BMC Medical Education

RESEARCH

Open Access

Continuing professional development for primary care physicians: a pre-post study on lung point-of-care ultrasound curriculum

Itamar Ben Shitrit[1,2*], Moshe Shmueli[1,2*], Karny Ilan[3], Ofri Karni[1], Ariel Avraham Hasidim[6,7], Mey Tal Banar[5], Yoav Goldstein[1], Oren Wacht[8] and Lior Fuchs[1,4]

Abstract

Background Point-of-care ultrasound is rapidly gaining traction in clinical practice, including primary care. Yet, logistical challenges and geographical isolation hinder skill acquisition. Concurrently, an evidentiary gap exists concerning such guidance's effectiveness and optimal implementation in these settings.

Methods We developed a lung point-of-care ultrasound (POCUS) curriculum for primary care physicians in a rural, medically underserved region of the south of Israel. The course included recorded lectures, pre-course assessments, hands-on training, post-workshop lectures, and individual practice. To evaluate our course, we measured learning outcomes and physicians' proficiency in different lung POCUS domains using hands-on technique assessment and gathered feedback on the course with a multi-modal perception approach: an original written pre- and post-perception and usage questionnaire.

Results Fifty primary care physicians (PCPs) showed significant improvement in hands-on skills, increasing from 6 to 76% proficiency ($p<0.001$), and in identifying normal versus abnormal views, improving from 54 to 74% accuracy ($p<0.001$). Ten weeks after training, primary care physicians reported greater comfort using lung ultrasound, rising from 10 to 54% ($p<0.001$), and improved grasp of its potential and limits, increasing from 27.5% to 84% ($p<0.001$). Weekly usage increased from none to 50%, and the number of primary care physicians not using at all decreased from 72 to 26% ($p<0.001$).

Conclusions A two-day focused in-person and remote self-learning lung-POCUS training significantly improved primary care physicians' lung ultrasound skills, comfort, and implementation.

Keywords Point-of-care ultrasound, Lung ultrasound, Primary care physicians, Continuing professional development

*Correspondence:
Itamar Ben Shitrit
itamab@post.bgu.ac.il
Moshe Shmueli
mosheshm@post.bgu.ac.il
[1] Joyce and Irving Goldman Medical School, Faculty of Health Sciences, Ben Gurion University of the Negev, Beer-Sheva, Israel
[2] Clinical Research Center, Faculty of Health Sciences, Soroka University Medical Center, Ben Gurion University of the Negev, PO Box 151, 84101 Be'er-Sheva, Israel
[3] General Surgery Department, Sheba Medical Center, Ramat Gan, Israel
[4] Medical Intensive Care Unit, Soroka University Medical Center, Faculty of Health Sciences, Ben Gurion University of the Negev, Beer-Sheva, Israel
[5] Medical School for International Health, Ben Gurion University of the Negev, Beer-Sheva, Israel
[6] Department of Pediatrics A, Schneider Children's Medical Center of Israel, Petah Tikva, Israel
[7] Sackler Faculty of Medicine, Tel Aviv University, Tel Aviv, Israel
[8] Department of Emergency Medicine, Faculty of Health Sciences, Ben Gurion University of the Negevin, Beer-Sheva, Israel

Background

In today's rapid healthcare environment, a comprehensive evaluation of training methodologies and duration is crucial to maximize benefits. Respiratory complaints are among the most common complaints for primary care physicians (PCPs) to evaluate and diagnose [1]. Lung ultrasound (LUS) is a practical, safe diagnostic tool used at the patient's bedside for diagnosis, follow-up, and procedures for pulmonary conditions [2]. LUS has demonstrated significant promise in various studies, enabling PCPs to make accurate and rapid diagnoses [3]. The Accreditation Council for Graduate Medical Education Family Medicine Residency program requirements include the integration of LUS among other point-of-care ultrasound (POCUS) applications starting in 2024 [4].

Numerous studies have presented that LUS utilization presents higher sensitivity than Chest X-ray and physical examination during the pulmonary assessment [5–9]. For example, LUS usage has been shown to be effective in diagnosing pleural effusion at a 97% sensitivity rate after only 3 h of training [10]. In addition, LUS has demonstrated high accuracy and sensitivity in diagnosing pneumonia in both adult and pediatric patients [11, 12]. Its utility has been proven particularly during the recent COVID-19 pandemic [13–17].

Challenges identified in ultrasound training include a shortage of trained faculty, limited equipment availability, physician discomfort interpreting images without a radiologist's oversight, the time constraints faced by PCPs, and geographical barriers that can hinder access to training opportunities [18]. Furthermore, a review discussing curriculum strategies for implementing POCUS revealed that none explicitly addressed the implementation of POCUS or the milestones associated with such changes in primary care settings. This highlights the pressing need for a targeted evaluation of a POCUS curriculum designed for primary care [19]. Despite vast literature demonstrating the importance of this bedside ultrasound modality [20], there is a lack of publicly accessible research on the methodologies and outcomes associated with such training programs specifically for PCPs [19].

Teaching procedural skills, such as LUS, poses significant challenges in healthcare education due to the necessity for specialized training in knowledge acquisition, communication, and performance [21–23]. A well-established instructional approach for POCUS training is "Peyton's Four-Step Approach," a core component of the European Society of Cardiology courses [23]. Peyton's approach includes demonstrating the skill at a normal pace without any comments, then repeating the procedure while describing all necessary sub-steps, having the student explain each sub-step while the teacher follows the student's instructions, and finally, having the student perform the complete skill independently. Complementing this approach, Sawyer et al. developed a six-step method for teaching skills that combines preparation, skill acquisition, and maintenance: "Learn, See, Practice, Prove, Do, Maintain" [24]. While these approaches emphasize in-person teacher-student interaction, other methods have demonstrated the feasibility of teaching POCUS remotely [25, 26]. Some presented the non-inferiority of e-learning techniques [25], while others have shown that simulator-based learning can be as effective as traditional face-to-face instruction [27].

In this prospective cohort study, we explore the potential of integrating traditional teaching methods with e-learning and simulator-based learning in a two-day LUS training program for PCPs. We hypothesized that a combined approach would influence PCPs' attitudes and competence in utilizing this modality in daily practice.

Methods

This prospective feasibility study took place in southern Israel at Ben Gurion University of the Negev and was conducted with the approval of the university's ethics board committee (reference number 15–2022). The Ben Gurion University of the Negev Medical Simulation Center has advanced simulators and state-of-the-art medical simulation rooms. These facilities provide realistic training environments for various medical procedures, including ultrasound training. Data gathering was carried out between January and June 2023. The study and teaching protocol detailed in this paper were written in line with the DoCTRINE guidelines, listing the criteria to report innovations in education [28].

Goals of the curriculum

To evaluate the effectiveness of a concise, integrative LUS training for PCPs, focusing on its practicality and 10-week lasting impact. The primary objective was to observe changes in PCPs' attitudes and integration of LUS into routine practice. Secondary objectives focus on evaluating their proficiency in conducting LUS and differentiating between normal and abnormal POCUS images.

