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COVID-19 advanced respiratory care educational training programme for healthcare workers in Lesotho: an observational study

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ABSTRACT

Objective To develop and implement a 'low-dose, high-frequency' (LDHF) advanced respiratory care training programme for COVID-19 care in Lesotho.

Design Prospective pretraining–post-training evaluation.

Setting Lesotho has limited capacity in advanced respiratory care.

Participants Physicians and nurses.

Interventions Due to limited participation in May–September 2020, the LDHF approach was modified into a traditional 1-day offsite training in November 2020 that reviewed respiratory anatomy and physiology, clinical principles for conventional oxygen, heated high-flow nasal cannula and non-invasive ventilation management. Basic mechanical ventilation principles were introduced.

Outcome measures Participants completed a 20-question multiple choice examination immediately before and after the 1-day training. Paired t-tests were used to evaluate the difference in average participant pretraining and post-training examination scores.

Results Pretraining and post-training examinations were completed by 46/53 (86.7%) participants, of whom 93.4% (n=43) were nurses. The overall mean pretraining score was 44.8% (SD 12.4%). Mean scores improved by an average of 23.7 percentage points (95% CI 19.7 to 27.6, p<0.001) on the post-training examination to a mean score of 68.5% (SD 13.6%). Performance on basic and advanced respiratory categories also improved by 17.7 (95% CI 11.6 to 23.8) and 25.6 percentage points (95% CI 20.4 to 30.8) (p<0.001). Likewise, mean examination scores increased on the post-training test, compared with pretraining, for questions related to respiratory management (29.6 percentage points, 95% CI 24.1 to 35.0) and physiology (17.4 percentage points, 95% CI 12.0 to 22.8).

Conclusions An LDHF training approach was not feasible during this early emergency period of the COVID-19 pandemic in Lesotho. Despite clear knowledge gains, the modest post-training examination scores coupled with limited physician engagement suggest healthcare workers require alternative educational strategies before higher advanced care like mechanical ventilation is implementable. Conventional and high-flow oxygen is better aligned with post-training healthcare worker knowledge levels and rapid implementation.

Strengths and limitations of this study

- The training aimed to adapt a 'low-dose, high-frequency' (LDHF) approach to improve the competence of doctors and nurses providing advanced respiratory care to severely ill patients with COVID-19 during the emergency phase of the pandemic.
- Challenges in trainee participation and respiratory equipment availability necessitated modifications to the planned LDHF training strategy.
- The training was modified to a single-day session across two hospitals, and participants were evaluated using a 20-question test administered before and after the session.

INTRODUCTION

The SARS-CoV-2 virus causes COVID-19.[1] COVID-19 severity ranges across the spectrum from asymptomatic to critically ill and includes respiratory failure requiring advanced respiratory support.[2 3] SARS-CoV-2 has claimed over four million lives worldwide with the latest surge mainly attributable to the Delta variant.[4] Across sub-Saharan Africa, COVID-19 cases and deaths also continue to escalate, stressing already fragile healthcare systems against a backdrop of limited SARS-CoV-2 vaccine access.[4]

Lesotho is a country in southern Africa with about two million people and a 49-year life expectancy.[5] It suffers from the second highest incidence of tuberculosis and second highest prevalence of HIV globally.[6 7] Lesotho's health system lacks capacity in both intensive and high care hospital services and has scarce medical oxygen resources. At the onset of the pandemic, the Lesotho Ministry of Health established isolation wards for patients with COVID-19 at all district-level hospitals nationally and appointed two district hospitals as dedicated COVID-19 treatment centers. From May 2020, the United Stated Agency for International Development

funded Jhpiego Lesotho, an affiliate of Johns Hopkins University, to provide COVID-19 case management support to the Lesotho Ministry of Health, with a focus on capacitating healthcare workers to provide advanced respiratory care through guideline development, training, patient care supervision, human resources support and broader technical assistance.

