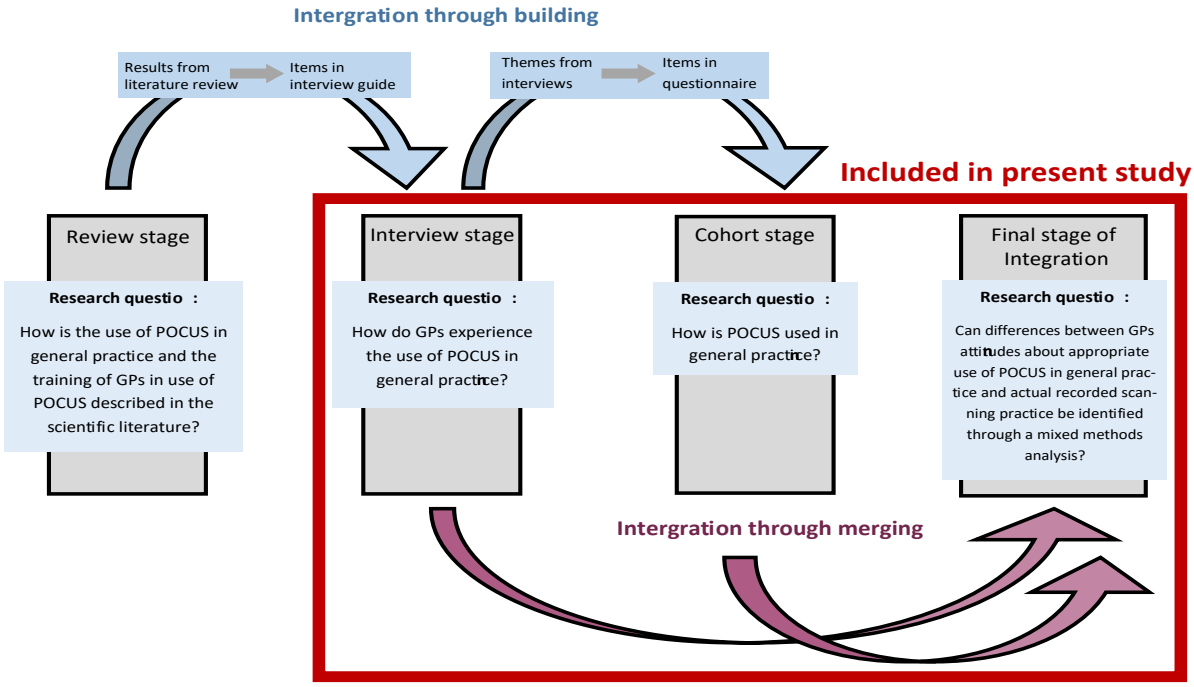
Supplemental materials for

Andersen C, Guetterman TC, Fetters MD, et al. General practitioners' perspectives on appropriate use of ultrasonography in prima ry care: a multistage mixed methods Study. *Ann Fam Med*. 2022;20(3):211-219.

Appendix 1: Overview of the entire study and stages leading to the current



POCUS= point-of-care ultrasonography, GPs= general practitioners

Review stage
We conducted a systematic literature review of published clinical studies describing the use of ultrasound in general practice or the training of GPs in the use of ultrasound. The details and results of this study have been previously reported (1).

Integration through building
The Literature review provided insight into the different ways of using ultrasound reported in different countries, and the identified key constructs in the review were used to develop an interview guide.

Interview stage
We used the interview guide in 24 semi-structured interviews with GPs to get an in-depth understanding of GPs' perspectives on the use of ultrasound in general practice. We included both ultrasound-users and non-users to include both perspectives. The analysis of the interviews revealed the following themes: two ways of using ultrasound, appropriate use of ultrasound in general practice, motivating factors and barriers, concerns related to ultrasound use, and the need for central regulations. The ultrasound-users descriptions of *two ways of using ultrasound in general practice* have been reported in another paper (2).

Integration through building
The interview study provided an insight into the use of ultrasound in Danish general practice and information appropriate for building a questionnaire for measuring the actual use and GP competencies. We used the key themes from the interviews to build measures for the instruments for a cohort study through discussions in the research group. Adjustments of the wording of items followed two rounds of pilot testing with five ultrasound-users.

