Teaching Ultrasound at the Point of Care in Times of Social Distancing

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ABSTRACT

Point-of-care ultrasound has become an integral aspect of critical care training. The Bedside Assessment by Sonography In Critical Care Medicine Curriculum was established at the University of Toronto to train critical care trainees in basic echocardiography and general critical care ultrasound. During the coronavirus disease (COVID-19) pandemic, our program needed to adapt quickly to ensure staff safety and adherence to infection-control protocols. In this article, we share our experience and reflect on the challenges and benefits of shifting from a primarily in-person teaching model to a hybrid model of remote and in-person teaching. Curricular changes were threefold: the transition to entirely web-based interactive didactic teaching and online imaging interpretation modules, the recruitment of sonographers at multiple academic sites as instructors to facilitate in-person practices with lower instructor to trainee ratio, and the use of a mobile application for informal group case-based discussions. Challenges included lost opportunities for scanning healthy volunteers, variability in attendance at online lectures, and a lower number of study submissions for review. However, curricular changes enabled maintenance of directly observed practice, high levels of engagement with recorded content, and an expansion of our reach to a global audience. We believe that future curricula should combine high-quality online curriculum and resources with the ongoing in-person delivery of key elements of curriculum to allow for direct observation and feedback as well as the maintenance of self-directed point-of-care ultrasound portfolios.

Keywords
critical care; ultrasound; medical education; virtual learning; curriculum design

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BACKGROUND

Point-of-care ultrasound (POCUS) is considered an essential component of critical care practice. International organizations recommend incorporating POCUS training into critical care medicine curricula (1, 2) and have developed frameworks to guide general ultrasound and echocardiography training in critical care (2, 3).

The coronavirus disease (COVID-19) pandemic has forced training programs to adapt their curricula to maintain learning opportunities despite pandemic restrictions. By describing our POCUS curriculum and its innovations before and during the pandemic, we hope to achieve two objectives: *1*) exemplify how the delivery of key curricular components can be adapted to address pandemic-related challenges and *2*) reflect on how these changes led to new opportunities and unexpected challenges that will need to be considered for ongoing curricular improvements.

OUTLINE OF BASIC PROGRAM DESIGN BEFORE THE PANDEMIC

At the University of Toronto, ultrasound training has been delivered to critical care medicine trainees since 2012. Over the past 10 years, our curriculum has been refined into two programs addressing complementary training needs: the Bedside Assessment by Sonography In Critical Care Medicine (BASIC; https://basiccriticalcareultrasound.org) and the advanced echocardiography training (Excellence in Critical Care Echocardiography leaders; http://www.echocardiography.ca). In this perspective, we focus on the former.

The BASIC curriculum is delivered by a group of sonographers and faculty from critical care, anesthesia, and cardiology. The curriculum was designed for critical care medicine residents, but it is also available to critical care international fellows and faculty. The program applies a standardized approach to POCUS that is based on the Indication, Acquisition, Interpretation, Medical Decision-making model (4). This framework provides a cognitive aid that supports the learning and performance of the key steps involved in the safe clinical use of POCUS. Published critical care ultrasound training consensus statements (2–7) and iterative feedback from trainees and faculty instructors have informed curricular content. The objectives of the BASIC curriculum are to teach the acquisition and interpretation of ultrasound images as well as integration of findings into the care of critically ill patients (4, 5). Trainees are expected to develop competencies in the acquisition and interpretation of basic critical care echocardiography; airway, lung, and diaphragmatic ultrasound; basic vascular and abdominal ultrasound, including focused assessment with sonography for trauma; and ultrasound for procedural guidance (2, 3, 6, 7).

Prior to the pandemic, our program followed the structure outlined in Figure 1A. Briefly, all teaching occurred at two of

Support to the Bedside Assessment by Sonography In Critical Care Medicine (BASIC) Curriculum was provided solely from institutional (St. Michael's Hospital) and departmental sources (Interdepartmental Division of Critical Care Medicine, University of Toronto, Toronto, ON, Canada).

