Virtual learning in global surgery: current strategies and adaptation for the COVID-19 pandemic

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Abstract
Modern surgical education has shifted to include technology as an integral component of training programs. The onset of the COVID-19 pandemic highlights the need to identify currently training modalities in global surgery and to delineate how these can be best used given the shift of global surgical training to the virtual setting. Here, we conducted a rapid review of the MEDLINE database examining the current status of training modalities in global surgical training programs and presented a case study of a virtual learning course on providing safe surgical care in the time of a pandemic. Our rapid review identified 285 publications, of which 101 were included in our analysis. Most articles describe training in high income country environments (87%, 88/101). The principal training modality described is apprenticeship (46%, 46/101), followed by simulation training (37%, 37/101), and virtual learning strategies (14%, 14/101). Our focused case study describes a virtual course entitled “Safe Surgical Care: Strategies During Pandemics,” created at the University of British Columbia by E.J., published 1-month postdeclaration of the pandemic. This multimodal course was rolled-out over a 5-week period and had significant engagement on an international level, with 1944 participants from 105 countries. With in-person training decreased as a result of the pandemic, virtual reality, virtual simulation, and telementoring may serve to bridge this gap. We propose that virtual learning strategies be integrated into global surgical training through the pursuit of increased accessibility, incorporation of telementoring, and inclusion in national health policy.

Keywords: Global surgery, Virtual learning, Surgical education, Telementoring, Surgical preparedness, Pandemic, COVID-19

Surgical education has changed significantly over time, with new technologies and assessment methods arising through broad training modalities. Specifically, both undergraduate and postgraduate surgical training have experienced shifts from didactic classroom-based teaching alone, to educational programs comprised of lectures, simulation, online conferences, online modules, and other technology-based methods[1-4]. The integration of these novel training approaches applies not only to technical skills acquisition, but also broadly in a holistic approach to teaching. This approach encompasses the 3 main educational pillars of skills, knowledge, and attitudes, with the hopes of improving transfer of content and skills learned in nontraditional learning environments back into the clinical setting[5].

The COVID-19 pandemic has restricted in-person international training opportunities in an unprecedented way in both high and low-middle income countries. As medical training for all levels of learners rapidly shifts to online modalities, one must consider mechanisms for international education programming, through cross-institutional local and international partnerships to offer ongoing surgical curricula in remote or low-resource settings. Virtual learning is already a significant component of medical education in low and middle-income countries (LMICs), with online resources serving as a successful means of improving accessibility for trainees and in supporting teaching faculty[6]. At present, online learning in LMICs is used in an integrated approach together with in-person training, in addition to online simulation and mentorship components[6]. Unfortunately, due to the COVID-19 pandemic, the latter is no longer possible, leaving surgical training programs (STP) in LMIC in many ways unsupported. Better utilization of virtual learning, and virtual or simulation-based training tools may allow the global surgical community to continue to work on increasing large-scale surgical capacity, as reflected in the Lancet Commission’s 2030 Global Surgery goals[7].

If we are to capitalize on the exponential growth of technological and educational innovations in surgical training for continuing global surgical education, it is critical to establish an understanding of the current status of global STP. This perspective piece aims to review current training modalities utilized in global surgery and proposes important considerations for how global surgical training needs to be modified and shifted to a virtual setting during the...
current COVID-19 conditions, where in-person educational opportunities are limited. As a specific case example, we describe the development, implementation, and implications of a virtual learning course offered globally by the University of British Columbia (UBC), focusing on the delivery of safe surgical care during the time of a global pandemic.

Learning strategies in surgery

We conducted a rapid literature review to determine the current status of surgical training modalities utilized specifically in LMICs[8]. We searched the MEDLINE database using the following key terms representing a variety of training types: didactic, apprenticeship, virtual learning, simulation training and virtual reality (see Appendix A, Supplemental Digital Content 1, http://links.lww.com/JSGH/A8 for search strategies and flow diagram).

The definitions used for the learning strategies are outlined in Table 1[9–14]. For the purposes of this review, the term Virtual Learning Strategy(ies) (VLS) will be used for all platforms that are virtual learning or web-based learning.