Cohort stage
In a cohort study, 20 GPs using an online format recorded their actual use of ultrasound during patient encounters in general practice over a one-month period. The results from this study describing the overall use of ultrasound in general practice and impact of ultrasound on the diagnostic process and treatment of patients have been previously reported (3).

Final integration stage
In the final integration phase of this multistage mixed methods study(4), we used merged the findings using joint display analysis (5) to compare and contrast the results from the interview and the cohort study.

This figure is adapted from (6) and published with permission.

Supplemental Appendix 2

Elaboration of the interview study according to the Standards for Reporting Qualitative Research (SRQR) guidelines:

This Appendix has been developed based on the methods described in a previous publication (Appendix 2 reference 1) and a PhD thesis from Aalborg University (Appendix 2 reference 2).

Qualitative approach and research paradigm

In the interviews, we used an approached inspired by descriptive phenomenology (Appendix 2 reference 3) in order to explore the GPs lived experiences. Using phenomenology, we were able to gain access to the participating GPs' lifeworld in terms of their perceived reality and describe how the phenomenon "ultrasound in general practice" was experienced and described by them in their reality (Appendix 2 reference 4). Phenomenology is a philosophical movement with several different methodological approaches from pure descriptive to more interpretive approaches. Across these approaches, phenomenological qualitative research aims to provide rich contextualized descriptions of lived experiences of a phenomenon and to see things as they appear. In our study, the principal investigator (CAA) was very close to the research field. To minimize the interpretation and the influence of CAA and to capture the essence of the phenomenon, as it was presented by the GPs, CAA preferred a method that was more descriptive than interpretive.

Researcher characteristics and reflexivity

CAA is a medical doctor with experience in using ultrasonography in general practice. Prior to the study, she wrote down her experiences and reflections about her preunderstanding of ultrasound use in general practice in order to create awareness about her preunderstanding. This enabled CAA to "bracket" her preunderstanding during the interviews and be intentionally open and naïve to the participants' lifeworld. The document containing CAA's preunderstanding was also used in the analytic process to insure that CAA was not merely reproducing her own preunderstanding.

CAA had no personal or professional relationship with the interviewees. However, the participants knew that CAA was researching ultrasound use in general practice, which may had influenced their preunderstanding of CAA. CAA was aware of this during the interviews and she made efforts to eliminate esoteric terms and any "insider" talk about ultrasound use in addition to critical elaborating questions.

Setting:

This study was conducted in office-based general practices in Denmark. Danish GPs are self-employed and work in small offices in solo practices or partnership practices. Patients are listed with a GP for primary health care and GPs act as gatekeepers for examinations and treatments by the specialists in secondary care. Denmark has a public tax-financed healthcare system where treatment is free of charge for patients. GPs are paid through a combination of remuneration and fee-for-service. At the time of this study, no fee was given for the performance of ultrasound in general practice and only a minority of GPs were performing such examinations. There were no credentialing demands and no regulations of the use of ultrasound in general practice as is the case with other procedures performed in Danish General practice. In terms of legal restrictions, GPs in Denmark are bound by the Hippocratic oath and the law of authorization which allows GPs to perform any procedure that they feel skilled to perform.

Participants and recruitment

Based on the concept of information power (Appendix 2 reference 5), we aimed for a sample size of 10-15 POCUS users and 10-15 non-users. We used a stepwise recruitment strategy based on the amount of information power in each interview. POCUS users were recruited from teaching sessions and through POCUS networks. Interested GPs were asked to provide their background characteristics (age, gender, experience as a GP, POCUS experience and training, type of practice and location) in a small online questionnaire and we then purposely selected eligible GPs aiming for maximum variation in the participants background characteristics.

Non-users were recruited based on their background characteristics through contacts in the research units, the Danish college for GPs, the quality units and the medical association for general practitioners in Denmark (Praktiserende Lægers Organisation PLO). The non-users were also purposively selected aiming for maximum variation in the background characteristics (age, gender, experience as a GP, POCUS experience and training, type of practice and location).

Data collection methods

Semi-structured interviews

Data collection instruments and technologies

An interview guide was developed based on findings from a preceding systematic review. The narrative descriptions in the review were converted into domains in a conceptual model. Items exploring each domain were further developed through discussion in the research group and through informal focus group discussion with GPs – both users and non-users of ultrasound in general practice.

