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A Longitudinal Study of Multimodal Bronchoscopy Training in Uganda

Dipan N. Karmali[1]*, A. Christine Argento[2]*, Bruce Kirenga[3,4], Hitesh Batra[5], Hans J. Lee[2], Christina R. MacRosty[6], Guil R. Lerner[1], Trishul Siddharthan[1], William Worodria[3,4], and Peter Jackson[7]

[1]Division of Pulmonary and Critical Care, University of Miami Health System, Miami, Florida; [2]Division of Pulmonary and Critical Care, Johns Hopkins University, Baltimore, Maryland; [3]College of Health Sciences and [4]Makerere Lung Institute, Makerere University, Kampala, Uganda; [5]Division of Pulmonary and Critical Care, University of Alabama Birmingham, Birmingham, Alabama; [6]Division of Pulmonary and Critical Care, University of North Carolina at Chapel Hill, Chapel Hill, North Carolina; and [7]Division of Pulmonary and Critical Care, Virginia Commonwealth University, Richmond, Virginia

ORCID IDs: 0000-0003-4806-3695 (D.N.K.); 0000-0002-3807-7690 (A.C.A.); 0000-0002-2023-2840 (B.K.); 0000-0002-4934-1434 (H.B.); 0000-0003-0134-8917 (H.J.L.); 0000-0001-6344-4408 (C.R.M.); 0000-0001-9914-1839 (T.S.); 0000-0002-8531-5567 (W.W.); 0000-0001-5108-9381 (P.J.)

ABSTRACT

Background: Flexible bronchoscopy is an essential tool in diagnosing and managing pulmonary diseases. However, there is limited capacity for bronchoscopy in low and middle income countries (LMICs). In 2019, a pilot program for flexible bronchoscopy training was launched for local physicians in Kampala, Uganda. We then conducted a follow up multimodal bronchoscopy course after 2 years.

Objective: The aim of this study is to assess a longitudinal multimodal bronchoscopy training in an LMIC setting.

Methods: A multimodal follow up curriculum was developed with pulmonologists from Uganda and the United States. The training was delivered to Ugandan providers who attended previous bronchoscopy training and new participants. The training included a prepared curriculum consisting of lectures, simulations, and deliberate

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*Co–first authors.

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Correspondence and requests for reprints should be addressed to Dipan N. Karmali, M.D., Pulmonary and Critical Care Fellow, University of Miami Health System, 1611 NW 12th Avenue, Central 600-D, Miami, FL 33136. E-mail: dipan.karmali@jhsmiami.org.

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practice-based proctoring. A 12-question multiple-choice exam was administered at the beginning and end of the course, assessing knowledge. Procedural competency was measured using a validated assessment tool called the BSTAT (Bronchoscopic Skills and Tasks Assessment Tool). Results were analyzed to evaluate the retention of knowledge among those who took part in previous training and the efficacy of the follow-up curriculum for participants without previous training.

Results: Among the participants who attended didactic training in 2022 (11), mean exam scores were improved after training, from 43.9 (standard deviation [SD], 11.3) to 59.8 (SD, 16.1) (mean difference [MD], +15.9; SD, 13.9; $P = 0.008$), but were lower compared with post didactic scores in 2019: 90.8 (SD, 6.1; MD, −31; $P < 0.0001$). Participants who completed BSTAT assessments (8) had mean scores similar in 2019 and 2022, at 72.1 and 75.2, respectively (MD, 3.1; $P = 0.38$).

Conclusion: This study provides an example of how a longitudinal multimodal bronchoscopy curriculum can improve competency and proficiency for local physicians in an LMIC.

Keywords:
global health education; low–middle-income countries; coronavirus disease (COVID-19)

Flexible bronchoscopy is considered an essential diagnostic tool for identifying infectious and noninfectious respiratory diseases (1). Furthermore, advanced bronchoscopy techniques are now able to provide therapeutic interventions for some endobronchial diseases. Despite the importance of bronchoscopy, in many low- and middle-income countries (LMICs) settings, there is limited or no bronchoscopic capability because of a lack of training and access to technical equipment (2).

