BMJ Open

Stakeholder perspectives on current determinants of ultrasound-guided thoracentesis in resource limited settings: a qualitative study

Jennifer Doran ,[1] Reem Hanna,[2] Tatenda Nyagura-Mangori,[3] Narayan Mahotra,[4] Santa Kumar Das,[5] Magaret Borok,[6] Ali Musani,[7] Anna M Maw[2]

To cite: Doran J, Hanna R, Nyagura-Mangori T, *et al*. Stakeholder perspectives on current determinants of ultrasound-guided thoracentesis in resource limited settings: a qualitative study. *BMJ Open* 2022;**12**:e064638. doi:10.1136/bmjopen-2022-064638

► Prepublication history for this paper is available online. To view these files, please visit the journal online (http://dx.doi.org/10.1136/bmjopen-2022-064638).

Received 21 May 2022
Accepted 21 November 2022

For numbered affiliations see end of article.

Correspondence to
Dr Jennifer Doran;
jennifer.doran@cuanschutz.edu

ABSTRACT

Objective Preprocedure pleural fluid localization using bedside ultrasound has been shown to reduce complications related to thoracentesis and is now considered the standard of care. However, ultrasound-guided thoracentesis (USGT) has not been broadly adopted in many low-resource settings. With increasing affordability and portability of ultrasound equipment, barriers to USGT are changing. The aim of this multisite qualitative study is to understand the current barriers to USGT in two resource-limited settings.

Setting We studied two geographically diverse settings, Harare, Zimbabwe, and Kathmandu, Nepal.

Participants 19 multilevel stakeholders including clinical trainees, attendings, clinical educators and hospital administrators were interviewed. There were no exclusion criteria.

Primary outcome To understand the current determinants of USGT adoption in these settings.

Results Three main themes emerged from these interviews: (1) stakeholders perceived multiple advantages of USGT, (2) access to equipment and training were perceived as limited and (3) while an online training approach is feasible, stakeholders expressed scepticism that this was an appropriate modality for procedural training.

Conclusion Our data suggests that USGT implementation is desired by local stakeholders and that the development of an educational intervention, cocreated with local stakeholders, should be explored to ensure optimal contextual fit.

STRENGTHS AND LIMITATIONS OF THIS STUDY

- ⇒ Multisite study that includes two geographically and culturally diverse hospitals.
- ⇒ Research team included clinicians who practice at both study sites.
- ⇒ Study participants did not include patients.
- ⇒ Sampling methods may have resulted in bias toward positive perceptions of point-of-care ultrasound.
- ⇒ Data collection was limited to qualitative data obtained from interviews.

INTRODUCTION

For generations, clinicians have performed thoracentesis, a diagnostic procedure to evaluate pleural fluid. Traditionally, localization and size of pleural fluid was determined by physical examination alone, including absent breath sounds and dullness to percussion. When X-ray of the chest (CXR) became available in high-resource settings, it assisted diagnosis of effusions prior to fluid sampling. However, CXR has significant limitations assessing indication or safety of thoracentesis.[1 2] The advent of point-of-care ultrasound (POCUS), ultrasound (US) performed and interpreted by a clinician at the bedside, has allowed proceduralists to better evaluate pleural effusions including location, size and characteristics prior to the procedure. Proceduralist performed US-guided thoracentesis (USGT) is considered the standard of care as there are substantial data demonstrating reduced complications and improved safety compared with blind techniques, which are performed without US guidance.[3–5]

Persistent practice of blind techniques is largely a result of the 'radiology gap' between high-resource and low-resource settings, as a large proportion of the global population lack access to even basic diagnostic imaging including CXR.[6] Factors contributing to the 'radiology gap' include the high cost required to procure and maintain most radiology equipment and the specialized expertise of necessary personnel that traditional radiologist performed imaging generally relies on, such as technologists to acquire images, radiologists to interpret the images and technicians to maintain the equipment.[6] In contrast, POCUS, which requires only a clinician and an US, is increasingly more portable and affordable, holding great promise as the

imaging modality most likely to bridge the 'radiology gap'.[7]

Recognizing advantages of US over other imaging modalities in low-resource settings, the WHO published a series of documents entitled 'Training in diagnostic ultrasound: essentials, principles and standards', designed to facilitate implementation of US globally.[8] This series recognizes the major limitation to broad, high-fidelity implementation of diagnostic US is that it is an operator-dependent imaging modality. Therefore, while access to equipment is necessary for global implementation, access alone is insufficient to ensure improved patient care without pairing appropriate training.