Our search identified 285 unique publications, of which 101 were included in our final analysis[1–4,13–110]. The majority of articles describe training in high income country (HIC) environments (87%, 88/101), for which the most common settings are North America (United States 45% and Canada 12%) and the United Kingdom (18%). The LMICs represented are West Africa region (2%) and several East African countries (Kenya 2%; Ethiopia 2%; Zambia 2%, and Tanzania 2%). The principal training modality utilized is apprenticeship (46%, 46/101), followed by simulation training (37%, 37/101), and VLS (14%, 14/101). For the 10 papers describing blended learning formats (ie, using more than 1 training method), the predominant learning method was used for descriptive analysis. Figure 1 shows training types by publication setting (LMIC vs. HIC) and Table 2 provides an example of each type of learning in the context of global surgery. Most publications discuss surgical education of trainees (96%, 97/101) while very few (8%, 8/101) discuss fully trained surgical staff (ie, professionals) as the target learners. The continuing professional development programs mentioned in these 8 publications were established primarily through North-South partnerships with surgeons from HIC visiting LMIC institutions for clinical rotations, surgical camps, or other in-person training. While apprenticeship remains an integral component of modern-day surgical training, this review demonstrates that more novel training models, specifically simulation training and VLS, are becoming more common within the global educational environment.

Effects of COVID-19 on global surgical training

The COVID-19 pandemic has changed the way we provide surgical training, particularly affecting regions of the world where training programs rely heavily on out-of-country specialists. While North American trainees were briefly pulled out of clinical rotations to minimize coronavirus exposure, most programs were

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**Table 1**

**Learning strategies defined.**

| Learning Strategy | Definition |
|-------------------|------------|
| Apprenticeship    | The process of learning a craft under the direct supervision of a skilled expert in that field[9] |
| Didactic method   | The provision of direct information from the expert to the learner. Can be in-person or virtual[10] |
| Simulation-based learning | The immersion of the learner in a replicated scenario to assess their knowledge, skills, communication and performance[11] |
| Virtual Learning (VLS) | The process of learning knowledge and/or skills through an online platform. Can be synchronous (virtual simulation with live debriefing, virtual classroom with live discussion) or asynchronous (online course). This includes online course management systems or sites (eg, Canvas, course Wikis, websites, podcasts, social media), and discussion boards (eg, Piazza)[12] Also referred to as e-learning, web-based learning[13] |
| Virtual reality    | The learner is placed in an environment created digitally to reproduce a certain situation (ie: a surgical procedure)[14] |

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**Figure 1.** Training methods identified in publications from 2010 to 2020. HIC indicates high-income countries; LMIC, low and middle-income countries.
This was not the case in many LMIC training programs, especially those interrupted in April 2020 because of the impossibility for foreign surgeons to travel to Africa. As an example, the CapaCare-supported STP in Sierra Leone had to be completely virtual. In this prospective cohort study, surgical clerkship students in Stanford, California, partook in a flipped-classroom learning environment over a 1-year period. Students completed 8 modules online and then practiced skills in simulation sessions. Students reported a positive learning experience with this type of learning.

Bridging the gap in knowledge through virtual learning

Even more so than Ebola, the COVID-19 pandemic has highlighted the fact that there are no physical barriers to knowledge. All countries have experienced and all have needed to respond appropriately to preserve delivery of surgical care, no matter what resources they had. As public health measures ramped up, and information started to circulate about the epidemiology and pathophysiology of this new viral disease, there was a clear lack of guidance from international and professional organizations on how to protect surgical staff and maintain surgical services. In this era of enhanced technology, where most of the world has access to an internet connection and a smartphone, information transmission can transcend national borders. In British Columbia, Canada, a rapid and efficient response led by our public health office led to an early control of the viral transmission and avoided the peak seen in other regions. However, many of our colleagues in other countries did not have that luck and were dreading the potential devastating impact of this viral pandemic on their practice. The global surgical community was looking for answers.

