Routine Application of Lung Ultrasonography in Respiratory Care: Knowledge, Perceptions, and Barriers to Instigate.

JITHIN KALATHIKUDIYIL SREEDHARAN (jithinksree@gmail.com)
Prince Sultan Military College of Health Sciences

MANJUSH KARTHIKA
Khawarizmi International College

Jaber S Alqahtani
Prince Sultan Military College of Health Sciences

Saad Alrabeeah
Prince Sultan Military College of Health Sciences

Musallam Alnasser
Prince Sultan Military College of Health Sciences

Abdullah Alqahtani
Prince Sultan Military College of Health Sciences

Mohammed Al Ahmari
Prince Sultan Military College of Health Sciences

Meshal Al Enezi
Prince Sultan Military College of Health Sciences

Abdullah A Ghazwani
Prince Sultan Military College of Health Sciences

Chris Sara Mathew
Khawarizmi International College

Abdulelah M Aldhahir
Jazan University

Suresh G Nair
Aster Medicity

Arulanantham Zechariah Jebakumar
Prince Sultan Military College of Health Sciences

Research Article

Keywords: Lung ultrasound, Respiratory Therapy, Curriculum, Training

Posted Date: April 18th, 2022

DOI: https://doi.org/10.21203/rs.3.rs-1548607/v1

Abstract

Background:

Lung Ultrasound (LUS) has been found to be beneficial in detecting respiratory disorders at the bedside. Understanding the important role of Respiratory Therapists (RTs) in the critical care, we aimed to assess their knowledge, perceived relevance of LUS to clinical practice, current skill gaps, and barriers to practice.

Materials and Methods:

A cross-sectional, nationwide survey comprising 28 questions were conducted among the RTs working in the Kingdom of Saudi Arabia. The validated questionnaire included 4 sections; the demographics, knowledge and perceptions, applicability and self-reported proficiency, and barriers to the use of LUS by RTs.

Results:

A total of 256 RTs across different regions of Saudi Arabia participated in this survey. The majority were males (71.9%) with a mean age of 30.7 (SD ± 7.7) years, and 46.1% of the total respondents were having <5 years of working experience. Only (18.1%) of the participants used ultrasound devices in their clinical practice, and (43%) of them had never received any training. 66% of the participants perceived LUS as an effective tool in the RT practice and immensely valuable in their daily practice (70%). A large proportion of RTs found LUS to be ineffective in calculating the lung score (50.4%), assessing the diaphragm (40.2%), and detecting pulmonary edema (38.3%). Calculating lung score has a lower mean score (mean score 2.55) on both skills and identifying its applicability to clinical practice (mean score 2.71) than other indications with almost mean scores of 3 and 4. Lack of training and curriculum (154/256; 60.2%) remains the top barrier that prevented RTs from using LUS in their clinical practice.

Conclusions:

While many RTs in Saudi Arabia perceived LUS as an effective tool in the RT practice, considerable competence gaps exist, indicating the need for LUS training. There is a need for incorporating LUS into the curriculum of RT schools and promoting competency-based training for the current RT workforce to help improve patient care.

Introduction

Lung ultrasound (LUS) is a point-of-care imaging tool routinely used in acute care settings, primarily to assess the pleura, lung parenchyma, and other associated structures like the ribs, intercostal muscles, and diaphragm. Traditionally, chest x-rays were considered the daily tool to evaluate lung pathologies, supported by longstanding data (1), however, there exists studies that question its diagnostic superiority and clinical impact (2-4). The evolution of the practice of LUS in recent past with superior quality and spatial resolution has yielded greater diagnostic accuracy (5). LUS was reported to be more advantageous than chest x-rays and computed tomography in terms of its availability, portability, reproducibility, absence

of radiation, real-time imaging, and documentation (6). This makes LUS a promising diagnostic tool while caring for a mechanically ventilated patient. While radiologists are the primary subject experts of diagnostic ultrasound, with its diverse scope, acute care professionals also have adopted this practice. Within the inter-professional team of intensive care units is the Respiratory Therapist (RT), who plays a significant role in the care of ventilated patients. Globally, due to the evolving nature of LUS amongst acute care physicians, it is not yet considered one of the core standard practices of a respiratory therapist. It is also reported that the scope of RTs in imaging areas, such as LUS is vast, but underutilized (7). A recently published scoping review about the involvement of RTs in ultrasound training and practice strikingly highlighted the paucity of articles, with the inclusion of only seven published studies (8). Although the need for incorporating LUS in the curriculum of RT schools and competency-based training for working RTs are echoed by few authors, no pieces of literature are available to support this as a global approach, except for some anecdotal updates (9). The respiratory therapy profession exists in the Kingdom of Saudi Arabia, since the 1970s, with a current status of 23 respiratory therapy schools, and a total of 1400 working respiratory therapists (10, 11). It is subjectively reported by some centers that, respiratory therapists are getting trained on LUS, within their department, and many of them are using this imaging modality. However, there is no objective data to justify the same with regards to the duration of their training, competency checks, and barriers to the practice. Hence, a national survey was planned to assess the scope of practice of LUS among RTs in Saudi Arabia. The domains of this survey included knowledge, perception, and barriers related to the practice of LUS. We hope that the results of this survey will set a reference mark for future projects, focusing on LUS training and thereby expanding the scope of practice of RT professionals in the Kingdom of Saudi Arabia.

Materials And Methods

This is a national survey-based study conducted online among RTs. Qualified RTs working in the public and private sector hospitals in the country, from different educational levels, gender and age groups, were involved in this study. Total of 256 RTs responded to all the survey questions; hence, they were chosen for the study. Respondents included people from different nationalities but active in the professional practice in the Kingdom of Saudi Arabia and from its all four geographic regions.