Until recently, even in high-resource settings, both access to US machines and training have been the most important barriers to broad adoption.[9] However, it is known that barriers to POCUS implementation are dynamic and changing.[10] Access to US machines continue to become increasingly accessible in even the most remote settings.[11] While access to training continues to be a significant challenge in low-resource settings, barriers to training may also be evolving. As internet access is increasingly more available globally, virtual training has growing potential.

Given the dynamic nature of factors that influence the implementation of POCUS as well as its great potential to improve diagnosis and procedural safety in low-resource settings, the objective of this study is to determine the current barriers and facilitators of USGT as part of planning for a context-sensitive longitudinal training program cocreated with local stakeholders in two geographically diverse resource-limited settings, Zimbabwe and Nepal.

METHODS

Study design

We performed a qualitative study to determine the use of USGT in two resource-limited settings. Data collected was obtained by semi-structured interviews of key stakeholders in diverse professional roles within multiple hospitals located in Harare, Zimbabwe, and Kathmandu, Nepal.

Conceptional framework

We selected the Pragmatic Robust Implementation and Sustainability Model (PRISM) to frame our investigation and interview guide development. PRISM is a multilevel contextual model that has multiple domains relevant to determinants of POCUS implementation for USGT including the external environment, which includes national policies, guidelines and incentives, and the internal setting such as setting characteristics, perspectives and implementation and sustainability infrastructure. PRISM is used in the planning stages of health intervention implementation efforts in order to facilitate assessment of the determinants of health interventions within a particular context as it will allow for selection of implementation strategies focused on addressing identified barriers thereby facilitating the likelihood of successful implementation.[12–14]

Study sample and setting

We interviewed multilevel stakeholders in Harare, Zimbabwe, and Kathmandu, Nepal. Both Tribhuvan University Hospital in Nepal and Parirenyatwa Hospital in Zimbabwe are large, public hospitals, 700 beds and 2000 beds, respectively, that serve a low socioeconomic community who cannot afford the care at private hospitals. Most clinicians had practiced in public government hospitals, which serve the impoverished population in both regions, and some had additionally worked within the private sector. The study participants included clinical specialists, trainees, medical educators, registered nurses, clinical scientists and administrators (table 1).

Interviewees were recruited on a volunteer basis by local site investigators (TNM, NM and SKD). Their training level and type is described in table 1. The interviewer (JD) had not visited either study site or met any of the interviewees prior to the interviews, which were conducted

Table 1 Stakeholder characteristics

Site	Zimbabwe (n=9)	Nepal (n=10)	Perceived proficiency using ultrasound (0–10, 10 being expert)
Profession			
Resident	4	1	IQR: 4.5 (1–5.5)
3rd year	–	1	9/10
4th year	4	–	2/10, 2/10, 1/10, 1/10
Internal medicine attending	2	3	3/10, 4/10, 1/10, 5/10, 1/10
Specialist	1	6	IQR: 7 (0–7)
Intensivist	1	1	7/10, 7/10
Clinical physiologist	–	1	0/10
Cardiothoracic surgeon	–	2	8/10, 2/10
Cardiologist	–	1	0/10
Paediatrician	–	1	0/10
Administrator	2	–	n/a

remotely. The interviewer was an internal medicine resident training in a United States academic medical center at the time of the interviews. Having trained in an environment in which ultrasounds are easily accessible and USGT is routinely performed, she may have been less aware of the potential disadvantages of USGT in other clinical settings.

The stakeholder interviews at both sites were conducted over Zoom video (Zoom Video Communications, 2021). Purposeful sampling was used for initial study recruitment and snowball sampling was used to complete enrollment. Purposeful sampling is a non-random sampling technique that is used to recruit participants who can provide in-depth and detailed information about the phenomenon being studied. Snowball sampling occurs when enrolled study participants identify possible future study participants among individuals they know.[15] Data collection continued until preliminary analyses indicated thematic saturation, defined as the point at which no additional themes emerge from the interviews.[16]

Patient and public involvement

No patients or the public were involved.

