WFUMB Ultrasound Open 3 (2025) 100084

Contents lists available at ScienceDirect

WFUMB Ultrasound Open

journal homepage: www.journals.elsevier.com/wfumb-ultrasound-open

Mapping the research on self-performed ultrasound: A scoping review

Miyako Muta [a], Mari Abe [a,b,g], Nao Tamai [c], Mizuho Itabashi [d,e], Gojiro Nakagami [a,f,*]

[a] Department of Gerontological Nursing/Wound Care Management, Graduate School of Medicine, The University of Tokyo, Tokyo, Japan
[b] Research Institute for Next-Generation Nursing Education, Tokyo, Japan
[c] Department of Nursing, Graduate School of Medicine, Yokohama City University, Kanagawa, Japan
[d] Department of Gerontological Nursing, Graduate School of Nursing Science, St Luke's International University, Tokyo, Japan
[e] Japan Drug Development and Medical Affairs, Eli Lilly Japan K.K, Kobe, Japan
[f] Global Nursing Research Center, Graduate School of Medicine, The University of Tokyo, Tokyo, Japan
[g] Department of Nursing, The University of Tokyo Hospital, Tokyo, Japan

ARTICLE INFO

Handling Editor: Prof. MD Manjiri Dighe

Keywords:
Echography
Point-of-care ultrasound
Self-care
Self-ultrasound
Telehealth

ABSTRACT

Objective: Point-of-care ultrasound (POCUS) is widely used for noninvasive, real-time patient assessment but requires specialized skills for image acquisition, limiting its self-care applications. Recent advancements include remote evaluation and artificial intelligence (AI)-assisted interpretation of ultrasound images. Self-performed ultrasound has emerged as a feasible approach but lacks standardized definitions and methods. This study reviews the literature on self-performed ultrasound to assess its current state and challenges, aiding future dissemination and application.

Methods: Research articles published through June 2024 were mapped across four databases using keywords related to 'self' or 'tele' and ultrasound terms. Two reviewers with POCUS expertise conducted primary and secondary screening.

Results: Of the 661 articles screened, 20 were included. These lacked a unified definition of self-performed ultrasound. However, all studies involved receiving guidance from an ultrasound specialist, either remotely or in-person, prior to or in real-time, and obtaining ultrasound images by applying the probe to one's own body. Participants did not necessarily have to interpret the images themselves. Participants included patients, pregnant women, healthy volunteers, and astronauts who performed ultrasound on various body parts. Instructions were provided either in-person or remotely, and images that were obtained were evaluated for image quality by experts.

Conclusion: With proper guidance, novices can successfully perform self-ultrasound. Standardized education, coupled with remote evaluation and AI-assisted interpretation, could expand the utility of ultrasound for health assessments beyond medical facilities, including in underserved regions and home settings.

1. Introduction

Point-of-care ultrasound (POCUS) is a real-time imaging technique conducted by healthcare professionals who bring ultrasound equipment to the patients [1]. POCUS is frequently used at the bedside to complement real-time patient evaluations. Therefore, POCUS is not only a useful tool for diagnosing a patient's disease, but also an important assessment method for nurses to assess patients' daily condition. Recent advancements in ultrasound equipment, such as improved image quality, miniaturization, and connectivity with external devices, such as smartphones [2], have expanded beyond medical institutions to include settings, such as homes and disaster zones, rendering it an essential diagnostic/assessment tool for patient evaluation [3–5].

POCUS generally involves two steps, image acquisition and interpretation, both of which require specialized skills. However, recent advancements, particularly the push for telemedicine in the wake of the Coronavirus Disease 2019 (COVID-19) pandemic, have facilitated the sharing of ultrasound images via videophones and internet platforms. This enables experts to conduct diagnostic imaging remotely [6,7] with high accuracy compared to conventional diagnostics techniques, eliminating the necessity for the operator, ultrasound, and reader to be in the same location. Recent studies have introduced reading aids using

* Corresponding author. Department of Gerontological Nursing / Wound Care Management, Graduate School of Medicine, The University of Tokyo, 7-3-1. Hongo, Bunkyo-ku, Tokyo, Japan.
E-mail address: gojiron@g.ecc.u-tokyo.ac.jp (G. Nakagami).

https://doi.org/10.1016/j.wfumbo.2025.100084
Received 12 January 2025; Received in revised form 19 March 2025; Accepted 21 March 2025
Available online 22 March 2025
2949-6683/© 2025 The Authors. Published by Elsevier Inc. on behalf of World Federation for Ultrasound in Medicine and Biology. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

artificial intelligence (AI) [8,9]. In addition, remote telemetry ultrasonography has also been used to acquire ultrasound images [10]. This technique enables inexperienced ultrasound operators guided by experts in remote locations to perform diagnostic imaging with the same precision as face-to-face guide methods [11,12]. This approach empowered inexperienced individuals to independently perform POCUS, a procedure previously performed by specialists or under the direct supervision of experts.

With the surge in telemedicine and AI-enhanced POCUS, the potential for "self-performed ultrasound" where individuals perform ultrasound on themselves, has become apparent [13]. This entails experts instructing non-medical personnel on ultrasound operations, enabling them to acquire images independently. A notable example is the evaluation of adult lungs during the COVID-19 pandemic [14]. The future utility of self-performed ultrasound for residents and patients is expected to vary. Combining remote-image diagnosis with AI-assisted interpretation can help verify the health status of individuals in underserved and depopulated areas. Furthermore, it can facilitate the longitudinal assessment of patients with chronic diseases in the comfort of their homes.

However, self-performed ultrasound remains an emerging concept with limited adoption. In previous studies, the definition, target population, and methods of self-performed ultrasound varied, lacking unified concepts or standards. Hence, this study aimed to review existing research on self-performed ultrasound, mapping definitions, target populations, methods, and feasibility. This study broadly maps the current usage of self-performed ultrasound and consolidates knowledge regarding self-performed ultrasound, thereby contributing to its future spread and development.

2. Materials and methods

1. Protocol and Registration

This review followed the guidelines outlined in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)-ScR extension for scoping reviews [15]. The final protocol was prospectively registered with the Open Science Framework on June 18, 2024. (https://osf.io/cyfxv/?view_only=982464a7e42541688c404339afe58f42).