Uganda is an LMIC in East Africa with a high burden of chronic respiratory diseases, including chronic obstructive pulmonary disease, and pulmonary infections, such as pneumonia and tuberculosis (TB) (3, 4). Uganda has a higher prevalence of human immunodeficiency virus (HIV) (5.4%) than neighboring East African countries, a high TB burden with an incidence of 199 in 100,000 people, and is ranked within the top 20 countries globally in HIV-TB co-infection prevalence (5, 6).

Given the frequency of pulmonary complications in immunocompromised individuals and challenges with obtaining a diagnosis from sputum testing or other conventional methods, bronchoscopy has emerged as a commonly used tool in high-income countries and has numerous potential applications within Uganda and other LMICs (7).

Several studies have already demonstrated the usefulness of flexible bronchoscopy to identify pulmonary infections in Uganda, particularly in immunocompromised patients in which sputum studies are inconclusive or unable to be obtained. Bronchoscopy in Uganda has been associated with potential cost savings when diagnosing pulmonary TB in patients with Acid-Fast Bacilli Smear (AFB)-negative sputum (8). In another study examining bronchoscopy to characterize the prevalence of localized pulmonary cryptococcosis in Ugandan patients with HIV infection, the authors found meaningful benefits of the procedure (9). In addition,

bronchoscopy has been shown to identify concomitant pulmonary infections, including *Pneumocystis carinii*, Kaposi's sarcoma, or *Cryptococcus neoformans*, in Ugandan patients with HIV infection (10). These studies align with current guidelines, which suggest performing flexible bronchoscopy and obtaining bronchial alveolar lavage (BAL) or bronchial washing samples to diagnose pulmonary infections in immunocompromised individuals when noninvasive samples cannot be obtained or if an alternative diagnosis is being considered (1, 11).

Building capacity for bronchoscopy in LMICs involves training local physicians with a curriculum focused on simulation training, high procedure volume, and spaced education to increase proficiency and competency among bronchoscopy learners (12). Procedure simulation and observed cases have been shown to improve performance and technical skills among bronchoscopy trainees (13–15). Spaced education is defined as an important learning tool that delivers knowledge over time via repetition (spacing effect) and uses question-and-answer formatted assessments to measure knowledge gain and retention (testing effect) (16–18). In addition, spaced education has been shown to improve skill acquisition and long-term skill retention among learners (19). Therefore, organizing more frequent, longitudinal training sessions can contribute to establishing sustainable bronchoscopy programs.

We have previously demonstrated the efficacy of a multimodal pilot program for bronchoscopy training in Kampala, Uganda, in 2019. During this training, simulation and didactic instruction were provided in concert with the development of a bronchoscopy suite and the donation of equipment and materials. The curriculum showed significant improvements in bronchoscopy knowledge and technical skills among a selected group of superusers (20). In accordance with the Working Group on Ethics Guidelines for Global Health Training guidelines, the team developed this curriculum as a longitudinal program that provided clinical learning for trainees locally and in neighboring cities throughout Uganda. In addition, by using a sliding payment system for patients and organizing donations of consumables, the program seeks to improve global health disparities among the patient population (8, 16, 21). The initial implementation plan called for future studies to increase bronchoscopy training capacity and provide simulations for larger physician groups. However, the coronavirus disease (COVID-19) pandemic interrupted future training plans because of travel restrictions, limited personal protective equipment (PPE) and COVID-19 testing within Uganda, and the need to prioritize oxygen for the clinical setting, thereby precluding its use for bronchoscopy. This study describes a delayed follow-up multimodal training program for bronchoscopy in an LMIC setting.

METHODS

The MLI (Makerere Lung Institute) bronchoscopy training program was developed in collaboration with the Association of Interventional Pulmonary Program Directors and the MLI in Kampala, Uganda (8, 20). To assess knowledge retention and promote the sustainability of the bronchoscopy program, this longitudinal follow-up study was developed. The study sought to evaluate the efficacy of follow-up training, including didactic and simulation-based instruction, delivered in April of 2022, and measure the durability of prior training among participants in the 2019 course.

Participants completed knowledge exams before and after training and simulation-based testing after training. Participants who attended the 2019 training were analyzed to measure retention of skills and knowledge, and others were assessed to understand the impact of this curriculum on bronchoscopy knowledge and technical skills for new participants.

