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CONSENSUS STATEMENT

Standards for Point-of-care Ultrasound Research Reporting (SPUR): A modified Delphi to develop a framework for reporting point-of-care ultrasound research

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Abstract

Background: Point-of-care ultrasound (POCUS) is a bedside diagnostic modality that depends on technical, operator-specific, patient-specific, and clinical context factors. Existing research reporting guidelines do not explicitly address these considerations as they pertain to replicability and generalizability of POCUS studies. The objective of this study was to create a framework to assist investigators, reviewers, and clinicians in reporting and evaluating the quality of POCUS research.

Methods: We applied a two-stage consensus-building approach. First, a steering committee reviewed available literature and existing guidelines to generate a novel list of items and explanatory subitems relevant to POCUS research. We vetted the list by soliciting public comments from individuals affiliated with POCUS-oriented professional organizations. Second, a consensus panel of experts, defined as POCUS researchers with a minimum of three first or senior author, POCUS-relevant publications completed a three-round Delphi survey. Consensus was defined as agreement by ≥80% of the panel. Items that did not reach consensus after three rounds were excluded.

†SPUR authors are listed in Appendix A.

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Results: Twenty POCUS experts participated in the study, completing all three survey rounds. The panel reached consensus to include 19/21 items and 62/119 subitems. The resulting instrument addresses variables related to technical hardware and settings (three items), specifics of the POCUS examination (two items), participant characteristics (two items), operator characteristics (five items), data analysis and interpretation (three items), and study-specific considerations (four items).

Conclusions: The Standards for Point-of-Care Ultrasound Research Reporting (SPUR) can aid researchers, reviewers, and clinicians in the design, dissemination, and critical appraisal of POCUS research.

INTRODUCTION

Point-of-care ultrasound (POCUS) is a diagnostic imaging modality performed by a treating clinician to answer focused clinical questions or as an adjunct to procedures. Many medical and surgical specialties utilize POCUS, tailoring imaging protocols and training pathways to their practice.[1–3] As POCUS applications expanded over the past three decades, the body of research into the utility of POCUS has grown exponentially.[4,5]

Reporting guidelines for study designs ensure reproducibility, reliability, standardization, and generalizability. For example, the Standards for Reporting of Diagnostic Accuracy Studies (STARD) guideline is one of the most accepted and utilized reporting assessment tools for diagnostic accuracy studies.[6] Several unique features set POCUS apart from other diagnostic modalities for which existing reporting guidelines were developed (e.g., laboratory testing or radiology-performed imaging studies).

First, POCUS is user-dependent and performed by the clinician at the patient's bedside. Therefore, the diagnostic value of POCUS depends on the operator's skill, the clinical context of the POCUS application, and on the operator's access to other clinical data.[7–9] A thorough description of the operator's training and clinical context (including patient selection and timing of the POCUS examination with respect to other aspects of the clinical evaluation) is important to assess the generalizability of a research study. Second, POCUS examinations encompass a broad range of clinical applications with substantial variation in scanning protocols and training for each application.[7,8] The heterogeneity of POCUS protocols is further compounded by the diversity of technical considerations such as transducer selection, hardware capabilities, screen size, and postprocessing features, which vary between devices and manufacturers.

While guidelines exist for a wide array of study designs and topics,[10] a rigorously developed guideline for reporting POCUS-specific research does not currently exist. Such a guideline is needed to provide a framework ensuring robust reporting, interpretation, and replicability of POCUS studies. To address this gap, we developed a POCUS-specific research reporting framework, which can be used as an adjunct to existing study reporting guidelines.