2. Eligibility Criteria

The eligibility criteria for including literature in this study was established using the *Population, Concept, and Contextual frameworks* [16] **Population:** We did not specify this aspect in our research as the inclusion of diverse target populations undergoing self-performed ultrasound was crucial for the comprehensive scope of this review. **Concepts:** The criteria were the study involving the use of ultrasound equipment to perform self-administered ultrasound examinations for the purpose of assessing one's own health condition. **Context:** The review was not limited to any specific country, healthcare system, or environment. Both experimental studies (randomized controlled trials and non-randomized controlled trials) and observational studies (prospective cohort studies, longitudinal studies, cross-sectional studies, feasibility studies, pilot studies and case reports) were included in this review. The following studies were excluded: (1) Studies that did not fit into the conceptual framework of this study. (2) Studies in review articles and conference abstracts. (3) Studies not published English or Japanese.

3. Information Sources

The following databases were searched: MEDLINE (via the PubMed Interface), Cumulative Index to Nursing and Allied Health Literature (CINAHL), EMBASE, and the Japan Medical Abstract Society (ICHUSHI). The search was conducted to the latest database update on June 30, 2024. These databases were searched using the following keywords: (("self performed" or "self performing" or "self operated" or "self operating" or "self learned" or "self learning" or "self guided" or "self guiding" or "self trained" or "self training") OR ("tele performed" or "tele performing" or "tele operated" or "tele operating" or "tele learned" or "tele learning" or "tele guided" or "tele guiding" or "tele trained" or "tele training")) AND (ultrasound or ultrasonograph* or echo or echograph* or ultrasonic). The asterisks indicate the wildcards.

4. Selection of Sources of Evidence

All literature retrieved from the database was screened using Rayyan literature management software [17] In the initial screening phase, two reviewers independently assessed titles and abstracts and excluded studies that did not meet the eligibility criteria. During the second screening phase, full-text articles were independently reviewed, and studies that failed to align with the eligibility criteria were excluded. In cases of disagreement between the two reviewers, a discussion ensued, and if a consensus could not be reached, a third reviewer was consulted.

5. Data Charting Process

The selected studies were documented using a data collection form designed by the authors. One reviewer independently recorded the variables for each eligible article, with confirmation provided by another reviewer. Any disagreements in the documentation were discussed, and if a consensus could not be reached, the issue was resolved by involving a third reviewer.

6. Data Items

The following variables were extracted and mapped: article abstract (author name, publication year, country), target population, purpose of conducting self-performed ultrasound, location, body part to which the ultrasound was applied, equipment details (device name, manufacturer, probe type), name of the self-performed ultrasound method used in the study, definition of self-performed ultrasound, teaching method, image interpretation method, and feasibility of self-performed ultrasound.

3. Results

1. Selection of Sources of Evidence

After removing duplicates, 507 citations were identified from search of electronic databases and review article references. The initial screening, based on the title and abstract, excluded 465 studies, leaving 42 articles for further review. In the secondary screening, full-text screening was carried out on these 42 articles. The exclusion criteria were as follows: four articles were excluded because the participants did not apply self-performed ultrasound, in seven articles had ineligible research designs (e.g., reviews, overviews, qualitative studies), one article was written in a language other than English or Japanese, and ten articles were only abstracts from conferences. Ultimately, 20 studies were included in this review (Fig. 1).

2. Characteristics of Sources of Evidence

The characteristics of the 20 included studies are presented in Table 1. These 20 articles were published between 2014 and 2024, with five articles published between 2014 and 2019 [18–22], and 15 articles published from 2020 onwards [23–37]. Participants involved with self-performed ultrasound included astronauts, healthy volunteers, pregnant women, and patients, with most studies targeting individuals without prior experience in performing ultrasound. Self-performed ultrasound has been used to monitor the health status of astronauts in

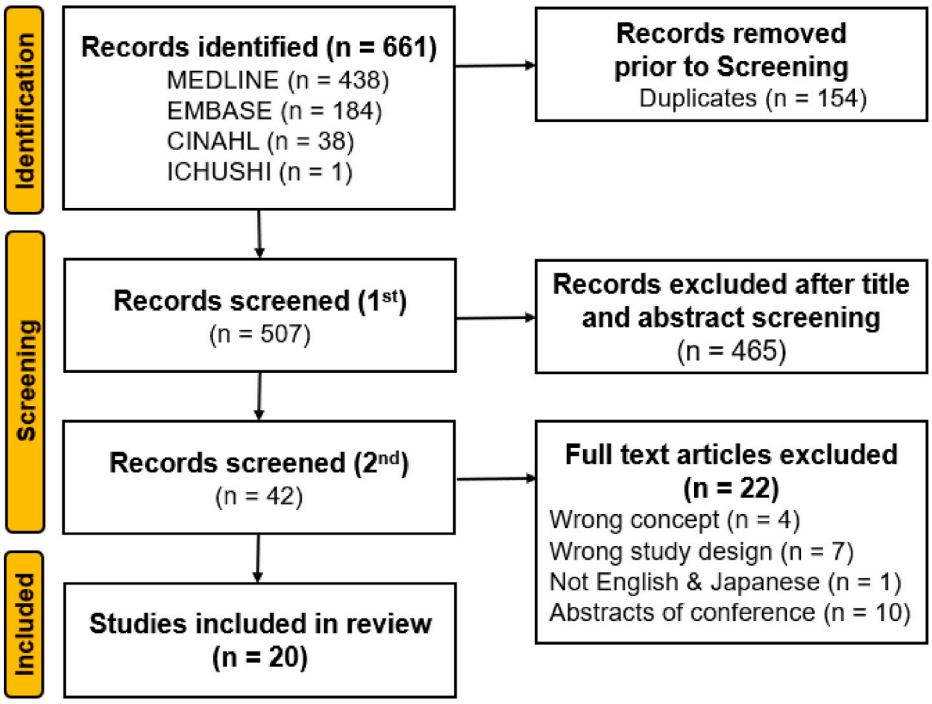


Fig. 1. Flowchart of the study selection process.