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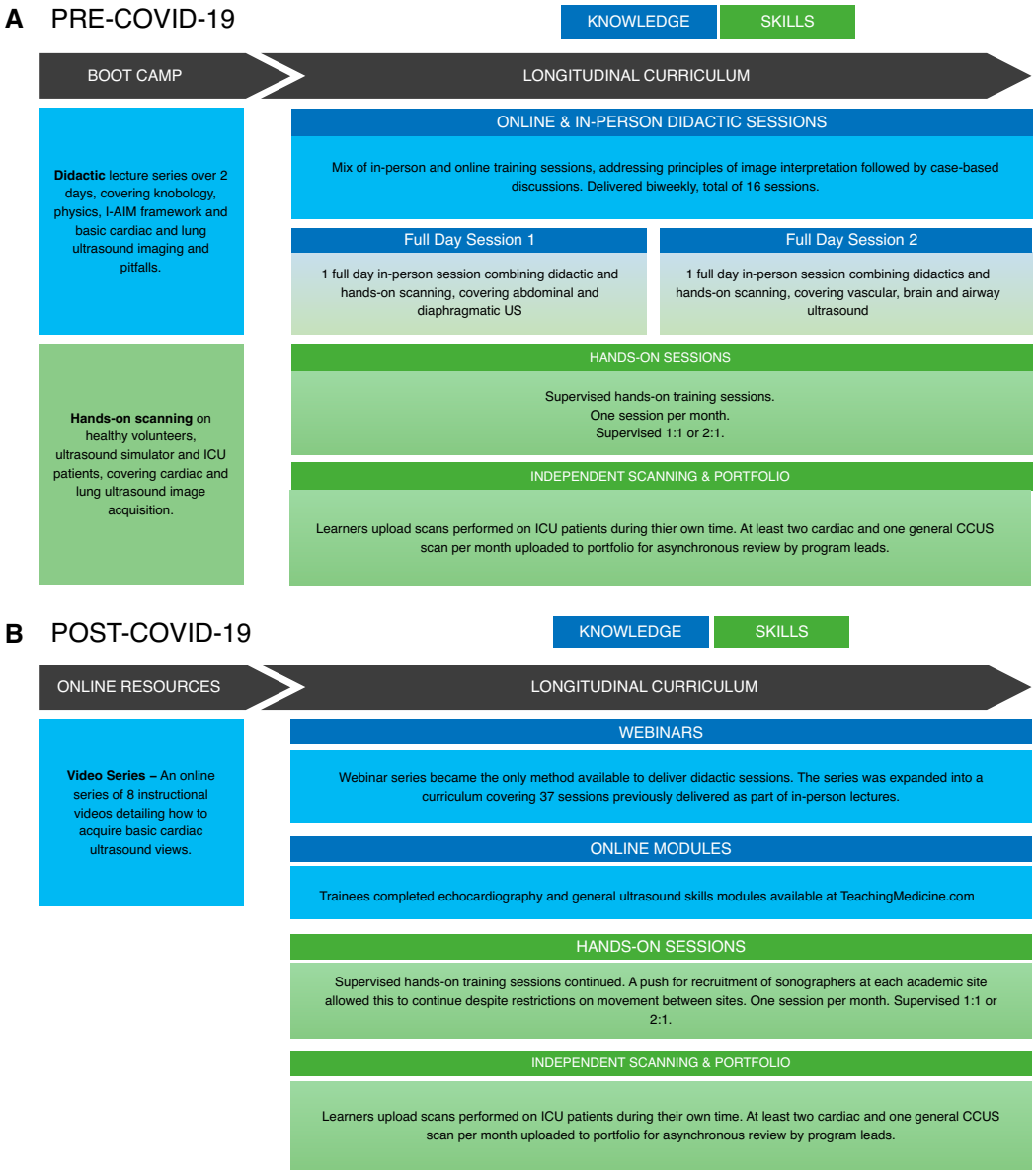