METHODS

Study design and objective

We performed a modified Delphi study to create a POCUS-specific reporting framework, titled Standards for Point-of-Care Ultrasound Research Reporting (SPUR). The objective of this consensus guideline is to assist researchers in study design and reporting their findings. The framework is also intended for journal reviewers, editors, and clinicians to evaluate the quality and generalizability of POCUS studies. The Delphi process is an appropriate methodology when a problem can be reasonably defined, and consensus can be reached by a panel of experts without extensive in-person discussion or clarification.[11] In this case, researchers were familiar with the value of standardized reporting, the variability in quality of published research, and the lack of a guideline for reporting POCUS investigations. Therefore, the Delphi process allowed a consensus panel of geographically dispersed experts to reach an anonymized consensus on elements relevant to POCUS research.

The reporting of this study follows the Conducting and Reporting of Delphi Studies (CREDES) guidelines.[12] The study consisted of fourth steps: (1) development and piloting of survey items by the steering committee, (2) public "call for comment," (3) recruitment of a "consensus panel" of experts, and (4) three iterative rounds of Delphi surveys. The study was approved by the institutional review board at the Oregon Health and Science University.

Study population and survey development

Steering committee

The steering committee was composed of 12 national leaders in POCUS research and included editors, authors, and peer reviewers. The steering committee met four times for 1 hour each from November 2022 through July 2023 to outline study objectives, develop the items of the Delphi survey, and finalize the inclusion criteria for study participants serving on the consensus panel.

Survey development

After developing the study objectives, the steering committee performed a literature search to assess for existing reporting guidelines specific to POCUS. The committee members independently searched PubMed and Google Scholar using the following terms: ("point-of-care ultrasound" *or* "POCUS") *and* ("reporting guideline" *or* "research reporting") and did not identify any relevant preexisting recommendations. The steering committee therefore utilized the existing STARD guideline for reporting of diagnostic studies[6] to identify sections that may benefit from POCUS-relevant clarification. This was supplemented by group discussion and addition of relevant reporting areas informed by the steering committee's clinical and research experience in POCUS. The committee stratified these relevant areas into six sections (File S1) and assigned two members to each section tasked with developing POCUS-relevant items for that section. Items were identified by negotiated consensus, erring toward inclusion of controversial items. Each item contained a list of subitems intended to clarify which features of a given item might be most relevant to POCUS research reporting. All items and subitems were then reviewed by the full steering committee for content and clarity. The survey was built using REDCap[13] and piloted by all members of the steering committee who provided ongoing feedback on usability, clarity, and content to develop the survey (File S1).

Call for comment

To solicit generalized broad feedback on the preliminary item list and any potential missed items, the steering committee gathered feedback from individuals affiliated with several large ultrasound communities across multiple specialties. Specifically, the list of items was disseminated via the following email listservs: American College of Emergency Physicians (ACEP), American Institute of Ultrasound in Medicine (AIUM), Canadian Association of Emergency Physicians (CAEP), Pediatric Emergency Medicine POCUS (P2) Network, and Society for Academic Emergency Medicine (SAEM). All members of each group were eligible to provide comments. Respondents were given the option to respond anonymously or to provide contact information if they were interested in being a member of the consensus panel. Respondents were asked to comment on existing items and suggest additional items or clarifications.

Consensus panel study participants

To capture a diverse and balanced consensus panel with respect to research experience, the steering committee defined a POCUS research expert as a researcher who had published a minimum of three original POCUS research manuscripts (not including case reports, narrative reviews, and book chapters) as a first or senior author. This definition was chosen to ensure that panel members had active experience in designing and executing POCUS research, while avoiding biasing the result in favor of advanced experts with a more extensive publication record, who may have access to resources not available to many POCUS researchers. The steering committee intentionally selected a diverse sampling of experts with respect to gender, geographic location, practice population (pediatric vs. adult), and department leadership roles. The steering committee specified a priori that no more than one consensus panel participant be recruited from a single institution and targeted a gender balance such that no greater than 60% of participants fell under a single gender category. Potential Delphi panelists were recruited using focused recruitment and snowball sampling.[14] We sought to expand the selection pool and avoid proximity and recruitment bias by soliciting potential members during the public "call for comments" described above. Based on steering committee consensus we planned to include 20 consensus panel members to maintain appropriate breadth of viewpoints while facilitating a high completion rate.