Target population of learners

This study enrolled 50 PCPs employed by the two largest Israeli health maintenance organizations (HMOs), Maccabi and Clalit, in the LUS training. The study included specialists/consultants in family medicine, defined as physicians certified after passing government tests, and trainees/residents in family medicine who are in a four-year residency program. None of these PCPs had previously undergone any US training, although all had access to ultrasound machines available in their clinics. Participation was entirely voluntary and required written consent. PCPs' performance results remained confidential and were not disclosed to any overseeing organizations, ensuring it had no impact on their evaluations.

Outcome-based learning objectives

The learning objectives of this unique course are listed below and were assessed both short and longer term, as illustrated in Fig. 1.

- *Developing Proficiency and Demonstrating Competence in LUS Usage*: Enable PCPs to master LUS examinations and utilize POCUS as a diagnostic tool, focusing on generating high-quality images and improving patient care. The goal was to enhance PCPs' proficiency in conducting examinations and making informed clinical decisions in pulmonary-related cases.
- *Acquiring Interpretation Skills*: Equip PCPs with the skills necessary to interpret LUS images accurately. This includes differentiating between normal and pathological images in conditions such as pneumonia, pleural effusion, lung consolidation, atelectasis, empyema, pneumothorax, hemothorax, massive pulmonary embolism (identified by a D-shaped left ven-

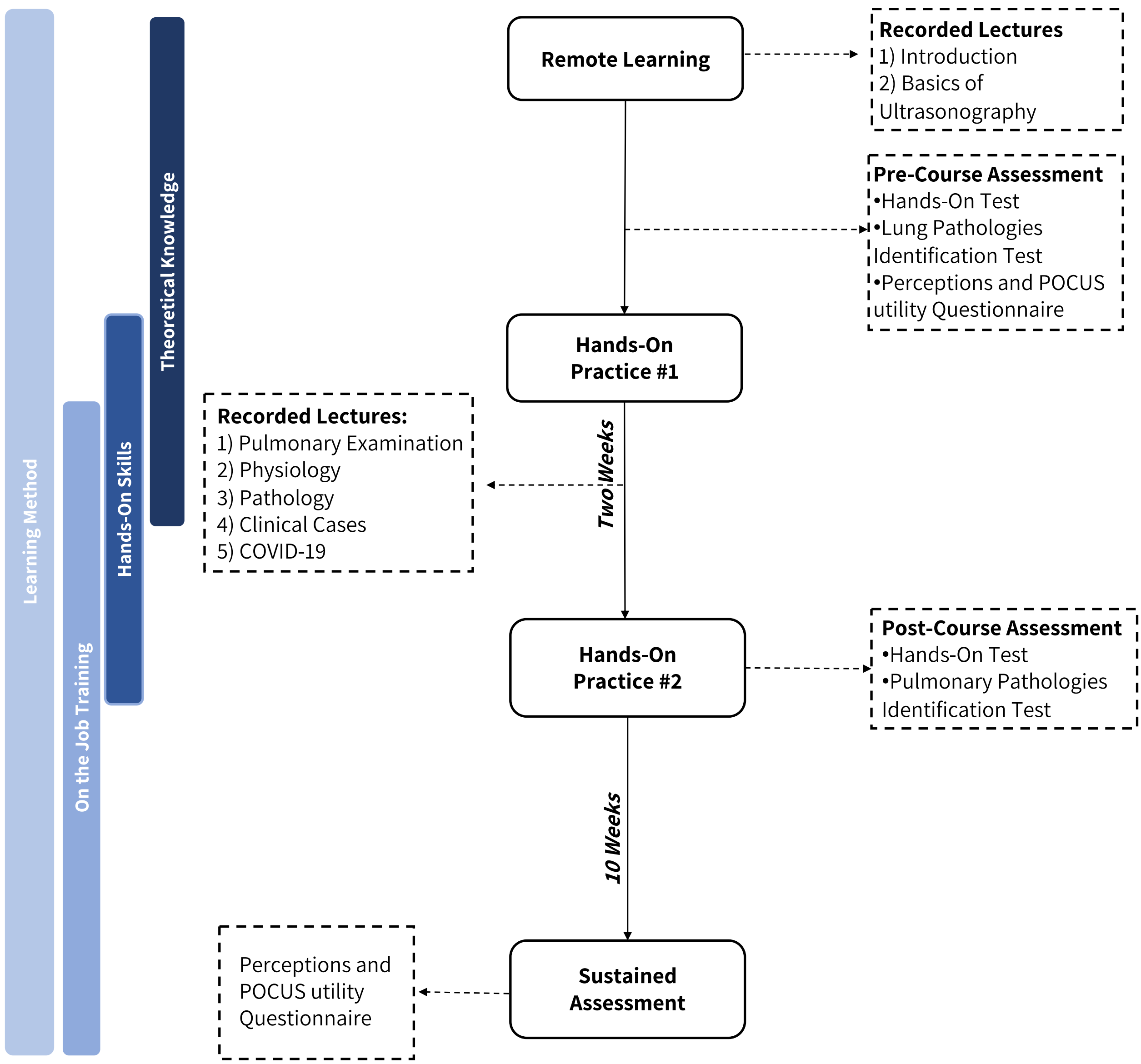

Fig. 1 Pre-course and 10-week post-course assessment, training, and evaluation

tricle or flattening of the interventricular septum due to right ventricular overload, and McConnell's sign, which is defined as right ventricular free wall akinesis with sparing of the apex), and pulmonary edema.

- *Evaluating Impact on Practice Integration and Attitudes*: Assess the effect of intensive POCUS training on PCPs' willingness and confidence to incorporate LUS into their daily primary care practice, focusing on successful technology adoption and adaptation in a clinical environment.

Curriculum implementation

Instructional setting and resources for curriculum delivery

The course took place in the Medical Simulation Center at Ben Gurion University of the Negev. To prepare for the practical workshops, PCPs received a total of six recorded lectures, amounting to five and a half hours. Two of these lectures centered on the general principles of POCUS usage and technology in clinical settings, while the remaining four lectures focused on the application of POCUS specifically for diagnosing pulmonary pathologies (Appendix S1—Course Syllabus). The hands-on workshops were conducted in small groups of up to five PCPs. During these workshops, the groups had the opportunity to practice on both the 3D Simbionix US Mentor simulator (Fig. 2) [29, 30] and live-patient models using the Venue Go™ by Ge Healthcare.

Description of instructional methods

1) *Introductory recorded lectures-* as a preparatory step for the practical workshops, PCPs received two recorded lectures totaling 1.5 h. The first lecture covered an introduction to ultrasonography and LUS, while the second focused on demonstrating lung examination in the primary care setting (Appendix S1).