The survey was conducted after ethical approval from the Prince Sultan Military College of Health Sciences, Dhahran (IRB number: IRB-2022-RC-008). Participants' consent was taken while collecting the data for the study. While clicking the survey link, the informed consent showed up first, followed by the questionnaire. Those who were not interested to take part in the survey were given the option to decline the participation and opted not to participate in the survey. Participants were appraised about the goals of the study in the informed consent and they were also notified that it is fully an anonymous survey, and warranted the privacy of their data. A systematic region-based approach was adopted for conveying information to the target population and we used a popular web-based survey platform to collect the responses. Questions corresponding to RT's knowledge and expertise, perception, and potential barriers to active implementation of LUS were employed to archive the response.

Questionnaire Development

The survey questionnaire was created in the English language. Studies describing the applications of LUS and the competencies required for its safe practice were reviewed [2, 3, 4, 12-20]. Drawing on this knowledge, two researchers with expertise in medical education, LUS, and survey design developed the questionnaire to investigate RT's knowledge and perceptions about LUS. An expert panel composed by the research group validated the questions. The panel members have encompassed professionals who have expertise in survey analysis besides proficiency in the English language. The panel examined the core content, language, appropriateness of questions for various domains, scoring patterns, etc. The experimental research group comprised of 25 judiciously selected participants of various ages, genders, and educational credentials. The expert panel appraised their observations and advised for necessary OR no modifications before launching the survey. The questions in each domain; knowledge, perception, and barriers underwent face validity and internal consistency and analyzed the responses to each question in the pilot study using Cronbach's alpha reliability test. The overall Cronbach's Alpha value is 0.936 (> 0.6) which was found to be acceptable.

The questionnaire was divided into four sections; the socio-demographic segment (Part-1) and the knowledge (Part-2), perception (Part-3), and barrier (Part-3) section. In the socio-demographic portion, respondents' particulars such as gender, age, nationality, geographical location, educational qualification, designation at the workplace, work experience in years, type of hospital with a number of beds, and details about the specialized area of work were collected. The participants' training and accreditation in LUS were identified via closed-ended questions. An incremental scale was utilized to quantify the participants' LUS practice. Participants were requested to rate the importance of LUS using a Likert scale in addition to their self-reported proficiency levels and knowledge of LUS. While in the remaining parts i.e. questions relevant to the knowledge included a set of answers just as 'Yes ', 'No' and 'Don't know' and a rating of 'very poor' to 'very good'. The perception questions confined the answers 'Strongly agree', 'Agree', 'Neutral', 'Disagree', 'Strongly Disagree', and one question with a rating scale of 1-5. Finally, the barrier section with one question listed the potential barriers, the data presented in frequencies, and one open-ended question. Each variable under the data has been scored as per the questionnaire apart from demographic characters.

Study Design

This was a cross-sectional descriptive study using a web survey hosted via Google Forms. Respiratory Therapists working in public and private sector hospitals in differing regions of the kingdom have been involved in this study. The survey was administered in the months of February and March 2022. Responses received in the course of the study were screened and further considered for analysis. Social media platforms like Twitter, LinkedIn, WhatsApp, and email communications were used for circulating the questionnaire of this study and requested to answer all the questions pertaining to the demographic data and all three major domains. Questions from the respective domain were presented sequentially, and a pop-up request turned up to answer the un-attended question before moving to the subsequent section.

Inclusion and Exclusion Criteria

Respiratory Therapists practicing in the public and private sector hospitals in the Kingdom of Saudi Arabia with internet accessibility and who were willing to participate in the study were included. RTs working in medical equipment companies, and those who are retired from active practice were fully excluded from the study. No personal appeal or gratuity was rendered to participants to take part in the study. None of the RTs who completed the survey were excluded from the study.

Statistical Analysis

All completed survey responses were evaluated and recorded in an excel spreadsheet and the statistical analysis has been performed with SPSS (Statistical Package for Social Sciences) Package with version 28. The dissemination of all qualitative variables both demographic and other variables (i.e. close-ended) values of samples have been examined with frequency tables among samples. The comparison tables have been calculated to find the association for comparing the qualitative variables by applying the chi-square test. Two-sided statistical tests with a p-value of ≤ 0.05 (95%) have been considered significant.

Results

A total of 256 RTs accepted the invitation to participate in this survey and analyzed it. Responses were received from February 2022 to March 2022. Of the 256 included participants, 184 (71.9%) were males; the mean age was 30.7 (SD ± 7.7) years; 234 (91.4%) were Saudi nationals. 186 (72.7%) participants reported a bachelor's degree in RT as their highest degree of education; 44(17.2%) Master and 14 (5.5%) Ph.D. as the highest degree of their education. The practice regions and practice experience (in years) of the participants were diverse; however, 105 (41%) of the sample practicing in the eastern region and 118 (46.1%) had less than 5 years of clinical experience. The demographics of the respondents are shown in [Table 1].

Table 1: Participants' Demographic Characteristics

Basic Characters	Frequency (n)	Percentage (%)
Gender		
Male	184	71.9
Female	72	28.1
Nationality		
Saudi	234	91.4
Non-Saudi	22	8.6
Education Qualification		
Diploma in Respiratory Care	6	2.3
Bachelor in Respiratory Care	186	72.7
Master Degree	44	17.2
Doctoral Degree (Ph.D.).	14	5.5
Other	6	2.3
Years of Experience		
Less than 5 years	118	46.1
5 – 10 years	65	25.4
11 – 20 years	55	21.5
More than 20 years	18	7.0
Region		
Central	77	30.1
Eastern	105	41.0
Northern	11	4.3
Southern	27	10.5
Western	36	14.1

Knowledge about Lung Ultrasound

The first part of the questionnaire concerns questions about the current use and knowledge of LUS. 48 (18.1%) participants used ultrasound devices in their clinical practice, and 24(43%) of them had never received any training. Conversely, couple of them have received formal training but have not applied it in their daily practice (50/179; 24%) (Chi-square = 19.24; P-value=0.001) [Table-3]. The majority of them were working in government hospitals (75%), with an average bed capacity of 100-399 (43.8%) under the title of

‘respiratory therapist’ (48.4%). The participants attained basic (32.4%) or elementary (29.7%) knowledge to perform an LUS examination, however, (32.8%) reported having no knowledge about LUS. Knowledge of the participants on various aspects concerning the LUS scan was assessed [Table 1.2]. Notwithstanding the participant’s present work profiles, level of knowledge, and primary training the large majority (81.6%) believe LUS is a promising diagnostic tool for an RT.

