of eye care services has repeatedly been shown to create economic

benefits, reduce gender inequality and improve sustainability of communities.[6] This is particularly true in low-resource settings such as SSA which also bears a disproportionately high burden of visual impairment.

The high burden of blindness in SSA is in an area where there is a disproportionately low number of ophthalmologists, with only 2.7 ophthalmologists per million population in SSA compared to a global mean of 31.7 per million.[7] The VISION2020: Right to Sight initiative recommended a target of four ophthalmologists per million population, however, 80% of countries in SSA have fewer than this.[76] Furthermore, not all ophthalmologists are competent in ophthalmic surgery due to lack of available training. This means it can be difficult to access surgical treatment of blindness in conditions such as cataract, glaucoma and diabetic retinopathy. There is also a challenge of coverage for patients living in rural areas with 70% of ophthalmologists in SSA working primarily in their respective countries' capital cities.[65] This relatively low number of ophthalmologists, low proportion of ophthalmic surgical skills with low coverage and output of eye care presents a mix of circumstances unlikely to overcome the high burden of blindness in SSA.[6]

Focusing on the surgical skills of ophthalmologists in SSA, several barriers to provision of surgical training have been identified.[7,8] With cataract surgery there is often low output leading to reduced opportunity for early stage surgeons to acquire and develop skills.[8] A recent survey found the median number of cataract surgeries performed by SSA-based ophthalmology trainees in their first 2 years of training was zero.[7] It is understandable therefore that further development of surgical training was the top ranked factor rated in a Delphi exercise for improving cataract surgical outcomes in Africa.[9] Similar difficulties exist with subspecialty surgery, with limited opportunities for both surgical trainees and trainers, in particular for glaucoma, vitreo-retinal and paediatric strabismus surgery.[8]

One solution to the reduced training opportunities for surgical trainers and trainees in SSA is provision of simulated ophthalmic surgery (SOS) training. This involves practical simulation-based surgical education by expert surgeon trainers. SOS training can be performed using a range of modalities from lower fidelity models such as apples and foam to higher fidelity such as synthetic eyes and virtual reality surgical simulators.[9] The efficacy of this method of training for cataract surgery has been proven with two randomised control trials in early career surgeons.[10,11] The intervention of this trial was with a 3-day SOS high impact practical course. It was shown to significantly improve surgical performance and rates of surgery performed within the year following intervention.[10] There is further evidence of simulated surgical training in other fields of surgery, particularly laparoscopic surgery.[12,13] An additional, important benefit of SOS training is reduced surgical complication rates by ophthalmologic surgeons, therefore reducing risk to patients and workload on healthcare systems due to complications.[14–17] Since 2017, the Division of Ophthalmology at the University of Cape Town (UCT) SOS training programme has provided simulation ophthalmic surgical training for over 260 surgeons from 22 countries in SSA and beyond. The focus of this training includes cataract, glaucoma, and vitreoretinal surgery, for both trainees and prospective surgical trainers. The training courses are conducted over 2–3 days, with funding support to trainees, which aimed at improving access to eye surgeons from across SSA. Training focus on deconstruction of individual surgical steps using the Peyton 4-stage approach to teaching a practical skill.[18] Once all steps are covered, trainees can then perform full procedures on high fidelity synthetic simulation eyes and an EyeSI virtual reality surgical simulator [Haag-Streit, Bern, Switzerland].[19,20] There is repeated practice of simulation with self-reflection and video analysis of performance. Class sizes are restricted to ensure good supervision from trainers (< 6 students for every trainer). These courses provide opportunities for novice and beginner eye surgeons and surgical trainers that are hard to find elsewhere on the continent. Whilst some evidence exists that this format of SOS training improves early acquisition of surgical skills, further information is needed on the long-term impact of this intervention.[10,119] This study aimed to determine the impact of Simulated Ophthalmic Surgical training undertaken at UCT on trainees and trainers in SSA for the purpose of understanding the study population and identifying the stage of adoption of SOS training within it. One solution to the reduced training opportunities for surgical trainers and trainees in SSA is provision of simulated