2) *Pre-course assessment*—The assessment was conducted in three parts: a hands-on assessment, a clips-based assessment, and a perceptions questionnaire. In the first part, a sample of 13 PCPs underwent a hands-on LUS proficiency test using healthy human models, demonstrating three LUS positions ('windows', as detailed in Appendix S2), reviewed by an expert for accuracy. The second part involved the entire cohort of PCPs in a

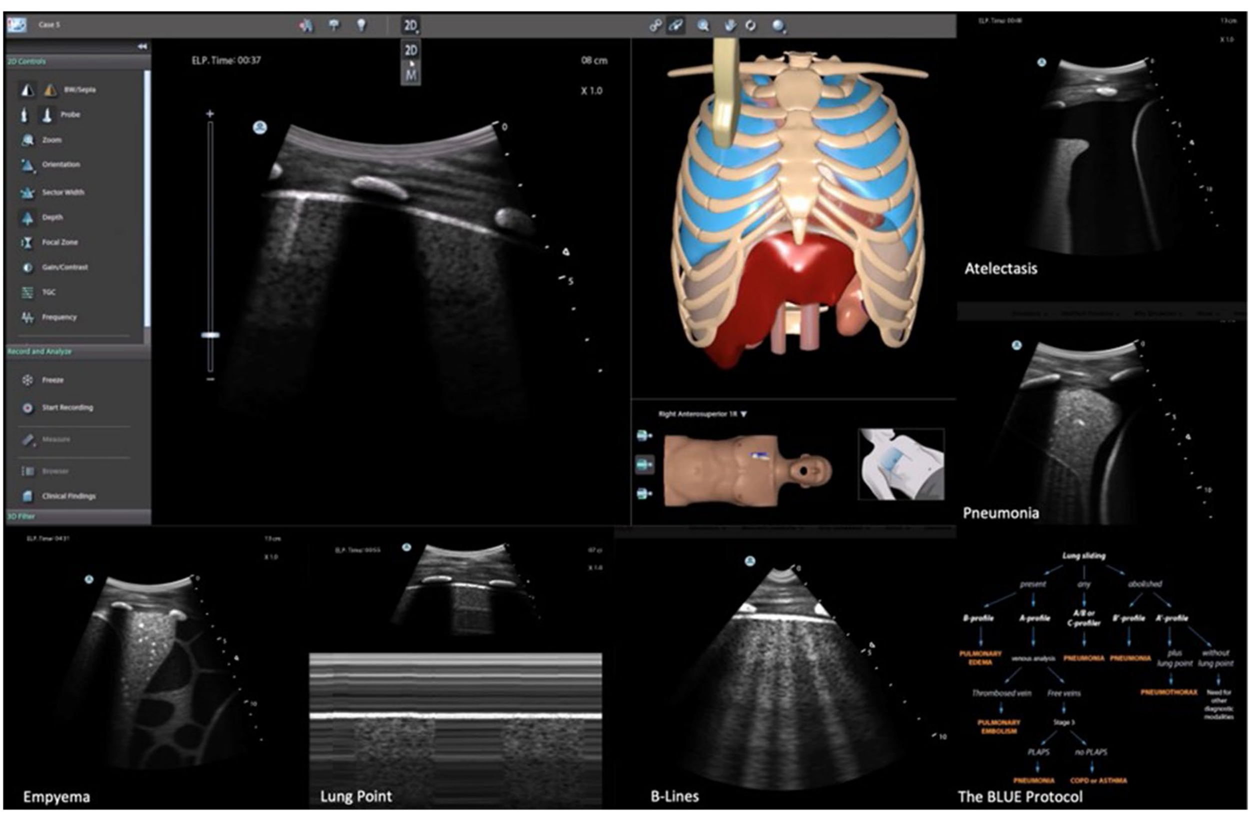

Fig. 2 The Simbionix Lung Module is an educational tool that offers simulated ultrasound imaging for various lung conditions, allowing for self-guided practice. It includes depictions of normal lung anatomy, atelectasis, pneumonia with its classic signs, empyema, the 'Lung Point' indicative of pneumothorax, and B-lines associated with interstitial edema. The module also integrates the BLUE Protocol decision tree to aid in the diagnosis of various lung pathologies (https://surgicalscience.com/simulators/u-s-mentor/lung-module/)

clips-based assessment, where they were tested on their ability to distinguish normal from pathological LUS scans (Appendix S3). Lastly, all PCPs completed a perceptions questionnaire with eleven Likert scale statements (Appendix S4), adapted from a validated study [31] (Cronbach's alpha = 0.84), to evaluate their perceptions and usage of the POCUS modality.

3) *Hands-on practice*—The PCPs underwent six hours of hands-on training in two three-hour sessions led by an intensive care physician with 15 years of experience in clinical POCUS. They practiced on the 3D Systems Simbionix US Mentor and live patients using the Venue Go™ by GE Healthcare. The training focused on acquiring standard LUS images, with participants learning transducer maneuvers (alignment, rotation, and tilt) for optimal imaging in each position (Figs. 2 and S2).

4) *Lung pathology recorded lectures-* After the first in-person workshop, participants viewed four one-hour lectures on LUS diagnosis before the second workshop. Lecture topics included Introduction to POCUS for PCPs, US Principles, Lung and Airway POCUS Examination—Physiology vs. Pathology, Lung US Examination Demonstration, Clinical Cases, and LUS in COVID-19 (Appendix S1).

5) *Individual practice using the US device-* PCPs were encouraged to practice image acquisition during regular clinics between the two in-person workshops without a required number of hours. While all had access to a device for practice in the clinic, as per the study's inclusion criteria, these independent practice sessions were not monitored.

Methods to evaluate achievement of outcome-based learning objectives

1) *Post-course assessment physiology and pathology assessment*—Following the training, PCPs completed two examinations. The first exam, which was identical to the one taken prior to the course (Appendix S3), assessed their ability to distinguish between normal and pathological LUS scans. The second test involved a hands-on ultrasound exam on human models, evaluated by a POCUS expert as correct or incorrect (Appendix S2). Despite the development of several validated structured tools, such as LUS-Objective Structured Assessment of Ultrasound Skills (LUS-OSAUS), we opted for a simplified tool specifically designed to meet the needs of PCPs, making it more suitable for our evaluation [32].

2) *Post-course lasting impact on attitudes and usage-* Physicians who completed the POCUS courses in 2023 reported their perceptions by mirroring the pre-course assessment with an eleven-statement questionnaire (Appendix S5). Responses were collected online ten weeks after the course ended (Fig. 1). This Likert scale questionnaire focused on their views about integrating LUS in clinical practice, including its potential to speed up diagnosis, improve decision-making, and positively affect patient care.

Statistical analysis

Summary statistics were calculated to describe the sample characteristics. The Chi-square, paired t-test, and the Wilcoxon singed-rank tests were used to compare pre and post-tests and questions. The assessment was conducted across the entire cohort. Shapiro–Wilk tests were performed to assess the distribution of variables. Skewed distributions were presented as median (IQR), while normally distributed variables were presented as mean (SD). Cronbach's alpha reliability test was used to assess the readability of the questionnaires ($\alpha = 0.909$). A priori *power analysis was conducted with assumptions of $\alpha = 0.05$, 80% pre-course non-utilization of LUS, and 30% post-course non-utilization. These assumptions were based on previous literature and our experience teaching LUS as part of continuing professional development* [33]. *These parameters indicated that a sample size of 30 participants was necessary to achieve 80% power and detect a minimal difference of 40% in LUS utilization pre- and post-course. The study was thus adequately powered to detect differences within the stated assumptions and limitations.* All statistical tests were performed at $\alpha = 0.05$ (two-sided) using R Studio 4.3.1.