The final interview guide included domains, sub-domains and items to guide the interview in a semi-structured way. The first questions were open-ended, inviting the interviewee to share their experiences, while the more closed questions and controversial questions were saved to the end of the interview. The semi- structured nature of the interview allowed for deviation from the order of questions in the interview guide and for an elaboration of themes introduced by the interviewees.

Participants

We interviewed 13 GPs who used POCUS and 11 non-users. Two GPs (non-users) were invited but declined to participate due to time constraints. One GP (POCUS user) was unable to participate at the scheduled time so instead a colleague from the same clinic participated. Recruitment of both POCUS users and non-users was done stepwise and stopped when no new information emerged in the interviews.

Data processing

All interviews were conducted, audio recorded and transcribed by the principal investigator (CAA). Participants were pseudo-anatomized using a key file and all study data were saved on a secure server at Aalborg University.

Transcripts were created using SoundScriber software (SOFTPEDIA) and Microsoft Word 2010 (Microsoft Office, Redmond, USA). Coding was done first by hand and second using in NVivo version 11 (QSR International Pty Ltd, Melbourne, Australia).

Data analysis

We used systematic text condensation, which is an inductive, cross-case systematic analysis originally inspired by phenomenology. The analysis included four steps: (1) developing total impression, (2) identifying and sorting meaning units, (3) condensation and (4) synthesizing (Appendix 2 reference 6).

1. Developing total impression

First, the interviews were read several times in order to get a general impression. In the first round of the analysis, CAA and a qualitative senior researcher (ASD) independently read through the transcripts and noted preliminary themes by hand in the margin. These themes were then compared and discussed, and an overview of the data was established. In the last round of analysis CAA conducted this step.

2. Identifying and sorting meaning units

At this step in the analysis, CAA thoroughly read the transcripts and identified meaning units as pieces of text including rich descriptions or information about one or more of the preliminary themes from the previous analytical step. As Systematic Text Condensation does not regard all text in the transcriptions as meaning units, some parts of the transcriptions were deselected at this point.

During the process of identifying meaning units, the preliminary themes were organized, re-organized and some re-defined into new themes. CAA documented all changes made during this coding process in a logfile and the transcripts were read and coded several times, to ensure that all meaning units within each theme were identified. Findings and the organization of themes were discussed by CAA and ASD. The transcriptions were coded using Nvivo software (Version 11, QSR international Pty Ltd, Melbourne, Australia) while the organization of themes was done by hand and using mind-maps.

3. Condensation

At this step in the analysis, all selected and decontextualized meaning units within each theme were condensed. Each theme was divided into subgroups and CAA then condensed the text within each subgroup. Through discussion, CAA and ASD renamed and re-organized themes and subgroups as new understanding emerged. Each condensate recounted and recapitulated the content of the subgroup by using the participating GPs' own words and expressions.

4. Synthesizing

CAA and ASD further developed an analytic text for each subgroup describing the content of the subgroup in the overall context. Quotes and headlines were chosen within each subgroup to illustrate the findings. Afterwards the transcripts were re-read by CAA searching for contradicting evidence and to ensure a correct interpretation.

After the first round of analysis including the first 4 interviews, the analytic process was repeated for the next 3-4 interviews. However, after step 3, the condensates were transferred into the analytical text from the first round. This process was repeated for the remaining interviews.

For the present study, we included the analytic results for the themes 'appropriate use of ultrasound in general practice' and 'the need for regulations'. Even though the transcripts had been coded previously, the transcriptions were re-read and examined in greater detail to identify more information, contradicting evidence, or missing meaning units relative to the selected themes. The analytical text was then rearranged and elaborated to include new findings and understandings

Techniques to enhance trustworthiness

Even though the transcripts had been coded previously, to ensure rigor, the transcriptions were re-read and examined in greater detail for more information, contradicting evidence or missing meaning units relative to these themes in the source data.