Data collection

Between March 2021 and September 2021, one investigator (JD, an internal medicine resident trained in USGT) conducted semi-structured interviews with key stakeholders. The interview questions were guided by the contextual domains of PRISM and evolved over the course of data collection. Interviews were audio-recorded and transcribed verbatim by a professional transcription service.

Data analysis

Three investigators (JD, AMM and RH) used a thematic analysis approach to evaluate data.[17] The team reviewed interview transcripts, immersed themselves in the data and reviewed a subset of transcripts to identify codes to collaboratively create a consolidated codebook. Once the codebook was comprehensive, they applied it independently to the remainder transcripts. Transcripts were entered and coded in Dedoose V.9.0.17 for data management.[18] Local investigators at both sites (MB and NM) reviewed the analysis in order to verify accuracy from the perspective of stakeholders of the study communities.

RESULTS

Of the 29 stakeholders invited to enroll, 19 stakeholders participated. In addition to internal medicine trainees and attendings, there were six subspecialists interviewed that included a cardiologist, cardiothoracic surgeons, and intensivists. Two hospital administrators were interviewed from Zimbabwe, one who worked in medical education and the other in facilitating research projects. The clinical stakeholders interviewed reported a wide range of experience with USGT from no experience to near expert (table 1). The two providers who felt they were near expert level included a third-year internal medicine resident and a cardiothoracic surgeon, both from Nepal. Among the interviewees in Zimbabwe, an intensivist reported the highest proficiency. The IQR was calculated for clinical stakeholders' self-reported proficiency scores.

Introduction to themes

Three main themes emerged from these data (table 2): (1) stakeholders perceived multiple advantages of USGT, (2) access to equipment and training were limited and (3) while an online training approach is feasible, stakeholders expressed skepticism. Without exception, participants felt that USGT was superior to blind techniques, and perceived advantages to all stakeholders including patients, clinicians and the healthcare system. Despite the perceived advantages, none of the clinician participants had incorporated USGT into their clinical practice most often due to lack of easily accessible equipment and lack of sufficient training. Finally, when asked to consider whether a remote learning curriculum would be feasible in the current context, participants expressed skepticism regarding whether bedside procedures could be responsibly taught remotely.

Theme 1: Stakeholders perceived advantages of USGT over blind procedures at multiple levels in the healthcare system

Across all participants, there was recognition that USGT should be the standard practice in their clinical settings given the multiple advantages they could foresee. All interviewees believed that USGT would improve management and diagnosis of pathologies in the pleural space with accuracy and efficiency. They anticipated feeling more confident about the indication to proceed with thoracentesis, being able to visualize the effusion clearly, and subsequently better explain this decision to their patients. This enthusiasm for USGT was expressed by participant A18 who stated 'I will learn. I will make my student learn… If ultrasound is there, it's always a thumbs-up to ultrasound. We will be more than happy to use ultrasound because we don't want to go blindly…If the ultrasound is there, then definitely we'll learn the ultrasound better. There is no doubt'. Interviewees reported that it would be safer for their patients and be cost-effective for their hospitals. 'Less painful. Less time-consuming. Less complications' as participant A16 iterated.

Subtheme 1: Perceived advantages to the patient

Clinician participants uniformly expressed that optimizing the experience and safety for their patients was their highest priority, making USGT very desirable. Per participant A8, by using USGT they would be 'providing a standard of care for patients because they do deserve to have good care provided for them…They actually get the proper care that they deserve and reduce complications'. Expressing a similar sentiment, participant A6 stated 'You're less likely to get complications with a visceral injury, lung puncture. Also, the complications of