Results

The study consisted of 50 PCPs who took part in the LUS-focused course. Participants' HMO affiliation with Maccabi (52%) or Clalit (48%) healthcare was similar. The study's participants were 70% specialists/consultants and 30% trainees/residents, with an average age of 42.66 (SD 9.35); participants had an even gender distribution. These baseline characteristics are shown in Table 1.

Table 1 Baseline characteristics

Variable	Statistic
Group, N (%)	
Clalit	24 / 50 (48%)
Maccabi	26 / 50 (52%)
Gender Female**,** N (%)	24 / 50 (48%)
Age, Mean (SD)	42.66 (9.35)
Experience, N (%)	
Specialist/consultant physician	35 / 50 (70%)
Trainee/resident physician	15 / 50 (30%)

Lung POCUS physiology and pathology assessment

Clips based assessment

Before training, PCPs took an eight-item test on lung ultrasound interpretation (Table 2, Figure S7). Scores for identifying standard lung views and transducer placement (Items 1 and 2, Zone 1) improved from 67 and 65% to 92% post-course ($p = 0.003$ and 0.002). Interpretation of Zone 3 lung scans (Item 3) increased from 48 to 78% ($p < 0.001$). Accuracy in detecting pneumothorax (Items 4 and 8) rose from 50 to 84% ($p < 0.001$). Recognition of "B-lines" for pulmonary edema (Item 5) improved from 50 to 76% ($p = 0.15$). Identifying pneumonia via air bronchogram videos (Item 6) increased from 54 to 82% ($p = 0.001$), and recognizing atelectasis signs (Item 7) improved from 48 to 92% ($p < 0.001$). Overall scores increased significantly from a mean of 54% to 74% and a median of 50% to 88% ($p < 0.001$).

Hands-on assessment

PCPs' lung POCUS proficiency was assessed at two-time points: pre-course with 13 (26%) randomly selected participants, indicating minimal competency and no prior hands-on experience showing a median score of 0% (IQR 0%), and post-course with 48 participants, showing significant improvement with a median score of 67% (IQR 33%) ($p < 0.001$).

Primary care physicians' perceptions of LUS

Forty PCPs (80%) completed the pre-course questionnaire (T1), and 50 PCPs (100%) completed the post-course questionnaire (T2). Logistic limitations (scheduling conflicts, technical difficulties, and personal circumstances) prevented 10 PCPs from completing T1 (Fig. 3, Appendix Table S6). Ten weeks post-course, LUS usage increased significantly: weekly use rose from 0 to 50%, and those not using LUS dropped from 72 to 26% ($p < 0.001$, $p < 0.001$). Comfort with LUS also improved, with "very comfortable" responses rising from 10 to 54%, and understanding its capabilities and limitations increased from 27.5% to 84% ($p < 0.001$, $p < 0.001$). Agreement on LUS's diagnostic capabilities increased from 68 to 98% ($p = 0.018$) and for LUS specifically, from 75 to 94% ($p = 0.028$). More PCPs believed LUS training improved diagnostic skills (70% to 86%, $p = 0.006$) and supported its inclusion in training programs (75% to 90%, $p = 0.006$).

Discussion

In this study, we documented the lasting impact of LUS training on its daily use in primary care (10-week follow-up). This study presented the impact of a relatively short LUS training for PCPs, marking a shift in their daily practice and attitudes and introducing a new, straightforward method for integrating LUS into primary care continuing education.

Prior studies have presented the importance and feasibility of delivering POCUS training within condensed timeframes [10, 34, 35]. Similarly to the presented study, a study from South Korea evaluating continuing professional development (CPD) programs for abdominal and thoracic ultrasound ($n = 221$ physicians) found that a two-day training program of less than 20 h effectively achieved the desired goals for basic competency; however, the teaching methods, evaluation criteria, and specific PCP subgroups were not targeted nor explained in the study [27].

Past surveys found PCPs perceive POCUS to be relatively easy to use, not overly time-consuming, and of high value to the practice [3, 36]. The current study aligns with these perceptions, as PCPs who participated

Table 2 Clips based assessment

Item	Time		*p*-value
	T1[1]	T2[2]	
1. A physiologic lung, N, (%)	32 / 48 (67%)	45 / 49 (92%)	0.003
2. Recognition of "bat sign", N, (%)	31 / 48 (65%)	45 / 49 (92%)	0.002
3. Physiologic lung, diaphragm, and liver/spleen, technic aspects, N, (%)	22 / 48 (46%)	38 / 49 (78%)	< 0.001
4. Normal lung sliding, N, (%)	15 / 48 (31%)	25 / 49 (51%)	0.052
5. B lines and pulmonary edema pathology, N, (%)	29 / 48 (60%)	37 / 49 (76%)	0.15
6. Dynamic air bronchogram and pneumonia, N, (%)	26 / 48 (54%)	40 / 49 (82%)	0.003
7. Recognition of "fish tail" and "spinal" sign (atelectasis), N, (%)	23 / 48 (48%)	45 / 49 (92%)	< 0.001
8. Recognition of "lung point" (pneumothorax), N, (%)	24 / 48 (50%)	41 / 49 (84%)	0.001
Total score mean (SD)	0.52 (0.26)	0.74 (0.24)	< 0.001

T1 – Pre course assessment, T2 – Short-term post course assessment

[1] n / N (%);Mean (SD), [2]Wilcoxon signed rank test with continuity correction; Paired t-test