Figure 1. Outline of the Bedside Assessment by Sonography In Critical Care Medicine curriculum (*A*) before and (*B*) after the coronavirus disease (COVID-19) pandemic. I-AIM = Indication, Acquisition, Interpretation, Medical Decision-making; CCUS = critical care ultrasound; ICU = intensive care unit; US = ultrasound.

the five main University of Toronto teaching sites. Learners first participated in a 2-day in-person "bootcamp" that included didactic and hands-on components on a variety of core content. Over the 8 months following the introductory bootcamp, participants completed two additional full-day, hands-on training workshops and engaged in regular complementary didactic lectures and case-based learning sessions. These sessions were delivered either in person or through a virtual platform (Zoom Video Communications). Session recordings were also available on our website (https://www.basiccriticalcareultrasound.org) for asynchronous learning. Finally, trainees were encouraged to practice their ultrasound skills in two ways: *1*) during monthly in-person scanning sessions in the intensive

care unit with immediate instructor feedback and *2*) through independent scanning with asynchronous, remote review of scan recordings by an instructor who provided delayed feedback to the trainee. The assessment of trainees' competencies relied on approximately quarterly online in-training testing of image interpretation and ultrasound knowledge as well as a final summative in-person assessment that tested knowledge, acquisition and interpretation skills, and the ability to integrate ultrasound findings into clinical decision-making. This final summative assessment was voluntary and only offered to trainees who had completed a predetermined number of scans.

IMPACT OF THE PANDEMIC

The COVID-19 pandemic led to the implementation of significant curricular changes. First, the adoption of physical-distancing policies across institutions reduced the maximum number of trainees allowed at one bedside and forced the cancellation of the large-group in-person training sessions (in-person bootcamp, workshops, and final summative assessment). Second, restriction of movement between hospital sites prevented trainees and instructors from receiving and delivering training and supervision at various sites. Third, access to hospitalized patients for scanning was reduced by the frequent need for isolation of patients at risk of COVID-19 infection. Performing direct examination of isolated patients for educational purposes was actively discouraged during the pandemic to minimize disease transmission and nonessential use of personal protection equipment. Finally, the increase in the faculty clinical workload limited faculty ability to supervise scanning sessions in real time, to review learners' portfolio, and to conduct in-training and summative assessments.

PROGRAM CHANGES IN RESPONSE TO THE PANDEMIC

Most medical training programs have faced similar challenges and have responded to the pandemic by rapidly creating online content and by implementing remote teaching strategies (8). However, ultrasound training requires the acquisition of both cognitive and psychomotor skills, which highly benefit from in-person training. Although we aimed to optimize opportunities for POCUS training using existing web-based and remote learning strategies, we also wanted to maintain in-person practice. We believe the strategies we identified to achieve these goals may serve as a guide for other programs that strive to minimize training disruptions during the current pandemic and future constraining circumstances. Our curricular changes are outlined in Figure 1B.

Online Learning

Introductory educational videos. To replace large-group in-person training sessions (i.e., "bootcamp") on image acquisition, we implemented a series of instructional videos for critical care echocardiography demonstrating the two-dimensional echo sequence, optimization of the views, and common pitfalls in imaging (https://vimeo.com/showcase/7433649). Learners are expected, though not required, to review videos before the virtual webinars and in-person scanning sessions. These nine instructional videos were made freely available online and have been accessed 1,589 times by 569 unique viewers worldwide between August 1, 2020, and May 18, 2021 (Figure 2A).

Online TeachingMedicine.com modules. We also enrolled trainees in the echocardiography and general ultrasound skills modules available at TeachingMedicine.com (https://www.