The challenge of delivering quality healthcare in resource-constrained low-income and middle-income countries (LMICs) like Lesotho is well known.[8–10] A 'low-dose, high-frequency' (LDHF) training approach is an established strategy that delivers shorter trainings spaced over time and is typically supplemented with practical clinical sessions at the workplace to reinforce learning, sustain changes in provider performance and facilitate new skill acquisition.[11] The LDHF approach has been shown to improve provider knowledge, patient management and outcomes in LMICs and may be more feasible to deliver in healthcare settings that cannot afford to have providers engaged in traditional offsite trainings for long periods of time at the expense of depleting patient care personnel.[12]

The COVID-19 pandemic has required a rapid pivot from long-standing priorities in southern Africa like HIV and tuberculosis care towards acute respiratory treatment and related programmatic support. Given the urgent need to capacitate medical providers to manage patients with severe and critical COVID-19, we developed and implemented an LDHF healthcare worker training course to improve knowledge and skills for advanced respiratory care. The aim of this study was to describe and evaluate the effectiveness of this training programme delivered during the early phases of the COVID-19 pandemic.

Table 1 Advanced respiratory care training: modules and primary objectives

Module	Objectives
1. Case report forms	Introduce hospital and COVID-19 standardised case management forms
2. Hypoxaemia detection and oxygen delivery	Ensure competency in detecting hypoxaemia and administering conventional low-flow oxygen
3. Severe COVID-19	Introduce and review severe and critical COVID-19 and evidence-based treatment
4. Respiratory anatomy and gas exchange introduction	Introduce and review respiratory anatomy and gas exchange principles
5. Mechanics of breathing: parts 1 and 2	Introduce and review breathing mechanics principles Part 1: lung volumes and pressures. Part 2: lung compliance.
6. Blood gas analysis: parts 1 and 2	Introduce and review arterial blood gas analysis Part 1: acid–base physiology, pathology and arterial blood gas collection. Part 2: evaluating compensation and anion gap.
7. Introduction to advanced respiratory care	Continue introduction to advanced respiratory care Conventional oxygen. Heated high-flow nasal cannula. Non-invasive ventilation. Invasive mechanical ventilation.

METHODS

Clinical setting

Berea Hospital is secondary hospital located approximately 30 km north of the capital city of Maseru in the town of Teyateyaneng in Berea District and served as the COVID-19 treatment centre for the northern region. Mafeteng Government Hospital is a regional hospital about 75 km south of Maseru in the district of Mafeteng and is designated as the COVID-19 treatment centre for the southern region. From May to November 2020, Berea Hospital had three inpatient wards and 50 patient beds allocated to COVID-19 care, and Mafeteng Government Hospital had one inpatient ward and 20 beds for patients with COVID-19. Clinical staffing fluctuated during this period; Berea Hospital had 6–8 doctors and 30–35 nurses, while Mafeteng Government Hospital had 8–9 doctors and 25–30 nurses. Doctors and nurses were all licensed and registered to provide patient care in Lesotho.

Neither Berea Hospital or Mafeteng Government Hospital offered 'high care' or 'intensive care' services. We considered high care an area of the hospital with higher nurse:patient ratios (ie, 1 nurse:5–6 patients), systems for close monitoring, and the capacity to deliver more advanced respiratory treatments like conventional oxygen and heated high-flow nasal cannula to severely ill patients and selected critically ill patients breathing spontaneously and generally stable. By comparison, we considered intensive care an area of the hospital with higher nurse:patient ratios (ie, 1 nurse:1–2 patients), systems for continuous, invasive monitoring and the capacity to deliver life sustaining respiratory treatments like non-invasive and invasive mechanical ventilation to critically ill patients.