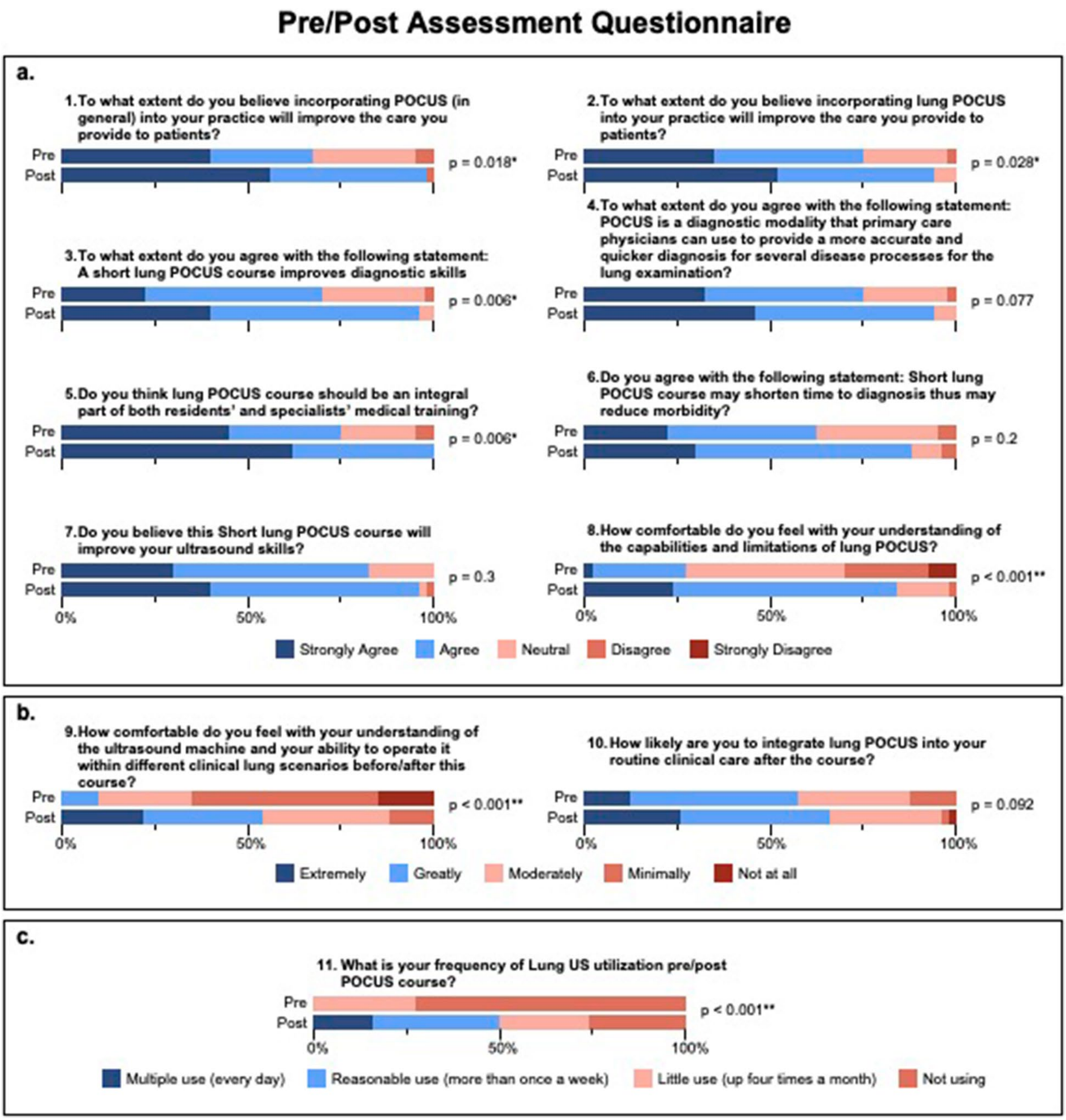

Fig. 3 Primary Care Physicians' Perceptions Of Point Of Care Ultrasound displays the pre- and post-assessment questionnaire results on primary care physicians' perceptions and engagement with lung point of care ultrasound. Part (**a**) illustrates a positive shift in primary care physicians' views on point of care ultrasound integration into practice, part (**b**) shows enhanced comfort and understanding of point of care ultrasound, and part (**c**) reflects increased lung ultrasound usage frequency. *P*-values provide statistical substantiation for the observed pre- to post-training changes. For specific percentages, see Appendix S6

in the focused course gained increased confidence and understanding of the diagnostic capabilities and limitations and supported the integration of LUS into their daily repertoire and internship curricula [37].

While this study demonstrated PCPs' proficiency in acquiring, interpreting, and diagnosing various pulmonary scenarios immediately following the course, it's reasonable to expect that the cohorts' proficiency may change over time in accordance with the time and effort spent practicing and learning LUS [38, 39]. Artificial intelligence (AI) and telemedicine solutions might serve as a solution to enhance image acquisition and interpretation precision [40–45]. For example, several studies presented that AI can be utilized to count the number of B-Lines, reflecting pulmonary edema [42, 46, 47]. Platforms like FaceTime ™ and Butterfly iQ+ ™ TeleGuidance have shown efficient image sharing and interpretation capabilities, with Butterfly iQ+ ™ supporting remote education using recorded lectures within the Butterfly iQ+ ™ application [48–51]. Therefore, further investigations into AI and Teleultrasound platforms for lung assessment are necessary to evaluate their long-term effectiveness years after learning the basics.

There are several limitations to this study. The evaluation of the lasting effect occurred after a 10-week follow-up, which may not reflect the longer-term impact, and relied solely on self-reported data, lacking real-life clinic information, possibly not fully representing the PCPs' clinical application of these skills. The small cohort of Israeli physicians may limit the generalizability of the findings. Additionally, the relatively short travel times within Israel may not reflect the logistical challenges in other regions, where longer travel times might require overnight stays, posing greater barriers to participation. Although the Symbyonix Simulator represented common pathologies, the assessments were conducted on healthy models rather than sick patients, which may partially encompass the challenges faced in real patient scenarios. Despite no formal curriculum in POCUS for study participants, it is plausible that younger participants gained informal POCUS training during hospital rotations, potentially influencing the study outcomes. Lastly, the unmonitored practice of ultrasound devices during the study could have influenced the PCPs' skill levels in the final evaluation.

In conclusion, this prospective cohort study showcased a pioneering, expedited LUS training program for PCPs. PCPs gained proficiency in using the innovative modality of LUS in their community, demonstrating their capacity to enhance practical skills and positively impact their perceptions regarding integrating this modality into their daily practices. This transformative approach can potentially revolutionize the diagnostic and treatment methods employed by PCPs for common pulmonary complaints in primary care settings.

Abbreviations

AI	Artificial Intelligence
CPD	Continuing Professional Development
DoCTRINE	Criteria to Report Innovations in Education
GE	General Electric
HMO	Health Maintenance Organization
IRB	Institutional Review Board
LUS	Lung Ultrasound
PCP	Primary Care Physician
POCUS	Point-of-Care Ultrasound
SD	Standard Deviation
TM	Trademark
US	Ultrasound

Acknowledgements
Not applicable.

Authors' contributions
I.B.S- Writing – Conceptualization, Methodology, Formal Analysis, Investigation, Writing—original draft M.S—Writing – Conceptualization, Methodology, Investigation, Writing—original draft K.I– Investigation, Writing—original draft A.A.H—Writing – review & editing O.K—Resources, Project administration, Writing – review & editing Y.G – Project administration O.W – Resources, Project administration L.F—Project administration, Supervision.