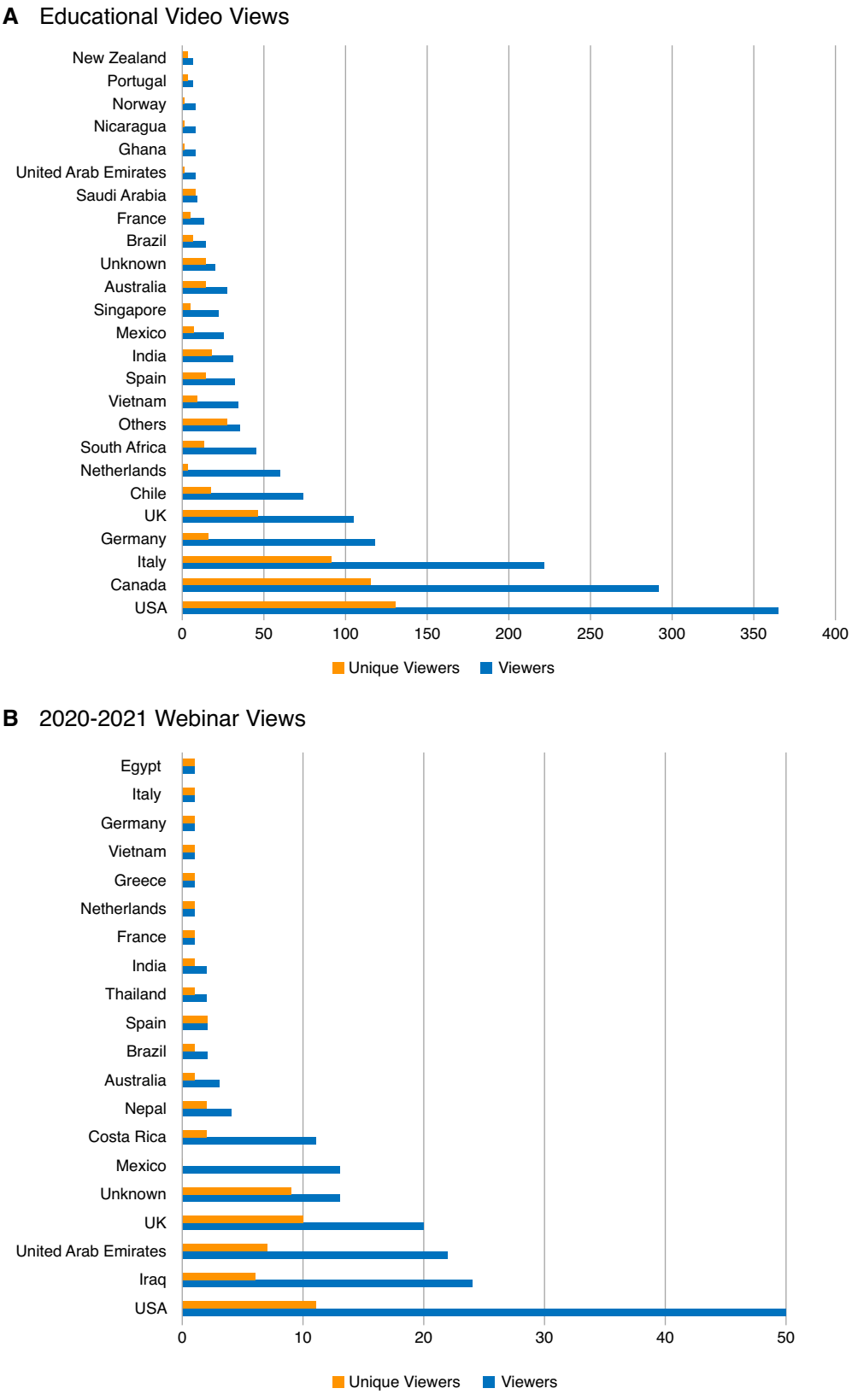

Figure 2. (*A*) "How to get the views" educational videos views by region. (*B*) The 2020–2021 webinars views by region (Canada excluded) between August 1, 2020, and May 18, 2021.