ophthalmic surgery (SOS) training. This involves practical simulation-based surgical education by expert surgeon trainers. SOS training can be performed using a range of modalities from lower fidelity models such as apples and foam to higher fidelity such as synthetic eyes and virtual reality surgical simulators.[9] The efficacy of this method of training for cataract surgery has been proven with two randomised control trials in early career surgeons.[10] The intervention of this trial was with a 3-day SOS high impact practical course. It was shown to significantly improve surgical performance and rates of surgery performed within the year following intervention.[10] There is further evidence of simulated surgical training in other fields of surgery, particularly laparoscopic surgery.[12,13]

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METHODOLOGY

The study population included all surgeons who has attended UCT a SOS training course between November 2017 and June 2024. 'Train the Trainer' courses were also conducted to orientate senior surgical trainers in education of SOS, for the purpose of leading future SOS training course. To attend each of the courses available (Basical Microsurgical Skills (BMS), Manual Small Incision Cataract Surgery (MSICS), Phacoemulsification (Phaco), Trabeculectomy (Trab), and Introduction to Pars Plana Vitrectomy (PPV)) strict entry requirements were applied to ensure courses are appropriate for the level of surgeon and best suited to benefit future practice.

Study Design

A cross-sectional, anonymous, quantitative survey of all surgical trainees and trainers who attended UCT for one or more SOS training course between November 2017 and June 2024.

The convenience sampling method was used. A self-administered electronic questionnaire was sent via email to each of the 201 trainees and another to the 22 trainers who had undergone the training using online software produced by SurveyMonkey.[21] Participation in survey was anonymous, without funding or payment.

Data Collection and Analysis

The questionnaire comprised 25 questions, covering the following:

- Identification of participants baseline demographics as well as type and number of SOS training course attended.
- Surgical experience output before and since course attendance.
- Review of experience of surgical training with focus on inclusion of SOS using sensitively phrased questions.
- Review of respondent's personal experience of previously evidenced enablers and barriers to surgical training in SSA.

A 5-point Likert scale was utilised for most questions. Other questions involved prioritisation or selection of pre-determined answers. Completing the questionnaire was estimated to take approximately 10 minutes.

Data were exported from SurveyMonkey into MicroSoft Excel [Version 16.0]. Data were presented using descriptive statistics.

Ethical Approval

Ethical approval for this study was granted by the Human Research Ethics Committee of the University of Cape Town, South Africa.

Privacy, Confidentiality and Consent

Apart from basic demographics (Gender and age range) no personally identifiable information was taken.

RESULTS

Respondent Characteristics

The trainee questionnaire received 100 respondents (49.7%) and the trainer survey received 18 responses (81.8%). 91% of trainee respondents were aged between 25-44. At the time of attending the course, 38% of trainee were medical officers, of which 58% were registrar grade. At time of completion of the questionnaire all respondents (100%) were working in SSA, across 20 different countries (Figure 1). The 3 most represented countries amongst trainees were South Africa (36%), Kenya (16%) and Uganda (11%). 74% of course trainees were working in non-private healthcare settings for most of their clinical time (59% government hospitals, 15% university hospitals). 72.2% of trainer respondents were working most of their time in non-private healthcare settings (9/18 in governmental and 4/18 in university hospitals). 66% of trainer respondents train junior surgeons at least weekly (12/18).