Authors' information
I. Ben Shitrit is an MD-MPH student at Ben-Gurion University of the Negev, and POCUS instructor, IsraPOCUS Academy at Ben Gurion Simulation Center, Be'er Sheva, Israel.
M. Shmueli is an MD-MPH student at Ben Gurion University of the Negev, and POCUS instructor, IsraPOCUS Academy at Ben Gurion Simulation Center, Be'er Sheva, Israel.
K.Ilan is an MD student at Ben Gurion University, Be'er Sheva, Israel.
O. Karni is a six-year medical student, Ben Gurion University of the Negev, and POCUS instructor, IsraPOCUS Academy at Ben Gurion Simulation Center, Be'er Sheva, Israel.
A.A. Hasidim, MD-MPH, is a resident in pediatrics at the Department of Pediatrics A, Schneider Children's Medical Center of Israel, Petah Tikva, Israel; Sackler Faculty of Medicine, Tel Aviv University, Tel Aviv, Israel.
A.A. Hasidim, MD-MPH, is a resident in pediatrics at the Department of Pediatrics A, Schneider Children's Medical Center of Israel, Petah Tikva, Israel; Sackler Faculty of Medicine, Tel Aviv University, Tel Aviv, Israel.
M.T. Banar, M.Sc., is a fourth-year MD student in the international plan, Ben Gurion University of the Negev, Be'er Sheva, Israel.
Y. Goldstein is a fifth-year MD student in Ben Gurion University of the Negev, Be'er Sheva, Israel.
O. Wacht is the head of the Department of Emergency Medicine, academic director of the field, and senior lecturer, Ben Gurion University of the Negev, Be'er Sheva Israel.
L. Fuchs is head of the IsraPOCUS Academy, Ben Gurion Simulation Center, senior lecturer, Ben Gurion University of the Negev, and senior physician and intensivist, Soroka Medical Center, Be'er Sheva, Israel.

Funding
No funding was provided.

Availability of data and materials
The datasets are available from the corresponding author upon reasonable request and subject to IRB approval.

Declarations

Ethics approval and consent to participate
The study was approved by the Ethical Review Board at Ben Gurion University (approval number: 15–2022). The research was performed in accordance with the Declaration of Helsinki, and all methods were carried out in accordance with relevant guidelines and regulations. All participants involved in the study were adults 18 years old and older. Written consent was obtained from the participants. The researcher ensured that participants were fully informed about the study's purpose, procedures, and their rights as participants.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

Received: 10 June 2024 Accepted: 3 September 2024
Published online: 10 September 2024