space, for examinations and assessments of women undergoing infertility treatment or pregnancy, and for monitoring the health status or diseases of healthy adults and patients. Notably, several studies have evaluated pneumonia associated with COVID-19 as part of disease monitoring. The settings for self-performed ultrasound varied, including nine studies conducted at home and three cases at the International Space Station (ISS). Other locations included hospitals, clinics, and research centers. The most frequently examined body parts were the abdomen (n = 9), followed by the chest (n = 6). Additionally, ultrasound was performed on various other parts of the body, including the upper and lower limbs and neck. The terminology used to describe self-performed ultrasound varied across studies, with no standardized terminology. However, many studies incorporated terms such as 'self' and 'perform' in combination with ultrasound. Self-performed ultrasound education was conducted face-to-face or remotely by professionals such as sonographers, physicians, and researchers. The methods of instruction vary widely and include e-learning programs, videos, and brochures. Furthermore, guidance from experts utilizes online videoconferencing with image-sharing capabilities. In all studies, ultrasound images obtained through self-performed ultrasound by the participants were evaluated by ultrasound experts using real-time or stored images. There was no study clearly defining self-performed ultrasound in the reviewed literature. However, one common element across all studies was receiving guidance from an ultrasound specialist, either remotely or in-person, prior to or in real-time, and obtaining ultrasound images by applying the ultrasound probe to one's own body, which could be considered as the current definition of self-performed ultrasound.

3. Synthesis of results: Feasibility of conducting self-performed ultrasound

In this review, the feasibility of self-performed ultrasound was considered an outcome, and relevant information was extracted from the articles. If feasibility was not explicitly included in the article outcomes, descriptions related to feasibility were extracted from other relevant sections of the article. The feasibility of self-performed ultrasound was primarily assessed by evaluating the quality of acquired ultrasound images. This evaluation was conducted by ultrasound experts who checked the necessary criteria, such as landmark delineation and image quality. In addition, in some studies, experts scored the technique of participants in performing self-performed ultrasound. Moreover, in studies where pregnant women self-performed ultrasound on their abdomen to evaluate fetal images, feasibility varied depending on the fetal part being imaged, with some studies reporting that the feasibility as evaluated by image quality was 50 % or less. However, most studies concluded that the feasibility of self-administered ultrasound was approximately 70 %, indicating a high likelihood of successful implementation.

4. Discussion

This review aimed to map the details of self-performed ultrasound by analyzing studies in which self-performed ultrasound was conducted, and to clarify its definitions, methods, and feasibility. By reviewing the 20 articles in this study, we comprehensively review the current state of research on self-performed ultrasound and clarify its feasibility.

Studies on self-performed ultrasound began to appear in 2014, with an increase in publications after 2020. This trend can be attributed to the COVID-19 pandemic in 2019, which highlighted the necessity for remote patient assessment [38,39]. None of the reviewed studies clearly defined self-performed ultrasound within their papers. However, all the selected articles describing the methods indicated that self-performed ultrasound involves receiving guidance from an ultrasound specialist, either remotely or in-person, before or in real-time, and obtaining ultrasound images by applying the ultrasound probe to one's own body. This can be considered the current definition of self-performed ultrasound.

In terms of the feasibility of self-performed ultrasound, the difficulty of fetal profiling has become apparent [40,41], which is attributed to the variability in fetal position that affect image qualities, making visualization challenging even for experienced ultrasound specialists [42,43] Mobile ultrasound devices for pregnant women have already been developed [40,41] and fetal profiling through self-performed ultrasound could potentially be used as a supplementary tool in conjunction with regular prenatal physical examinations. However, approximately 70 %

Table 1
Mapping of self-performed ultrasound studies.

Study	Participants	Study Design	Purpose of self-performed ultrasound	Location	Body part (organs) to which the ultrasound was applied	Ultrasound equipment name	Self-performed ultrasound name	Teaching methods	Image interpretation person	Feasibility outcome	Feasibility evaluation methods	Result
Pivetta et al. 2020, Italy (23)	A 26-year-old female nurse with experience in POCUS who was exposed to COVID-19 while working in an emergency department.	Case report	To evaluate pneumonia (COVID-19)	Home	Chest (lung)	Butterfly iQ, Butterfly Network Inc, Guilford CT, USA	Self-performed lung ultrasound	・Self-guidance (~Day8) Participant has experience with POCUS ・Remote guided (Day 9~) Online video calls with expert via ultrasound screen sharing	Two ultrasound expert operators ・One expert provided teleguidance ・One expert scored the image quality	Image quality was compared between the self-guided and remote expert guided	All results were reviewed by two operators who were blinded to the acquisition and interpretation. The scoring convention used was as follows: 0, no lung visualized; 1, image poorly informative, pleural line partially visualized; 2, image interpretable, pleural line partially visualized but sufficient for evaluation; 3, image easily interpreted, pleural line well visualized. Images scored 0 or 1 were considered nondiagnostic.	Overall, 114 images were acquired. The median quality score for unsupervised scans (n = 35) was significantly lower than for supervised teleguidance scans (n = 79) (2 vs 3, respectively; P < 0.001), but only three images were reviewed as nondiagnostic (2.6 %).
Duggan et al. 2022, USA (25)	30 healthy adult volunteers aged 18 years or older with no prior medical training	Prospective study	To evaluate the lungs for heart failure	Home	Chest (lung)	Butterfly iQ, Butterfly Network Inc, Guilford CT, USA	Novice-performed POCUS	Remote guidance ・28 tutorial slideshow with instructions on how to perform self ultrasound was mailed	Two POCUS experts (emergency medicine faculty with fellowship training in emergency POCUS)	The number of interpretable zones and quality scores of novice-obtained scans were compared with expert-obtained scans using Wilcoxon signed-rank test	All images were blinded and randomized as to who acquired each clip and lung zone scanned	A total of 480 LUS clips were obtained from both non-expert and expert POCUS scanners. Overall, 84 % (n = 201) of the clips obtained by the non-expert were considered interpretable, which was not different compared to 87 % expert-obtained clips which as interpretable (n = 209), p = 0.30.
Pivetta et al.	21 COVID-19 patients without signs	Proof-of-concept observational study	To evaluate pneumonia (COVID-19)	Home	Chest (lung)	Butterfly iQ, Butterfly Network Inc,	Self-performed lung ultrasound	Direct guidance and remote guidance	Two residents in emergency medicine, already	The probability of obtaining a sonographic	Evaluated 2 anterior, 2 lateral, and 2 posterior	94.1 % of 728 zones evaluated were

(*continued on next page*)

Table 1 (*continued*)