Data collection and analysis

Consensus panel participants were asked to select one of three options for each item: "Yes, should be included"; "Yes, should be included with modification"; or "No, should NOT be included." Unless the participant selected "No, should NOT be included," participants would then be presented with a list of clarifying subitems. All questions were mandatory for the survey response to be completed. Each item allowed for open-text feedback or comments. Modifications were made based on the panel's comments after review by members of the steering committee. Modifications deemed to substantially change the item's intent advanced to the subsequent round for repeat voting. Each panel member was assigned a coded study ID number to track response rate and demographics. The study ID code was known only to a single author (NS), such that all responses were shared anonymously with the steering committee and consensus panel. The anonymized aggregate ratings for each statement (including items and subitems) as well as comments were shared with the members of the consensus panel for asynchronous review during subsequent rounds.

A priori, we decided to perform a total of three rounds unless consensus for all statements was achieved earlier. Prior to study initiation we also defined consensus as ≥80% agreement among members of the consensus panel to include or exclude a statement. Statements excluded by consensus were eliminated from subsequent survey rounds. Statements included by consensus were advanced to the final framework. Included statements were shown to the consensus panel in subsequent rounds to provide context but were not voted on as they had already met criteria for inclusion. All statements that did not achieve consensus after three rounds were excluded from the final framework.

RESULTS

Response to community call for comment

Public call for comment was disseminated via email listservs to members of POCUS professional societies, resulting in 118 individual responses. Sixty respondents (51%) provided comments on the survey resulting in 14 survey modifications. A pediatric study–specific item was added and included three subitems. Six subitems were added to other items, and three wording changes were made to improve clarity.

Consensus panel recruitment

Invitations to the consensus panel were sent out to 23 experts. Twenty experts (87%) accepted the invitation and all 20 (100%) completed all three Delphi rounds. Consensus panel characteristics are summarized in Table 1. The panel was composed of 50% men and 50% women (other gender identification options were offered but not selected by participants). Out of 20 experts, 18 (90%) practice at an academic institution. However, 50% of participants did practice at a community site at least some of the time. All 20 participants were members of their department's ultrasound section or division, with 85% holding ultrasound-based leadership titles.

TABLE 1 Consensus panel characteristics.

Participant characteristics	*N* (%) or mean (±SD), range
Years since residency graduation	13.4 (±7.3), 3–32
0–5	2 (10)
6–10	6 (40)
>10	12 (60)
Gender	
Women	10 (50)
Men	10 (50)
Practice environment	
Academic site only	9 (45)
Community site only	1 (5)
Both academic and community sites	9 (45)
Adult patients only	5 (25)
Pediatric patients only	3 (15)
Both adult and pediatric patients	11 (55)
Hold an ultrasound based leadership title	17 (85)
Systemwide ultrasound director	2 (10)
Ultrasound section or division director	10 (50)
Ultrasound fellowship director	8 (40)
Ultrasound research director	8 (40)
Other ultrasound-based leadership title	4 (20)
Country of practice	
United States	15 (75)
Canada	3 (15)
Italy	1 (5)
Australia	1 (5)
Specialty (board certification)	
Emergency medicine (board certified or board eligible)	15 (75)
Pediatric emergency medicine and general pediatrics	4 (20)
Internal medicine	3 (15)
Critical care	1 (5)
Engagement in ultrasound research	
No. of ultrasound original publications	23.3 (±13.2), 3–48
No. of ultrasound first or senior author original publications	12.9 (±8), 3–29
Serve as a journal peer reviewer	17 (85)
Serve as a journal editor	6 (30)

Delphi

The results of the three serial rounds are presented in Figure 1. After the first round, 18/21 (85.7%) items and 53/119 (44.5%) subitems reached agreement for inclusion. The steering committee reviewed all proposed revisions and determined whether revisions may be accepted as is or required repeat voting. Only one of the included items required significant revision, leading to the need for repeat voting in the second round. After the second round, two items were included, and two items had persistent disagreement. The consensus panel consistently noted that many subitems may be relevant to some, but not all study types, which resulted in persistent disagreement for 72% (44/61) of the remaining subitems. Therefore, seven items were modified to stipulate that they ought to be included only "when relevant to the study objectives." After the third round, one additional item was excluded. The remaining item and 35 subitems had persistent disagreement and were excluded from the final framework.