LDHF advanced respiratory care educational training programme: overview

The educational training programme (table 1) was designed to use a LDHF approach to introduce new concepts and advanced respiratory care treatments during 1-hour sessions per week spaced over several months, with supervised clinical care between sessions to cement the translation of theoretical concepts to the bedside. LDHF trainings were intended to be held onsite at the treatment centres. We developed the training content based on review of a variety of resources as well as prior anecdotal knowledge and practical experience in providing advanced respiratory care to patients in LMICs. The trainings reviewed clinically relevant respiratory anatomy and

physiology as a foundation for the principles for providing COVID-19-related advanced respiratory care. The training also included both basic and selected advanced concepts, and the fundamentals of conventional oxygen delivery (ie, 'oxygen'), heated high-flow nasal cannula (ie, 'high flow') and non-invasive ventilation (NIV). Modules were designed to be linked and to introduce concepts incrementally, so each new module was built on the previous one. Trainings were to coincide with supervised bedside experiences at the treatment centres where participants would apply their knowledge to patient care and use oxygen, high flow and in selected situations for NIV. In addition, modules were intended to be supplemented with case discussions of patients with COVID-19 currently or recently hospitalised to highlight key clinical teaching points. Targeted cadres were physicians and nurses that provided direct care to patients with COVID-19 at the treatment centres. Hospital administrators approved the delivery of the trainings at each hospital and encouraged, but did not mandate, participation. Participants were further incentivised to participate through the receipt of continuing professional development credits and food and drinks during each session. Later in the study period, we did introduce a virtual option after installing monitors and equipment at each hospital, but we did not have the capacity to provide internet data and IT support to accommodate an individualised virtual option when participants were not physically present at the hospital. The broader goal was to build capacity towards high care and to set the foundation for the potential future introduction of intensive care and invasive mechanical ventilation.

Modified advanced respiratory care educational training programme: 1-day training

After 5 months from May to September 2020, the LDHF approach was considered untenable due to limited and inconsistent attendance exacerbated by a lack of respiratory equipment, including high-flow and NIV devices and related supplies, that had not yet been received in the country due to shipment delays. Thus, we modified the training into a 1-day session to optimise participation (see the online supplemental file 1 for the training agenda). Content was consolidated and limited to core concepts. Due to time constraints and lack of equipment, we excluded case discussions, practical hands-on sessions and bedside patient-based teaching. All training sessions were facilitated in person by one to two physicians (JS and EDM). A total of 70 healthcare workers (15 physicians, 54 nurses and 1 nursing assistant) were invited to participate in any of four 1-day modified trainings held between 9 and 17 November 2020 at offsite conference venues near the two treatment centres.

Pretraining and post-training examinations of the modified 1-day programme

We administered a 20-question, multiple choice, paper-based examination immediately before and after the 1-day training to evaluate participant baseline and acquired knowledge as an assessment of training effectiveness. All participants were requested to complete the examination individually and without training-related resources over 30 min. The examination included one to three questions per module and evaluated both basic and selected advanced topics covered in the training (see online supplemental table 1). When appropriate to the content, questions were formulated so that learners who successfully applied their knowledge, rather than identify information by rote, would correctly answer the question.

Patient and public involvement

Given the COVID-19 restrictions placed on public gatherings throughout the period of this study in Lesotho, we were unable to involve and communicate to the public the development, design, recruitment, conduct and results in this research.

Statistical analysis

Participant performance on both the pretraining and post-training examinations of the modified 1-day training was assessed. The primary outcome was the average change in the overall test score between the pretest and post-test examinations. In addition, we sought to analyse if results differed by the content level (basic vs advanced) and type (respiratory physiology vs management). We used the two-proportion z-test to assess for differences in proportions. Paired t-tests were used to evaluate the difference in average scores of participants between the pretraining and post-training examinations overall, and by content level and type. Stata V.16.1 was used for all analyses.

RESULTS

A total of 53/70 (75.7%) invited participants attended the modified 1-day training, and of the 53 attendees, 46 (86.7%) completed both the pretest and post-test examinations and were included in this analysis. Nurses comprised 43/46 (91.3%) participants.