Study	Participants	Study Design	Purpose of self-performed ultrasound	Location	Body part (organs) to which the ultrasound was applied	Ultrasound equipment name	Self-performed ultrasound name	Teaching methods	Image interpretation person	Feasibility outcome	Feasibility evaluation methods	Result
2022, Italy (24)	of pneumonia and indication to discharge					Guilford CT, USA		・At the time of enrolment, each patient received a brief explanation of how to perform the LUS evaluation along with a printed schematic summary. ・With the teleguidance, patients were instructed on the operation of US device	trained in LUS and the two staff emergency physicians with expertise in LUS had more than 1000 LUS performed	image of adequate quality	zones, exploring the upper and lower lung parenchyma.	categorized as not low quality.
Pratzer et al. 2023, USA (26)	8 stable ambulatory patients with heart failure	Feasibility study	To evaluate heart failure	Home	Chest (lung)	Butterfy iQ, Butterfy Network Inc, Guilford CT, USA	Patient-administered lung ultrasound	Direct guidance and remote guidance ・Guidance was provided both verbally and visually. The first 3 patients were instructed on how to use the probe during an in-person clinic visit the others were using an entirely remote approach via video call (Due to COVID-19)	Real time image: ultrasound trained clinician (video call) Record image: Two independent reviewers	Percentage of interpretable clips LUS exams with at least four out of six interpretable clips	The deidentified clips were later reviewed and evaluated by two independent reviewers. Clips were assessed for visibility of the pleural line/rib interspace and visibility of at least one A-line or any B-lines to be graded as interpretable.	A total of 89 ultrasound sessions resulted in 534 clips of which 88 % reviewer 1 and 84 % reviewer 2 were interpretable.92.1 % of LUS exams had at least 4 out of 6 interpretable clips per reviewer on and 89,9 % per reviewer 2.
Schneider et al. 2023, Israel (27)	19 chronic hemodialysis patients	Prospective pilot single-center study	To early detect and evaluate pulmonary congestive disease in dialysis patients	Dialysis clinic	Chest (lung)	Venue Go TM, GE Healthcare, Chicago, USA	Self-lung ultrasound	Direct guidance ・A brochure explaining B-lines and how to identify and count them using examples with images.	An experienced physician operator	Rate of obtaining high-quality lung images where anatomical landmarks are well visualized	A blinded operator evaluated the B-lines of all the clips and rated the videos according to three categories (excellent, good, and unacceptable).	The percentage of patients rated Good and Excellent is 78.2 % for enrollment, 61.7 % for second visit, 57.1 % for third visit.
Elmi et al. 2024, Canada (28)	25 patients aged 18 years or old are diagnosed with COVID-19	Prospective cohort study	To evaluate the pneumonia	Home	Chest (lung)	Butterfly iQ, Butterfly Network Inc, Guilford CT, USA	Self administered at-home lung ultrasound (SAAH-LUS)	Remote guidance ・Participants received a single 20-min virtual training session led by a study coordinator to learn about the	Two POCUS experts (emergency physicians)	Percentage of the scans for interpretability and inter-rater agreement between the two reviewers	Two POCUS expert reviewers reviewed the 10 lung zones scans for interpretability, and inter-rater agreement	Across 1339 scans obtained from 10 different lung zones, the average proportion of interpretability was 96 % with a chance-corrected

(*continued on next page*)

Table 1 (*continued*)

Study	Participants	Study Design	Purpose of self-performed ultrasound	Location	Body part (organs) to which the ultrasound was applied	Ultrasound equipment name	Self-performed ultrasound name	Teaching methods	Image interpretation person	Feasibility outcome	Feasibility evaluation methods	Result
								operation of the US system, connection to remote guidance, and image transmission. ・Teleguidance occurred 1 day by an emergency physician who experienced in LUS.			between the two reviewers was also computed.	agreement, or Cohen's kappa, reported as $\kappa = 0.67$.
Hadar et al. 2020, Israel (29)	100 women with a singleton fetus at 14 + 0 to 39 + 6 gestational weeks	Observational noninterventional clinical trial	To evaluate the condition of the fetus at home during pregnancy	Home	Abdomen (full uterine and fetus)	INSTINCT, PulseNmore, Omer, Israel	Self-operated home ultrasound system	Direct guidance ・Each participant received personal face-to-face instructions on how to use the device and its associated mobile application.	Two professionals, either an obstetrician-gynecologist or an experienced ultrasound technician	The extent to which each ultrasound parameter could be identified by evaluation of the ultrasound images and video after the examination.	After delivery, scans were evaluated for the following biophysical parameters, scored as either seen or not seen fetal heart activity, subjective assessment of normal amniotic fluid volume, fetal tone, fetal body movements, and fetal breathing movements (for those at or beyond 27 + 0 gestational weeks)	Success in detection was 95.3 % for fetal heart activity, 88.3 % for body movements, 69.4 % for tone, 92.2 % for normal amniotic fluid volume, and 23.8 % for breathing movements.
Pontones et al. 2023, Germany (30)	46 women with singleton pregnancies between 17 + 0 and 29 + 6 weeks of gestation	Prospective, Single center, interventional cohort study	To evaluate the condition of the fetus during pregnancy	Not specified	Abdomen (fetal heartbeat, fetal profile, amniotic fluid in each of the four quadrants of the abdomen)	A: Instinct, Pulse Nmore Ltd., Omer, Israel B: Butterfly iQ, Butterfly Network Inc, Burlington, Massachusetts, USA.	Self-guided ultrasound examination	Direct guidance ・Explained over 5–10 min using example images by an experienced examiner	One experienced ultrasound examiner	Feasibility and acceptance, success rates of medically supervised self-examinations with mobile ultrasound devices	The participants examined the fetal heartbeat, fetal profile and amniotic fluid. Aspects of feasibility were evaluated using a questionnaire. Success rates in relation to image and video quality were evaluated by healthcare professionals.	Two thirds of the women were able to imagine performing the self-guided examination at home. Success rates for locating the target structure were 52.2 % for videos of the fetal heartbeat, 52.2 % for videos of the amniotic fluid in all four quadrants and 17.9 % for videos of the fetal profile.