At UBC, on April 28, 1-month postdeclaration of the global pandemic, a multidisciplinary team created a virtual course called “Safe Surgical Care: Strategies During Pandemics,” geared toward surgical providers from all disciplines and with the aim to arm them with tools to better respond to the pandemic. This course was our response to bridge the knowledge gap between affected and unaffected countries, and between well-prepared and less well-prepared surgical systems. Our aim was to share the knowledge acquired from the early experience with COVID-19, especially since the pandemic disproportionally hit the middle-high income countries, such as China, Italy, and the United States, before it spread to the low-income countries.

| Training Type | References | Description of Program/Findings |
|---------------|------------|---------------------------------|
| Apprenticeship | Pollock et al.[103] | The Pan-African Academy of Christian Surgeons (PAACS) was established in 1997 to increase surgical capacity, through developing a formal surgical residency training program in Kenya, Ethiopia, Gabon, and Cameroon. The program is developed using principles of competency based medical education, and is primarily apprenticeship-based. This program has successfully graduated 18 general surgeons and 1 pediatric surgeon working in Sierra Leone, and subsequently disseminated through the Virtual reality Wohaibi et al.[104] |
| Didactic | Liebert et al.[74] | In this prospective cohort study, surgical clerkship students in Stanford, California, partook in a flipped-classroom learning environment over a 1-year period. Students completed 8 modules online and then practiced skills in simulation sessions. Students reported a positive learning experience with this type of learning. |
| Simulation | Dreyer et al.[79] | A 5-day emergency surgical skills simulation (including crisis resource management and technical skills such as burr holes) developed by COSECSA for surgical trainees in Zambia. Six-month follow-up survey showed a perceived increased comfort in managing surgical emergencies by trainees. |
| VLS | Goldstein et al.[74] | The School for Surgeons online platform, developed by the College of Surgeons of East, Central, and Southern Africa (COSECSA) in collaboration with the Royal College of Surgeons of Ireland, includes evidence-based reviews, modules with self-assessments, basic surgical skills training and case-based discussions. A user survey indicated positive uptake and experience in using the platform. |
| Virtual reality | Wohabi et al.[104] | A virtual reality trainer for laparoscopic cholecystectomy and appendectomy in the United States was shown to improve intraoperative performance in residents who used it for 6 mo. |

VLS indicates Virtual Learning Strategies.

The course was created by E.J., in collaboration with UBC Continuing Professional Development (UBC CPD) and UBC Extended Learning (UBC ExL) and hosted on the EdX platform. It showcased the work of key players in the pandemic response, including, but not limited to, surgeons from different specialties, anesthesiologists, emergency and operating room nurses and microbiologists. The course offered a blended learning experience. The didactic content was presented in four different modules rolled out over 5 weeks (Table 3). Each module had clear objectives that were delineated at the beginning and at the end of the module, as well as summarized in a recorded lecture. We combed the data from the most recent literature to provide content that was as evidence-based as possible and illustrated it with examples from high- and low-resource settings. We created a series of podcasts and videos to bridge the gap in knowledge through virtual learning.

| Module Title and launch date. |
|-----------------------------|
| Week | Module Title | Launch Date |
| 1 | What a Surgical Provider Should Know about Pandemics | April 28 |
| 2 | Surgical Surge Response for Pandemics | May 5 |
| 3 | Protection of Surgical Healthcare Worker | May 12 |
| 4 | Defining and Maintaining Essential Services | May 19 |
| 5 | Global Impact and Ethical Considerations | May 26 |
videos explaining key procedures, such as the donning and doffing process. Podcasts with experts were recorded weekly and transcribed for the learners. The content was made as visual and multimodal as possible, so as to appeal to the audience and be easy to read (Fig. 2). Each module had a discussion board where participants could share their experience and interact asynchronously with the course authors and invited experts. After the 5 weeks of the course were completed, we created an “Ask Me Anything” section, where a dedicated surgeon was chosen to moderate the discussion forum for a 7-day period, which allowed us to prolong our direct interaction with learners. Self-assessment was available through a quiz after each module, providing immediate and direct feedback to learners. For physicians, continuing medical education credits (CME) were offered.

Global reach
As of September 28, 1944 participants had registered for the course. These participants were from 105 countries, from all continents and all regions: there are currently 105 learners from India, 39 from Brazil and 25 from Nigeria (Fig. 3). The demographic characteristics are presented in Figure 4. Most uptake occurred in the first 2 weeks of the course, with the curve flattening over the remaining weeks (Fig. 5). The most engagement with the course was seen on the week of May 3, with over 400 active learners and 54 participating in discussion posts (Fig. 6). The feedback received for the course was overwhelmingly positive, especially on the quality of the content and its interactivity and variety. This course empowered learners, “It has improved staff morale to share what I have learned with the rest of the team [...]” increased knowledge “[...] this course has given me new material to incorporate into my practice.” and inspired leadership in surgical care providers: “I will be able to plan the protocol for surgical processes in our institute.” Furthermore, it created a community of learning from diverse settings and created mutual accountability among users: “Invited one of my colleagues to attend this course. So we are both determined to make the necessary changes in our power to help deliver health services in a safer way for both our team and patients.”