Table 1.2 Assessment of knowledge of participants concerning lung ultrasound scan.

Basic Characters	Frequency (n)	Percentage (%)
Institution Type		
▪ Government Hospital	192	75.0
▪ Military Hospitals	6	2.3
▪ Ministry of Health	15	5.9
▪ Private Sectors	39	15.3
▪ University Hospitals	4	1.6
What is the current number of beds in the Hospital?		
▪ Less than 100	50	19.6
▪ 100 – 399	112	43.8
▪ 400 – 599	49	19.1
▪ 600 and above	45	17.6
Designation/Position		
▪ Demonstrator/Clinical Instructor	8	3.1
▪ Head/Chief/In-charge	24	9.4
▪ Lecturer/Asst. Professor	23	9.0
▪ Respiratory Technician	14	5.5
▪ Respiratory Therapist	124	48.4
▪ Respiratory Therapy Supervisor	20	7.8
▪ Senior Respiratory Therapist	43	16.8
Have you ever used an Ultrasound device		
▪ Yes	48	18.8
▪ No	208	81.3
Have you ever undergone any form of training (Online, Certificate Program/Workshop, etc.) / education in performing lung ultrasound?		
▪ Yes	77	30.1
▪ No	179	69.9
What information do you have about lung ultrasound and its use in Respiratory Therapy?		
▪ Basic Knowledge to perform a diagnostic study	83	32.4
▪ Elementary knowledge	76	29.7
▪ I have completed Training and I can work as a trainer for	6	2.3
LUS	84	32.8
▪ No Knowledge	7	2.7
▪ Sufficient knowledge to perform diagnostic studies on a routine basis		
Do you think that Lung Ultrasound could help in your daily clinical practice and could be useful for your specialty in the future?		
▪ Yes	209	81.6
▪ No	16	6.3
▪ Undecided	31	12.1

Perceived applicability, self-reported skills, and skill gap in diagnostic applications of LUS

Ultrasound was perceived to be highly useful (66%) in the practice of Respiratory Therapy. The participants had greater confidence and agree that LUS can be performed by non-physicians (80.6%), and it was highly valuable in their daily practice (70.7%). A significant majority (79%) highly recommended incorporating the LUS training formally into the RT curriculum. Half of the respondents expressed a lack of institutional support (50.4%) and their interest to receive continuous training (79.3%) [Table 2].

Table 2: Respiratory Therapists' perception about the LUS in their clinical practice.

	Fully Agree n(%)	Partially Agree n(%)	Neither Agree Nor disagree n(%)	Some Disagreement n(%)	Totally Disagree n(%)
LUS can be performed by Non-physicians.	137 (53.6)	69 (27)	35 (13.7)	9 (3.5)	6 (2.3)
LUS, performed by Non-physicians is useful in daily practice.	121 (43)	71 (27.7)	46 (18)	9 (3.5)	9 (3.5)
The training in my RT school introduced me to LUS practice.	82 (32.1)	51 (19.9)	41 (16)	24 (9.4)	58 (22.7)
In my experience, LUS is a useful tool in RT practice.	103 (40.2)	66 (25.8)	57 (22.3)	19 (7.4)	11 (4.3)
Do you think that LUS should be taught to RT students and included in the curriculum?	148 (57.9)	54 (21.1)	35 (13.7)	9 (3.5)	10 (3.9)
The hospital encouraged me and there have been workshops	26 (10.2)	33 (12.9)	68 (26.6)	37 (14.5)	92 (35.9)
I am interested to receive training and using LUS?	155(60.5)	48 (18.8)	35(13.7)	9 (3.5)	9 (305)

LUS: Lung Ultrasound, RT: Respiratory Therapist

Table 3: The significance of the use of ultrasound devices with regards to the training.

Chi square = 19.24; P-value = 0.001

When comparing the applicability in clinical practice and participant skills and knowledge, a significant difference was found, with the indications such as Identifying pneumothorax, identifying lung consolidation/pneumonia, identifying pleural effusion and identifying pulmonary edema on current skills or knowledge (p = 0.001). The other indications were not statistically significant and the participants observed those indications were not much applicable to their clinical practice and current skills and knowledge [Table

Have you ever used a lung ultrasound device?	Have you ever undergone any form of training (Online, Certificate Program/Workshop, etc.) / education in performing lung ultrasound?	
	No **n(%)**	Yes **n(%)**
No	158 (76.0)	50 (24.0)
Yes	21 (43.8)	27 (56.3)
Total	179 (69.9)	77 (30.1)

4].