Synthesis and interpretation

The following themes emerged through the analytic process: *selected focused ultrasound examinations, explorative ultrasound examinations, motivation for using ultrasonography, ultrasonography as part of the consultation, selection of an ultrasound curriculum, consequences of the GP ultrasound examination, achieving ultrasound competencies, continuous self-studying, structure of the learning process, barriers, concerns, appropriate use of ultrasound in general practice, need for regulations, ultrasonography as a niche, ultrasonography as part of the future general practice and patients reactions to ultrasonography.*

For the present study, we included the analytic results for the themes *appropriate use of ultrasound in general practice* and *the need for regulations.*

Ethics

All participants provided oral and written content to participate in the study. According to Danish law no ethical approval was needed. The study was reported to the Danish Data Protection Agency (2016-41-4768) and the Committee for Multi Practice Studies in General Practice (MPU-20-2016).

Appendix 2 references

1. Andersen CA, Davidsen AS, Brodersen J, Graumann O, Jensen MB. Danish general practitioners have found their own way of using point-of-care ultrasonography in primary care: a qualitative study. BMC Fam Pract 2019;20(1):89.

2. Andersen CA. The use of point-of-care ultrasound in general practice. [dissertation]: Aalborg University Denmark, Aalborg University Press; 2020

3. Giorgi A, Phenomenology and psychological research. Pittsburgh: Duquesne University Press; 1985 4. Brinkmann, S., & Tanggaard, L. (2015). Qualitative methods (*Kvalitative metoder: En grundbog). 2nd edition* . Copenhagen. Hans Reitzel.

5. Malterud K, Siersma VD, Guassora AD. Sample Size in Qualitative Interview Studies: Guided by Information Power. Qual Health Res. 2015;26:1753–60.

6. Malterud K. Systematic text condensation: a strategy for qualitative analysis. Scand J Public Health. 2012 Dec;40(8):795-805.

Supplemental Appendix 3

Elaboration of the cohort stage according to the STROBE guidelines

This Appendix elaborates on the methods and results from the cohort stage. The appendix has been developed based on the methods described in a previous publication (Appendix 3 reference 1) and in a PhD thesis from Aalborg University (Appendix 3 reference 2).

Study design

A prospective observational study

Setting

This study took place in office-based general practices in Denmark. In Denmark all patients are listed with a GP for primary healthcare and patients' access to healthcare is through their GP. GPs provide primary healthcare treatment for patients and refer patients to secondary care treatment if needed. Hence, GPs act as gatekeepers for secondary care services including imaging.

Denmark has a public healthcare system where treatment is free for patients. GPs are self-employed and paid through a combinations of fee-for-service and remuneration. At the time of this study, no fee was available to GPs performing ultrasound in general practice.

For this study, we included GPs working in both solo practices and partnership practices.

Participants

The participating GPs were recruited through voluntary ultrasound networks e.g. Facebook groups and ultrasound teaching sessions. All interested GPs were asked to provide detain on their background characteristics and based on this information, we enrolled the first 20 GPs, who met the inclusion criteria and not the exclusion criteria.

To be included GPs had to be using ultrasound on a daily basis, have participated in formalized ultrasound training, have more than 6 months experience with ultrasound use, apply ultrasound on a minimum of two anatomical areas, work four days a week and have a minimum of 1400 patient listings. We excluded GPs with an ultrasound system more than 10 years old or who had a possible conflict of interest.

All patients who the GP found suited for an ultrasound examination during the study period, were offered participation in the study. Patients were excluded if they were unable to provide informed consent. Children were excluded if parents were unable to provide informed consent.

Variables

For a complete list of the variables used in the cohort study, see the original study protocol (Clinical trials registration number: NCT03375333). For this mixed method study, we included sub-analyses of the following variables:

Categorization of organs scanned used in the analysis of the quantitative results