Participants

In 2022, 11 participants from various regions of Uganda, consisting of pulmonologists, anesthesiologists, and general surgeons with varying bronchoscopy experiences, attended a 2-day session of didactic learning and simulation training and completed knowledge assessment tools. Eight of these participants completed posttraining simulation-based assessments. Four participants were considered experienced providers because they had completed a bronchoscopy training course; three of these participants completed the 2019 program and were considered superusers, as defined below. All participants had completed advanced medical training (U.S. residency equivalent) (Table 1).

Ten participants in the 2019 pilot program who completed pre and post knowledge exams were used as a comparison group. Three of these individuals, known as superusers, completed the full pilot course, which included simulation training and BSTAT (Bronchoscopy Skills and Tasks Assessment Tool) assessments. Furthermore, these superusers performed proctored bronchoscopy from April 2019 to March 2020, after which bronchoscopy was halted for oxygen, PPE conservation, and infectious risk during the COVID-19 outbreak.

Table 1. Number of participants in 2019 and 2022 who completed phases of the bronchoscopy course

Completed Phase	2019, *n*	2022, *n*
Pre didactic exam	10	11
Post didactic exam	10	11
BSTAT assessment	3	8*
Patient bronchoscopy	3	3

Definition of abbreviation: BSTAT = Bronchoscopic Skills and Tasks Assessment Tool.
*Remaining participants were unable to complete the BSTAT assessment because of patient care obligations.

Course Description

The training course was delivered by board-certified pulmonary critical care physicians from four institutions in the United States; three of the course instructors had also completed fellowship training in interventional pulmonology. The course consisted of three phases: *1*) in-person didactic session with interactive lectures covering core bronchoscopy topics; *2*) in-person simulation training with observed and guided usage of the flexible bronchoscope on mannequins; and *3*) live cases that were performed by learners and proctored by faculty instructors. Didactic sessions included six faculty-prepared presentations delivered over 4 hours. These included airway anatomy, BAL, indications and patient selection for bronchoscopy, needle biopsy and brushing, transbronchial biopsy, and sedation and complications from bronchoscopy. The simulation involved the performance of clinical bronchoscopies with BAL and foreign body removal on low-fidelity models proctored by faculty. In addition, three bronchoscopies with airway inspection and BAL were conducted on live persons and supervised by Ugandan faculty (B.K. and W.W.). These faculty members conducted bronchoscopies in Uganda and were assessed by the study team on technical skills in the three 2019 superusers.

All patients provided informed consent to undergo bronchoscopy procedures. Superusers were prioritized for live patient bronchoscopy, given the limited availability of patients receiving bronchoscopy, and to improve their expertise as future trainers. The course content was on the basis of a modified version of *The Essential Flexible Bronchoscopist* and its step-by-step curriculum (20, 22).

The prior course in 2019 included a similar didactic session but offered 2 full days of simulation time as opposed to 1 day. In addition, the pilot program identified superusers through expressed interest and recommendation by B.K. and W.W. ($n = 3$), who completed simulation training, proctored bronchoscopy, and BSTAT administration. All participants in 2022 were given equal opportunity to complete all aspects of the program except for live patient bronchoscopy, which was limited to experienced users.

Study Protocol

A 12-question multiple-choice exam obtained from *The Essential Flexible Bronchoscopist* was administered at the beginning and end of the course, measuring the understanding of periprocedural protocol, procedure indications, and relevant anatomy (22). In addition, BSTAT, a 10-item validated measurement tool with domains including equipment handling, ability to maneuver the bronchoscope, knowledge of segmental anatomy, ability to enter each segment, performance of standard diagnostic tasks, and recognition of secretions and mucosal abnormalities, was administered on the final day. BSTAT scores are categorized as novice (<60), advanced beginner (60–79), intermediate beginner (80–99), and competent (100) (23). The same written exam and BSTAT assessments were administered in 2019 and 2022.

Statistics

Mean scores were calculated as a composite measure of each instrument, with lower scores indicating lower knowledge or procedural assessment. Mean scores were calculated before and after the course. Paired *t* tests were used to compare subgroups within this course session as well as participants from a bronchoscopy course in 2019. All associations were considered significant at $P \leq 0.05$. Data were analyzed using Stata MP version 17 and Microsoft Excel version 16.62.