Review of Simulation Courses

Trainee respondents had attended a total of 122 SOS courses; a summary of their responses can be found in Table 2. 64.7% of courses were in cataract surgery (79/122 total, 57 MSICS, 22 Phaco). At the time of attending a MSICS course 87.7% of students had completed 10 or less MSICS surgeries. 93% of trainees felt an increase in surgical confidence following attending the courses, 78% self-reported a decrease in surgical complications and 76% felt there was improvement in post operative visual outcomes in the surgery that they were taught. 8 of the 18 surgical trainers who responded had the opportunity to supervise simulation course trainees in live surgery following their completion of a course, 75% of these trainers noticed a reduced complication rate in the taught surgery. 77.8% of trainers who taught on simulation courses agreed that their confidence as a trainer had improved (14/18). These findings are visualised in Figure 3.

Reflections on Simulation Training in SSA

Following completion of the simulation course only 50% were able to practice the taught skill in a live theatre setting within 1 month of the course (24% within 1-3 months, 18% within 3 months – 1 year, 8% not at all since). The 8 trainees who were unable to practice their taught skills in a live theatre setting following the course had attended 9 courses (Phaco (4), Trab (2), PPV (2), MSICS (1)). Prior to attending SOS courses at UCT, 77% of trainee respondents had never had the opportunity to practice simulation surgical training techniques previously. Following attending a course, 66% had not had any further opportunity to practice SOS. Of the 10 trainers working in SSA 60% have not had the opportunity to simulation techniques outside of UCT, 30% were able to less than yearly and 10% were able to only several times a year. 82% of trainee respondents and 80% of SSA based trainer respondents agreed that their current clinical setting would be receptive to incorporation of simulation surgical techniques. 72% of SSA based trainers and 65% of trainees disagreed that there were sufficient quality materials and equipment at their setting required to practice simulation surgical techniques.

Reflections on Barriers and Enablers of Ophthalmology Surgical Training in SSA

Trainees and trainers were questioned on their opinions of previously evidenced barriers and enablers to surgical training in SSA.[7,22] These reflections are illustrated in Figures 4 and 5.

DISCUSSION

The two surveys returned higher than expected levels of response (50% Trainee, 82% Trainer). The trainee responses identified that UCT caters primarily for early to mid career ophthalmologists which is in keeping with targeted approach of producing high impact early skills acquisition. All trainee respondents work clinically in SSA which is reassuring for retention of skills within the region. As seen in Figure 1 respondents are based mostly in Southern and Eastern Africa. This suggests that for this training model to be suitably scaled to cover the whole of SSA there needs to be multiple centres for training across SSA. 74% of trainee and 72% of trainers work majority of their clinical time in the public sector. This is beneficial for penetration of surgical and teaching skills into areas of service provision where there is greatest level of impact on LMIC health inequity. This is further evidence of the importance of having a robust and responsible course selection criteria for trainee and trainers.

The main aim of SOS training is to improve the speed of surgical skills acquisition. The desired secondary aims are improved output of ophthalmic surgery, improved access to care and reduced patient harm through complication rates during the learning process. Alongside this, the nature of simulation enables this form of surgical training to be conducted in a non-patient setting at a time which suits the trainer and trainees. Investigating whether SOS training can improve surgical skills is an assessment of its efficacy. The efficacy of these courses has been supported already at UCT with two RCT level studies.[10,11] This survey assesses self-reported surgical confidence, complication rates and visual outcomes rather than objective measures of efficacy. 93% of trainees felt an improvement in confidence in the taught skill following completion of courses. Trainers also benefitted with 78% feeling more confident in their teaching skills. This increased confidence was backed up with self-reported decrease in complication rate (78% trainees reported, 75% trainer reported) and improvement in post operative visual outcomes (76% trainees reported). These responses add to the growing consensus that incorporation of simulation training improves surgical outcomes.[14,16]

This survey aimed to understand the impact of these surgical simulation courses. One issue identified by this survey was how soon after the course the trainees had the opportunity to practice the skills learnt within a live patient setting. Only 50% were able to practice the taught skills within 1 month of the course and 26% could not practice within 3 months. This suggests that while enthusiasm exists, systemic challenges—such as lack of funding, equipment

shortages, and limited trainer availability—impede widespread adoption.