Table-4: RTs perceptions of the applicability of LUS and their self-reported proficiency in LUS

Procedure		Applicability in the clinical practice			Participant's current skills or knowledge		
		Have you ever undergone any form of training (Online, Certificate Program/Workshop, etc.) / education in performing lung ultrasound?			Have you ever undergone any form of training (Online, Certificate Program/Workshop, etc.) / education in performing lung ultrasound?		
		Yes **N (%)**	No **N (%)**	Significance (P-value)	Yes **N (%)**	No **N (%)**	Significance (P-value)
Identifying pneumothorax	Good	27 (35.1)	87 (48.6)	0.65	20 (26)	74 (41.3)	0.001*
	Fair	22 (28.6)	43 (24.0)		28 (36.4)	44 (24.6)	
	Poor	28 (36.4)	49 (27.4)		29 (37.7)	61 (34.1)	
Identifying lung consolidation/pneumonia	Good	24 (31.2)	74 (41.3)	0.98	23 (29.9)	69 (38.5)	0.001*
	Fair	19 (24.7)	50 (27.9)		21 (27.3)	45 (25.1)	
	Poor	34 (44.2)	55 (30.7)		33 (42.9)	65 (36.3)	
Identifying pleural effusion	Good	32 (41.6)	89 (49.7)	0.43	28 (36.4)	74 (41.3)	0.024*
	Fair	19 (24.7)	35 (19.6)		28 (36.4)	42 (23.5)	
	Poor	26 (33.8)	55 (30.7)		21 (27.3)	63 (35.2)	
Identifying pulmonary edema	Good	22 (28.6)	71 (39.7)	0.38	23 (29.9)	65 (36.3)	0.011*
	Fair	23 (29.9)	42 (23.5)		21 (27.3)	44 (24.6)	
	Poor	32 (41.6)	66 (36.9)		33 (42.9)	70 (39.1)	
Assessing the diaphragm	Good	29 (37.7)	67 (37.4)	0.86	29 (37.7)	61 (34.1)	0.13
	Fair	16 (20.8)	41 (22.9)		21 (27.3)	43 (24.0)	
	Poor	32 (41.6)	71 (39.7)		27 (35.1)	75 (41.9)	
Arterial blood sampling/line insertion	Good	43 (55.8)	91 (50.8)	0.63	44 (57.1)	92 (51.4)	0.32

	Fair	17 (22.1)	40 (22.3)		16 (20.8)	34 (19.0)	
	Poor	17 (22.1)	48 (26.8)		17 (22.1)	53 (29.6)	
Assessing the airway/intubation	Good	29 (37.7)	84 (46.9)	0.27	29 (37.7)	83 (46.4)	0.37
	Fair	13 (16.9)	32 (17.9)		16 (20.8)	31 (17.4)	
	Poor	35 (45.5)	63 (35.2)		32 (41.6)	65 (36.3)	
Calculating the lung score	Good	12 (15.6)	51 (28.5)	0.18	15 (19.5)	48 (26.8)	0.55
	Fair	19 (24.7)	45 (25.1)		18 (23.4)	46 (25.7)	
	Poor	46 (59.7)	83 (46.4)		44 (57.1)	85 (47.5)	

The survey respondents perceived that LUS was least applicable in the following areas; calculating the lung score (50.4%), assessing the diaphragm (40.2%), identifying pulmonary edema (38.3%), and assessing the airway/intubation (38.4%). On the contrary, the largest perceived skill gap reported was also reported in calculating the lung score (50%), identifying pulmonary edema (40%), and assessing the diaphragm (39.9%) [Table 4]. Skill gap was defined as the difference between the perceived applicability of an application or procedure and self-rated skills/knowledge in that application or procedure (21). A comparison was carried out between each reported skill, and between skill and application in clinical practice in relation to all the indications. Calculating lung score has a lower mean score on both skills (Mean score 2.55) and identifying its applicability to clinical practice (Mean score 2.71) than other indications with almost mean scores of 3 and 4 [Figure-1].

Barriers to use LUS

A proportion (90/256; 35.2%) of respondents were having no interest to implement LUS in their practice, however, lack of proper training and curriculum (154/256; 60.2%) remains the top reason and a barrier that prevented them from using LUS. Numerous barriers were identified of which the top four were: lack of available USG machines on site (113/256; 44.1%) or lack of learner time (84/256; 32.8%) [Figure-2].

Discussion

This study was the first to investigate Saudi Arabia's registered respiratory therapists about their use (or lack of use) of LUS. Even though the sample size captured only a small section (17.4%) of Saudi Arabia's RTs, the key demographic and professional variables of RTs in the Kingdom were reflective of the survey sample. A greater part of the participants were male, worked in a clinical capacity, and was employed in

government practice and practiced within the respiratory care field. These findings are not surprising as they reflect the demographic and professional trends seen in Saudi Arabia (11). The findings from the current study might indicate decreased use of LUS by RTs. However, it is imperative to remark that the current study only surveyed around 17.4% of registered RTs in the Kingdom, and therefore the level of LUS practice reported may not necessarily be a true representation of the whole cohort. A large international study is also warranted to offer a more accurate overview of the use of LUS by RTs (8). It is possible that the paucity of definite guidelines or position statements for the RTs to perform LUS may have led to the uncertainty as reflected in the survey results. Furthermore, this uncertainty is likely to be perpetuated given that LUS is an emerging tool for RTs and its prodigious use in the respiratory care field is still evolving (7). It is anticipated that the outcomes of this research will improve the understanding in this regard. There is clearly a need for both national and international regulatory bodies to acknowledge this situation and to work with professional leaders to establish guidelines to provide certainty for the scope of practice and training (20). We also found there is a strong association between the utility of lung ultrasound devices with training and without training. Table-3 shows the majority of samples who have not received training are not using the device and its significance. At the same time, it is worth mentioning, that an insignificant share of participants who did not receive any formal training is using LUS in their clinical practice [Table- 3]. This aspect has to be investigated in the context of the proliferation of ultrasound machines in the hands of untrained health professionals. Perhaps as discussed by Filly. R in his editorial 30 years ago, these findings can be an unfortunate realization that diagnostic sonography truly is the next stethoscope: used by many, understood by few (22).