Regulatory

All didactic content and assessment tools were approved by the MLI. Training and learner assessment were conducted under local guidelines and regulations governing quality improvement and education projects and were considered exempt from local regulatory review. All patient bronchoscopies were proctored by Ugandan faculty (B.K. and W.W.), both of whom hold active Ugandan medical licenses granting them privileges to perform and proctor bronchoscopy within Uganda. Assessments were conducted by observation of these procedures by the training staff.

RESULTS

Baseline Characteristics

A total of 11 participants attended this training and completed pre and post knowledge exams; 8 participants completed the BSTAT assessment. Four of these participants attended the training course in 2019. The trainees were majority male (10/11 [91%]), and the average age of participants was 35 years old (standard deviation [SD], 3.85). A variety of specialties were represented in the course, including general medicine, pulmonary, thoracic surgery, anesthesia, and nursing (Table 2).

Table 2. Baseline characteristics of participants in the Makerere Lung Institute Bronchoscopy course 2022

Variables	Total
Sex, *n* (%)	
Male	10 (91)
Female	1 (9)
Specialty, *n* (%)	
General medicine	5 (45)
Pulmonary	2 (18)
General surgery	3 (27)
Anesthesia	1 (10)
Average age, yr	35*
2019 course attendance, *n* (%)	4 (26)

*One participant did not report age.

Knowledge Assessment

All participants, experienced and new trainees, underwent knowledge assessments before and after didactic and simulation learning in 2019 and 2022. In 2022, the average pre-exam score was 43.9 (SD, 11.3), and the average postexam score was 59.8 (SD, 16.1), which represented a significant increase (mean difference [MD], +15.9; SD, 13.9; $P = 0.008$). In 2019, the average pre-exam score was 31.6 (SD, 14.6), and the average postexam score was 90.8 (SD, 6.1), which also represented a significant improvement (MD, +59.2; SD, 19.5; $P < 0.001$). Average pre-exam scores in 2022 were not different compared with 2019 (MD, +12.8; $P = 0.07$). The average postexam score in 2022 was lower than in 2019 (MD, −31; $P < 0.0001$) (Figure 1).

To assess knowledge retention, subjects who attended the initial bronchoscopy training in 2019, experienced participants who attended both sessions, and new trainees were compared. Experienced participants had an average postexam score of 66.7 (SD, 6.80), which was higher (MD, +16.7; SD, 10.9; $P = 0.05$) compared with their average pre-exam score of 50 (SD, 6.80). Inexperienced participants had an average postexam score of 55.9 (SD, 19), which was higher (MD, +15.4; SD, 17.7; $P = 0.05$) compared with their average pre-exam score of 40.5 (SD, 13.1).