Table 2 Identified themes

Themes identified	Subthemes	Exemplary quotations
Stakeholders perceived advantages of USGT over blind procedures at multiple levels in the healthcare system	Improved management and diagnosis	A4: You get a quick diagnosis. You quickly pick up empyema's. You quickly pick up those fluids… you can quickly get a diagnosis.
	Improved safety with fewer complications	A16: Less painful. Less time-consuming. Less complications
	Improved cost for patients and the hospital	A3: the cost of buying this ultrasound scan and training the personnel is more in the initial stage. With time, when we compare the savings on the hospital stay, the good outcome of our patients, it will outweigh the cost of procuring these ultrasound scans.
Perceived barriers to adoption: access to equipment, training and traditional professional roles	Limited access to equipment	A7: I think the only time you can get an ultrasound scan is in the ultrasound scan department. There's no portable ultrasound scan, currently
	Limited access to training	A3: we really need the trainers. If we can have competent people who are able to do this point-of-care ultrasound scans to teach the trainees and, also, maybe, the interns in the other postgraduate, the junior faculty… this would be a very good investment
	Concern USGT is not within non-radiologists' scope of practice	A17: In our settings, radiologists will not be happy (having) ultrasound (done) by other people
Scepticism of online training for a bedside procedure despite apparent feasibility	Ethical concerns regarding learning an invasive procedure without a bedside supervisor	A18: One cannot say, 'Okay, you insert it like this' in a laptop and you (tell) patient 'I have seen it on video.' It is not a good practice.
	Inefficacy and logistical challenges of remote learning	A15: You cannot get confidence done by learning virtually. You have to be bedside…If you're learning virtually, it might take one month. If you're learning bedside, if your teacher is in front of you, you are touching, you can learn in 10 days, so it's a time period.

USGT, ultrasound-guided thoracentesis.

putting a huge chest drain [is] likely going to be less… You're likely to get less complications from doing ultrasound guided method compared to blindly'.

Subtheme 2: Perceived advantages to the clinician

Multiple participants perceived an important advantage of USGT to be reduced clinician anxiety experienced with blind procedures. Participant A18 stated that although he is experienced in performing thoracentesis, the procedure still elicits anxiety, 'It's my heartrate. If I have to do blindly, it'll run around 100. I'll [have] more panic when I do it blindly. I'll be very cautious. I'll percuss the patient five times before I insert a needle'. This was further echoed by participant A13 who stated, 'For a doctor, obviously, there is advantage of using ultrasound since we can visualize, the precision is more [and] we are confident enough in our procedure'. By having US guidance, 'at least you know where you are going' stated participant A4, unlike blind procedures. Stakeholders also felt that using US would not only increase their success rates, but would also improve their ability to decide whether thoracentesis was even indicated. Participant A3 reported US 'diagnostics are wonderful', making it valuable not only for the procedure but also for establishing the diagnosis. With improved preprocedural confidence in the indication for a thoracentesis and improving confidence in the clinician's ability to perform the procedure safely, there was universal agreement that USGT should be the standard of care. 'I'm trying to find any disadvantage [of US guidance]. I'm not finding any', stated participant A3.

In addition to improved confidence and reduced anxiety, the stakeholders felt that USGT would increase efficiency. Participant A2 stated USGT is 'probably going to be faster 'cause then the clinician is less likely to fail in terms of completing the procedure'. Multiple clinician participants reported when using a blind technique, they often are unsuccessful on the first attempt and need to perform multiple needle insertions to obtain pleural fluid. Participant A14 stated 'by doing blindly, sometime[s] we have to do twice or thrice we have to try it in patient', but as participant A18 stated, 'if you're using an ultrasound, you are not going blindly. You are seeing the road, and you are driving. Blindly, headlight is off, just you're driving on moonlight'.

Subtheme 3: Perceived advantages to the healthcare system

Although the primary goal was to improve care for their patients, the stakeholders recognized if they could do

the procedures more accurately and efficiently, this would also benefit the healthcare system. Given that all the stakeholders were either working at a government-funded hospital or had previously worked at one, they acknowledged that cost was a limiting factor for how they practice medicine. As participant A8 stated 'the reason why people improvise and people do blind thoracentesis is actually an issue of cost because I don't have the necessary equipment to provide the safest [care]—in the end, people actually end up improvising. I think this is all because of cost for the hospital, it seems expensive for them to buy thoracic ultrasound machines and especially if they know that people can still do blind thoracentesis and all'. However, needing to wait longer for diagnostic labs and time spent managing complications seen with blind thoracentesis, may actually cost the hospital more in the long run than the cost of the US. 'If we calculate all that, the ultrasound might be cheaper than the blind one', participant A19 stated.

Theme 2: Perceived barriers to adoption: Access to equipment, training, and traditional professional roles

Despite unanimous agreement that USGT should be the standard of care, participants reported significant barriers to adoption, limiting broad use. All participants perceived lack of accessible equipment and longitudinal training as the most important barriers to adoption in their local settings. Additionally, there was concern that using US would be perceived as outside the scope of practice for non-radiologist practitioners.