Availability of simulation training opportunities outside of UCT was limited, with 66% of trainees and 60% of SSA based trainers not having any further simulation training opportunities. This is despite a strong consensus amongst both trainee and SSA based trainers that their setting would be receptive to incorporation of simulation training (81% and 80% respectively). This disparity is likely due to broader infrastructural limitations, with 65% of trainees and 70% of SSA based trainers feeling that there was inadequate equipment for simulation training in their setting. In another survey of SSA based ophthalmology trainees which asked specifically about the availability of SOS training, 76.7% agreed there were material available but only 29.2% felt there was a specific SOS curriculum within their setting. Key contributors to this were absence of direct supervision, lack of access to consumables and educational materials.[7] Outside the field of ophthalmology, a survey of 43 general surgical trainees' experiences of simulation-based training across 11 countries in SSA found three common barriers to adoption. Lack of resources, lack of funding and insufficient maintenance of equipment.[23]

Trainees and SSA based trainers overall disagreed that low availability of suitable cases and competition between junior surgeons was a barrier to surgical training. There was a mixed response to whether lack of direct supervision from senior surgeons was a barrier to training. Within these responses there was consistently a greater than 10% of respondents who strongly agreed these barriers were present. This as expected suggests that barriers to training are highly specific within each setting and indicates that previously evidenced barriers are less generalised than previously thought.[7,22] One issue that respondents felt impacted their surgical training was inadequate time on the surgical list to train. This sentiment was not shared by SSA based trainers where 60% agreed there was sufficient time on the list. Both trainees and trainers overall felt they had sufficient time away from non-surgical duties to practice/train surgical skills. Response to proposed enablers to surgical training were consistent with a previous survey of 124 SSA ophthalmic trainee surgeons which found that whilst that 71.8% were satisfied overall with their training programme, only 50.4% were satisfied with live surgical training in their hospital.[6]

Study Limitations

One challenge of understanding training in SSA is the nature of early career training usually requiring frequent change of setting of surgical practice. Meaning frequent changes in units and surgical trainers. This may make it harder to measure changes in surgical practice. An issue with using self-reported responses concerning sensitive areas of surgical practice such as complication rate and surgical output are vulnerable to social acceptability and recall bias. To combat this, we used sensitively phrased questions, however without an objective measure of surgical outcomes these responses can only be used as a guide to real world outcomes. This could be improved by incorporating pre and post training surgical audits to provide empirical evidence of simulation training efficacy. Finally, the study does fully explore institutional policy influences on surgical opportunities, focusing on opinion of clinicians, a more comprehensive report would include opinions of policy makers and administrative staff.

CONCLUSION

This study evaluated the impact of UCT's SOS training on trainees and trainers in SSA. Findings suggest that simulation training improves trainer confidence, enhances trainee preparedness, and may reduce surgical complication rates. However, significant barriers—including limited institutional adoption, time constraints, and resource shortages—hinder the widespread implementation and impact of simulation training. Addressing the study's limitations—such as selection

bias, reliance on self-reported data, and generalizability issues—will further refine understanding of simulation training's role in enhancing ophthalmic surgical capacity across SSA.

To maximize the benefits of simulation-based ophthalmic education, SSA institutions must invest in simulation infrastructure, integrate training into routine surgical education, and allocate dedicated time for trainers to mentor junior surgeons. Addressing these challenges will be critical to strengthening the region's ophthalmic workforce, reducing the burden of avoidable blindness and improving patient outcomes in the region.

Declarations

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Conflicts of Interest

There are no conflicts of interest financial or otherwise to declare.

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Authorship Contribution Statement

OK was the principal investigator for this study and was responsible for writing the research proposal, creation and distribution of the survey and data analysis. DM and WD provided vital supervision of the research and guiding of the research protocol and direction. All authors had involvement in writing and editing of the manuscript.

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Tables

Table 2: Summary table of responses to trainee and trainer survey.