Pretraining examination performance: 1-day modified training

No participants achieved a score of 80% or greater on the 20 pretraining examination questions, with the lowest and highest scores of 20% (n=4) and 75% (n=15). Overall, the mean pretraining examination score was 8.9/20, or 44.8% (SD, 12.1%) (figure 1 and online supplemental figure 1 and online supplemental table 2). The examination questions were stratified into basic (7/20, 35%) and advanced concepts (13/20, 65%). Although participants scored higher on basic topics (mean score 3.8/7; 54.0%, SD 18.8%) than advanced concepts (mean score 5.2/13; 39.8%, SD 12.6%), this difference did not reach statistical significance (p=0.542) (figure 2 and online supplemental table 3). Examination questions were also subdivided into respiratory physiology (10/20) and respiratory management (10/20) topics, with participants achieving average scores of 4.5/10 (45.5%, SD 18.6%) and 4.2/10 (42.0%,

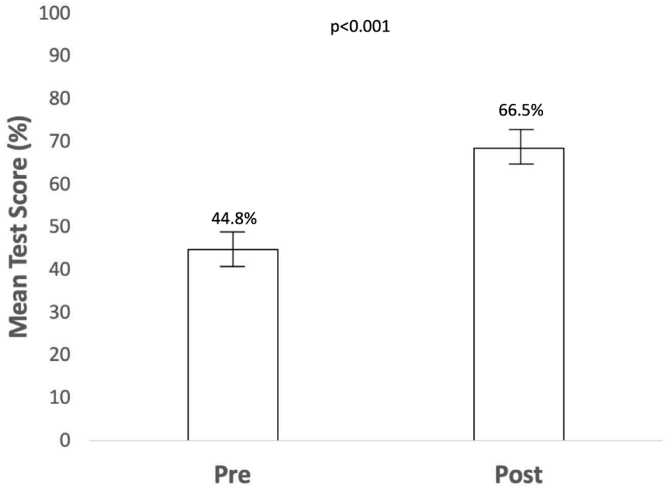

Figure 1 Mean pre-examination and postexamination scores by percentage. Bars represent 95% CIs.

SD 15.1%) (p=0.892) (figure 3 and online supplemental table 4). Three doctors completed the pretraining examination and scored an average of 63.3% (SD 16.0%).

Post-training examination performance: 1-day modified training

On the post-training examination, 9/46 (19.5%) participants scored ≥80% with an average score of 13.7/20 (68.5%, SD 13.6%) (figure 1, online supplemental figure 1 and online supplemental table 2). Two participants scored highest at 100% (n=20) and three scored lowest at 45% (n=9). The average scores on basic and advanced topics were 5.0/7 (71.7%, SD 17.6%) and 8.5/13 (65.4%, SD 17.7%) (p=0.774) (figure 2 and online supplemental table 3), and those for respiratory physiology and management were 7.5/10 (75.0%, SD 17.9%) and 5.9/10 (59.3%, SD 16.4%) (p=0.454) (figure 3 and online supplemental table 4). On the post-training examination, doctors (n=3) scored an average of 90.0% (SD 5.0%).

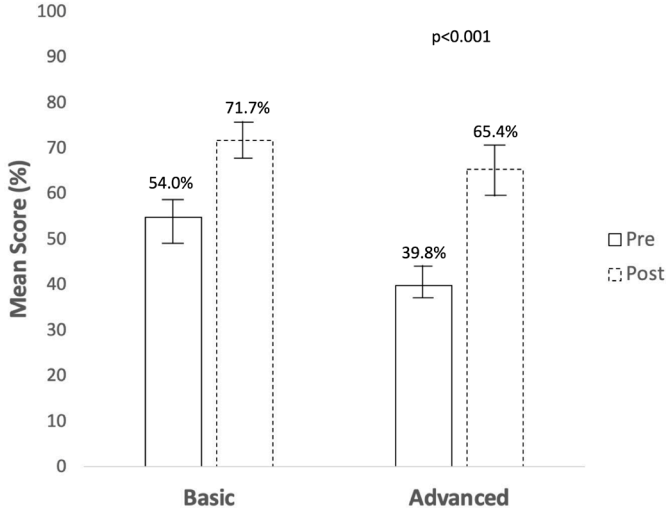

Figure 2 Mean pre-examination and postexamination scores for basic and advanced concepts by percentage. Bars represent 95% CIs.