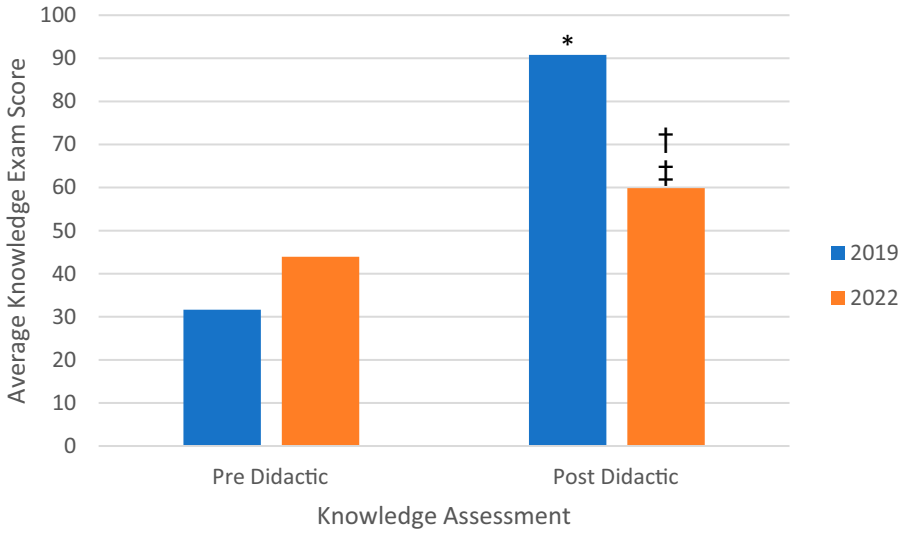

Figure 1. Mean pre and post didactic knowledge exam scores from bronchoscopy training among all participants in 2019 and 2022. *$P \leq 0.05$ for comparison between 2019 pre didactic and post didactic knowledge exams. †$P \leq 0.05$ for comparison between 2022 pre didactic and post didactic knowledge exams. ‡$P \leq 0.05$ for comparison between 2019 and 2022 post didactic knowledge exam.

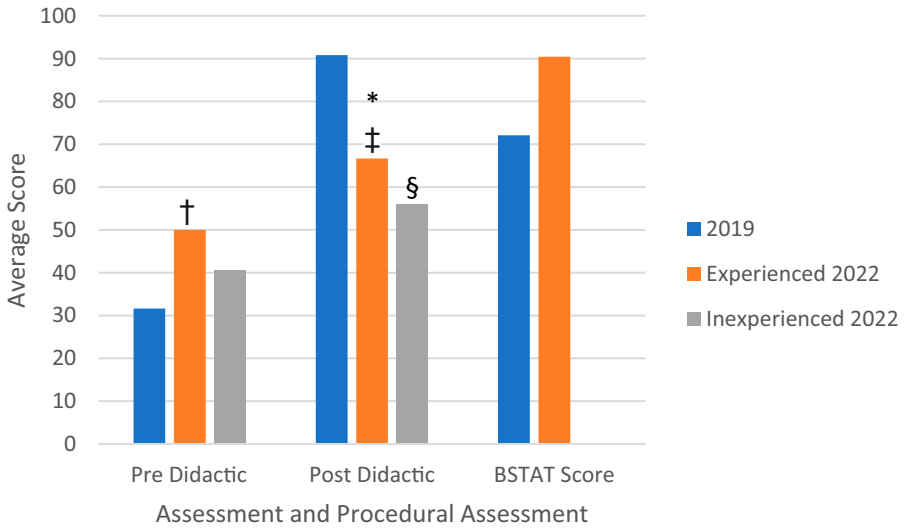

Figure 2. Mean pre and post knowledge exam scores and mean BSTAT scores from participants in bronchoscopy training in 2019 and experienced participants in 2022. Experienced participants are those who participated in the 2019 training session. Inexperienced participants are those who have no prior experience in bronchoscopy. *$P \leq 0.05$ for comparison of pre didactic and post didactic scores in experienced participants in 2022. †$P \leq 0.05$ for comparison of pre didactic scores between participants in 2019 and experienced participants in 2022. ‡$P \leq 0.05$ for comparison of post didactic scores between participants in 2019 and experienced participants in 2022. §$P \leq 0.05$ for comparison of pre didactic and postdidactic scores in inexperienced participants in 2022. BSTAT = Bronchoscopic Skills and Tasks Assessment Tool.

Compared with the mean pre-exam score in 2019 participants, the experienced subgroup in 2022 had a higher mean pre-exam score (MD, +18.4; SD, 14.3; $P = 0.004$), but when comparing their postexam score in 2019, the experienced participants had a lower mean postexam score in 2022 (MD, −24.1; SD, 21.7; $P < 0.001$). Also, the postexam scores in 2022 of experienced participants were not significantly higher than those of inexperienced participants (MD, +10.7; SD, 15.4; $P = 0.11$) (Figure 2).