The results of the survey showed a significant gap between perceived applicability and self-reported skill and knowledge in many ultrasound diagnostic applications and procedures in respiratory patient care. The current study was conducted momentarily after the pandemic of coronavirus disease, and yet the usage of LUS in calculating the lung score and correlating it with the clinical findings and laboratory markers in ascertaining the severity were considered least relevant. The point should be made that the ultrasound expertise and competence of the participants to execute LUS were both limited. Thus, participants were unlikely to be conversant with the latest research on the role of LUS in the assessment of coronavirus disease (23, 24).

The participants expressed greater confidence in the ability of non-physicians in performing LUS (80.6%), and they strongly believe that it is highly useful in effective patient management (70.7%) as customary. These findings are supported by Swamy et.al; they advise that nurses, allied healthcare professionals, and students can precisely obtain and interpret LUS images after a transitory training period in most cases (25). Disappointingly, our findings also indicate that RTs were unable to implement LUS into practice because of the lack of mentors (18%). Prioritizing institutional support for staff training and infrastructure for continuous quality assurance activities, including implementing a service option, is essential for expeditiously incorporating LUS into the scope of practice of an RT. The scores relating to the applicability of each indication of LUS studied were higher than that of the sample's self-reported proficiency in that skill except for arterial blood gas sampling and line insertion [Figure 1] and it is suggestive of the presence of significant skill gaps relating to LUS among RTs. These gaps can only be addressed by the institution of a

training program with formal processes for supervision, governance, and accreditation (26). Furthermore, our efforts for assessing the skill gaps can guide educational interventions to resolve these deficiencies.

This survey is the first published research that has specifically explored the barriers that prevent RTs from using LUS. The barriers identified included lack of training, no interest, lack of learner time, legal issues, availability of ultrasound machines, lack of formal training and curriculum, lack of mentors, lack of formal accreditation, and LUS exams were usually performed by other specialists/conflict with the specialty. Lack of formal training was a major barrier (60.2%), as there are very limited LUS training opportunities in Saudi Arabia and the Respiratory Care bachelor's program at Prince Sultan Military College of Health Sciences (PSMCHS) is the only program that has incorporated LUS formally into the curriculum in the recent past. This requisite was further substantiated by the response of the participants, the majority of them (66%) felt LUS training is useful for their professional practice and opined LUS must be taught to RC students and integrated into their curriculum (79%). The PSMCHS-RC curriculum for LUS was designed to offer organized, interdisciplinary LUS training to RT students through their final year courses by recognizing the importance of ultrasound as an imaging modality in Respiratory Care practice (27). Other medical residency programs such as emergency medicine and internal medicine that have incorporated LUS learning into core curricula have proven benefits from a longitudinal model, given the ability of beginners to retain and reuse core concepts (15, 28). With this incorporation of LUS training in the RT curriculum, we hypothesize that more recent cohorts of learners would enter respiratory care practice with higher LUS knowledge and skills (29, 30). Another key barrier identified was the shortage of ultrasound equipment, which can be assumed to be due to the views about the prohibitive cost of ultrasound equipment. This issue was compounded by the lack of a clear structure to specifically document the LUS service or as a stand-alone service provided by the RTs. However, to our knowledge, there are currently no studies nationally or internationally that assessed the primary need of LUS training for RTs, and evaluate changes in learning needs over time, thus it remains unknown whether the lack of baseline LUS knowledge and skills is a verdict unique to this country or that this finding is also existing elsewhere.

Strengths and Limitations

This is the first nationwide survey globally on the practice of LUS amongst Respiratory Therapists. The strength of the study includes a fair response rate. Participation bias is possible as RTs who use LUS regularly may be keener to participate in the survey. Learners may in fact know more (or less) than they report. However, regardless of whether our participants were under-estimating their self-reported skills and knowledge, the fact that learners feel their skills are inadequate mandates an educational response from the programs or leadership, at least for skills where competencies are an expectation.

Conclusions

Ultrasound is certainly one of the most user-dependent diagnostic technologies that exist. LUS can be a prevailing tool to improve patient safety through enhanced and expedited diagnosis and procedural guidance. Even though some very elementary uses of ultrasound can be picked up rapidly, substantial skill is necessary to acquire and interpret fitting information. Building an LUS program for RT, which optimizes

patient safety and patient-centered outcomes necessitates judgment and oversight of this influential tool. The establishment of applicable resources together with robust training and competency assessment, image processing, policy to ensure quality, and defining and empowering a qualified person as accountable will ensure the best outcomes. The training curricula must-have modules that take account of the learning needs of the students at the undergraduate level. Additionally, the RT program would need to develop mentors and be as affordable as possible.

Future studies should evaluate not only the quantitative but the content and quality of LUS education at the undergraduate level despite the perceived widespread integration of LUS, there continues to be a large LUS skill and knowledge gap. Therefore, LUS educators should not yet assume any significant learner baseline LUS knowledge or skills when developing their LUS curriculum for RTs. It is necessary to establish the scope of practice and institutional privileges. RTs need to be aware of their limitations while performing LUS, and it is critical to know when to call for help from an expert professional (such as a radiologist or an intensivist) when needed.

Abbreviations

LUS: Lung Ultrasound

RT: Respiratory Therapy

RTs: Respiratory Therapists

RC: Respiratory Care

PSMCHS: Prince Sultan Military College of Health Sciences

SPSS: Statistical Package for Social Sciences

SD: Standard Deviation

Declarations

Availability of data and materials

The datasets generated and/or analyzed during the current study are not publicly available but are available from the corresponding author on reasonable request.

Ethics declarations

This study was approved by the ethics committee of the Prince Sultan Military College of Health Sciences, Dhahran (IRB number: IRB-2022-RC-008). Participants provided informed consent electronically and anonymously. All study procedures were performed in accordance with the relevant institutional guidelines and regulations.

Consent for publication

Not applicable

Competing interests

The authors declare that they have no competing interests.

Acknowledgments

The authors wish to thank the Vice Deanship of Postgraduate Studies and Research at PSMCHS for their continuous support.