Subtheme 1: Limited access to equipment

All participants reported having US present in at least one of the hospitals they practiced. However, easy and timely access was a major barrier to adoption of USGT. 'They (ultrasound machines) are available. I know where to get them, but I think it's a bit difficult for me to get them because I work at a different hospital from where they are kept. If I needed an ultrasound machine, it means, actually, I have to drive to that hospital, get a machine, then drive to my hospital, then drive that machine back. That is really cumbersome' participant A8 stated. Some stakeholders had never seen bedside US being used for procedures and thought there may be an US available to them but did not know how to find it if they wanted, making determining true accessibility difficult to discern.

Additionally, there was fear that even if US became available in the main government hospitals, it would not necessarily be accessible in rural hospitals. Some clinician stakeholders expressed concern that if they adopted USGT in their current practice, they would lose valuable skills needed to perform blind technique when US was not available. Participant A18 stated, 'It's kind of like driving an automatic vs a manual car. If you get stuck somewhere with a manual, but you can only drive automatic, what are you gonna do? It's almost like learning how to do a blind thoracentesis is challenging, really challenging 'cause you don't have imaging, but at the same time, it could be easy to learn ultrasound, but it just isn't practical'. Stakeholders also expressed concern that the introduction of POCUS into their practice may erode their physical examinations skills more generally beyond just their ability to localize pleural fluid. As participant A4 stated 'people [will be] running away from examining patient[s] the proper, conventional way of examining'.

Subtheme 2: Limited access to training

Clinical interviewees believed without longitudinal mentoring from faculty skilled in POCUS, providing US machines alone would be insufficient to implement USGT. 'We need an expert, someone to guide us for the ultrasound-guided or ultrasound of the chest… If we find more expert[s] who teach us, then it will be very grateful for us to know', stated participant A14. Many of the Zimbabwe stakeholders recalled a clinician from an academic institution in the United States had visited Harare to teach an USGT seminar. For those who attended, they were not able to later perform the skill independently, nor teach other trainees who were unable to attend the session. When probed why, they reported that the seminar learning was insufficient in time and hands on practice. 'I only attended one session—I think it was in 2019— with one of the respiratory physician[s]. I only managed to attend for about two hours or so' stated participant A3. Many stakeholders believed an expert needed to be present for a prolonged period to assist them with their daily technique and clinical interpretation of different pleural and lung US findings. Only then would they feel competent enough to practice independently and teach their colleagues. As participant A7 stated, 'you will probably need somebody who is proficient, who knows how to use the ultrasound scan. If you don't know how to [use the] piece of equipment, chances are you will not know how to interpret what you see'.

Individual time available to learn USGT appeared to vary by level of training, specialty and willingness to adopt USGT into their practice. Participant A17 stated 'hospitals are very busy', making available time difficult for something that was not directly patient centered. However, if offered, they felt trainees should have time protected that may not be available for practicing attendings. As participant A3 stated 'Time wise, I'm sure people will make time for the postgraduate trainees to be available to be trained, especially if it's just a one week or a two week program. Most probably, the department will make time for the trainees to be available'. But as participant A21 stated, as a practicing cardiologist 'I have so many things to do that I might not be able to dedicate as much time as my trainee might have, you know'.

Subtheme 3: Concern USGT is not within non-radiologists' scope of practice

Most stakeholders stated the radiologists traditionally provided all imaging services in their local settings, indicating POCUS for USGT may be perceived as outside the scope of practice for non-radiologists'. There was

concern that radiology colleagues would feel they were encroaching on their job description and role in patient care if they performed US themselves. Participant A17 stated 'because radiologists think that their bread and butter is ultrasound they don't want it done by other physician[s]… In our settings, radiologists will not be happy [having] ultrasound [done] by other people'.

Additionally, some stakeholders felt that along with their current job description that their level of training precluded them from incorporating USGT into their practice, even if education was offered. Regardless of time available to learn, and if accepted within the scope of their practice, they believed they were too advanced in their career to develop this skill. These stakeholders ideally may want to learn USGT; however as participant A21 stated, they 'may have missed the boat'. He went on to say 'it's just a matter of time and your age, I think. If you're a young person, then you'll think of it as a simple thing to learn. If you started later, probably you'll have second thoughts about it'.