Table 1. Educational outcomes of the BASIC curriculum during the academic years 2019–2020 and 2020–2021

Educational Outcomes	2019–2020 (August 1, 2019, to June 30, 2020)	2020–2021 (August 1, 2020, to May 18, 2021)
Participants, *n*	15	23
Didactic sessions		
Online and in-person didactic sessions, *n*	10 (3 in person/7 webinars)	18 (18 webinars)
Live attendance to didactic sessions, median (IQR; min–max)	NA	15 (7; 7–35)
Webinars available online	16	23
Views/webinar, median (IQR; min–max)	3 (6.5; 0–17)	16 (15; 2–40)
Supervised scanning sessions		
Number of sessions, *n*	38	78
Sessions offered per participant	2.5	3.4
Sessions attended per participant, median (IQR; min–max)	4 (3; 0–8)	4 (4; 1–12)
Competency assessments		
Directly observed competency assessment forms, *n*	59	94
Directly observed completed competency assessment forms/ participant, median (IQR)	4 (2; 1–6)	4 (2; 2–8)
Self-directed portfolio		
Asynchronous review studies	135	27

Definition of abbreviations: BASIC = Bedside Assessment by Sonography In Critical Care Medicine; IQR = interquartile range; max = maximum; min = minimum; NA = not applicable.

teachingmedicine.com/). These interactive modules address image acquisition, sonoanatomy, and the integration of cardiac ultrasound in management of cases of shock. The modules combine opportunities for active learning and self-assessment. Trainees were expected to complete the eight modules within the first 6 months of the program; however, completion rates for these eight modules ranged between 30.4% and 43.5% (Table 1).

Webinars. Using the online system that we had implemented before COVID-19, we developed a series of webinars to replace all in-person didactic teaching. The webinar

series was expanded to include topics previously taught during in-person boot-camp and workshop sessions. During the webinars, learners can interact with the instructors and ask questions about difficult concepts and topics not covered in the core online material. Webinars are recorded for asynchronous learning, such as for trainees who were on call during the live sessions. Webinars have anecdotally resulted in increased attendance and allowed us to share our material with other groups within the University of Toronto and internationally (Figure 2B). This teaching modality also facilitates the participation of national and international ultrasound experts in our curriculum delivery.

Supervised Scanning

To overcome the limited mobility of trainees and instructors across sites and the decreased availability of physician–instructors, the University of Toronto Critical Care Medicine Division mobilized funding to enlist the help of one to two sonographers at our five main teaching sites to act as instructors for hands-on supervised scanning. Recently graduated critical care faculty with expertise in POCUS also volunteered to help with scanning supervision. To access supervised scanning, trainees book sessions through our central website. A minimum of one monthly session is recommended. After each scan, supervisors provide verbal feedback to the trainees and complete an electronic competency assessment form (*see* data supplement). The feedback form items were created using a competency-based approach (9) and implemented using Google Forms (Google, LLC). The increased number of instructors allowed us to offer more scanning sessions to our trainees. However, the median number of sessions attended per participant did not increase (four sessions per participant [interquartile range, 3; minimum–maximum, 0–8] in 2019–2020 and four sessions per participant [4; 1–12] in 2020–2021), suggesting that, although we were able to maintain in-person scanning opportunities, trainees did not take advantage of these opportunities (Table 1). Data