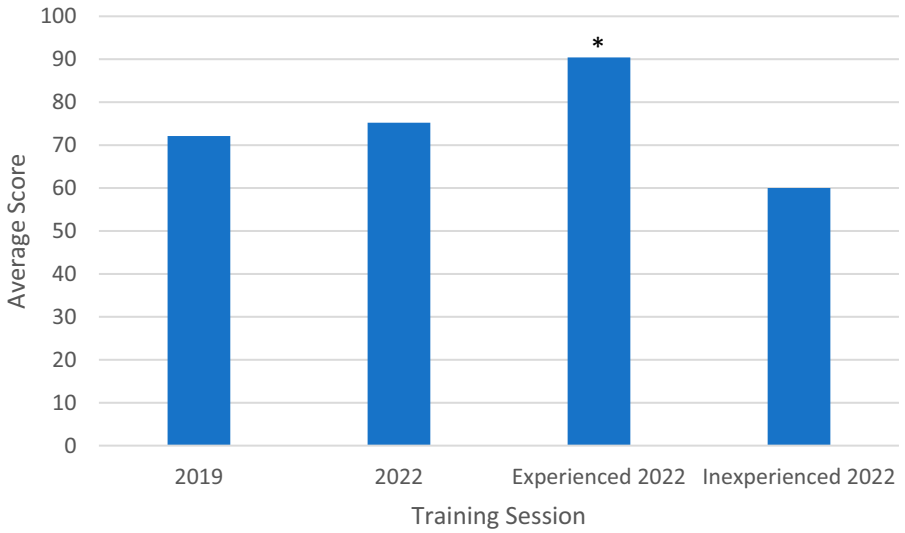

Figure 3. Mean Bronchoscopic Skills and Tasks Assessment Tool scores from participants in 2019 and 2022. Experienced participants are those who participated in the 2019 training session. Inexperienced participants are those who have no prior experience in bronchoscopy. *$P < 0.05$ for comparison between 2019 participants and 2022 experienced participants.

Clinical Assessment

The mean BSTAT assessment scores in 2019 and 2022 were 72.1 and 75.2, respectively (MD, 3.1; $P = 0.38$). All 2019 participant BSTAT scores were categorized as advanced beginners. BSTAT scores in 2022 were categorized as follows: experienced providers: one competent provider and three intermediate beginners; inexperienced providers: one intermediate beginner, two advanced beginners, and one novice. The mean BSTAT score in experienced participants in 2022 was higher than the superuser scores in 2019: 90.4 versus 60 (MD, +18.3; $P = 0.004$). In addition, experienced providers in 2022 demonstrated a higher average BSTAT score of 90.4 (SD, 7.21) compared with the average score of 60.0 in inexperienced participants in the 2022 training (MD, +30.4; SD, 27.5; $P = 0.06$) (Figure 3).

DISCUSSION

In this study, we describe the delivery of a follow-up bronchoscopy training course in Uganda after the implementation of an initial bronchoscopy program in 2019. Our findings show an increase in the mean postexam knowledge assessment score compared with the mean pre-exam score, as well as higher mean BSTAT scores in both the 2019 and 2022 training sessions. This demonstrates the benefit of our curriculum design in enhancing bronchoscopy knowledge among local physicians in Uganda. The mean BSTAT score of the eight participants who completed all aspects of the training falls into the advanced beginner category, which indicates progression toward competence. Collectively, these findings suggest the feasibility of bronchoscopy training in Uganda and demonstrate the need for ongoing longitudinal education and evaluation of global health implementation studies.

In addition, our findings show experienced participants had higher pre-exam scores and modestly higher mean BSTAT scores in 2022 compared with 2019. It is worth noting that the experienced group ($n = 4$) included three superusers whose aggregate 2019 BSTAT scores were compared with the 2022 group scores and demonstrated a notable but insignificant improvement. This suggests knowledge retention among participants with prior bronchoscopy training. Using spaced education to reinforce the learner's knowledge base and improve technical skills is an important aspect of maintaining competency and increasing the capacity of bronchoscopy in Uganda.

Our findings show that with reduced instruction time, participants in the 2022 course showed evidence of knowledge gain with higher mean postexam scores compared with their mean pre-exam scores, although the degree of knowledge gain is smaller compared with the 2019 training. This supports prior studies that reveal lecture-based programs produce knowledge retention, but the degree of retention is poor when compared with more interactive teaching models (24). The length of training in 2022 was shorter, resulting in less didactic and simulation instruction compared with the 2019 session. This was largely because of the availability of instructors and attendees who reported significant increases in clinical responsibilities. The 2022 course had 1 day less of hands-on simulation instruction, which may have led to decreased opportunities for instructors to use alternative teaching methods to engage learners, like audience participation and small group learning sessions. If shorter courses are needed to accommodate instructors

and participants, then using alternative modes of learning may enhance the degree of knowledge gained in both didactic and procedural training (25). The optimal time spent in didactic and procedural training needs to be further assessed to maximize the efficiency and quality of learning and address time constraints for both instructors and participants.