(*continued on next page*)

Table 1 (*continued*)

Study	Participants	Study Design	Purpose of self-performed ultrasound	Location	Body part (organs) to which the ultrasound was applied	Ultrasound equipment name	Self-performed ultrasound name	Teaching methods	Image interpretation person	Feasibility outcome	Feasibility evaluation methods	Result
Nir et al. 2023, Israel (31)	10 women between 40 + 1 and 40 + 6 weeks of gestation	Prospective pilot study	To evaluate the condition of the fetus during pregnancy	Medical center	Abdomen (amniotic fluid)	INSTINCT, PulseNmore, Omer, Israel	Remote fetal ultrasound	Direct guidance ・The women were introduced into a private room and instructed in person by an obstetrician how to use the remote ultrasound device	Not specified	Measurement of amniotic fluid volume on ultrasound images	The telemedicine control center was in a separate room within the medical center and kept real-time monitoring of the amniotic fluid volume measurement taken by the participant independently. The single deepest vertical pocket was used for amniotic fluid volume assessment.	Satisfactory amniotic fluid volume measurements were achieved in 100 % of participants.
Gerris et al. 2014, Belgium (18)	123 women under 41 years of age, each with two ovaries, received ICSI treatment.	Non-inferiority RCT	To monitor the follicles of women undergoing ART cycles	Not specified	Abdomen (ovary, uterus)	Laborie, Medical Inc, Toronto, Canada	Self-operated endovaginal telemonitoring	Direct guidance ・Sonographic training was directly given to all women at the initiation of a treatment attempt at the center ・how to make video images, an how to upload and send them to the center.	Researcher	The primary image quality criterion was to detect follicles that were identifiable and measurable in serial recordings.	Comparing the number of follicles ≥15 mm in diameter before puncture, the total number of positive HCGs, and the number of ongoing pregnancies (≥12 weeks, with at least one fetus having cardiac activity) between the SOET group and the non-SOET group.	The clinical results showed similar conception rates (P = 0.47) and ongoing pregnancy rates (SOET: 15/59 = 25 %; non-SOET: 16/62 = 26 %) (P = 1.00) were obtained. Similar numbers of follicles ≥15 mm diameter at oocyte retrieval (OR) were obtained in the two groups.
Pereira et al. 2016, Germany (19)	60 women undergoing ART cycles	Single center, observational, single-blinded cohort study	To monitor the follicles of women undergoing ART cycles	University-affiliated in vitro fertilization center.	Abdomen (ovary, uterus)	SONAURA (SOET)	Self-operated endovaginal telemonitoring	Direct guidance ・After the examination, the participants were taught the SOET system including how to recognize the uterus and both ovaries, and practiced on their own afterwards.	An operator (details not provided)	Video images were considered unsuitable for analysis if the endometrium or if at least one of the ovaries could not be visualized.	Video images were considered unsuitable for analysis if the endometrium or if at least one of the ovaries could not be visualized.	In 16 cases, 26.7 % of the images were considered unsuitable for analysis (Suitable 73.3 %).
Dalewyn et al. 2017,	15 women who were treated with the home	Pilot study	To monitor the follicles of women	Home	Abdomen (ovary, uterus)	Not specified	Self-operated endovaginal telemonitoring	Not specified	A physician	Correlation coefficient of the thickness of the endometrial	The physician measured the number of follicles, 2D	The number of follicles correlates well between SOET and conventional 2D

(*continued on next page*)

Table 1 (*continued*)

Study	Participants	Study Design	Purpose of self-performed ultrasound	Location	Body part (organs) to which the ultrasound was applied	Ultrasound equipment name	Self-performed ultrasound name	Teaching methods	Image interpretation person	Feasibility outcome	Feasibility evaluation methods	Result
Belgium (20)	sonography device (SOET)		undergoing ART cycles							lining between the echo image taken by the patient himself and the echo image taken by the physician 12 h later.	dimensions, and endometrial thickness	ultrasound. ICC of three measurements is 0.832 right, 0,815 left.
Muta et al. 2024, Japan (32)	11 women aged 40 years or older with urinary incontinence	Observational study	To evaluate the effectiveness of PFMT	Home	Abdomen (bladder)	iViz air, FUJIFILM, Tokyo, Japan	Self-performed ultrasound	Remote guidance ・e-learning (video materials)	Two researchers with enough experience in ultrasound	The number of times the bladder area was successfully extracted	Researchers used an AI-based bladder extraction system to assess whether the entire bladder was depicted from recorded US videos. If they disagreed, they were excluded.	Self-performed ultrasound can be performed in 81.8 % of women with UI in their 40–60s.
Muta et al. 2024, Japan (33)	56 women aged 20 years or old without urinary incontinence and 40 years or older with and without urinary incontinence	Cross sectional observational study	To evaluate the effectiveness of PFMT	Hospital and research center	Abdomen (bladder)	iViz air, FUJIFILM, Tokyo, Japan	Self-performed ultrasound	Direct guidance ・Researcher instructed how to use ultrasound	Researcher with enough experience in ultrasound and sonographer	The number of images in which the bladder is adequately visualized	The recorded ultrasound images were blinded and the entire bladder was evaluated for clear delineation by two raters after the study. Any disagreements between the two were excluded.	1428/1554 bladder images were deemed evaluable by two evaluators.
Arbeille et al. 2018, France (21)	Astronaut (No number of people specified)	Not Specified	To conduct comprehensive health assessments of astronauts on the ISS	ISS	Abdomen (liver, gallbladder, biliary truck), vessels (portal and hepatic veins), neck (carotid artery, jugular vein, thyroid), eye grobe	Orcheolite TE, Sonoscanner, Paris, France	Remote echography	Direct guidance ・30 min of pre-flight practice Remote guidance ・Real-time guidance from an ultrasound technician on the ground	Sonographer and project manager Space Center (on the ground)	Feasibility of conducting tele-operate ultrasound with motorized probe system on the ISS	Reviewer evaluates ultrasound images by tele-scanning in real-time (delay of 1–2 s) on the ground (No specific evaluation criteria mentioned)	The ultrasound images, video and audio that were downlinked to the ground-based sonographer in real time and the saved data that were downlinked after the examination were of very good quality.
Scott et al. 2021, USA (34)	11 astronauts	Not specified	To evaluate muscle mass of astronauts aboard the ISS	ISS	Lower limb (RF, VM, VL, GM, and GL)	Not specified	Teleguided self-ultrasound scanning	Remote guidance ・Conducted at ground center	Two sonographers	Quality of ultrasound images for RF, VM, VL, GM, and GL	Not specified	Over an average of 168 ± 57 days of spaceflight, 74 Tele-SUS sessions were performed. 91 % (449 of 492 performed) of the