	Alumni (n=100)		Trainer (n=18)	
Age	25-34	26%	35-44	16.7%
	35-44	65%	45-54	44.4%
	>44	9%	>54	38.9%
Gender	Female	52%	Female	33.3%
Healthcare Role at time of Course	Medical Officer	28%	n/a	
	Resident/Registrar	58%		
	Consultant	10%		
	Clinical Officer	4%		
Healthcare Role at time of survey	Medical Officer	16%	n/a	
	Resident/Registrar	15%		
	Consultant	65%		
	Clinical Officer	2%		
	Non -Clinical Role	1%		
Healthcare Setting at time of survey	Government Hospital	59%	Government Hospital	50%
	University Hospital	15%	University Hospital	22.2%
	Private Hospital	15%	Private Hospital	5.6%
	Non Governmental Hospital	10%	Non Governmental Hospital	11.1%
	Non-Clinical	1%	Non-Clinical	2%
Country of practice at time of survey	Sub-Saharan Africa	100%	Sub-Saharan Africa	55.6%
	South Africa	36%	South Africa	44.4%
	Kenya	16%	United Kingdom	27.8%
	Uganda	11%	USA	11.1%
	Zimbabwe	9%	Zimbabwe	5.6%
			eSwatini	5.6%
Simulation Courses Attended	MSICS	57	MSICS	18
(122 trainees, 55 Trainer)	Trabeculectomy	29	Trabeculectomy	6
	Phacoemulsification	22	Phacoemulsification	19
	Basic Microsurgical Skills	13	Basic Microsurgical Skills	7
	Pars Plana Vitrectomy	10	Pars Plana Vitrectomy	5
'Overall financial/opportunity cost of attending course was appropriate'	Strongly Agree	37%	Strongly Agree	38.9%
	Agree	47%	Agree	50%

	Neutral	13%	Neutral	5.6%
	Disagree	2%	Disagree	5.6%
	Strongly Disagree	1%	Strongly Disagree	0%
'I attended the course at an appropriate time in my surgical training'	Strongly Agree	58%		
	Agree	36%	n/a	
	Neutral	2%		
	Disagree	4%		
	Strongly Disagree	0%		
'Prior to attending course how often did you have the opportunity to practice simulation techniques'	Never	77%		
	Less than Yearly	12%	n/a	
	Yearly	1%		
	Several times a year	4%		
	Monthly or more	8%		
'Since attending the course how often have you had the opportunity to practice simulation techniques'	No opportunity since	61%		
	Less than Yearly	13%	n/a	
	Yearly	5%		
	Several times a year	9%		
	Monthly or more	12%		
'How soon after attending course had opportunity to practice the taught skills in a live patient setting'	No opportunity since	8%		
	Within a year	18%	n/a	
	Within 1-3 months	24%		
	Within a month	23%		
	Within a week	27%		
How often do you get the opportunity to train junior surgeons in simulation techniques outside of UCT-CEHI	n/a		SSA based Respondents (n=10):	
			No opportunity since	60%
			Less than yearly	30%
			Several times a year	10%

Figures



Figure 1

Map of Africa, highlighted in green are countries in which course alumni respondents spend majority of their clinical time practicing ophthalmology.