Organs scanned (Answers categories in cohort questionnaire)	Anatomic areas of application	Applications included in a training curriculum (Formalized training programs)	Applications assessed using the OSAUS tool
Heart	Heart	Heart, CECLUS, DUDS basic	FATE
Lung	Lung	Lung, CECLUS	Lung
Liver	Abdomen	Abdomen advanced, DUDS basic	Not assessed
Pancreas	Abdomen	Abdomen advanced, DUDS basic	Not assessed
Gall bladder	Abdomen	Abdomen basic, CECLUS, DUDS basic	Abdomen
Ascites	Abdomen	Abdomen basic, CECLUS, DUDS basic	Abdomen
Kidney	Abdomen	Abdomen basic, CECLUS, DUDS basic	Abdomen
Bladder	Abdomen	Abdomen basic, CECLUS, DUDS basic	Abdomen
Aorta	Abdomen	Abdomen basic, CECLUS, DUDS basic	Abdomen
Uterus	Ob/Gyn	Ob/Gyn basic, CECLUS, DUDS basic	Ob/Gyn
Fetus	Ob/Gyn	Ob/Gyn basic, CECLUS, DUDS basic	Ob/Gyn
Fluid in the pouch of Douglas	Ob/Gyn	Ob/Gyn basic/ Abdomen basic, CECLUS, DUDS basic	Ob/Gyn
Ovaries	Ob/Gyn	Ob/Gyn advanced	Not assessed
Placenta	Ob/Gyn	Ob/Gyn advanced	Not assessed
Musculoskeletal joints	MSK	MSK, CECLUS, DUDS basic	MSK
Musculoskeletal joints for puncture/injection	MSK	MSK, CECLUS, DUDS basic	Not assessed
Muscle	MSK	MSK, CECLUS, DUDS basic	MSK
Tendon	MSK	MSK, CECLUS, DUDS basic	MSK
Bone	MSK	MSK, DUDS basic	Not assessed
Deep veins in the lower limbs	DVT	DVT, CECLUS	DVT
Subcutaneus process	Subc. Proc.	Other, CECLUS	Not assessed
Breast	Other	Other, DUDS basic	Not assessed
Thyroid	Other	Other, DUDS basic	Not assessed
Lymph nodes	Other	Other	Not assessed
Carotid artery	Other	other, DUDS basic	Not assessed
Veins for puncture	Other	other, CECLUS, DUDS basic	Not assessed
Other	Other	other, DUDS basic	Not assessed

This figure is adapted from Appendix 3 reference 2 and published with permission.
MSK= musculoskeletal, DVT= Deep vein Thrombosis, Ob/Gyn= Obstetrics or Gynecology, Subc. Proc.= subcutaneous processes
CECLUS= Basic POCUS course for general practitioners, DUDS= Basic ultrasound course for radiologists

The proportion of individual POCUS users' intended focused versus exploratory examinations

Prior to the use of POCUS, the participating GPs were asked if they intended to use POCUS to: 1) confirm or disconfirm a specific clinical condition (rule-in or rule-out), 2) explore the patient's symptoms (without having a concrete suspicion of a specific condition) or 3) both.

We aimed to report the proportion of focused versus explorative examinations for each participating GP. We divided the answers into the categories of focused examinations (Including examinations with the intention to confirm or disconfirm a specific clinical condition) and explorative examinations (including examinations performed with the intention to explore the patient's symptoms and examinations where the GPs intended to both confirm/disconfirm and explore)

The proportion of focused examinations aiming to confirm/disconfirm a specific clinical condition varied between GPs from 50% to 100%. There were four outliers. Two GPs only performed half of their examinations as focused examinations and two GPs solely performed focused examinations. Despite this difference, these four GPs had a similar broad application of POCUS and similar educational background,

with extensive POCUS education aimed at training POCUS examinations for answering clinical questions.

The number of individual POCUS users' different anatomical areas of application.

After the use of POCUS, the participating GPs were asked to register the organs they had scanned. The organs were listed in the online registration tool and GPs were able to provide free texts answers if organs were missing on the list. The results of this registration have been reported (Appendix 3 reference 1).

POCUS was used in a wide range of different clinical situations. The GPs registered 126 ICPC2 (International Classification of Primary Health Care) codes as their main diagnoses before conducting the POCUS examination. The GPs registered scanning 834 different organs in 570 POCUS examinations with 67% of POCUS examinations restricted to include only one organ. The most common applications were musculoskeletal and obstetric (please see Appendix 3 reference 1 for details).