(*continued on next page*)

Table 1 (*continued*)

Study	Participants	Study Design	Purpose of self-performed ultrasound	Location	Body part (organs) to which the ultrasound was applied	Ultrasound equipment name	Self-performed ultrasound name	Teaching methods	Image interpretation person	Feasibility outcome	Feasibility evaluation methods	Result
												images were rated high quality.
Sorriento et al. 2022, Italy (35)	3 healthy volunteers	Not specified	To evaluate patients with knee osteoarthritis	Not specified	Lower limb (knee)	ArtUS EXT-1H System, Telemed, UAB, Vilnius, Lithuania	Ultrasound self-acquisition	Direct guidance ・Before starting the acquisition, a training session of ~10min was performed, in which the clinician instructed the subject on the different procedures to be carried out.	Not specified	Acquire informative ultrasound images, similar to the reference images performed by the musculoskeletal radiologist.	Not specified	The untrained subjects were able to self-acquire informative B mode images comparable to the corresponding images acquired by expert clinicians. (No specific numbers specified)
Strauss et al. 2024, Germany (36)	5 adult patients 18 years or older suffer from moderate or severe hemophilia A or B	Feasibility study	To evaluate and early detect of hemophilic arthropathy in patients with hemophilia	Home	Lower limb (knee)	Butterfly iQ+, Butterfly Network Inc., Burlington, Massachusetts, USA.	Self-conducted sonographic monitoring	Direct guidance ・After recruitment, patients learn about HEAD-US and are technically evaluated with expert guidance by hemipterologist	A radiologist with 8 years of experience in musculoskeletal imaging	The number of anatomic landmarks identifiable on the individual images and the number of correct answers	Based on previous study, the correct depiction of 17 landmarks per examination was counted	Altogether 2334 landmarks were depicted, amounting to 82.7 % of 2822 possible landmarks on the available images.
Saati et al. 2023, USA (37)	22 patients who scheduled for primary care visits at the clinic	Prospective observational cohort study	To evaluate skin and soft tissue infections	Clinic	Antecubital fossa (skin and soft tissue)	Lumify L12-4 Broadband Linear Array Transducer, PHILIPS, Koninklijke Philips N.V., Amsterdam, Netherlands	Self scan	Remote guidance ・Probe operation instruction at different locations in the same clinic	Two POCUS physician experts	Scoring of scanning technology, scanning skills interpretability. A score >7 was considered adequate for diagnostic interpretation.	Reviewers were not involved in participant enrollment and were blinded to each other's scores. For each subcategory the expert assigned a score of Poor (0 point), Adequate (1 Point), or Ideal (2 point).	The average score was 10.15/14, with a minimum score of 5/14, and maximum score of 14/14 and a standard deviation (SD) of 2.39 using a two tailed Z-score. Setting alpha at 0.05 the 95 % CI was (5.47–14.83).
Zamboni et al. 2018, Italy (22)	A 37-years female astronaut	Not specified	For remote evaluation of cardiac function of astronauts aboard the ISS	・Ground astronaut center ・ISS	Neck (jugular vein)	Vivid-Q scanner, GE Medical Systems Ultrasound, Horten, Norway	Self-performed B-mode ultrasound	Not specified	Researcher	Not specified	Not specified	Not specified

Abbreviation ART; Assisted reproductive technology, COVID-19; Coronavirus disease 2019, GL; Gastrocnemius lateralis, GM; Gastrocnemius medialis, HEAD-US; Hemophilia early arthropathy detection with ultrasound, ICSI; Intracytoplasmic Sperm Injection, ISS; International Space Station, LUS; Lung ultrasound, PFMT; Pelvic floor muscle training, POCUS; Point-of-care ultrasound, RF; Rectus femoris, SOET; Self-operated endovaginal telemonitoring, TVS; Transvaginal ultrasound, VL; Vastus lateralis, VM; Vastus medialis.

of the participants were able to successfully perform the self-performed ultrasound of the abdomen, chest, and limbs. This indicates that individuals with no prior ultrasound experience can adequately carry out self-performed ultrasound under proper guidance. The self-performed ultrasound technique became feasible for inexperienced individuals through education provided by specialists, either in person or remotely, using brochures, images, and videos. Studies conducted on the ISS have demonstrated the development of robot-assisted probes, which allow specialists to adjust the angle, depth, and brightness of the probe remotely. However, since such robotic assistance is not yet common, self-performed ultrasound practitioners must learn to apply the probe to the landmarks of the target organs effectively. To implement self-performed ultrasound, it is crucial to develop standardized educational methods for proper identification of landmarks and application of the probes.

None of the studies required practitioners to interpret the images obtained through self-performed ultrasound. Instead, specialists, such as sonographers or physicians, evaluate the images either in real-time, face-to-face, or remotely, or they assess the saved images with a time delay. Interpreting ultrasound images requires specialized knowledge and considering that many of the studies involved participants with no prior ultrasound experience, requiring interpretation of the images would increase the difficulty of the procedure. Currently, ultrasound devices have been developed with the capability for sharing images and videos remotely in real-time, and advancement in AI-assisted interpretation of ultrasound images are also underway. The active utilization of these technologies could significantly contribute to the advancement of self-performed ultrasound [44–47].

However, this study had certain limitations. First, because only English and Japanese languages were targeted, related studies in other languages were excluded. Additionally, the studies included in this review did not necessarily consider the feasibility of self-performed ultrasound as a primary outcome, which limits the accuracy of the feasibility assessment.

This review includes several feasibility, pilot, and case studies likely due to the recent emergence of self-performed ultrasound as a technique and the limited number of studies available. Further interventional studies are required to verify the efficacy of self-performed ultrasound. This review revealed that self-performed ultrasound can be performed even by individuals with no prior ultrasound experience through standardized education on applying the probe to landmarks and real-time remote interpretation assistance. The development of self-performed ultrasound could be utilized for supplementary examinations and timely monitoring of health conditions and diseases in non-medical settings such as spaces, regions with insufficient medical infrastructure, and at home.