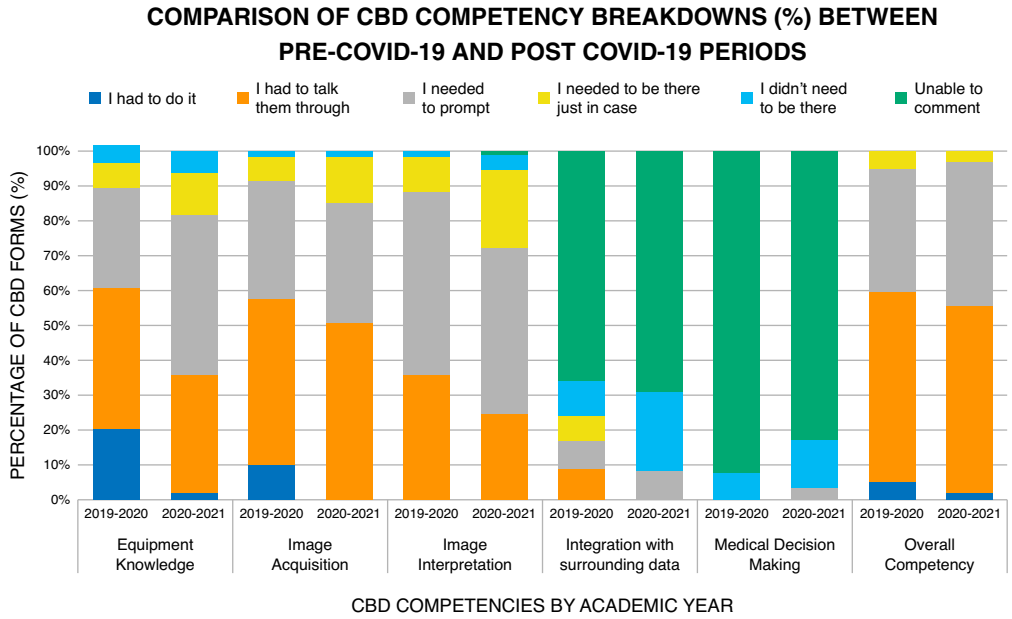

Figure 3. Competency assessments by academic year. CBD = Competence By Design; COVID-19 = coronavirus disease.

from the competency assessment forms suggest that no significant changes occurred in competency acquisition when compared with the prepandemic training (Figure 3).

Asynchronous Review

To achieve and maintain an adequate level of competency, ongoing deliberate supervised practice is required. Given time and resource constraints, many programs, including ours, have developed strategies to facilitate the asynchronous review by faculty of ultrasound images acquired by trainees. To avoid the challenges of working with different archiving systems across teaching sites, we have adopted two strategies: *1*) a centralized process to submit electronic "reporting forms" (data supplement) using Google Forms and *2*) the use of a free, secure, cloud-based ultrasound image sharing platform (www.sonoclipshare.com) where deidentified images can be uploaded. The reporting forms provide relevant clinical details required for interpretation of the scan, the learner's self-evaluation of the quality of the scan, and their clinical interpretation. Forms and images are uploaded by the trainee and reviewed by an instructor who provides feedback via SonoClipShare.

Assessment

During the pandemic, we had to cancel in-training online assessments and the final in-person summative assessment. Trainee assessment therefore currently mostly relies on review of competency assessment forms.

Electronic Messaging Group

Creating an electronic messaging group using the mobile application WhatsApp (Facebook, Inc.) was instrumental to the program's success. The messaging group was originally used as a tool for instructors to issue reminders about webinars and scanning sessions. However, it rapidly became a method of disseminating important resources such as guidelines, landmark trials, and online resources. Both instructors and trainees can share learning material and deidentified ultrasound clips for group discussions.

UNEXPECTED BENEFITS AND OPPORTUNITIES

Maintaining the delivery of a POCUS curriculum during the pandemic has resulted in two major benefits: *1*) increased access to training resources for existing trainees and *2*) extended reach of the program to new audiences. Learners in our program now have better access to our training resources. By moving our entire didactic curriculum online, we created a repository of lectures that residents can consult at their convenience. This change resulted in increased numbers of webinar attendees and asynchronous views. Enlisting the help of sonographers to assist with direct supervision also increased trainees' opportunities for onsite supervised practice (Table 1). In addition, learners from other programs and countries can now access our resources. Previous trainees, now working in distant locations, are also able to join our sessions (Figure 2B).