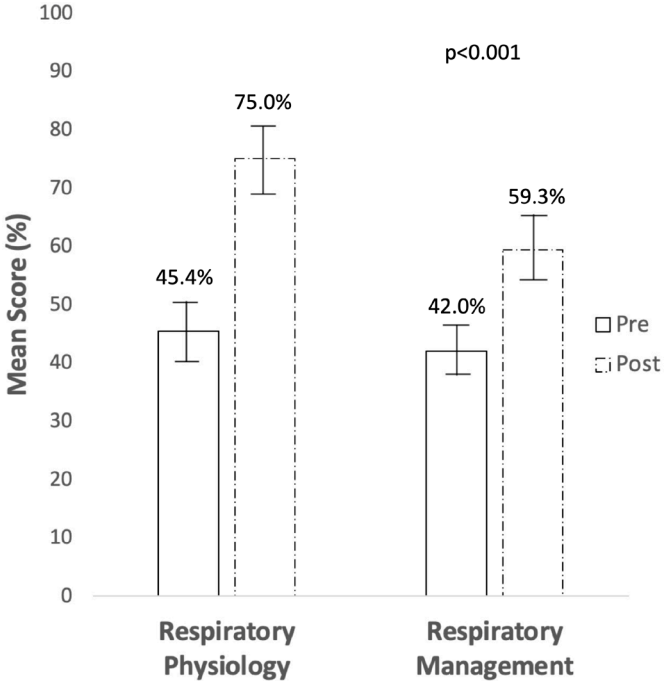

Figure 3 Mean pre-examination and postexamination scores for respiratory physiology and respiratory management topic areas by percentage. Bars represent 95% CIs.

Comparing pretraining and post-training examination performance: 1-day modified training

Overall, performance improved between the pretest and post-test examinations by an average of 23.7 percentage points (95% CI 19.7% to 27.6%) (p<0.001) (figure 1 and online supplemental table 2). Similar improvements were observed for basic and advanced concepts as well as respiratory management and physiology topics (figures 2 and 3, and online supplemental tables 3 and 4). Specifically, there was an average increase of 17.7 percentage points (95% CI 11.6% to 23.8%, p<0.001) in basic concepts and 25.6 percentage points (95% CI 20.4% to 30.8%, p<0.001) in advanced concepts. For respiratory management and physiology, there was a mean improvement of 17.4 (95% CI 12.0% to 22.8%, p<0.001) and 29.6 percentage points (95% CI 24.1% to 35%, p<0.001) between pretraining and post-training examinations. Among physicians, while there was an average increase of 26.6 percentage points (95% CI −16.9% to 70.2%, p=0.119), this finding did not reach statistical significance.

DISCUSSION

In this report, we described and evaluated a new training course for advanced respiratory care administered in the sub-Saharan African country of Lesotho. The training targeted doctors and nurses responsible for treating severe to critically ill patients with COVID-19 at dedicated COVID-19 treatment centres. The main goal of the training is to capacitate healthcare workers to provide advanced respiratory care for patients with COVID-19 in

a setting with limited acute respiratory services during an active and fluid emergency pandemic situation. We found that while average participant scores improved, both mean pre-examination and post-examination training scores were generally low. The two most likely reasons for these findings include overall misalignment of the training content and/or approach with participant background and experience in acute respiratory care, as well as practical training implementation challenges that may have limited its effectiveness. This training programme was intended to be an LDHF educational approach delivered weekly, spaced over several months, and supported by case discussions and bedside practical training. However, we ultimately had to modify the training to a more traditional 1-day offsite session to ensure full participation for all modules as healthcare providers were not consistently available week-to-week. The authors acknowledge that modifying the training to a 1-day session likely attenuated the outcome with respect to retention and implementation of newly learnt concepts and skills. Despite changing our approach, we were still only able to engage three physicians to participate in the training. Our findings and implementation experience raise caution around how quickly and the degree to which the Lesotho healthcare system can be empowered to more immediately provide higher levels of advanced respiratory care during the emergency phase of the COVID-19 pandemic.