Author Contributions

JS, MK, and JSA conceptualized and designed the research and the questionnaire. MAA, SA, AA, AAG, MAE, and AMA conducted the data collection with support from JS and JSA. JS, CSM, and AZJ organized the data collection and performed the quantitative analysis with support from SA and JSA. MK and SGN performed the qualitative analysis. JS drafted the manuscript. All authors participated in the critical revision of the manuscript, approved the final manuscript as submitted, and agree to be accountable for all aspects of the work.

Funding

Not applicable

Author information

Affiliations

- Department of Respiratory Care, Prince Sultan Military College of Health Sciences, Dammam, Saudi Arabia

Jithin K Sreedharan, Jaber S Alqahtani , Saad M AlRabeeah ,Musallam Alnasser, Abdullah S Alqahtani, Mohammed Alahmari, Meshal Alenezi, Abdullah A Ghazwani

- Vice Deanship of Postgraduate Studies and Research, Prince Sultan Military College of Health Sciences, Dammam, Saudi Arabia

Arulanantham Zechariah Jebakumar

- Respiratory Care, Department of Health and Medical Sciences, Khawarizmi International College, Abu Dhabi, United Arab Emirates

Manjush Karthika, Chris Sara Mathew

- Respiratory Therapy Department, Faculty of Applied Medical Sciences, Jazan University, Jazan, Saudi Arabia

Abdulelah M Aldhahir

- Department of Anesthesiology and Critical Care Medicine, Aster Medicity, India

Suresh G Nair

Corresponding author

Correspondence to jithinksree@gmail.com

References

1. Henscke CI, Pasternack GS, Schoroeder S, Hart KK, Herman PG. Bedside chest radiography. Diagnostic efficacy. Radiology 1983; 149(1):23-26.
2. Greenbaum DM, Marschall KE. The value of routine daily chest x-rays in intubated patients in the medical intensive care unit. Crit Care Med 1982;10(1):29-30.
3. Bekemeyer WB, Crapo RO, Calhoon S, Cannon CY, Clayton PD. Efficacy of chest radiography in a respiratory intensive care unit. A prospective study. Chest 1985;88(5):691-696.
4. Rouby JJ, Puybasset L, Cluzel P, Richecoeur J, Lu Q, Grenier P. Regional distribution of gas and tissue in acute respiratory distress syndrome. II. Physiological correlations and definition of an ARDS Severity Score. CT Scan ARDS Study Group. Intensive Care Med 2000;26(8):1046-1056.
5. Xirouchaki N, Kondili E, Prinianakis G, Malliotakis P, Georgopoulos D. Impact of lung ultrasound on clinical decision making in critically ill patients. Intensive Care Med 2014;40(1):57-65.
6. Alqahtani, J., Oyelade, T., Sreedharan, J., Aldhahir, A., Alghamdi, S., Alrajeh, A., Alqahtani, A., Alsulayyim, A., Aldabayan, Y., Alobaidi, N. and AlAhmari, M., 2020. Diagnostic and clinical values of non-cardiac ultrasound in COPD: A systematic review. BMJ Open Respiratory Research, 7(1), p.e000717.
7. Karthika M, Wong D, Nair SG, Pillai LV, Mathew CS. Lung Ultrasound: The Emerging Role of Respiratory Therapists. Respir Care. 2019 Feb;64(2):217-229.
8. C Kappel, D Chaudhuri, K Hassall, et al. Point-of-care ultrasound training for respiratory therapists: A scoping review. Can J Respir Ther 2022;58:28–33
9. Cassandra Wagner. Loma Linda University incorporates lung ultrasound training in respiratory care program. https://news.llu.edu/academics/loma-linda-university-incorporates-lung-ultrasound-training-respiratory-care-program. [Last Accessed on March 15, 2022].
10. Mohammed A et.al. Respiratory Care Education in Saudi Arabia: National Survey of Local Universities. Respiratory Care Oct 2021, 66 (Suppl 10) 3610526;
11. Alotaibi G. Status of respiratory care profession in Saudi Arabia: A national survey. Ann Thorac Med. 2015 Jan-Mar;10(1):55-60. doi: 10.4103/1817-1737.146878. PMID: 25593609; PMCID: PMC4286847.