The final endorsed list included 19 items and 62 subitems (Table 2). A checklist version of SPUR is presented in Table S1. Statements that were not included are listed in Table S2. With respect to technical settings, the panel recommended reporting a description of hardware and software packages used as well as the type of Doppler used when applicable. The panel did not reach consensus on inclusion of specific examination settings (e.g., gain, depth, or physical settings such as mechanical index) or image processing procedures. The panel agreed to exclude statements pertaining to transducer cleaning (one item and four subitems). The panel agreed to include a thorough description of the POCUS examination performed, including the rationale and previous evidence relevant to the examination as well as the physical characteristics of the examination setup such as patient location and positioning during the examination.

With respect to participant-specific variables, the consensus panel agreed to include demographic characteristics that could

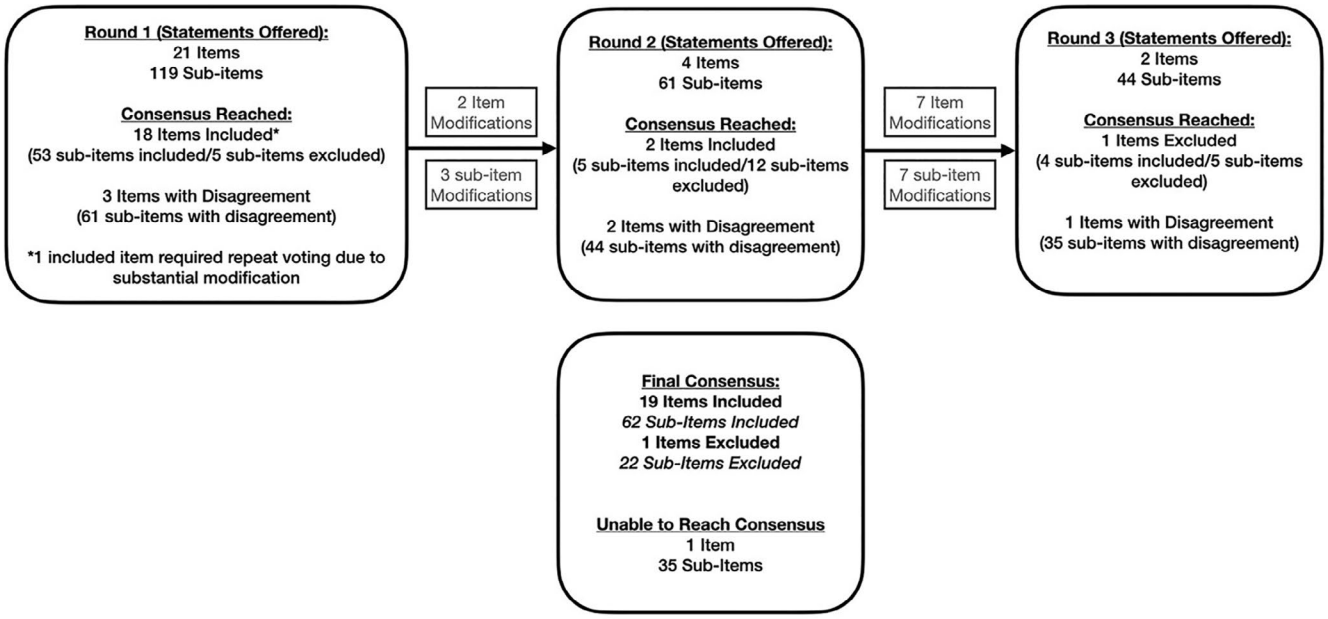

FIGURE 1 Flow diagram of Delphi process by round.

affect POCUS findings such as age, sex, gender, and body mass index. The panel agreed that a detailed description of the operator(s) performing the ultrasound examination (such as medical training, ultrasound training, and study protocol–specific training) should be included. The panel determined that the operator(s) role with respect to patient care and extent of blinding to other clinical data must be described.