Despite modifications to the LDHF training approach and modest gains in knowledge from the training, it is important to note that we did observe improvement in examination scores among nearly all participants. Overall, this shows that appropriate education and training can improve knowledge gaps, and this is consistent with prior experience.[13 14] The three physicians who participated in the training did score well on the post-training examination, achieving an average score of 90%. While our evaluation examined only short-term knowledge retention, other studies have found similar educational programmes may still promote both long-term retention and benefit clinical outcomes.[15 16]

The generally modest participant examination scores before and after the training may reflect a mismatch between content and/or approach with trainee background and experience levels in acute respiratory care. Given the participants were all registered medical professionals, they were expected to have a pre-existing working knowledge of the fundamentals of patient respiratory care. The training was additionally premised on the notion that linking clinically relevant respiratory anatomy and physiology to key clinical principles of advanced respiratory care would build an appropriate foundation for healthcare workers to both understand and apply concepts at the bedside. Hence, the content of several modules reviewed key areas of respiratory physiology like lung pressures, volumes, compliance and acid–base concepts that underlie high-flow, NIV and invasive mechanical ventilation delivery. An introductory understanding of these principles would enable healthcare providers to select a suitable respiratory modality for the patient, programme effective and safe settings for that modality, and then appropriately monitor patient responsiveness to the treatment including adverse events and clinical deterioration. The pretraining examination scores suggest that the content at baseline may be either too new or advanced for these participants. On the other hand, the post-training examination scores also imply that a 1-day approach and goal of delivering intensive care with mechanical ventilation in the near term of the pandemic needs reconsideration.

Historically, clinical guidelines and associated trainings in LMICs tend to be more algorithmic rather than concept driven. The WHO Integrated Management of Childhood Illness guidelines were developed in the late 1990s and are a highly successful example of this approach in LMICs.[17 18] Implementation of these guidelines over the past two decades has contributed to substantial reductions in child mortality in resource-limited settings.[19] While revising this advanced respiratory care training from concept building to algorithmic management is a consideration, independent thought and problem solving by healthcare workers remain vital to achieving both patient safety and positive clinical outcomes in high care and intensive care settings. Modalities such as NIV and invasive mechanical ventilation are more complex oxygen delivery strategies, while conventional oxygen delivery and high flow are relatively simpler and may be better aligned with an algorithmic approach. Thus, from the perspective of healthcare workers, oxygen and high flow may be more feasible for LMICs like Lesotho to rapidly upscale, while NIV and invasive mechanical ventilation are likely to require longer term, more intensive, alternative educational strategies.

We also faced multiple practical challenges implementing this training and this likely contributed to its modest impact. Initially, we planned to disseminate the training using an LDHF approach on a weekly or biweekly basis spaced over several months. This would allow the content to be spread out and be better digested by learners and allow for an opportunity to interweave COVID-19 patient-based discussions to enrich the module content and solidify learning. In addition, we intended to have hands-on practical sessions with new respiratory equipment like high flow and NIV. We attempted this approach between May and September 2020, but we were unable to consistently engage healthcare workers on or off duty, and attendance was inconsistent despite participation incentives (eg, food and refreshments and continuing professional development credits). Provider availability was also further constrained due to requirements for a 2-week quarantine after clinical shifts. Although equipment was installed at each treatment centre to facilitate virtual trainings and meetings, we did not have the capacity to conduct virtual trainings to individuals unable to be at the hospital as many participants lacked laptops, Wi-Fi and/or funds for data. We also experienced lengthy delays in the arrival of respiratory equipment into the