EXPECTED AND UNEXPECTED CHALLENGES

Cancellation of the Boot Camp and Summative Assessments

In-person teaching limitations led to the cancellation of bootcamp sessions, which provided dedicated time to learn core POCUS principles. The bootcamp also provided an opportunity to practice on healthy models. POCUS on critically ill patients is challenging, and the ability to distinguish between normal and abnormal ultrasound findings is an important skill to master. We believe that in-person

introductory sessions should remain a part of any POCUS curriculum. In the context of ongoing restrictions, these sessions may need to be delivered to smaller groups in conformity with social-distancing regulations. In addition, the cancellation of in-person summative assessments has translated into a greater reliance on the feedback forms completed during the in-person scanning sessions to assess trainee competencies. As these supervised scans were done for educational rather than clinical purposes, we have been unable to assess trainees' ability to integrate POCUS findings withing medical decision-making. Moving forward, we hope to implement some of the assessments in the workplace during regular clinical activities, therefore being able to assess competency and provide feedback on the integration of POCUS in the management of critically ill patients.

Administrative Burden and Logistics

Expanding the number of in-person scanning sessions required increased human and financial resources and administrative work. Before COVID-19, our faculty had used income from continuing medical education ultrasound teaching events to partially fund this course. As most external ultrasound courses got cancelled during COVID-19, this funding decreased dramatically, but the University stepped in to assist with financial support. Moreover, former BASIC curriculum trainees volunteered to teach new trainees. We envision a model in which senior trainees and sonographers provide a renewable pool of supervisors as our numbers of former trainees and new trained faculty increase. Although financial support remains an ongoing issue, the recognition of POCUS as a core critical care competency provides strong incentives for training programs to appropriately address this new educational need.

Self-Directed Portfolio

We found that trainee engagement with the personal portfolio during COVID-19 decreased significantly, with far fewer unsupervised scans submitted. Furthermore, the smaller number of unsupervised scans was not offset by an increase in supervised scan submissions despite expanding our supervision capacity (Table 1). Increased clinical workload, additional barriers to self-directed scanning because of infection control, and reduced interactions with the program leads who emphasize the importance of regular practice may explain reduced trainee engagement. In addition, our sites mostly lack the ability to store POCUS studies on integrated hospital reporting systems, creating another obstacle to portfolio creation. The pandemic has brought to the forefront some of the barriers hindering trainees' consistent engagement in building self-directed portfolios. Programs should aim to design systems to streamline and simplify this process.

Limitations of an Online Curriculum

The shift to an online curriculum presented distinct challenges. Although we know that remote learning can result in anxiety and digital fatigue (10), how to best address this problem is unclear. As a first step, there is a need to detect learners' fatigue by monitoring engagement, a task that presented its own challenges. Within our program, we can currently monitor completion of online modules via TeachingMedicine.com and live webinar attendance, but we cannot track engagement with asynchronous online resources outside the overall number of views (Figure 4). In addition, we were concerned about a loss of the sense of "community" among our trainees (11), traditionally established through participants' in-person interactions. We feel that webinars do not