The panel agreed that a detailed description of methods relating to assessment of image quality and image interpretation should be reported. This included reporting of the qualifications and number of reviewers, scale(s) used to rate images, and inter-rater reliability. The panel agreed that the methodology for resolving disagreements in interpretation should be reported. However, when provided with various methods for resolving disagreements, the panel did not endorse any single method as a preferred, "best practice" method (Table S2). Rather, they felt that several methods could be appropriate depending on study design and study team resources.

The panel also assessed study-specific considerations. The panel agreed that authors should continue to consult preexisting study-specific reporting guidelines. With respect to pediatric POCUS studies, the panel agreed that a description of age range–specific anatomy and physiology as well as engagement of parental consent and participant assent should be reported. With respect to POCUS studies relevant to procedural guidance, the panel agreed that inclusion of subitems pertaining to the use of dynamic and static guidance as well as the importance of specifying a comparator group and outcome measures assessed should be reported.

Because POCUS is a noninvasive and low-cost modality relative to other medical imaging tests, it has particular utility in limited resources settings (LRS), where strict adherence to all elements of a reporting guideline may not be feasible. The panel agreed that studies in LRS warranted specific consideration and that such studies hold value even if complete reporting is not possible due to limitation of resources. The panel also agreed that a description of the LRS environment and imaging capabilities should be included in such POCUS studies.

DISCUSSION

Standardized research reporting is important to ensure a clear understanding of the methodology used in a study and allows for reproducibility, generalizability, and validity of results.[15] While guidelines exist to increase the quality and transparency of health research reporting,[6,16,17] there are currently no guidelines that address the nuances specific to POCUS research. In this study we set out to develop a POCUS-specific best practice reporting guideline using a modified Delphi process. After three rounds of survey, POCUS research experts agreed on 19 items and 62 subitems for the final SPUR. These items included details regarding POCUS hardware and settings, imaging protocol specifics, participant characteristics, operator characteristics, and image quality assessment.

Importantly, SPUR is intended to be used in conjunction with (not in lieu of) preexisting published reporting guidelines such as those included in the EQUATOR network.[10] Past studies have described only moderate adherence of POCUS research studies to reporting guidelines, with an average of only 66% of items in the STARD guideline being addressed.[18] The barriers to the use of STARD and other major guidelines are incompletely understood and may be due to a combination of awareness, feasibility of adherence to guidelines, insufficient research training, language barrier, and incomplete characterization of POCUS-specific characteristics.[19] Low adherence to guidelines may also be due to the

TABLE 2 Items included that met consensus: Final list of items (with endorsement round [R] and percentage) that must be described in sufficient detail to allow replication of relevant studies.

