RESEARCH ARTICLE

The Effectiveness and Challenges of E-learning in Surgical Training in Low- and Middle-Income Countries: A Systematic Review

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ABSTRACT

E-learning encompasses the use of electronic media, online tools, and technologies in education and has been shown to be generally effective and satisfying for students, compared to traditional methods such as didactic lectures. Within surgical education, there is growing demand for e-learning platforms in low- and middle-income countries (LMICs). A systematic review was conducted to evaluate the effectiveness and challenges of e-learning for surgical trainees in LMICs. Out of 87 studies, five studies met the inclusion criteria and reported either neutral or positive improvements in cognitive and procedural skills, compared to baselines or controls for surgical trainees in LMICs. Using a qualitative synthesis approach, the researchers identified common challenges and barriers, such as low bandwidth, limited connectivity, and poor surgical details, which led to poor knowledge synthesis. This suggests that more emphasis needs to be placed on developing a strong online foundation that could be easily accessed and is user-friendly and intuitive, especially in LMICs. However, the research was limited by the lack of literature surrounding surgical e-learning interventions in LMICs and more research is required in this area.

INTRODUCTION

E-learning represents learning facilitated by electronic technologies and involves accessing an educational curriculum outside of a traditional classroom, often in the form of interactive multimedia, audiovisual clips, and virtual models [1]. Current literature suggests that e-learning broadly encompasses a variety of teaching methods, such as virtual patient cases, online tutorials, and blended-learning styles that combine traditional didactic lectures with online components [2].

A major challenge within low-resource settings and low- and middle- income countries (LMICs) is that it is very difficult to increase the number of medical trainees, while preserving the quality of their training [3]. Often, this is due to the shortage of faculty in most medical schools in LMICs [4]. However, e-learning provides the opportunity to greatly improve the learning environment by teaching key concepts through readily available online resources and improving the medical faculty's availability. Of all LMICs, Brazil, Egypt, India, and South Africa have published the most articles on e-learning in medical education [5]. However, it is currently unclear whether surgical education provided through e-learning is effective in LMICs.

This systematic review aims to evaluate the effectiveness of e-learning for surgical trainees in LMICs by identifying changes in cognitive and psychomotor skills from baseline values such as traditional test scores and control groups without e-

learning interventions. This review will also describe the challenges and barriers that were encountered with using various e-learning interventions to gain a better understanding of the possible recommendations moving forward.

METHODOLOGY

Using the search terms 'global surgery' and 'e-learning', we searched for clinical studies in PubMed without restrictions from inception to July 2019, yielding 22 articles. Additionally, the reference lists of systematic reviews of e-learning interventions was also searched for surgical e-learning interventions in LMICs [3,5]. In total, 87 unique studies were identified (22 from PubMed and 65 from reference lists). Articles were included if: (i) they evaluated a surgical e-learning intervention, (ii) they were conducted in a LMIC as defined by the 2020 World Bank Data; (iii) study designs were experimental or observational (e.g. case-control, cohort, survey); and (iv) they reported clear outcomes.

Articles were excluded if: (i) they did not meet any of the four inclusion criteria; (ii) they were not primary literature; and (iii) they were not in English. 10 articles underwent a full review, and 5 articles met inclusion criteria. A PRISMA flowchart is available upon request.

Abstract screening and data extraction were conducted, and all outcomes and interventions were documented from included articles with respect to the following domains: country of study, participants, topic, type of e-learning intervention, psychomotor skills, cognitive skills, non-technical skills, challenges, and overall evaluations. Risk of bias (ROS) was conducted using the Newcastle–Ottawa Scale (NOS). The ROS is available upon request.

RESULTS

From 87 unique studies, 56 studies were not primary literature, 1 was not in English, 12 were not conducted in LMICs, and 8 studies did not involve surgical e-learning, leaving 5 studies for inclusion, summarized in Table 1 [6-10]. Using the NOS for ROS, the 5 studies had total scores ranging from 5-8,

with 2 studies being fair quality and 3 studies behind good quality. E-learning interventions include online modules with animations, video-conferencing of rounds, a web-based online course, the School of Surgeons educational website, and a blended-learning course [6-10]. All 5 studies demonstrated an improvement in cognitive skills after surgical e-learning and rated the e-learning intervention positively. Two studies utilized control groups with traditional learning interventions and compared it to e-learning interventions [7,8]. Mars found that there was no quantitative difference for knowledge acquisition between e-learning versus traditional learning, as measured by test scores [7]. Corrêa et al. found that students preferred teacher/traditional learning styles by a small margin as they were rated 10/10 compared to computer interventions of 9.5/10 [8].

For psychomotor skills, only 2 studies reported students' perceptions [6,8]. Adanu et al. indicated that all students agreed the e-learning intervention improved their procedural skills; however, another study by Corrêa et al. found that students preferred teacher/traditional learning styles for explaining surgical manipulation, eliminating doubts, and correcting the surgical manual practice after exposure to both types of interventions [6,8].

Among all 5 articles, non-technical skills such as communication, situation awareness, decision-making, teamwork, and leadership were not tested or reported. There were similar challenges and barriers involved with the e-learning interventions: electronic media could not be played on some computers, costs of good bandwidth were very high and prohibitive, slow Internet connection speed led to lag time and decreased visual quality of videos and slides, absence of teachers/mentors, and absence of details in surgical techniques [6-10].