country and high-flow and NIV equipment was not available in Lesotho at this time. Collectively, these challenges made it difficult to build on key concepts, hold active dialogue on cases and use hands-on sessions to facilitate translating concepts from the theoretical to the tangible. As such, we transitioned trainings into a traditional offsite 1-day session, which required a modified approach that compressed the training content, limited case-based discussions and reduced practical hands-on experience. Given simulation training along with group problem solving can be more effective at improving performance and knowledge, future traditional trainings will be better served if done over multiple days—or as initially planned over several months—to allow more time for these key complementary approaches.[20 21] Based on our challenges facilitating a longer, more varied LDHF training approach, it will be important to monitor how a longer traditional training approach impacts provider participation and costs. Further evaluation of the degree to which a traditional training approach impacts clinical outcomes of patients with COVID-19 as well as longer-term knowledge retention are needed. Given conditions around the pandemic have matured, an LDHF approach could also be reattempted.

There are two additional limitations worth noting. First, these results primarily reflect nurses as only three doctors participated. While the backbone of clinical care is nurses and nurses are key to patient monitoring during advanced respiratory care, this training may be more suitable for doctors than nurses. Given the very limited doctor participation, we were unable to stratify our analysis by cadre as initially planned. For advanced respiratory care to be successful, it will be important for doctors to participate in future trainings, and reasons for their lack of attendance need clarification. In addition, given the severe human resource constraints in the health sector of Lesotho, nurses need to function independently when providing advanced respiratory care since doctors are few and unable to be continuously available for all patients. Second, to deploy the training quickly, we made assumptions about the baseline educational background and working medical knowledge of providers. Before revising and redeploying this training, a deeper understanding of healthcare worker educational backgrounds is needed. This information could be gathered using surveys, focus groups and/or structured interviews.

There are several additional lessons learnt from educating healthcare workers during an emergency pandemic context worth noting. To maximise retention and skill application of advanced respiratory care concepts, an LDHF approach is preferred. However, successful LDHF implementation will require ongoing buy-in and commitment from key stakeholders including hospital administrators, physicians, nurses and other medical staff to ensure long-term participant retention. It will also require training material investment in simulation mannequins and equipment, as well as maintenance of them, to ensure ability to perform hands-on skills training and case simulations longitudinally. Pandemic restrictions and time permitting, it may be beneficial to first pilot a novel educational training programme like this to a single, smaller facility and to evaluate successes and challenges prior to cascading further.

In sum, this study illustrates the challenges and lessons learnt in designing and administering an advanced respiratory care educational training programme in Lesotho during the emergency phase of the COVID-19 pandemic. If an LDHF approach is not feasible, then future renditions of this training will need to be lengthened to at least 2 days and better incorporate case based and simulation training with respiratory equipment. Longer-term educational and training strategies for NIV and invasive mechanical ventilation that are feasible during COVID-19 in Lesotho also need development, and an LDHF approach could be revisited now that the pandemic has matured, but our findings suggest these interventions are unlikely to meaningfully impact COVID-19 care in the immediate term. Conventional and high-flow oxygen approaches—as well as a stronger emphasis on management algorithms—are likely to be a more successful short-term strategy for rapidly strengthening capacity in advance respiratory care for severe and critically ill patients with COVID-19 in Lesotho.

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Contributors EDM was responsible for conceptualisation and design, curated the data and was the guarantor. EDM and JES collected the data. EDM and VOO were responsible for data analysis and data interpretation and wrote the original draft. EDM, VOO, JES, TC, LM-M, MR-O and BH were responsible for writing, review and editing.

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Patient consent for publication Not applicable.

Ethics approval This study involves human participants and was approved by the Johns Hopkins University Institutional Review Board (IRB00279223) Lesotho National Health Research Ethics Committee (ID 12-2021). The participants gave informed consent to participate in the study before taking part.