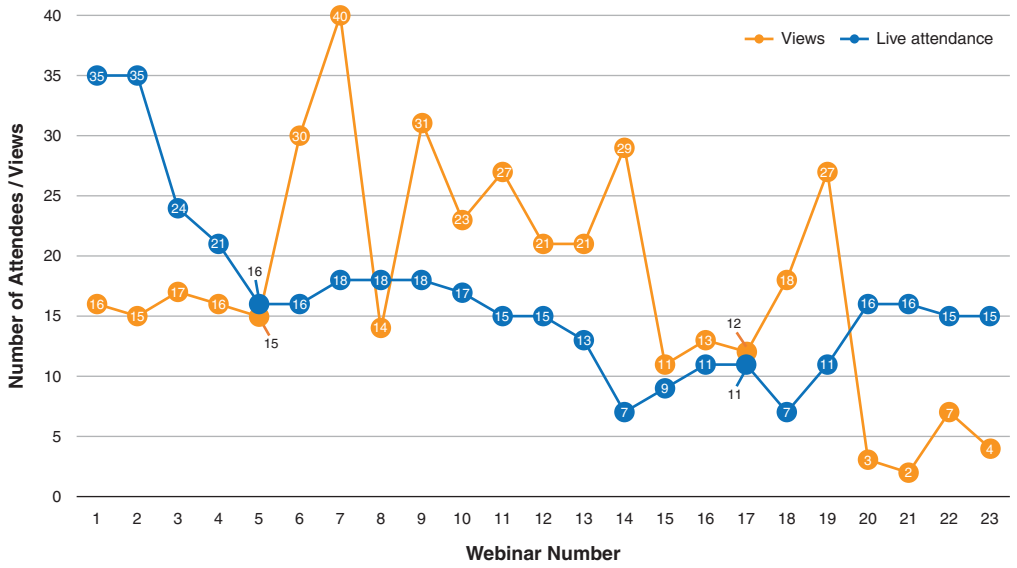

Figure 4. Comparison of webinar attendance versus recording views.

promote the same opportunities for relationship building as in-person meetings. Interestingly, the messaging group may have fostered community building. Furthermore, the reduced movement between sites has led to greater consistency in pairing between trainers and trainees. Longitudinal relationships with a given supervisor may limit a trainee's sense of isolation and facilitate individualized feedback tailored to the trainee's learning trajectory.

NEXT STEPS

To address the challenges outlined above, we plan to implement a new, improved iteration of our BASIC POCUS program. A study on student perspective found that the most valued aspects of remote education were the active learning components (12). Therefore, we are planning to adopt a learning management system to facilitate curriculum delivery and trainee monitoring: tracking webinar attendance and module completion, distributing online quiz and monitoring trainee progress over time, and issuing prompts for uncompleted required tasks. In addition, we hope to develop a "group supervision" model by which two to three trainees are assigned a single faculty supervisor who is responsible for reviewing the images acquired during self-directed scanning and for providing longitudinal feedback to each trainee. We hope that this small group model will contribute to the development of a sense of community and motivate trainees to complete their learning portfolio and to incorporate the management and decision-making aspects in their case review. In summary, we hope to offer a hybrid curriculum that utilizes technologies to reduce the burden of delivering an online curriculum, so that faculty can focus on high-quality in-person training. Trainees would have longitudinal and frequent access to the same faculty mentor for individualized and timely feedback. Finally, we hope to reestablish a formal assessment strategy that is informed by Competence By Design (CBD) and the Indication, Acquisition, Interpretation, Medical Decision-making frameworks. The supervised scanning sessions, portfolio, and online curriculum will aim to provide a greater degree of insight into the learning trajectories of our trainees.

CONCLUSION

The COVID-19 pandemic has compelled training programs to rapidly implement innovative solutions to maintain learning opportunities in an environment in which direct contacts with patients and between learners had to be limited. POCUS education is no different. We have modified our program with the goal to overcome many of these barriers and have learned key lessons in the process. First, we have found that online learning provides a fantastic opportunity for the sharing of resources. We developed our own resources but also utilized those developed by others. The wealth of online content has been invaluable during the pandemic, and we feel that programs should take greater advantage of existing resources. Furthermore, programs should aim to collaborate to create high-quality online resources that draw on expertise across institutions and to prevent parallel designing efforts. We also found that delivering an online curriculum can increase accessibility at the cost of intensive resource utilization. Educators need to seek out tools that can help them in this respect. Given our experience, we believe that POCUS training should continue to embrace hybrid models of learning and new technologies that can improve access to POCUS education. Previous educational frameworks regarding POCUS curriculum development make little mention of online technologies to facilitate program delivery (2). Given the lessons learned during the COVID-19 pandemic, expanding these guidelines may be considered. Finally, based on our identification of unexpected challenges and benefits, we want to emphasize the importance of a robust curriculum evaluation strategy to systematically capture the intended and unintended impact of curricular changes. Although we can appreciate the opportunities created by a partial transition to online education, it is also important to reflect on what might be lost in the process. We should continue to cautiously and reflectively embrace new educational technologies and aim to strike the right balance between the benefits of face-to-face learning and the accessibility of an online curriculum.

Author disclosures are available with the text of this article at www.atsjournals.org.

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