5. Conclusions

This scoping review elucidated the methodologies used in studies of self-performed US. The potential for advancement of self-performed ultrasound is high, especially with the implementation of standardized educational programs and the integration of remote imaging evaluation alongside AI-assisted interpretation systems. The widespread adoption of self-performed ultrasound in the future could enable certain ultrasound examinations in environments lacking medical professionals, potentially aiding in diagnosis, assessment and health management. Nonetheless, further research is required to determine the feasibility of self-performed ultrasound across various subjects and settings.

Data availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Conflict of interest statement

The authors declare no competing interests.

Acknowledgements

No funds were used in this study.

References

[1] Moore CL, Copel JA. Point-of-care ultrasonography. N Engl J Med 2011;364(8):749–57.
[2] Rykkje A, Carlsen JF, Nielsen MB. Hand-held ultrasound devices compared with high-end ultrasound systems: a systematic review. Diagnostics 2019;9(2).
[3] Mellor TE, Junga Z, Ordway S, Hunter T, Shimeall WT, Krajnik S, et al. Not just hocus POCUS: implementation of a point of care ultrasound curriculum for internal medicine trainees at a large residency program. Mil Med 2019;184(11–12):901–6.
[4] Sullivan JF, Do Brasil M, Roman JW, Milder EA, Carter E, Lennon RP. Utility of point of care ultrasound in humanitarian assistance missions. Mil Med 2021;186(1):789–94.
[5] Lo H, Eder N, Boten D, Jenssen C, Nuernberg D. Handheld ultrasound (HHUS): potential for home palliative care. Ultrasound Int Open 2022;8(2):E68–76.
[6] Carbone M, Ferrari V, Marconi M, Piazza R, Del Corso A, Adami D, et al. A tele-ultrasonographic platform to collect specialist second opinion in less specialized hospitals. Updates Surg 2018;70(3):407–13.
[7] McBeth PB, Crawford I, Blaivas M, Hamilton T, Musselwhite K, Panebianco N, et al. Simple, almost anywhere, with almost anyone: remote low-cost telementored resuscitative lung ultrasound. J Trauma Inj Infect Crit Care 2011;71(6):1528–35.
[8] Shen YT, Chen L, Yue WW, Xu HX. Artificial intelligence in ultrasound. Eur J Radiol 2021 Jun;139:109717.
[9] Matsumoto M, Tsutaoka T, Nakagami G, Tanaka S, Yoshida M, Miura Y, et al. Deep learning-based classification of rectal fecal retention and analysis of fecal properties using ultrasound images in older adult patients. Jpn J Nurs Sci 2020;17(4):1–8.
[10] Pian L, Gillman LM, McBeth PB, Xiao Z, Ball CG, Blaivas M, et al. Potential use of remote telesonography as a transformational technology in underresourced and/or remote settings. Emerg Med Int 2013;2013:1–9.
[11] Ferreira AC, O'Mahony E, Oliani AH, Araujo Júnior E, da Silva Costa F. Teleultrasound: historical perspective and clinical application. Int J Telemed Appl 2015;2015:306259.
[12] Boniface KS, Shokoohi H, Smith ER, Scantlebury K. Tele-ultrasound and paramedics: real-time remote physician guidance of the focused assessment with sonography for trauma examination. AJEM (Am J Emerg Med) 2011;29(5):477–81.
[13] Kirkpatrick AW, McKee JL, Couperus K, Colombo CJ. Patient self-performed point-of-care ultrasound: using communication technologies to empower patient self-care. Diagnostics 2022;12(11):1–11.
[14] Kirkpatrick AW, McKee JL, Ball CG, Ma IWY, Melniker LA. Empowering the willing: the feasibility of tele-mentored self-performed pleural ultrasound assessment for the surveillance of lung health. Ultrasound J 2022;14(1).
[15] Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, et al. PRISMA extension for scoping reviews (PRISMA-ScR): checklist and explanation. Ann Intern Med 2018;169(7):467–73.
[16] Peters MDJ, Godfrey CM, Khalil H, McInerney P, Parker D, Soares CB. Guidance for conducting systematic scoping reviews. Int J Evid Base Healthc 2015;13(3):141–6.
[17] Ouzzani M, Hammady H, Fedorowicz Z, Elmagarmid A. Rayyan-a web and mobile app for systematic reviews. Syst Rev 2016;5(1):1–10.
[18] Gerris J, Delvigne A, Dhont N, Vandekerckhove F, Madoc B, Buyle M, et al. Self-operated endovaginal telemonitoring versus traditional monitoring of ovarian stimulation in assisted reproduction: an RCT. Hum Reprod 2014;29(9):1941–8.
[19] Pereira I, von Horn K, Depenbusch M, Schultze-Mosgau A, Griesinger G. Self-operated endovaginal telemonitoring: a prospective, clinical validation study. Fertil Steril 2016 Aug;106(2):306–310.e1.
[20] Dalewyn Edjg L. Correlation between follicle dimensions recorded by patients at home (SOET) versus ultrasound performed by professional care providers. Facts Views Vis Obgyn 2017;9(3):153–6.
[21] Arbeille P, Chaput D, Zuj K, Depriester A, Maillet A, Belbis O, et al. Remote echography between a ground control center and the international space station using a tele-operated echograph with motorized probe. Ultrasound Med Biol 2018 Nov 1;44(11):2406–12.
[22] Zamboni P, Sisini F, Menegatti E, Taibi A, Gadda G, Tavoni V, et al. Ultrasound monitoring of jugular venous pulse during space missions: proof of concept. Ultrasound Med Biol 2018 Mar 1;44(3):726–33.
[23] Pivetta E, Girard E, Locascio F, Lupia E, Martin JD, Stone M. Self-performed lung ultrasound for home monitoring of a patient positive for Coronavirus disease 2019. Chest 2020 Sep 1;158(3):e93–7.
[24] Pivetta E., Ravetti A., Paglietta G., Cara I., Buggè F., Scozzari G., Maule M.M., Morello F., Locatelli S., Lupia E. Feasibility of self-performed lung ultrasound with remote teleguidance for monitoring at home COVID-19 patients. Biomed 2022 Oct 13;10(10):2569.
[25] Duggan N.M., Jowkar N., Ma I.W.Y., Schulwolf S., Selame L.A., Fischetti C.E., Kapur T., Goldsmith A.J. Novice-performed point-of-care ultrasound for home-based imaging. Sci Rep 2022 Nov 28;12(1):20461.