Section	Items and subitems	Round No. (%)
1. Technical variables and machine settings	The ultrasound hardware used in the study	R1 (100%)
	Machine manufacturer(s)	R1 (95%)
	Machine model	R1 (90%)
	Transducer type	R1 (100%)
	Transducer frequency range	R1 (90%)
	The examination settings used in the study	R1 (90%)
	Factory preset(s) used	R3 (80%)
	Software package(s) (e.g., AI, image guidance, and/or measurement packages)	R2 (85%)
	Use of Doppler mode(s)	R1 (100%)
	Type of Doppler (power, color, spectral [e.g. PWD/CWD], tissue)	R1 (95%)
2. Ultrasound exam	The acquired ultrasound examination protocol	R1 (100%)
	Describe the rationale for selecting a particular examination protocol	R1 (80%)
	Specify if the examination protocol has been described previously (e.g., novel protocol, protocol described in case reports, endorsed by professional society)	R1 (90%)
	Specify all the view(s) acquired	R1 (90%)
	Specify the minimum view(s) required for inclusion in analysis	R1 (95%)
	If some views were acquired, but not required for analysis, specify reasons for not including those views in the analysis	R1 (80%)
	The setting and setup of the ultrasound examination	R1 (85%)
	The location of the examination (e.g., ED, ward, private room)	R2 (80%)
	The position of the patient (e.g., prone, sitting, supine)	R1 (80%)
3. Participant/ subject	Variables that are specific to the subject(s) baseline or demographic characteristics *and* may affect ultrasound findings	R1 (100%)
	Age	R1 (90%)
	Sex	R1 (90%)
	Gender	R3 (85%)
	BMI	R1 (95%)
	Variables that are specific to the subject(s) illness severity *and* may affect ultrasound findings	R2 (80%)
4. Operator	Variables related to the operators' medical training	R1 (95%)
	Level of medical training (e.g., PA/NP, research associate, medical student, resident with PGY level, fellow, attending, etc.)	R1 (95%)
	Level of training in ultrasound specifically (e.g., ultrasound fellowship, course completion, RDMS, ABEM FPD or other training of the sonologist)	R1 (95%)
	Variables related to the operators' prior experience with ultrasound	R1 (90%)
	The number of *study-specific* ultrasound examinations ever performed by the operator (may be reported as a range, e.g., 25–50, 50–100, >100 exams)	R2 (85%)
	Variables related to the operator's training on the study ultrasound protocol/examination	R1 (95%)
	Specify whether study-specific training occurred	R1 (95%)
	Describe the training protocol structure (e.g., didactics, asynchronous learning, hands-on, image review, washout period)	R1 (95%)
	Specify the total length of time spent on training for the study protocol	R1 (80%)
	Specify whether a certain proportion of hands-on examinations performed in training had to be normal or abnormal	R3 (80%)
	Define a standard to assess proficiency in the study ultrasound protocol/examination needed to enroll subjects in the study (e.g., number of scans, inter-rater reliability between operator and expert, proportion of interpretable examinations)	R1 (80%)
	Specify the background of the trainer who provided training of the operators	R1 (80%)

TABLE 2 (Continued)