Opportunities, challenges, and a vision for the future
Challenges
Virtual platforms face several challenges. First, they require sufficient internet connectivity and bandwidth to support interactive materials, such as downloads, videos and live streaming[115]. Unfortunately, this is not the case in most low-income countries: in 2018, only 24% of sub-Saharan Africa was connected[116]. Today, in Nigeria, 118 million do not have access to the internet[117]. In addition, virtual platforms are often costly to create, and therefore likely to require a subscription or one-time fee for use. As of August 2020, 15/20 computer-based platforms are freely accessible, but 5 of them—and the ones that are the most relevant and high quality—are not[16]. The most well-known, Incision, costs 23.99 euros/month[118]. Freely accessible platforms are oftentimes of variable quality, are not peer reviewed, and may contain industry bias. More recently, the first of a series of papers addressing the risks and opportunities of a transition to VLS has been published in Rural and Remote Health[119]. Encompassing medical education at large, these
articles will provide a guide to navigating the obstacles brought by this growing technology.

**Opportunities**

While the benefits and positive outcomes from the inclusion of VLS in surgical training are clear, it is important to consider that most are implemented in conjunction with subsequent practice and skill refinement under close supervision, during clinical rotations and in everyday patient care. Fortunately, there is a growing number of VLS modalities that offer alternatives to this classic form of apprenticeship. In addition to interactive didactic platforms, such as the reverse classroom concept brought by the ATLS hybrid edition, directed feedback can be given virtually and could potentially replace classic apprenticeship in the near future\(^{[120]}\). Specifically, telementoring and telecoaching may offer largely equivalent benefits of apprenticeship, with in person experiences being used more as a complimentary adjunct. Over the past few years, the surgical educational community has developed an interest in the feasibility and efficacy of telementoring and telecoaching for surgeons with a number of studies exploring this concept in both local and international settings\(^{[121,122]}\). Telementoring specifically, is defined by a relationship, facilitated by telecommunication technology, in which an expert (mentor) provides guidance to a less experienced learner (mentee) from a remote location and as an educational strategy, provides a unique solution for ongoing advancement of quality surgical care during the COVID-19 pandemic\(^{[123]}\). Such educational support innovations are perfect at a time of restricted travel and face-to-face clinical mentorship, and should be pursued both now as a workaround, as well as moving forward as a bridge between direct interpersonal training opportunities such as: telementoring through complex cases (both preoperatively and intraoperatively), virtual discussions/MCCs, and technical skills training through video review and/or laparoscopic skills development\(^{[124]}\). The surgical community has already started in pieces to embrace such strategies. Examples include a training course developed for surgical staff in Brazil with remote mentoring via live video feed using Google Glass, a program for surgeons in Botswana using telesimulation and telementoring for laparoscopic training, and a virtual surgical simulation course for trainees in Zambia\(^{[55,79,124]}\). Potential issues of this approach, which require attention and careful planning, include potentially increased operative times in cases of directed OR telecoaching as well as challenges with mentor-mentee coordination across time zones\(^{[122,125]}\).

As another tool in our toolbox, virtual reality may serve as a unique modality to replace apprenticeship while conserving human resources. With its ability to place the learner in an immersive environment, close to that of a real patient interaction, virtual reality training has been shown to correlate to improved performance in the OR environment\(^{[104]}\). Since the literature on this topic is scarce, more research is needed to determine its place in surgical training globally.

Future development of surgical training programs, especially those where trainees are based in rural or remote regions, should take into careful consideration the utility of the aforementioned strategies of telementoring, telesimulation, virtual simulation, and virtual reality. The integration of these tools within the training curricula should be fluid and complement natural opportunities where face-to-face mentorship would be incorporated; for example, the surgical team participating in a virtual discussion preoperatively\(^{[124]}\). Conversely, when opportunities for in-person training arise, virtual sessions may be scheduled pre-emptively to allow trainees to build early techniques and then utilize face-to-face training for complex technical skill development.

**Vision for the future**

We propose a strategic plan to integrate VLS into surgical training globally, in a stepwise manner.