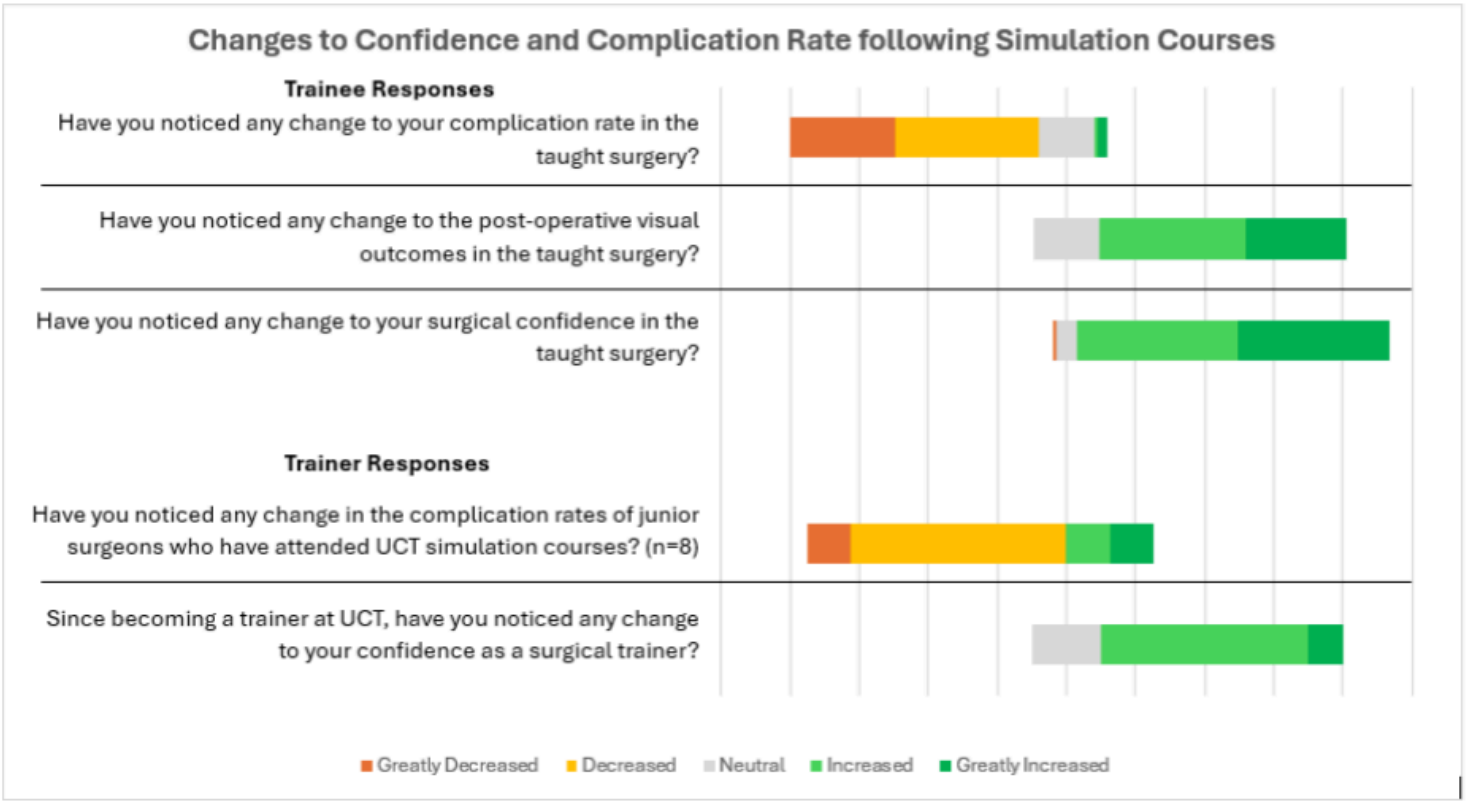


Figure 2

Figure 3: Changes to surgical confidence and complication rate following attendance to simulation course as reported by Trainee and Faculty Respondents. Most trainees reported greatly reduced or reduced complication rates, and greatly increased or increased confidence and post-operative visual outcomes.