[26] Pratzer A, Yuriditsky E, Saraon T, Janjigian M, Hafiz A, Tsay JJ, Boodram P, Jejurikar N, Sauthoff H. Feasibility of tele-guided patient-administered lung ultrasound in heart failure. Ultrasound J 2023;15(1):8.
[27] Schneider E., Maimon N., Hasidim A., Shnaider A., Migliozzi G., Haviv Y.S., Halpern D., Abu Ganem B., Fuchs L. Can dialysis patients identify and diagnose pulmonary congestion using self-lung ultrasound? J Clin Med 2023 Jun 2;12(11): 3829.
[28] Elmi N, Sadri Y, Myslik F, Chenkin J, Cherniak W. Respir Res 2024 Mar;25(1):111.
[29] Hadar E, Wolff L, Tenenbaum-Gavish K, Eisner M, Shmueli A, Barbash-Hazan S, et al. Mobile self-operated home ultrasound system for remote fetal assessment during pregnancy. Telemedicine and e-Health 2022 Jan 1;28(1):93–101.
[30] Pontones C.A., Titzmann A., Huebner H., Danzberger N., Ruebner M., Häberle L., Eskofier B.M., Nissen M., Kehl S., Faschingbauer F., Beckmann M.W., Fasching P. A., Schneider M.O. Feasibility and acceptance of self-guided mobile ultrasound among pregnant women in routine prenatal care. J Clin Med 2023 Jun 22;12(13): 4224.
[31] Nir O, Dvir G, Galler E, Axelrod M, Farhi A, Barkai G, et al. Integrating technologies to provide comprehensive remote fetal surveillance: a prospective pilot study. Int J Gynecol Obstet 2024 Feb 1;164(2):662–7.
[32] Muta M, Takahashi T, Tamai N, Sanada H, Nakagami G. Development of an e-learning program for biofeedback in pelvic floor muscle training for adult women using self-performed ultrasound: an observational study. Jpn J Nurs Sci 2024 Oct; 21(4):e12609.
[33] Muta M, Takahashi T, Tamai N, Suzuki M, Kawamoto A, Sanada H, Nakagami G. BMC Womens Health 2024 Apr;24(1):219.
[34] Scott J.M., Downs M., Martin D.S., Hougland E., Sarmiento L., Arzeno N., Pettit D. R., Ploutz-Snyder R., Cunningham D., Jones L.W., Do R., Ploutz-Snyder L. Teleguided self-ultrasound scanning for longitudinal monitoring of muscle mass during spaceflight. iScience 2021 Mar 21;24(4):102344.
[35] Sorriento A., Cafarelli A., Spinnato P., Russo A., Lisignoli G., Rabusseau F., Cabras P., Dumont E., Ricotti L. Design, development and validation of a knee brace to standardize the US imaging evaluation of knee osteoarthritis. IEEE J Transl Eng Health Med 2021 Dec 22;10:1800308.
[36] Strauss AC, Marquardt N, Oldenburg J, Pieper CC, Attenberger U, Hmida J, et al. Self-conducted sonographic monitoring of the knee in patients with haemophilia—a feasibility study. Haemophilia 2024 Jul 1;30(4):1025–31.
[37] Saati A, Au A, Joshi A, Davis R, West FM, Lewiss RE. Can untrained patients perform their own skin and soft tissue ultrasound examination by teleguidance? POCUS J 2023 Nov 27;8(2):159–64.
[38] Anthony Jr. B. Use of telemedicine and virtual care for remote treatment in response to COVID-19 pandemic. J Med Syst 2020 Jun 15;44(7):132.
[39] Wosik J., Fudim M., Cameron B., Gellad Z.F., Cho A., Phinney D., Curtis S., Roman M., Poon E.G., Ferranti J., Katz J.N., Tcheng J. Telehealth transformation: COVID-19 and the rise of virtual care. J Am Med Inform Assoc 2020 Jun 1;27(6):957-962.
[40] Pontones C.A., Titzmann A., Huebner H., Danzberger N., Ruebner M., Häberle L., Eskofier B.M., Nissen M., Kehl S., Faschingbauer F., Beckmann M.W., Fasching P. A., Schneider M.O. Feasibility and acceptance of self-guided mobile ultrasound among pregnant women in routine prenatal care. J Clin Med 2023 Jun 22;12(13): 4224.
[41] Hadar E, Wolff L, Tenenbaum-Gavish K, Eisner M, Shmueli A, Barbash-Hazan S, et al. Mobile self-operated home ultrasound system for remote fetal assessment during pregnancy. Telemedicine and e-Health 2022 Jan 1;28(1):93–101.
[42] Chaichanalap R., Hanprasertpong T. Success rate to complete optimal 20 + 2 ISUOG planes for foetal ultrasonographic structural screening during early second trimester pregnancy in Thailand. Ultrasound J 2021 Aug 14;13(1):36.
[43] Silvestri MT, Pettker CM, Raney JH, Xu X, Ross JS. Frequency and importance of incomplete screening fetal anatomic sonography in pregnancy. J Ultrasound Med 2016 Dec 1;35(12):2665–73.
[44] Takahashi T., Nakagami G., Murayama R., Abe-Doi M., Matsumoto M., Sanada H. Automatic vein measurement by ultrasonography to prevent peripheral intravenous catheter failure for clinical practice using artificial intelligence: development and evaluation study of an automatic detection method based on deep learning. BMJ Open 2022 May 24;12(5):e051466.
[45] Matsumoto M., Tsutaoka T., Yabunaka K., Handa M., Yoshida M., Nakagami G., Sanada H. Development and evaluation of automated ultrasonographic detection of bladder diameter for estimation of bladder urine volume. PLoS One 2019 Sep 5; 14(9):e0219916.
[46] Matsumoto M, Tsutaoka T, Nakagami G, Tanaka S, Yoshida M, Miura Y, Sugama J, Okada S, Ohta H, Sanada H. Deep learning-based classification of rectal fecal retention and analysis of fecal properties using ultrasound images in older adult patients. Jpn J Nurs Sci 2020 Oct;17(4):e12340.
[47] Matsumoto M, Nakagami G, Kitamura A, Kurita M, Suga H, Miyake T, Kawamoto A, Sanada H. Ultrasound assessment of deep tissue on the wound bed and periwound skin: a classification system using ultrasound images. J Tissue Viability 2021 Feb;30(1):28–35.