Theme 3: Skepticism of online training for a bedside procedure despite apparent feasibility

Given that absence of local expertise and training opportunities were identified as primary barriers to adoption, stakeholder perceptions of remote training options were explored. Stakeholders at both sites reported previous experience with remote learning in their local settings that was made possible by reliable internet access. Participant A22 stated 'Internet is easily accessible…there is a power cutoff sometimes. For few minutes, it can stop. Otherwise, there is no problem'. Participant A20 noted 'Online learning started very recently… During this COVID period, we had lot of experience using these Zoom things because, before, these things were not there…For [the] last one and half year, I think I am doing all Zoom classes. I think it will help and people will participate'.

Despite acknowledging that education online with real-time virtual forums is feasible, multiple stakeholders believed they would not be fully trained in USGT without bedside supervision and worried that performing an invasive procedure on a patient without complete training would be inappropriate and unethical. As participant A18 stated 'You cannot play with the patient, and you cannot just guess in a patient. We should be very sure when you insert a needle. Somebody should be there first…That's matter of confidence only. That is the one, and you should be very confident before you touch a patient'.

Another barrier to virtual learning was time constraints. Stakeholders believed online learning required more time than in person, making it inefficient. Participant A21 further explained with virtual teaching 'the real-life experience will not be there, so it may not carry in my day-to-day work. I may not be motivated enough to do it because I haven't done one just by looking at a video. I think the biggest shortcoming of just that bit of the program would be that I have never got a chance to do it under the supervision of somebody else who knows better than me' further emphasizing the perceived shortcomings of virtually learning USGT. Additionally, there was concern that if conducted by clinicians in another part of the world, aligning the appropriate time could be compromised due to time zone differences. Participant A22 stated 'You are across the globe, other side of the globe. Different timing. We need to manage time. Time is the factor how to learn…Timing. Timing is the one thing that might be limiting factor'.

DISCUSSION

Our results demonstrate that while stakeholders perceived USGT as a highly desirable practice, access to equipment and adequate training remain important barriers to broad adoption in these two geographically diverse, low-resource settings. Although the presence of reliable internet access made remote training options seem feasible, interviewees expressed skepticism that virtual learning alone was an appropriate training modality for bedside procedures. While the barriers of access to equipment and training are noted in multiple other studies, to our knowledge, skepticism toward remote procedural training is a novel finding that may be useful in guiding future USGT implementation efforts.[19 20] The primary concern expressed about remote US procedural training is that it would be unethical without an expert at bedside to help guide learners. An implementation strategy to address this concern may be to clarify to learners that the skill being taught is US-guided pleural fluid localization to assist in an invasive procedure that they are already performing regularly.

The traditional approach to providing POCUS training to clinicians in low-resource settings is to have experts, often faculty from academic medical centers in high-resource countries, travel to remote practice areas, spend time imparting skills for the local clinicians, then after a fairly brief time, return to their home countries. Our study results suggest this approach, in isolation, may be insufficient to impart adequate skill and confidence to result in adoption. The study data also suggests that there are perceived disadvantages to learning a procedural skill via virtual training alone. Taken together, the study findings suggest a hybrid curriculum that includes both in-person and virtual components may be the best approach to achieve USGT adoption by learners in this context.

The concern expressed by some participants that adoption of USGT would negatively impact their skill at performing blind thoracentesis and the necessary physical examination techniques when an US device is not available is also noteworthy. While this concern has also been raised in high-resource settings, the potential negative impact on physical examination skills may be greater in low-resource settings where clinicians rely more heavily on the physical examination given limited access to basic imaging modalities, including US. An implementation strategy to address this concern might be to emphasise

that when POCUS is available, it can actually augment physical examination skills by offering immediate feedback on the accuracy of the physical examination. In turn, this would potentially make future blind thoracenteses safer than they otherwise would be without US-guided practice.

Lastly, two additional concerns raised by interviewees was whether radiologists would be accepting of medical specialties performing USGT, and whether more senior practitioners would feel motivated to learn a new skill to enhance a procedure they have been performing for years. Again, these concerns are not unique to low-resource settings. A potential implementation strategy to address the concern that USGT will create tension with radiologists may be to point out that radiologists are not typically involved in performing thoracenteses in these practice settings as the procedure is typically performed blind. Therefore, USGT does not infringe on a previously established radiology practice in these hospitals. An implementation strategy that addresses the potential barrier of senior clinicians being less likely to adopt USGT may be to invest finite resources into training early career clinicians and senior clinicians who are still heavily involved in clinical education in an effort to integrate USGT into the standard practice more quickly.