For this mixed method study, organs were grouped in the following categories: heart, lung, abdomen (including liver, gall bladder, pancreas, aorta, kidney, bladder, ascites), musculoskeletal (including joints, muscle, tendon, bone, and joint puncture), subcutaneous processes, obstetric and gynecological (including uterus, ovaries, placenta, fetus, and the pouch of Douglas), deep venous thrombosis, and others (including thyroid, carotid artery, lymph nodes, breast, blood vein for venous access, and free text answers)

We aimed to report the number of different applied categories for each participating GP. The GPs applied POCUS for between two and more than eight different applications. Some POCUS applications were more common than others: gynecological/obstetric (20 GPs), musculoskeletal (18 GPs), abdominal (15 GPs), subcutaneous processes (13 GPs), lung (10 GPs), heart (8 GPs), deep vein thrombosis (8 GPs) and other applications (5 GPs).

The proportion of individual POCUS users' ultrasound scans performed in areas of applications, where the GP had received formalized training

Prior to the study the individual GPs were asked to describe which ultrasound training and education they had received. These narratives included a description of an ultrasound curricula or a reference to an ultrasound course including a certain ultrasound curriculum. Hence, we were able to extract information about which areas of application the GPs had received formalized training.

For each individual GP, we calculated the total number of examinations preformed in anatomic areas of application where the GP had received formalized training and the total number of examinations performed within anatomic areas where the GP had no previous training.

All GPs had participated in formalized training in the use of POCUS (Table 1). Ten GPs had participated in musculoskeletal ultrasound courses, three in abdominal courses, two in obstetric or gynecology courses and 15 GPs had participated in an extensive 12-month ultrasound course covering several anatomic areas of application. In addition, 16 GPs had received training in pelvic ultrasound during residency, three GPs had received ultrasound training while working in other specialties and one had participated in an extensive residency ultrasound training program including abdominal applications in another European country.

Most of the GPs had a training program that exceeded what they actually scanned, but only five GPs restricted themselves to perform all their POCUS examinations within areas of applications that had been part of their previous training curriculum. Despite having a larger curriculum, these five GPs stayed

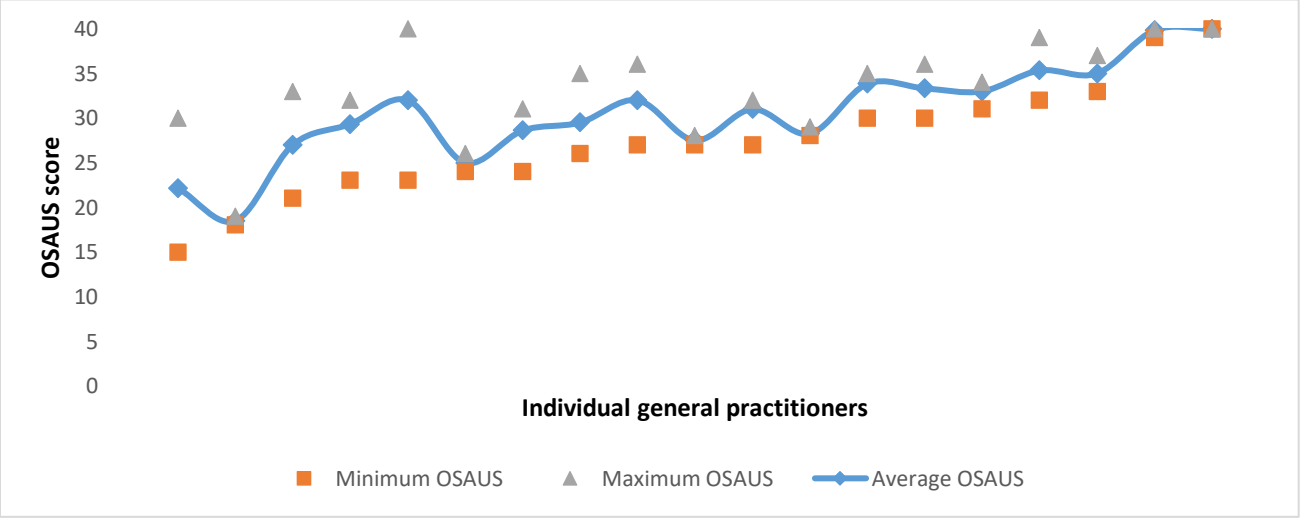
within 2-4 areas of application. The remaining GPs performed examinations outside their previous training curriculum - typically one to seven times during the registration period. However, two GPs performed 19 and 52 examinations outside their previous training curriculum. These two GPs did not differ from the remaining GPs in terms of previous experience with POCUS. However, one of these GPs did use POCUS more often than others.