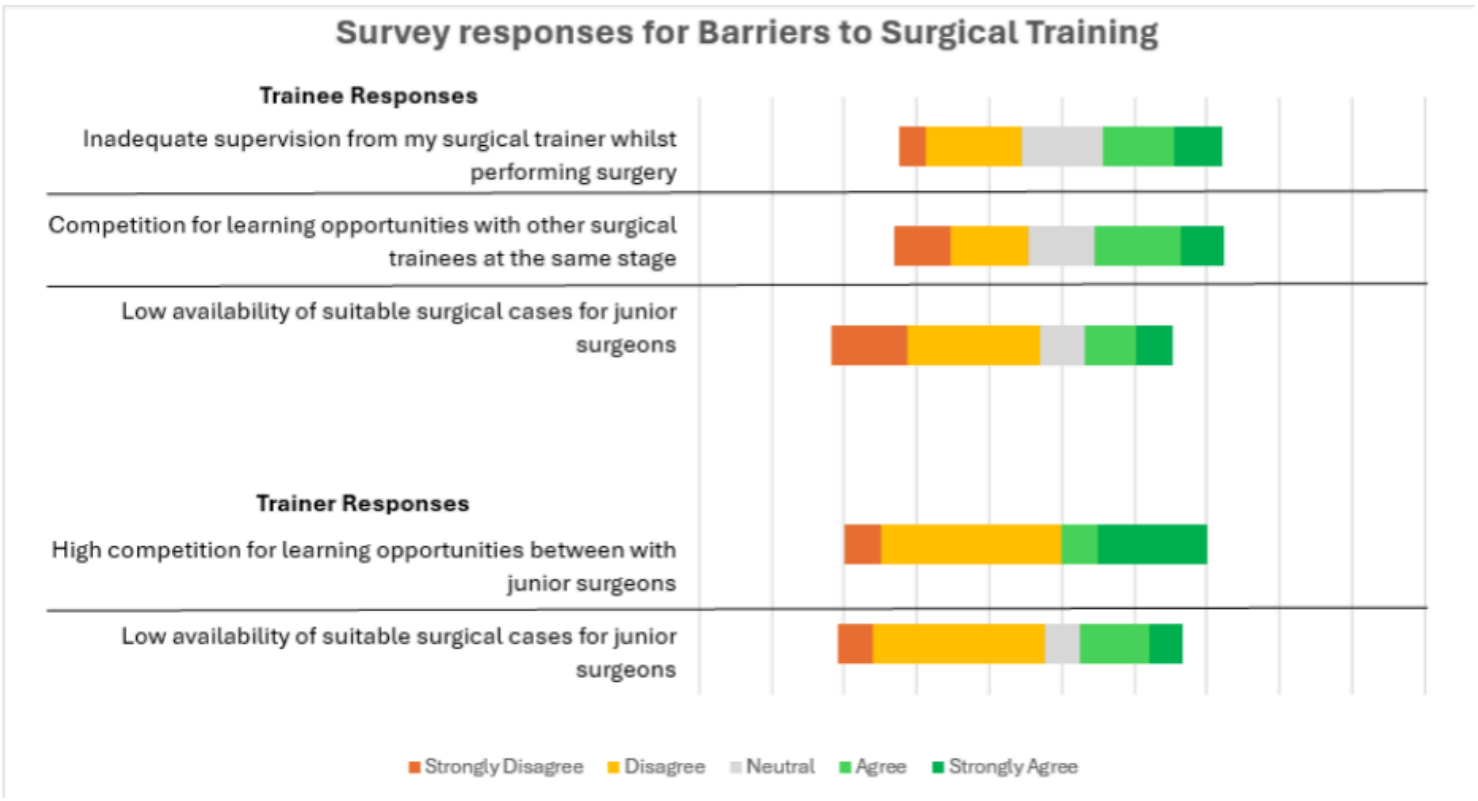


Figure 3

Figure 4: Survey respondents' opinions on known barriers to surgical training in SSA. All trainer respondents are SSA based. There was variation in agreement of the presence of barriers to surgical training.