Strengths and limitations

This study included two culturally diverse settings, which allows for increased generalizability when determining barriers to USGT adoption in resource-limited settings. The study was evaluated and reviewed by members of the research team who are practicing clinicians at both sites, which helped to more accurately capture the cultural context. The interview data was analyzed by multiple members of the research team to allow comprehensive data interpretation and mitigate personal bias.

An important limitation of this study is that no patients were interviewed, narrowing our understanding of the patient perspective with regard to determinants of USGT. Despite available evidence suggesting patients respond favorably to POCUS, and USGT is clearly a safer technique than blind, it is important for future investigations to explore the full value proposition for patients including aspects of cost.[21 22] Another study limitation is that the participants were enrolled on a voluntary basis with prior knowledge of the study objectives, which may have biased the results toward an increased interest in USGT adoption. Additionally, using interviews conducted remotely as the sole source of data also may have limited the study results. Triangulating direct observation of the clinical settings with interview data would have provided a more comprehensive assessment of the determinants. Finally, interview data were analyzed by investigators from an academic medical center in the United States who were unfamiliar with the settings. However, local collaborating clinicians were asked to evaluate the analysis and contribute to the manuscript to ensure they agreed with the study results in order to mitigate potential bias.

CONCLUSION

These data suggest that USGT is perceived as a highly desirable practice despite significant barriers to adoption including access to equipment and longitudinal training. As US technology becomes increasingly more affordable and portable, improved access is expected even in low-resource settings. The presence of reliable internet access suggests that remote or hybrid training may be a feasible approach to further USGT training. Concerns regarding the appropriateness of remote training and losing skills required for blind techniques will inform our future efforts to cocreate an USGT training program that is both contextually sensitive and optimally responsive to the needs and goals of local clinicians.

Author affiliations
[1]Department of Medicine, University of Colorado Hospital, Aurora, Colorado, USA
[2]Division of Hospital Medicine, University of Colorado, Aurora, Colorado, USA
[3]Department of Medicine, Harare University Teaching Hospital, Harare, Zimbabwe
[4]Division of Physiology, Tribhuvan University Institute of Medicine, Maharajgunj, Nepal
[5]Division of Pulmonary and Critical Care Medicine, Tribhuvan University Teaching Hospital, Kathmandu, Nepal
[6]Unit of Internal Medicine, University of Zimbabwe Faculty of Medicine and Health Sciences, Harare, Zimbabwe
[7]Division of Pulmonary and Critical Care Medicine, University of Colorado, Aurora, Colorado, USA

Correction notice This article has been corrected since it first published. In article-title 'resources limited' has been changed to 'resource limited'.

Contributors JD: Conception of the work, design of the work, acquisition of data, analysis and interpretation of data, drafting the work, revising the work critically for important intellectual content, final approval of the version to be published, agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The guarantor accepts full responsibility for the work, has access to the data, and controlled the decision to publish. RH and AMM: Design of the work, analysis and interpretation of data, drafting the work, revising the work critically for important intellectual content, final approval of the version to be published, agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. TNM, NM, SKD and MB: Interpretation of data, drafting the work, revising the work critically for important intellectual content, final approval of the version to be published, agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. AM: Design of the work, interpretation of data, drafting the work, revising the work critically for important intellectual content, final approval of the version to be published, agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Funding This work was supported by grant K12 HL137862 funded by National Heart, Lung and Blood Institute.

Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval This study involves human participants. The study was exempt by institutional review board of the University of Colorado and institutional review board of Tribhuvan University, Kathmandu, Nepal. In Zimbabwe, the process was conducted as an internal hospital audit of a POCUS training programme, which had been conducted by one of the authors (AM) at Parirenyatwa Hospital, Harare, Zimbabwe in 2019. Postcard consent was obtained from all participants and verbal consent was obtained at the beginning of each interview.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement All data relevant to the study are included in the article or uploaded as online supplemental information.