References

1. Finley CR, Chan DS, Garrison S, Korownyk C, Ccfp MD, Kolber MR, Campbell S, Dean M, Eurich T, Lindblad AJ, Pharmd A, Vandermeer B, Allan GM. What are the most common conditions in primary care? Can Fam Physician;64. Available from: www.cfp.ca. [cited 2024 Jan 27].
2. Lin-Martore M, Kornblith AE. Diagnostic Applications of Point-of-Care Ultrasound in Pediatric Emergency Medicine. Emerg Med Clin North Am. 2021;39(3):509–27. Available from: https://pubmed-ncbi-nlm-nih-gov.ezproxy.bgu.ac.il/34215400/. [cited 2023 Aug 26].
3. Bornemann P, Jayasekera N, Bergman K, Ramos M, Gerhart J. Point-of-care ultrasound: Coming soon to primary care? With a little training, FPs can successfully use point-of-care ultrasound for various cardiac, pulmonary, and vascular assessments. J Fam Pract. 2018;67(2):70–80. Available from: https://go.gale.com/ps/i.do?p=AONE&sw=w&issn=00943509&v=2.1&it=r&id=GALE%7CA529222774&sid=googleScholar&linkaccess=fulltext. [cited 2023 Nov 29].
4. Acgme. ACGME Program Requirements for Graduate Medical Education in Family Medicine. Available from: www.acgme.org/OsteopathicRecognition. [cited 2023 Nov 29].
5. Kimura BJ. Point-of-care cardiac ultrasound techniques in the physical examination: better at the bedside. Heart. 2017;103(13):987–94. Available from: https://heart.bmj.com/content/103/13/987. [cited 2023 Aug 26].
6. Kizito PM, Bagonza KD, Odakha JA, Nalugya LG, Opejo P, Muyingo A, Chen H, Harborne D. Diagnostic performance of point of care ultrasound compared to chest x-ray in patients with hypoxia at a Teaching Hospital Emergency Department in Uganda. Afr J Emerg Med. 2023J 1;13(2):61–7.
7. Camelo IY, Pieciak R, Castro-Aragon I, Setty B, Etter L, Gill C. 156. Correlation between WHO (World Health Organization) case definition of severe pneumonia and lung POCUS (Point of Care Ultrasound) vs Chest X-ray (CXR) findings to diagnose pediatric Community-Acquired Pneumonia (CAP) in limited resource settings. Open Forum Infect Dis. 2021;8(Supplement_1):S94–5. https://dx.doi.org/10.1093/ofid/ofab466.156. [cited 2023 Aug 26].
8. Nakao S, Vaillancourt C, Taljaard M, Nemnom MJ, Woo MY, Stiell IG. Diagnostic accuracy of lung point-of-care ultrasonography for acute heart failure compared with chest x-ray study among dyspneic older patients in the emergency department. J Emerg Med. 2021Aug 1;61(2):161–8.
9. Sorlini C, Femia M, Nattino G, Bellone P, Gesu E, Francione P, Paternò M, Grillo P, Ruffino A, Bertolini G, Cariati M, Cortellaro F. The role of lung ultrasound as a frontline diagnostic tool in the era of COVID-19 outbreak. Intern Emerg Med. 2021;16(3):749–56. Available from: https://link.springer.com/article/10.1007/s11739-020-02524-8. [cited 2023 Aug 26].
10. Steinmetz P, Oleskevich S, Dyachenko A, McCusker J, Lewis J. Accuracy of medical students in detecting pleural effusion using lung ultrasound as an adjunct to the physical examination. J Ultrasound Med. 2018;37(11):2545–52. Available from: https://pubmed-ncbi-nlm-nih-gov.ezproxy.bgu.ac.il/29574857/. [cited 2023 Aug 26].
11. Balk DS, Lee C, Schafer J, Welwarth J, Hardin J, Novack V, Yarza S, Hoffmann B. Lung ultrasound compared to chest X-ray for diagnosis of pediatric pneumonia: A meta-analysis. Pediatr Pulmonol. 2018;53(8):1130–9. Available from: https://pubmed-ncbi-nlm-nih-gov.ezproxy.bgu.ac.il/29696826/. [cited 2023 Aug 26].
12. Long L, Zhao HT, Zhang ZY, Wang GY, Zhao HL. Lung ultrasound for the diagnosis of pneumonia in adults: a meta-analysis. Medicine. 2017;96(3). Available from: https://pubmed-ncbi-nlm-nih-gov.ezproxy.bgu.ac.il/28099332/. [cited 2023 Aug 26].
13. Volpicelli G, Gargani L, Perlini S, Spinelli S, Barbieri G, Lanotte A, Casasola GG, Nogué-Bou R, Lamorte A, Agricola E, Villén T, Deol PS, Nazerian P, Corradi F, Stefanone V, Fraga DN, Navalesi P, Ferre R, Boero E, Martinelli G, Cristoni L, Perani C, Vetrugno L, McDermott C, Miralles-Aguiar F, Secco G, Zattera C, Salinaro F, Grignaschi A, Boccatonda A, Giostra F, Infante MN, Covella M, Ingallina G, Burkert J, Frumento P, Forfori F, Ghiadoni L, Fraccalini T, Vendrame A, Basile V, Cipriano A, Frassi F, Santini M, Falcone M, Menichetti F, Barcella B, Delorenzo M, Resta F, Vezzoni G, Bonzano M, Briganti DF, Cappa G, Zunino I, Demitry L, Vignaroli D, Di Pietro LSS, Bazzini M, Capozza V, González MM, Gibal RV, Ibarz RP, Alfaro LM, Alfaro CM, Alins MG, Brown A, Dunlop H, Ralli ML, Persona P, Russel FM, Pang PS, Rovida S, Deana C, Franchini D. Lung ultrasound for the early diagnosis of COVID-19 pneumonia: an international multicenter study. Intensive Care Med. 2021;47(4):444–54. Available from: https://pubmed.ncbi.nlm.nih.gov/33743018/. [cited 2024 Jul 17].
14. Trauer MM, Matthies A, Mani N, McDermott C, Jarman R. The utility of lung ultrasound in COVID-19: a systematic scoping review. Ultrasound. 2020;28(4):208. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10028381/. [cited 2024 Jul 17].
15. Volpicelli G, Lamorte A, Villén T. What's new in lung ultrasound during the COVID-19 pandemic. Intensive Care Med. 2020;46(7):1445–8. Available from: https://link.springer.com/article/10.1007/s00134-020-06048-9. [cited 2024 Jul 19].
16. Fuchs L, Galante O, Almog Y, Dayan RR, Smoliakov A, Ullman Y, Shamia D, Ohayon RBD, Golbets E, El Haj K, Taylor J, Weissberg I, Novack V, Barski L, Rosenberg E, Gohar E, Abed MA, Sagy I. Point of care lung ultrasound injury score—a simple and reliable assessment tool in COVID-19 patients (PLIS I): a retrospective study. PLoS One. 2022;17(5):e0267506. Available from: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0267506. [cited 2024 Jul 19].
17. Dayan RR, Blau M, Taylor J, Hasidim A, Galante O, Almog Y, Gat T, Shavialiova D, Miller JD, Khazanov G, Ghalion FA, Sagy I, Shitrit I Ben, Fuchs L. Lung ultrasound is associated with distinct clinical phenotypes in COVID-19 ARDS: A retrospective observational study. PLoS One. 2024;19(6):e0304508. Available from: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0304508. [cited 2024 Jul 19].
18. Hall JWW, Holman H, Barreto T, Bornemann P, Vaughan A, Bennett KJ, Chamberlain J, Micks T, Maurer DM, Bergus GR. Point-of-care ultrasound in family medicine residencies 5-year update: a CERA study. Fam Med. 2020;52(7):505–11. Available from: https://pubmed-ncbi-nlm-nih-gov.ezproxy.bgu.ac.il/32640473/. [cited 2023 Aug 26].
19. Sena A, Alerhand S, Lamba S. Milestone Approach to Designing a Point-of-Care Ultrasound Curriculum for Transition-to-Residency Programs in the United States. Teach Learn Med. 2021;33(3):270–81. Available from: https://www.tandfonline.com/doi/abs/10.1080/10401334.2020.1814296. [cited 2023 Nov 29].
20. Buda N, Mendrala K, Skoczyński S, Pasquier M, Mazur P, Garcia E, Darocha T. Basics of Point-of-Care Lung Ultrasonography. Ingelfinger JR, editor. 2023;389(21):e44. https://doi.org/101056/NEJMvcm2108203. Available from:https://www.nejm.org/doi/full/10.1056/NEJMvcm2108203. [cited 2023 Nov 29].
21. Burgess A, van Diggele C, Roberts C, Mellis C. Tips for teaching procedural skills. BMC Med Educ. 2020;20(2):1–6. Available from: https://bmcmededuc.biomedcentral.com/articles/10.1186/s12909-020-02284-1. [cited 2024 Jun 9].
22. Nicholls D, Sweet L, Muller A, Hyett J. Teaching psychomotor skills in the twenty-first century: Revisiting and reviewing instructional approaches through the lens of contemporary literature. Med Teach. 2016;38(10):1056–63. Available from: https://pubmed.ncbi.nlm.nih.gov/27023405/. [cited 2024 Jun 9].
23. Nikendei C, Huber J, Stiepak J, Huhn D, Lauter J, Herzog W, Jünger J, Krautter M. Modification of Peyton's four-step approach for small group teaching - a descriptive study. BMC Med Educ. 2014;14(1):1–10. Available from: https://bmcmededuc.biomedcentral.com/articles/10.1186/1472-6920-14-68. [cited 2024 Jun 9].
24. Sawyer T, White M, Zaveri P, Chang T, Ades A, French H, Anderson J, Auerbach M, Johnston L, Kessler D. Learn, see, practice, prove, do, maintain: an evidence-based pedagogical framework for procedural skill training in medicine. Acad Med. 2015;90(8):1025–33. Available from: https://pubmed.ncbi.nlm.nih.gov/25881645/. [cited 2024 Jun 9].
25. Jedwab R, Boas S, Potashner D, Ostrovsky D, Wacht O, Taragin BH, Gat T, Dayan RR, Fuchs L. A Comparison of Online Self-Training and Standard Bedside Training in Lung Ultrasonography for Medical Students. Acad Med. 2024;99(3):304–9. Available from: https://pubmed.ncbi.nlm.nih.gov/37801582/. [cited 2024 Jun 9].
26. Eke OF, Henwood PC, Wanjiku GW, Fasina A, Kharasch SJ, Shokoohi H. Global point-of-care ultrasound education and training in the age of COVID-19. Int J Emerg Med. 2021;14(1):1–4. Available from: https://intjem.biomedcentral.com/articles/10.1186/s12245-021-00338-9. [cited 2024 Jun 9].