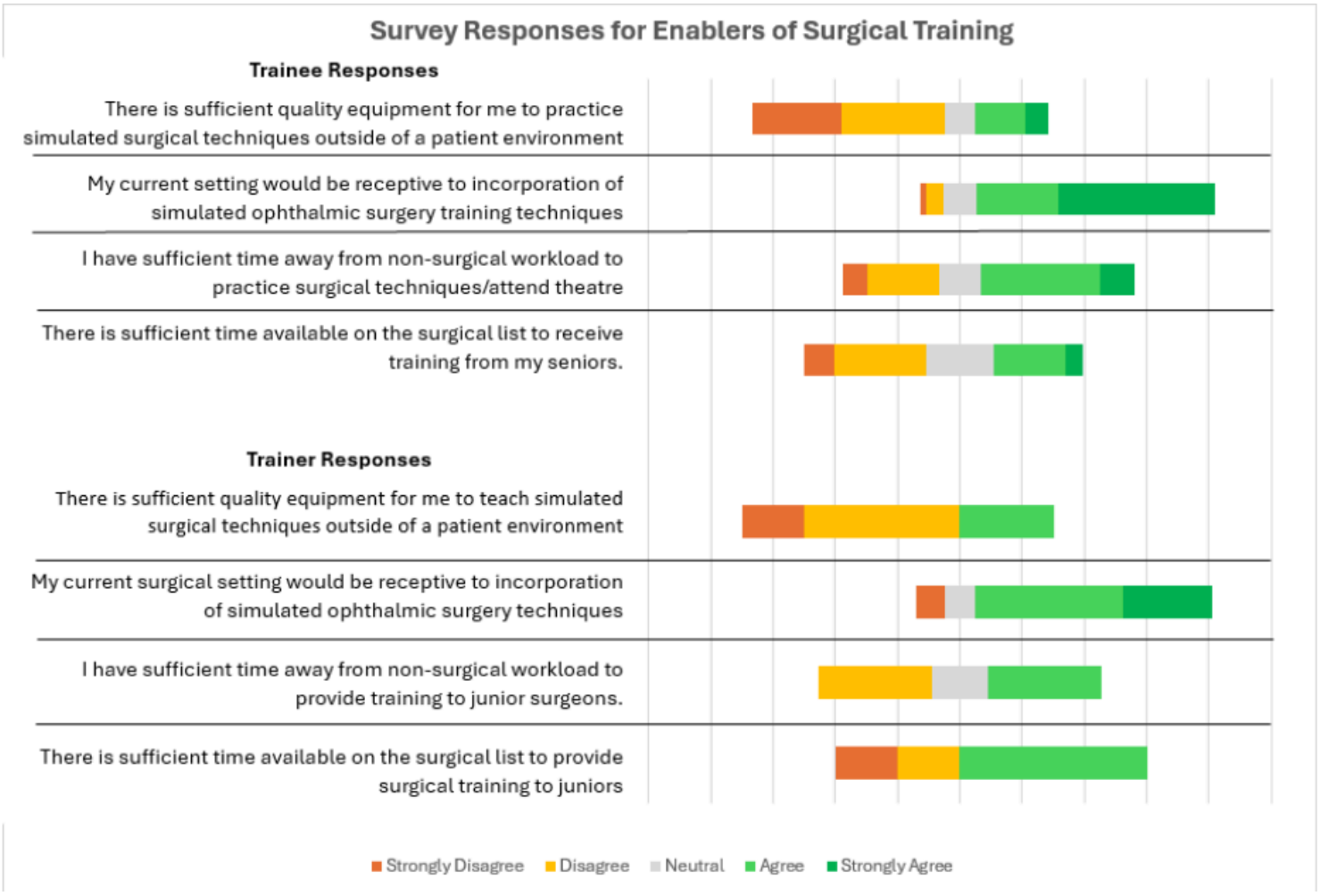


Figure 4

Figure 5: Survey respondents' opinions on known enablers of surgical training in SSA. All trainer respondents are SSA based. Both trainees and trainers agreed their setting would be receptive to simulated ophthalmic surgery training.