ORCID iD
Jennifer Doran http://orcid.org/0000-0001-8163-9698

REFERENCES

1 Dancel R, Schnobrich D, Puri N, *et al*. Recommendations on the use of ultrasound guidance for adult thoracentesis: a position statement of the society of hospital medicine. *J Hosp Med* 2018;13:126–35.
2 Soni NJ, Franco R, Velez MI, *et al*. Ultrasound in the diagnosis and management of pleural effusions. *J Hosp Med* 2015;10:811–6.
3 Mercaldi CJ, Lanes SF. Ultrasound guidance decreases complications and improves the cost of care among patients undergoing thoracentesis and paracentesis. *Chest* 2013;143:532–8.
4 Daniels CE, Ryu JH. Improving the safety of thoracentesis. *Curr Opin Pulm Med* 2011;17:232–6.
5 Diacon AH, Brutsche MH, Solèr M. Accuracy of pleural puncture sites: a prospective comparison of clinical examination with ultrasound. *Chest* 2003;123:436–41.
6 Mollura DJ, Soroosh G, Culp MP, *et al*. 2016 RAD-AID conference on international radiology for developing countries: gaps, growth, and United Nations sustainable development goals. *J Am Coll Radiol* 2017;14:841–7.
7 Barnes TW, Morgenthaler TI, Olson EJ, *et al*. Sonographically guided thoracentesis and rate of pneumothorax. *J Clin Ultrasound* 2005;33:442–6.
8 World Health Organization. Training in diagnostic ultrasound: essentials, principles and standards. Report of a WHO Study Group. In: *World health organ Tech Rep Ser*, 1998: 875:i-46; back cover.
9 Bobbia X, Abou-Badra M, Hansel N, *et al*. Changes in the availability of bedside ultrasound practice in emergency rooms and prehospital settings in France. *Anaesth Crit Care Pain Med* 2018;37:201–5.
10 Wong J, Montague S, Wallace P, *et al*. Barriers to learning and using point-of-care ultrasound: a survey of practicing internists in six North American institutions. *Ultrasound J* 2020;12:19.
11 Abrokwa SK, Ruby LC, Heuvelings CC, *et al*. Task shifting for point of care ultrasound in primary healthcare in low- and middle-income countries-a systematic review. *EClinicalMedicine* 2022;45:101333.
12 McCreight MS, Rabin BA, Glasgow RE, *et al*. Using the practical, robust implementation and sustainability model (PriSM) to qualitatively assess multilevel contextual factors to help plan, implement, evaluate, and disseminate health services programs. *Transl Behav Med* 2019;9:1002–11.
13 Feldstein AC, Glasgow RE, practical A. A practical, robust implementation and sustainability model (PriSM) for integrating research findings into practice. *Jt Comm J Qual Patient Saf* 2008;34:228–43.
14 Glasgow RE, Harden SM, Gaglio B, *et al*. RE-AIM planning and evaluation framework: adapting to new science and practice with a 20-year review. *Front Public Health* 2019;7:64.
15 Palinkas LA, Horwitz SM, Green CA, *et al*. Purposeful sampling for qualitative data collection and analysis in mixed method implementation research. *Adm Policy Ment Health* 2015;42:533–44.
16 Hennink MM, Kaiser BN, Marconi VC. Code saturation versus meaning saturation: how many interviews are enough? *Qual Health Res* 2017;27:591–608.
17 Guest GN E. *Applied thematic analysis*. Sage Publication, 2012.
18 Dedoose version 9.0.17, web application for managing, analyzing, and presenting qualitative and mixed method research data. sociocultural research consultants, LIC
19 Maw AM, Galvin B, Henri R, *et al*. Stakeholder perceptions of point-of-care ultrasound implementation in resource-limited settings. *Diagnostics* 2019;9. doi:10.3390/diagnostics9040153. [Epub ahead of print: 18 10 2019].
20 Boniface KS, Drake A, Pyle M, *et al*. Learner-centered survey of point-of-care ultrasound training, competence, and implementation barriers in emergency medicine training programs in India. *AEM Educ Train* 2020;4:387–94.
21 Claret P-G, Bobbia X, Le Roux S, *et al*. Point-of-care ultrasonography at the ED maximizes patient confidence in emergency physicians. *Am J Emerg Med* 2016;34:657–9.
22 Howard ZD, Noble VE, Marill KA, *et al*. Bedside ultrasound maximizes patient satisfaction. *J Emerg Med* 2014;46:46–53.