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REFERENCES

1 Zhou P, Yang X-L, Wang X-G, *et al*. A pneumonia outbreak associated with a new coronavirus of probable bat origin. *Nature* 2020;579:270–3.
2 Huang C, Wang Y, Li X, *et al*. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. *Lancet* 2020;395:497–506.
3 Umakanthan S, Sahu P, Ranade AV, *et al*. Origin, transmission, diagnosis and management of coronavirus disease 2019 (COVID-19). *Postgrad Med J* 2020;96:753–8.
4 Johns Hopkins University and Medicine. Coronavirus resource center. Available: https://coronavirus.jhu.edu/map.html [Accessed 28 Sep 2021].
5 United Nations Statistics Division. Lesotho country profile. Available: https://data.un.org/CountryProfile.aspx/_Images/CountryProfile.aspx?crName=Lesotho [Accessed 5 Sep 2021].
6 Avert. Lesotho. Available: https://www.avert.org/professionals/hiv-around-world/sub-saharan-africa/lesotho [Accessed 5 Sep 2021].
7 endTB. Lesotho. Available: http://www.endtb.org/lesotho [Accessed 5 Sep 2021].
8 Kruk ME, Gage AD, Arsenault C, *et al*. High-Quality health systems in the sustainable development goals era: time for a revolution. *Lancet Glob Health* 2018;6:e1196–252.
9 Holloway KA, Ivanovska V, Wagner AK, *et al*. Have we improved use of medicines in developing and transitional countries and do we know how to? two decades of evidence. *Trop Med Int Health* 2013;18:656–64.
10 Arsenault C, Jordan K, Lee D, *et al*. Equity in antenatal care quality: an analysis of 91 national household surveys. *Lancet Glob Health* 2018;6:e1186–95.
11 Jhpiego. Low dose, high frequency: a learning approach to improve health workforce competence, confidence, and performance. Available: https://hms.jhpiego.org/wp-content/uploads/2016/08/LDHF_briefer.pdf [Accessed 28 Sep 2021].
12 Evans CL, Johnson P, Bazant E, *et al*. Competency-based training "Helping Mothers Survive: Bleeding after Birth" for providers from central and remote facilities in three countries. *Int J Gynaecol Obstet* 2014;126:286–90.
13 Enweronu-Laryea C, Engmann C, Osafo A, *et al*. Evaluating the effectiveness of a strategy for teaching neonatal resuscitation in West Africa. *Resuscitation* 2009;80:1308–11.
14 McCollum ED, Higdon MM, Fancourt NSS, *et al*. Training physicians in India to interpret pediatric chest radiographs according to World Health organization research methodology. *Pediatr Radiol* 2021;51:1322–31.
15 Horwood C, Butler L, Barker P, *et al*. A continuous quality improvement intervention to improve the effectiveness of community health workers providing care to mothers and children: a cluster randomised controlled trial in South Africa. *Hum Resour Health* 2017;15:39.
16 Deorari AK, Paul VK, Singh M, *et al*. Impact of education and training on neonatal resuscitation practices in 14 teaching hospitals in India. *Ann Trop Paediatr* 2001;21:29–33.
17 World Health Organization. Handbook: IMCI integrated management of childhood illness, 2005. Available: https://apps.who.int/iris/handle/10665/42939 [Accessed 5 Sep 2021].
18 Word Health Organization. Integrated management of childhood illness: chart booklet, 2014. Available: https://apps.who.int/iris/bitstream/handle/10665/104772/9789241506823_Chartbook_eng.pdf [Accessed 5 Sep 2021].
19 Sazawal S, Black RE, Pneumonia Case Management Trials Group. Effect of pneumonia case management on mortality in neonates, infants, and preschool children: a meta-analysis of community-based trials. *Lancet Infect Dis* 2003;3:547–56.
20 Meza PK, Bianco K, Herrarte E, *et al*. Changing the landscape of obstetric resident education in low- and middle-income countries using simulation-based training. *Int J Gynaecol Obstet* 2021;154:72–8.
21 Rowe AK, Rowe SY, Peters DH, *et al*. Effectiveness of strategies to improve health-care provider practices in low-income and middle-income countries: a systematic review. *Lancet Glob Health* 2018;6:e1163–75.