First, we would suggest surgical educators in HICs make the existing VLS globally accessible, capitalizing on the current rapid rate of educational program development. Surgical principles are universal, and therefore educational tools geared toward anatomy, basic surgical techniques, perioperative care etc. can be
Figure 4. Age and education of the 1944 learners as of September 28, 2020.

Figure 5. Enrollment activity of participants from the course launch date (April 28, 2020).
scaled from high to low resource settings and vice-versa. Virtual platforms such as the School for Surgeon in Africa contain a wide breadth of information and tools that can benefit both trainees and surgeons from all around the globe [126].

Second, we recommend that surgical educators across the globe integrate a telementoring component to all VLS platforms. One benefit of virtual platforms is the possibility of longitudinal engagement. Telementoring gives the learner the opportunity to receive direct feedback from experts in the field, allows for a productive and individualized mentor-mentee relationship and has potential for longitudinal follow-up and growth. It gives weight to the relationship and enriches the discussion. In fact, at UBC, a telementoring program between Revelstoke Queen Victoria Hospital and Vancouver General Hospital in trauma training has established a clear timeline of telementored simulations (q4 mo) to allow for both maintenance of competency and maintenance of the relationship [127].

Finally, VLS as a priority in establishing surgical capacity should be considered in ongoing national health policy. The second core indicator of the Lancet Commission is the SAO (Surgeon, Anesthesia and Obstetrics) provider density [7]. Effective and sustainable training programs are a cornerstone of this indicator. We have shown, through our review of the literature, relevant examples from LMICs and the success of the virtual pandemic course, that VLS strengthens surgical education and can also improve retention by offering continuing professional development. Hence, the integration of a strong VLS component in all surgical training programs should be one of the strategic objectives to increase the SAO density. By setting specific, measurable, attainable, relevant and time-bound targets for VLS, and keeping governments accountable for those targets, we are more likely to create effective and sustainable platforms. National governments and their ministries should ensure adequate information technology support and bandwidth, foster partnerships with professional organizations, humanitarian medical organizations and academic institutions and create an accessible virtual learning environment in the multidisciplinary surgical community. A first step was taken by Rwanda in their 2018–2024 National Surgical Obstetrics and Anesthesia Plan (NSOAP); under strategies for skills and knowledge retention, they mention “Societies will advocate for their providers to have access to online free resources to streamline CME efforts” [128]. HICs should also contribute to meeting these targets by providing infrastructure and creative funding solutions (ie, collaborative grants, revenue-generating online courses benefiting LMICs, etc.). The virtual Graduate program on Global Surgical Care at UBC as already begun this process: this not-for-profit program offers bursaries to applicants from LMICs thanks to cost recovery from tuition fees [129].

To be effective, like any other educational program, a VLS needs to have a clear needs assessment to ensure engagement of all stakeholders in surgical care delivery and ensure locally relevant content. Furthermore, virtual learning needs predefined objectives and a method to measure the intervention. Each VLS should be evaluated using a validated framework, to provide opportunity for improvement and, as Cameron stated in his chapter entitled E-learning in Global Surgery, the possibility of “reverse innovation.” [12,130]

**Conclusion**

While face-to-face apprenticeship remains a common and integral component of modern-day surgical training, this review demonstrates that more novel training models, specifically simulation training and VLS, are becoming commonplace within the educational environment. Especially in the case of VLS and telementoring, these strategies present the opportunity for building surgical capacity in rural and remote regions. Here, online delivery mitigates costs and resource restrictions associated with significant on-ground program infrastructural establishment and promotes trainee accessibility in an albeit more independent learning format.

The future of global surgical training resides in blended learning with a strong virtual learning component. While we do not have a clear idea of what the post-pandemic world will look like,
like, our hope is that those platforms continue to grow and become integral parts of global surgical education, both for the surgeon-in-training and for the trained surgeon looking for continuing professional development. As we adjust to new ways of surgical education, we call on the global surgical community to capitalize on this opportunity to continue to work to build strong virtual learning platforms that allow us to transcend physical boundaries.

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Author contribution

E.J. and I.Z. conceived the presented idea. I.Z. performed the rapid review and the analysis. E.J., I.Z. and F.S wrote the manuscript with input from all authors.

Conflict of interest disclosure

The authors declare that they have no financial conflict of interest with regard to the content of this report.

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