The COVID-19 pandemic changed medical education delivery in both high-income countries and LMICs. More specifically, LMICs experienced delays in accommodating for the pandemic because of a lack of technological infrastructure and high cost, which caused educational systems to temporarily shut down (26). Moreover, the pandemic's effect on global health education was magnified because of travel restrictions, high clinical demands on existing clinicians, and limited availability of PPE and oxygen for use in bronchoscopy. These issues reduced opportunities for longitudinal in-person bronchoscopy training at MLI and may explain why participants who previously attended the 2019 course had a lack of significant improvement in mean post-exam and BSTAT scores. As a result, opportunities for spaced education training were delayed, which may have limited knowledge retention. The research team plans to modify the curriculum to include virtual teaching modules for remote learning and increase the frequency of in-person courses to better train local practitioners moving forward.

Our findings support using a multimodal curriculum in an LMIC setting; however, lower mean post didactic knowledge scores in our recent training compared with the mean post didactic scores in 2019 reflect a continued need to integrate alternative learning modalities. Current studies in bronchoscopy education are performed in high-income countries and highlight the importance of a multimodal approach to improve knowledge and technical proficiency. For example, the inverted or flipped classroom model creates a more inclusive and interactive learning environment in which learners are engaged in problem-based discussions or question-and-answer sessions with their instructors. This style of learning has been shown to improve knowledge acquisition and retention (16, 27–30). Studies have used this learning style by way of supplementing in-person sessions with more virtual modules dedicated to reviewing and troubleshooting bronchoscopy. This gives learners an opportunity to solidify acquired knowledge through student-led discussions during live sessions and self-paced individual learning of core concepts. Furthermore, using a virtual platform before these in-person training sessions has been shown to enhance clinical performance (31).

Limitations

There were several limitations associated with this study. One of the leading limitations to increasing bronchoscopy capacity is the limited number of pulmonary physicians trained in the procedure. This issue arose in our study, as shown by the small number of participants in the training. This remains a leading limitation, followed by equipment availability and facilities capable of supporting bronchoscopic procedures (2). However, it is worth noting that this is a larger cohort compared with the 2019 course and represents a reasonable number of trainees, given the equipment, faculty, and space available for this course. A benefit to a smaller group of learners is that instructors can provide more individualized instruction when appropriate. Second, this study

intentionally reduced its didactic and simulation training length in 2022 compared with the 2019 course. As a result, only a limited number of subjects may have been available for the designated training period at a centralized location. However, organizing this course was necessary to provide a sustainable course length for future sessions while accommodating trainee and instructor time. In the future, offering several identical abbreviated training courses on different dates over a longer period may reduce conflicts with clinical responsibilities and allow more trainees to participate. In addition, this is a study that provides training tailored to the setting of MLI, though it does include physician and nursing learners from other regions in Uganda that are implementing this knowledge and opening their own bronchoscopy suites. It is important to recognize that medical and cultural differences exist between LMIC settings; therefore, the course design should be customized for optimal learning in different educational environments.

Future studies are needed to evaluate the effect of additional curriculum changes on knowledge retention and skill acquisition. In addition to the increased frequency of in-person sessions and implementation of virtual instruction, trainers could provide supplemental material, like practice cases and relevant research articles, for local physicians to review between trainings. As more local physicians participate in these courses, the problem-based learning model may also improve competency with bronchoscopy. The study team plans to review cases remotely with physicians performing bronchoscopy in Uganda to review indications and procedural planning. Modifying the curriculum with more frequent sessions, virtual modules, and case reviews will optimize learning among experienced participants and engage new learners who may not be able to travel within Uganda to a central location. As these changes are implemented, they will be reviewed, and the potential for expansion to other LMIC settings will be actively evaluated.

Conclusions

An abbreviated follow-up bronchoscopy program resulted in significant increases in knowledge exam scores and similar simulation-based assessment scores to a previous longer training program. Further institutional support and more frequent multimodal training sessions with formalized assessments may be essential in improving bronchoscopy capacity in Uganda.

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