Section	Items and subitems	Round No. (%)
	Variables related to the operators' knowledge and/or blinding of the subjects' clinical presentation	R1 (95%)
	Specify if the operator is blinded to the subjects' clinical history	R1 (90%)
	Specify if the operator is blinded to the subjects' clinical test results (e.g., labs and imaging)	R1 (90%)
	Specify the timing when the operator performed the ultrasound with respect to the overall clinical care timeline (e.g., after history but before CT or other confirmatory testing)	R1 (90%)
	Variables related to the operators' interaction with the clinical team taking care of the subject	R1 (85%)
	Specify whether the ultrasound operator is a member of the clinical team taking care of the subject	R1 (80%)
	Specify whether the ultrasound operator is communicating all ultrasound results to the clinical team taking care of the subject	R2 (85%)
	If the clinical team is generally blinded to ultrasound results, specify whether the ultrasound operator is communicating some critical or incidental ultrasound results to the clinical team (e.g., unexpected finding of tamponade in a study of patients with heart failure)	R3 (90%)
	Describe how the ultrasound operator and ultrasound examination may be impacting clinical management	R1 (80%)
5. Data analysis and interpretation	Assessment of image quality must be described in sufficient detail to allow replication	R1 (100%)
	Specify the qualifications of the image quality reviewer(s)	R1 (95%)
	Specify whether the image quality reviewer(s) are involved in other portions of the study	R1 (80%)
	Specify the scale by which image quality is assessed	R1 (90%)
	Variables related to the interpretation of ultrasound results used in the study analysis	R1 (100%)
	Specify the qualifications of the reviewers who are interpreting the POCUS results	R1 (100%)
	Specify whether the operator provides interpretation of the POCUS results	R1 (90%)
	Specify the number of reviewers interpreting the POCUS results	R1 (90%)
	Specify how disagreements between reviewer interpretations are resolved	R1 (100%)
	Provide a measure of inter-rater reliability between the people interpreting the POCUS results	R1 (95%)
	If more than one aspect of the POCUS is being interpreted, a range of inter-rater reliability measures should be reported (e.g., a cardiac ultrasound study should report separate kappa values for interpretation of LV function, RV size, and RV function)	R1 (85%)
	When more than one reviewer provides an interpretation, describe which interpretation is used for the final analysis	R1 (95%)
	Specify whether the reviewer(s) providing interpretation are blinded to the subjects' clinical data	R1 (100%)
	When more than one reviewer provides POCUS interpretation, the methods for interpreting POCUS results and resolving disagreements must be described and adhere to a minimum standard	R2 (90%)
6. Study-specific design considerations	Authors should continue to utilize any preexisting reporting guidelines relevant to the study type (e.g., EQUATOR Network guidelines).	R1 (100%)
	Randomized controlled trials: CONSORT guideline	R1 (95%)
	Observational studies: STROBE	R1 (90%)
	Systematic reviews: PRISMA	R1 (95%)
	Diagnostic studies: STARD	R1 (90%)
	Prognostic studies: TRIPOD	R1 (90%)
	Case Reports: CARE (when feasible based on journal guidelines)	R1 (85%)
	Studies evaluating the use of ultrasound in pediatric patients must describe ultrasound specific methods in sufficient detail to allow replication	R1 (95%)
	Specify the position of the child during the ultrasound examination	R1 (90%)
	Specify the effect of age range–specific anatomy and physiology on the scan protocol	R1 (80%)
	Specify whether parental consent and/or patient assent was obtained	R1 (90%)
	Studies evaluating the use of ultrasound for procedural guidance must describe ultrasound specific methods in sufficient detail to allow replication	R1 (90%)

(Continues)

TABLE 2 (Continued)

Section	Items and subitems	Round No. (%)
	Whenever possible, a comparator group should be included in studies evaluating the use of ultrasound for procedural guidance	R1 (80%)
	Specify whether ultrasound was used in a dynamic (simultaneous imaging and procedure performance) or static (separate steps for imaging and procedure performance) manner	R1 (80%)
	Clearly specify and justify the outcome measure in a manner that allows replication	R1 (85%)
	If a simulator or phantom was used, describe this in sufficient detail to allow replication	R1 (80%)
	Studies evaluating the use of POCUS in LRS warrant specific reporting considerations	R1 (90%)
	POCUS studies in LRS hold value even if complete reporting is not possible due to limitation of resources	R1 (90%)
	When possible, POCUS studies in LRS should describe the relevant environment in sufficient detail	R1 (90%)
	When possible, POCUS studies in LRS should describe the availability of relevant comprehensive/radiology performed ultrasound imaging	R1 (80%)
	When possible, POCUS studies in LRS should describe the availability of relevant non–ultrasound imaging services	R1 (80%)

Abbreviations: AI, artificial intelligence; BMI, body mass index; CWD, continuous wave doppler; EUFAC, Emergency Ultrasound Fellowship Accreditation Council; FPD, focused practice designation; LRS, limited-resource settings; LV, left ventricle; NP, nurse practitioner; PA, physician assistant; PGY, postgraduate year; POCUS, point-of-care ultrasound; PWD, pulsed wave doppler; RDMS, registered diagnostic medical sonographer; RV, right ventricle.

inherent differences between POCUS and non-POCUS diagnostic modalities. SPUR aims to ameliorate these prior limitations in reporting guidelines by delineating POCUS-specific characteristics to standardize reporting of published research. These guidelines provide a critical appraisal tool for ultrasound clinicians, researchers, reviewers, and editors to improve the rigor of POCUS research being performed and reported.