12. Arora S, Cheung AC, Tarique U, Agarwal A, Firdouse M, Ailon J: First-year medical students use of ultrasound or physical examination to diagnose hepatomegaly and ascites: a randomized controlled trial. J Ultrasound. 2017, 20:199-204. 10.1007/s40477-017-0261-6
13. Koratala A, Segal MS, Kazory A: Integrating point-of-care ultrasonography into nephrology fellowship training: a model curriculum. Am J Kidney Dis. 2019, 74:1-5. 10.1053/j.ajkd.2019.02.002
14. Kappel, C., Chaudhuri, D., Hassall, K., Theune, S., Sharif, S., Alhazzani, W. and Lewis, K., 2022. Point-of-care ultrasound training for respiratory therapists: A scoping review. *Canadian Journal of Respiratory Therapy*, 58, pp.28-33.
15. Watson K, Lam A, Arishenkoff S, et al.: Point of care ultrasound training for internal medicine: a Canadian multi-centre learner needs assessment study. BMC Med Educ. 2018, 18:217. 10.1186/s12909-018-1326-8
16. Brown GM, Otremba M, Devine LA, Gray C, Millington SJ, Ma IW: Defining competencies for ultrasound-guided bedside procedures: consensus opinions from Canadian physicians. J Ultrasound Med. 2016, 35:129-41. 10.7863/ultra.15.01063
17. Price S, Via G, Sloth E, et al.: Echocardiography practice, training and accreditation in the intensive care: document for the World Interactive Network Focused on Critical Ultrasound (WINFOCUS). Cardiovasc Ultrasound. 2008, 6:49. 10.1186/1476-7120-6-49
18. Smallwood N, Matsa R, Lawrenson P, Messenger J, Walden A: A UK wide survey on attitudes to point of care ultrasound training amongst clinicians working on the Acute Medical Unit. Acute Med. 2015, 14:158-64.
19. Day J, Davis J, Riesenberg LA, et al.: Integrating sonography training into undergraduate medical education: a study of the previous exposure of one institution's incoming residents. J Ultrasound Med. 2015, 34:1253-7.10.7863/ultra.34.7.1253
20. Anstey JE, Jensen TP, Afshar N. Point-of-Care Ultrasound Needs Assessment, Curriculum Design, and Curriculum Assessment in a Large Academic Internal Medicine Residency Program. South Med J. 2018;111(7):444–8.
21. Watson K, Lam A, Arishenkoff S, et al. Point of care ultrasound training for internal medicine: a Canadian multi-centre learner needs assessment study. BMC Med Educ. 2018;18:217.
22. Filly, R., 1988. Ultrasound: the stethoscope of the future, alas. Radiology, 167(2), pp.400-400.
23. Guitart C, Suárez R, Girona M, Bobillo-Perez S, Hernández L, Balaguer M, et al. Lung ultrasound findings in pediatric patients with COVID-19. Eur J Pediatr 2021;180:1117-23.
24. Trias-Sabrià, P., Molina-Molina, M., Aso, S., Argudo, M., Diez-Ferrer, M., Sabater, J., Dorca, J., Santos, S. and Suarez-Cuartin, G., 2021. Lung Ultrasound Score to Predict Outcomes in COVID-19. *Respiratory Care*, 66(8), pp.1263-1270.
25. Swamy V, Brainin P, Biering-Sørensen T, Platz E. Ability of non-physicians to perform and interpret lung ultrasound: A systematic review. Eur J Cardiovasc Nurs. 2019 Aug;18(6):474-483. doi: 10.1177/1474515119845972. Epub 2019 Apr 24. PMID: 31018658; PMCID: PMC6919316.

26. Liu RB, Donroe JH, McNamara RL, Forman HP, Moore CL. The practice and implications of finding fluid during point-of-care ultrasonography. JAMA Intern Med. 2017;177:1818-1825.
27. Student Handbook-Respiratory care program (Page 8-Course Description), Prince Sultan Military College of Health Sciences, Dhahran. Available from: http://www.psmchs.edu.sa/wp-content/uploads/2020/09/Respiratory-Care-Student-Handbook.pdf . [Last accessed on 2022 March 18]
28. Anstey JE, Jensen TP, Afshar N. Point-of-Care Ultrasound Needs Assessment, Curriculum Design, and Curriculum Assessment in a Large Academic Internal Medicine Residency Program. South Med J. 2018;111(7):444–8.
29. Heldeweg, M., Vermue, L., Kant, M., Brouwer, M., Girbes, A., Haaksma, M. E., Heunks, L., Mousa, A., Smit, J. M., Smits, T. W., Paulus, F., Ket, J., Schultz, M. J., & Tuinman, P. R. (2022). The impact of lung ultrasound on clinical-decision making across departments: a systematic review. The ultrasound journal, 14(1), 5.
30. See KC, et al. Lung ultrasound training: curriculum implementation and learning trajectory among respiratory therapists. Intensive Care Med 2016, 42:63-71.