DISCUSSION

Overall, these 5 studies showed similar cognitive improvements compared to the surgical e-learning interventions conducted in high-income countries identified by Jayakumar et al [3]. There was a comparable trend of improved test scores,

Table 1. Summary of e-learning surgical interventions in low- and middle-income countries (LMICs).

Author	Country	Participants	Topic	Type of e-learning	Cognitive Skills	Psychomotor Skills	Challenges	Overall evaluation
Adanu et al., 2010.	Ghana	153 third year medical students	Surgery (abdominal hysterectomy)	Modules with interactive text, videos, lectures, photos, and animations.	87% reported that e-learning animations was the most important aspect to understanding the content.	All students reported improvement compared to traditional skills alone.	Some electronic media could not be played on computers.	95% of students reported having access to a computer. 100% of students indicated that the e-learning program was "more effective" than other methods of learning.
Mars, 2012.	South Africa	68 surgical students	General surgery	Videoconferencing of rounds.	83% of participants rated videoconferencing highly as a learning tool.	N/A	Lag time, low video quality, low bandwidth.	No difference found for knowledge acquisition between e-learning versus traditional learning, measured by test scores.
Corrêa et al., 2003.	Brazil	22 undergraduate dental students	Oral surgery	Web-based course in a multimedia lab.	TV and computer were rated an average score of 8.7 and 9.5 out of 10 respectively. Teachers were rated an average score of 10/10.	Students preferred teacher/traditional learning styles for explaining surgical manipulation.	Low video quality, absence of surgical technique details, inadequate content sequence.	Psychomotor skills such as performing surgical manual practice was rated 10-20% higher for teacher-based intervention compared to computer and TV intervention.
Goldstein et al., 2014.	12 countries in Africa and Asia.	75 surgical trainees/attendings	Surgery	Full online access to SCORE and School for Surgeons websites.	63% of participants rated the content as relevant. 74% would use the content for an assigned reading for trainees.	N/A	Slow internet connection, no access to computer.	85% of participants believed the content helped prepare for a surgical case and upcoming lectures.
Vaca et al., 2018.	Tanzania	30 clinicians	Ponseti method	Blended learning with a hands-on skills workshop.	Scores improved from 44 to 69.8 from pre-test to post-test.	N/A	Low bandwidth, low quality.	100% responded that they would be comfortable with future e-learning trainings.

[a]LMIC, low-middle income country; N/A, not available; SCORE, Surgical Council on Resident Education; COSECSA, College of Surgeons of East, Central and Southern Africa.

measured by an increase from pre-test to post-test scores or from baseline traditional learning scores. In a few instances, there was no significant improvement in test scores between the e-learning and traditional learning groups, suggesting that e-learning interventions were mostly either neutral or positive with respect to learning acquisition and retention [7].

However, the most similar outcomes were the positive reception and feedback to the e-learning interventions. Almost all participants reported that they enjoyed using the e-learning intervention and would recommend using it for other studies or recommend it to their colleagues [6-10]. They also believed the content helped them for upcoming lectures, surgical cases, and discussions with colleagues. Moreover, the e-learning programs were typically easier to access and could be replayed for enhanced understanding and retention.

Interestingly, while the surgical e-learning interventions were viewed almost entirely positively

in the systematic review of surgical e-learning interventions in high-income countries by Jayakumar et al., the participants from LMICs reported several challenges. This suggests that while e-learning is a very useful resource and can provide similar or higher levels of knowledge and retention on surgical topics, care must be met in ensuring that students have high connectivity to the Internet and video resources [2].

With respect to procedural skills, all medical students in the study by Adanu et al., agreed that the e-learning intervention improved their understanding of the procedural skills [6]. However, in the study conducted by Corrêa et al, students preferred traditional teacher-based learning styles for "surgical manipulation" and "eliminating doubts" [8]. While e-learning could supplement some learning aspects of surgical procedures, direct observership is still required for conducting procedures. This could explain why blended-earning approaches are one of the most popular interventions as they combine learning facilitated

by e-learning modules with hands-on workshops [5]. With respect to non-technical skills such as communication, collaboration, or teamwork, there was no available data found. This could be due to the difficulty in measuring and directly evaluating these non-technical skills [1]. While a common concern is that e-learning programs can lead to a lack of face time, professional isolation, decreased learning experiences, and fewer soft skills being developed, this still needs to be evaluated further [4]. Overall, the strength of evidence of this study is moderate as the ROS was low, but more studies are required. Limitations include lack of studies, particularly ones that examine non-technical skills, and trainee differences in experiences and expertise with using e-learning interventions.

CONCLUSION

In this review, only 5 studies were found which evaluated the effectiveness of e-learning in surgical disciplines for trainees in LMICs. E-learning interventions reported neutral to positive test-scores and student satisfactions, but there were several challenges highlighted by technical issues such as low bandwidth, lack of connectivity, and poor IT resources. This suggests that more emphasis needs to be placed on developing a strong online foundation that could be easily accessed and is user-friendly and intuitive, especially in LMICs. With the high demand of healthcare workers and qualified medical educators in low-resource settings [3,4], E-learning can act as a tool to increase both the quality and quantity of medical and surgical educational programs. However, to do so requires in-depth stakeholder discussions and the development of an educational framework to ensure that these e-learning programs are sustainable and can be implemented into health systems. Our study identified that surgical e-learning interventions must have supporting IT resources in order to be effective, and when available, improves cognitive skills and is rated positively compared to traditional methods. Furthermore, blended-learning approaches may also be effective and should continue to be explored, as a means of combining lonline modules and hands-on workshops to augment psychomotor skills.

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