Throughout the course of the Delphi process, the consensus panel consistently encountered the need to balance attention to detail with feasibility and applicability to POCUS studies generally, rather than a small subset of study designs. This creates the possibility that some items included in the framework may not be relevant to all study types, while others were not included but are highly relevant to a small subset of studies. Due to the heterogeneous nature of POCUS applications, it is difficult to maintain generalizability to all study types and simultaneously include all relevant reporting elements. Therefore, investigators and reviewers should consider SPUR as a framework guiding POCUS study design and reporting, rather than as a prescriptive checklist.

POCUS research has undergone dramatic expansion over the years and is now one of the top three most rapidly growing fields in emergency medicine research.[20] The need for a portable, non-invasive diagnostic tool during the COVID pandemic and recent advances in artificial intelligence drove an explosion in POCUS research activity in the past five years.[5,21] However, most studies continue to be small and observational with heterogeneous methodologic quality.[21] A reporting framework for POCUS research is an essential starting point to standardize key elements specific to POCUS. Future research should address whether utilization of the framework improves the quality, generalizability, and heterogeneity of published studies. As the field of POCUS research matures to include larger, randomized studies focused on clinical outcomes, it might also be essential to reexamine and potentially improve on SPUR.

LIMITATIONS

Several limitations must be considered when applying SPUR to POCUS research study reporting. First, the steering committee and consensus panel were composed predominantly of North American emergency physicians. We sought to mitigate this limitation by including international experts and members who have POCUS research experience in a global health context and in other specialties. However, other factors may still play a significant role in the design and evaluation of POCUS research conducted in different clinical studies or by specialists in other fields. Second, we acknowledge that our definition of POCUS research expert is subjective and that a minimum of three first or senior author original research publications may not constitute expertise for some readers. While expertise can be difficult to define, our definition encompasses a broad range of investigators with experience in performing POCUS research. Such a range is necessary to ensure stakeholder representation and to help make the framework relevant to both early and later career investigators.

CONCLUSION

This study utilizing a modified Delphi methodology addresses the significant heterogeneity in the design and reporting of point-of-care ultrasound research studies. The resulting Standards for Point-of-Care Ultrasound Research Reporting (SPUR) framework can help researchers, editors, reviewers, and clinicians in the design, reporting, reproduction, and critical appraisal of point-of-care ultrasound research.

CONFLICT OF INTEREST STATEMENT

Nikolai Schnittke: Research support to institution from Philips; received equipment (portable ultrasound transducer) from Exo Imaging. Frances M. Russell: Received equipment from Butterfly Network. Jason Nomura:

Research support to institution from Bayer; consulting for Philips and Caption AI; lecture honoraria from American College of Emergency Medicine; Board of Governors member (unpaid) for American Institute of Ultrasound in Medicine. Cristiana Baloescu: Research support to institution from Philips and Caption Health; Educational presentation for Philips. Patricia Henwood: Patient-Centered Outcomes Research Institute Capacity Building Award. Daniel J. Kim: Consulting for clinician advisory board of Fujifilm Sonosite. Lori Ann Stolz: Consulting for Philips, Butterfly, ThinkSono, and Caption Health. Irene W. Y. Ma: Research support to division from research chair position (The John A. Buchanan Chair in General Internal Medicine, University of Calgary) and Health Science & Medical Education Research and Innovation Grant, University of Calgary; lecture honoraria from American College of Physicians, University of Alberta, International Pediatric Nephrology Association, and Cornell Weill Medicine; Vice President of the American Institute of Ultrasound in Medicine (unpaid); Governor of Prairies Provinces Chapter; American College of Physicians (unpaid). Benjamin K. Nti: Consulting for GE HealthCare. Niccolò Parri: Grant support from Angelini Pharma; lecture honorarium from Mindray.

DATA AVAILABILITY STATEMENT

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

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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APPENDIX A

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