Figures

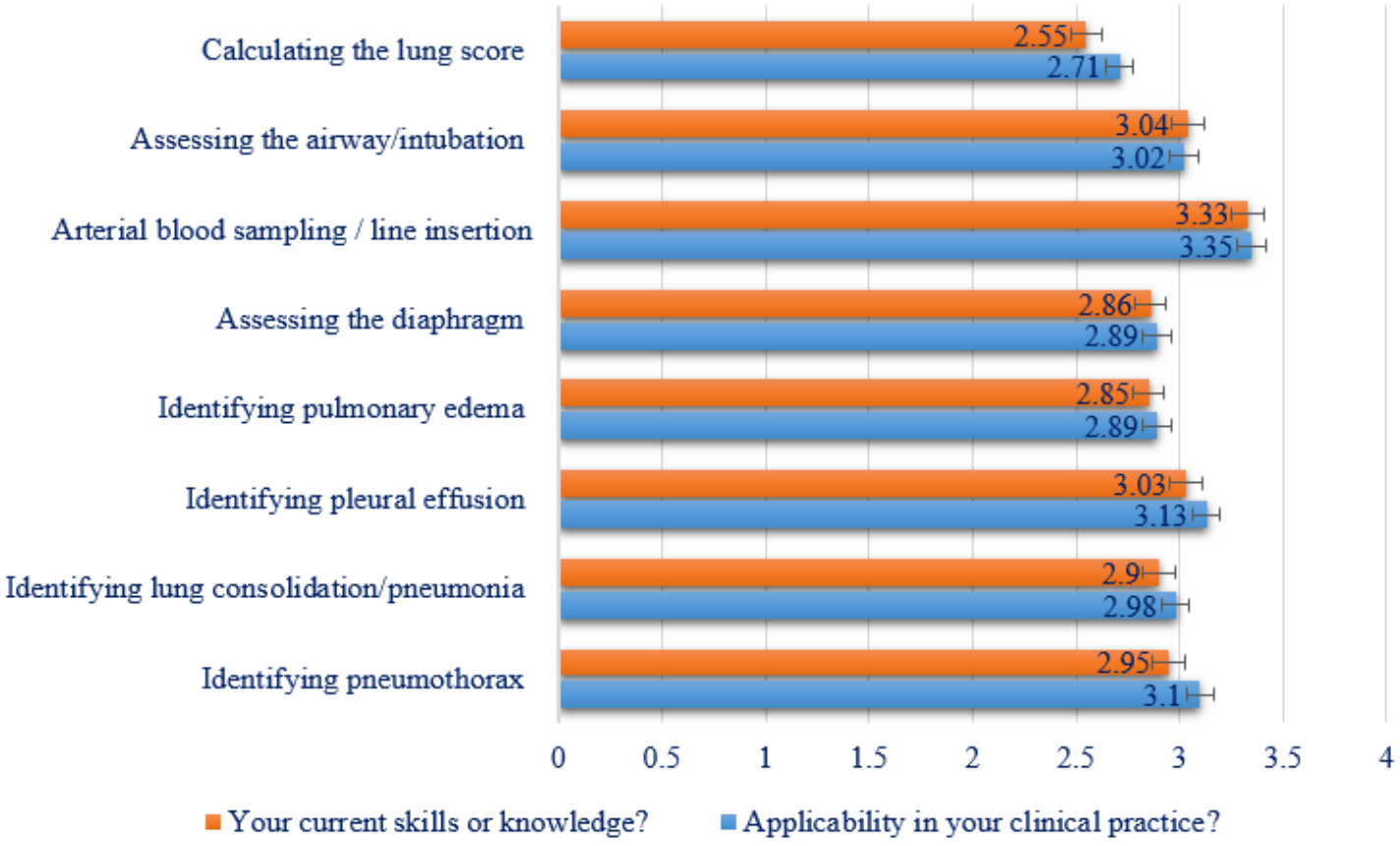

Figure 1

Skill gap of ultrasound diagnostic applications and bedside procedures in Respiratory Care. Skill gap of ultrasound diagnostic applications is demarcated as the variance between comprehended appropriateness of an application and self-scaled skills in carrying out bedside procedures, in the basic ground of proper training, showed as mean gap; error bars point out standard deviations

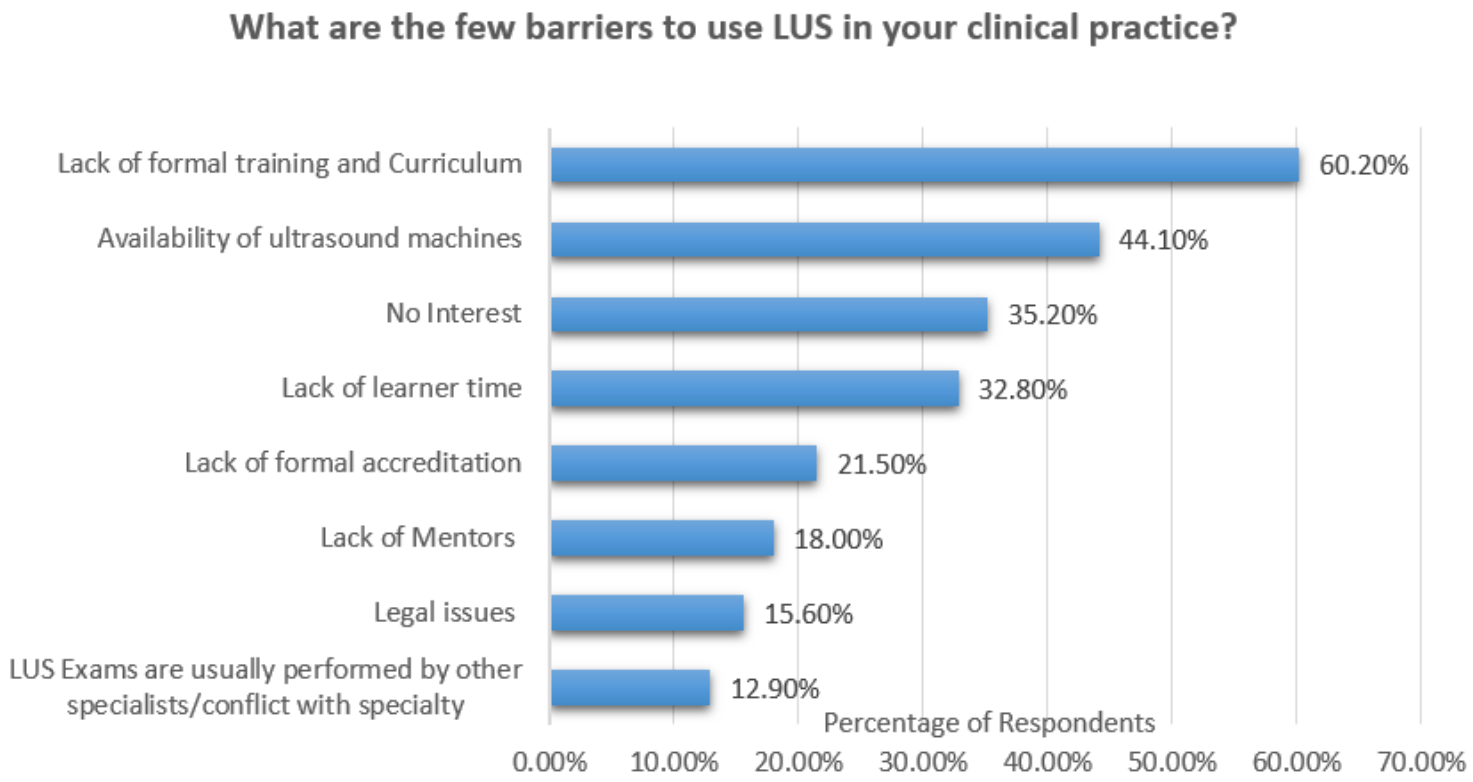

Figure 2

Barriers to implement LUS in RT practice

Perceived barriers to LUS use by RTs. RTs were asked the question "What are some barriers to the use of LUS in your clinical practice?" Respondents were allowed to select more than one response. Percentages calculated as the number of responses divided by total n = 256). LUS: Lung Ultrasound