27. Simon R, Petrisor C, Bodolea C, Golea A, Gomes SH, Antal O, Vasian HN, Moldovan O, Puia CI. Efficiency of Simulation-Based Learning Using an ABC POCUS Protocol on a High-Fidelity Simulator. Diagnostics. 2024;14(2):173. Available from: https://www.mdpi.com/2075-4418/14/2/173/htm. [cited 2024 Jun 9].
28. Blanco M, Prunuske J, Dicorcia M, Learman LA, Mutcheson B, Huang GC. The DoCTRINE Guidelines: Defined Criteria To Report INnovations in Education. Acad Med. 2022;97(5):689–95. Available from: https://journals.lww.com/academicmedicine/fulltext/2022/05000/the_doctrine_guidelines__defined_criteria_to.27.aspx. [cited 2023 Nov 29].
29. Pietersen PI, Konge L, Graumann O, Nielsen BU, Laursen CB. Developing and Gathering Validity Evidence for a Simulation-Based Test of Competencies in Lung Ultrasound. Respiration. 2019;97(4):329–36. Available from: https://pubmed.ncbi.nlm.nih.gov/30404101/. [cited 2023 Nov 29].
30. Ultrasound Mentor - Surgical Science. Available from: https://surgicalscience.com/simulators/u-s-mentor/. [cited 2023 Nov 29].
31. Tuvali O, Sadeh R, Kobal S, Yarza S, Golan Y, Fuchs L. The long-term effect of short point of care ultrasound course on physicians' daily practice. PLoS One. 2020;15(11):e0242084. Available from: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0242084. [cited 2023 Aug 26].
32. Di Pietro S, Mascolo M, Falaschi F, Brambilla W, Ruzga R, Mongodi S, Perlini S, Perrone T. Lung-ultrasound objective structured assessment of technical skills (LUS-OSAUS): utility in the assessment of lung-ultrasound trained medical undergraduates. J Ultrasound. 2021;24(1):57. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7223719/. [cited 2024 Jul 18].
33. Andersen CA, Guetterman TC, Fetters MD, Brodersen J, Davidsen AS, Graumann O, Jensen MB. General practitioners' perspectives on appropriate use of ultrasonography in primary care in Denmark: a multistage mixed methods study. Ann Fam Med. 2022May 1;20(3):211–9.
34. Clay RD, Lee EC, Kurtzman MF, Dversdal RK. Teaching the internist to see: effectiveness of a 1-day workshop in bedside ultrasound for internal medicine residents. Crit Ultrasound J. 2016;8(1). Available from: https://pubmed.ncbi.nlm.nih.gov/27515967/. [cited 2023 Aug 26].
35. Bornemann P. Assessment of a Novel Point-of-Care Ultrasound Curriculum's Effect on Competency Measures in Family Medicine Graduate Medical Education. J Ultrasound Med. 2017;36(6):1205–11. Available from: https://pubmed-ncbi-nlm-nih-gov.ezproxy.bgu.ac.il/28206672/. [cited 2023 Aug 26].
36. De São José BP, Camargos PAM, Bateman ED, Botelho CMA, De Seixas Maciel JGF, Mancuzo EV, De Amorim CR. Primary care physicians' ability to diagnose the most prevalent respiratory diseases. International Journal of Tuberculosis and Lung Disease. 2016Oct 1;20(10):1392–8.
37. Bornemann P, Bornemann G. Military family physicians' perceptions of a pocket point-of-care ultrasound device in clinical practice. Mil Med. 2014;179(12):1474–7. Available from: https://doi.org/10.7205/MILMED-D-14-00241. [cited 2023 Dec 9].
38. Sena A, Alerhand S, Lamba S. Milestone approach to designing a point-of-care ultrasound curriculum for transition-to-residency programs in the United States. Teach Learn Med. 2021;33(3):270–81. Available from: https://pubmed.ncbi.nlm.nih.gov/33085534/. [cited 2024 Jan 27].
39. Smith CJ, Barron K, Shope RJ, Beam E, Piro K. Motivations, barriers, and professional engagement: a multisite qualitative study of internal medicine faculty's experiences learning and teaching point-of-care ultrasound. BMC Med Educ. 2022;22(1):1–9. Available from: https://bmcmededuc.biomedcentral.com/articles/10.1186/s12909-022-03225-w. [cited 2024 Jan 27].
40. Wang H, Uraco AM, Hughes J. Artificial Intelligence Application on Point-of-Care Ultrasound. J Cardiothorac Vasc Anesth. 2021;35(11):3451–2. Available from: https://pubmed.ncbi.nlm.nih.gov/33838980/. [cited 2024 Jan 27].
41. Gohar E, Herling A, Mazuz M, Tsaban G, Gat T, Kobal S, Fuchs L. Artificial Intelligence (AI) versus POCUS Expert: a validation study of three automatic ai-based, real-time, hemodynamic echocardiographic assessment tools. J Clin Med. 2023;12(4):1352. Available from: https://www.mdpi.com/2077-0383/12/4/1352/htm. [cited 2024 Jan 27].
42. Schneider E, Maimon N, Hasidim A, Shnaider A, Migliozzi G, Haviv YS, Halpern D, Abu Ganem B, Fuchs L. Can dialysis patients identify and diagnose pulmonary congestion using self-lung ultrasound? J Clin Med. 2023;12(11). Available from: https://pubmed.ncbi.nlm.nih.gov/37298024/. [cited 2024 Jan 27].
43. Baum E, Tandel MD, Ren C, Weng Y, Pascucci M, Kugler J, Cardoza K, Kumar A. Acquisition of cardiac point-of-care ultrasound images with deep learning: a randomized trial for educational outcomes with novices. CHEST Pulmonary. 2023;1(3):100023.
44. Hermann M, Hafner C, Scharner V, Hribersek M, Maleczek M, Schmid A, Schaden E, Willschke H, Hamp T. Remote real-time supervision of prehospital point-of-care ultrasound: a feasibility study. Scand J Trauma Resusc Emerg Med. 2022;30(1). Available from: https://pubmed.ncbi.nlm.nih.gov/35331304/. [cited 2024 Jan 27].
45. Epstein D, Petersiel N, Klein E, Marcusohn E, Aviran E, Harel R, Azzam ZS, Neuberger A, Fuchs L. Pocket-size point-of-care ultrasound in rural Uganda — A unique opportunity "to see" where no imaging facilities are available. Travel Med Infect Dis. 2018May;1(23):87–93.
46. Damodaran S, Kulkarni AV, Gunaseelan V, Raj V, Kanchi M. Automated versus manual B-lines counting, left ventricular outflow tract velocity time integral and inferior vena cava collapsibility index in COVID-19 patients. Indian J Anaesth. 2022;66(5):368. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9241188/. [cited 2024 Jan 27].
47. Sonko ML, Arnold TC, Kuznetsov IA. Machine Learning in Point of Care Ultrasound. POCUS Journal. 2022;7(Kidney):78. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9994292/. [cited 2024 Jan 27].
48. Nix K, Liu EL, Oh L, Duanmu Y, Fong T, Ashenburg N, Liu RB. A Distance-Learning Approach to Point-of-Care Ultrasound Training (ADAPT): A Multi-Institutional Educational Response During the COVID-19 Pandemic. Acad Med. 2021;96(12):1711–6. Available from: https://pubmed.ncbi.nlm.nih.gov/34524135/. [cited 2024 Jan 27].
49. Otto CM. Heartbeat: Telemedicine for echocardiography screening. Heart. 2019;105(4):261–3. Available from: https://pubmed.ncbi.nlm.nih.gov/31693482/. [cited 2024 Jan 27].
50. Solomon SD, Saldana F. Point-of-care ultrasound in medical education–stop listening and look. N Engl J Med. 2014;370(12):1083–5. Available from: https://pubmed.ncbi.nlm.nih.gov/24645940/. [cited 2024 Jan 27].
51. Mouratev G, Howe D, Hoppmann R, Poston MB, Reid R, Varnadoe J, Smith S, McCallum B, Rao V, DeMarco P. Teaching medical students ultrasound to measure liver size: comparison with experienced clinicians using physical examination alone. Teach Learn Med. 2013;25(1):84–8. Available from: https://pubmed.ncbi.nlm.nih.gov/23330900/. [cited 2024 Jan 27].

Publisher's Note