The proportion of individual POCUS users' ultrasound scans performed in anatomic areas of applications, where the GP was skilled to perform the examination.

Prior to the study, the participating GPs had their POCUS competencies assessed in the following applications: heart, lung, abdomen, DVT, musculoskeletal, and obstetrics/gynecology. The GPs were, however, only assessed in the applications that they used during patient encounters in general practice. The GPs were asked to perform the POCUS examinations in a standard setting while a radiologist assessed their competencies using a modified version of the generic tool: The Objective Structured Assessment of Ultrasound Skills (OSAUS) (Appendix 3 reference 3). The adapted version of the tool rated the participants': (1) knowledge of the indication for the examination, (2) applied knowledge of ultrasound equipment, (3) performed image optimization), (4) systematic approach while performing the examination, (5) ability to Interpret images, (6) overall medical decision (7) interpretation of case 1 and (8) interpretation of case 2 on a scale from 1-5. Hence, each participant was rated on a scale from 0-40. An Objective Structured Clinical Examination (OSCE) assessment sheet was used to ensure that the OSAUS evaluation could be sufficiently assessed. This assessment has been described in greater detail in the previous article (Appendix 3 reference 1).

Nineteen GPs participated in this baseline assessment, where a total of 89 examinations were rated on the OSAUS scale. Overall scores ranged from 15 to 40 with a mean of 31.3 (95% CI 30.1-32.5), with individual variation and variation across applications. According to the OSCE assessment sheet, 16 GPs passed all applications while the remaining three GPs each failed one out of 2-6 applications.

Individual ultrasound skills among point-of-care ultrasound users in the cohort study



This figure is adapted from Appendix 3 reference 2 and published with permission.
OSAUS: objective structured assessment of ultrasounds skills assessed on a scale from 0-40.

The following provides elaboration on the baseline assessment of GPs' POCUS skills. The OSAUS item scores are provided across applications, illustrating that for some GPs, heart and abdominal applications seemed to cause problems, as well as, image optimization across applications.

Objective structured assessment of GPs POCUS skills across applications

OSAUS item scores of 19 GPs Median (range)		**Heart**	**Lung**	**Abdomen**	**Deep veins**	**Obstetrics/ gynecological**	**Musculo-skeletal**
		(N=11)	*(N=12)*	*(N=17)*	*(N=15)*	*(N=18)*	*(N=16)*
	Knowledge of the indication for the examination	4 (2-5)	4 (3-5)	4 (2-5)	4 (3-5)	4 (3-5)	4 (3-5)
	Applied knowledge of ultrasound equipment	3 (3-5)	4 (3-5)	4 (3-5)	4 (2-5)	4 (2-5)	4 (2-5)
	Image optimization	4 (1-5)	4 (2-5)	3 (3-5)	4 (3-5)	3.5 (1-5)	3.5 (2-5)
	Systematic approach while performing the examination	4 (1-5)	4 (2-5)	4 (1-5)	4 (2-5)	4 (3-5)	4 (2-5)
	Ability to Interpret images	4 (2-5)	4 (3-5)	4 (2-5)	4 (3-5)	4 (2-5)	4 (2-5)
	Medical decision making	4 (2-5)	4 (3-5)	4 (2-5)	4 (4-5)	4 (3-5)	4 (2-5)
	Interpretation of case 1	4 (1-5)	3.5 (2-5)	4 (3-5)	4 (4-5)	4 (2-5)	4.5 (2-5)
	Interpretation of case 2	4 (3-5)	4 (2-5)	4 (3-5)	4 (3-5)	5 (3-5)	4 (2-5)

This figure is adapted from Appendix 3 reference 2 and published with permission.
POCUS = Point-of-care ultrasonography, OSAUS= Objective Structured Assessment of Ultrasound Skills, GPs= general practitioners
Nineteen GPs had their ultrasound skills assessed at baseline of two and six POCUS applications depending on their personal curriculum. The assessment was made using an adapted version of the Objective Structured Assessment of Ultrasound Skills assessment tool which consisted of eight items scores on a five-point Likert scale

For this mixed method study, we used a cut-off OSAUS score of 24 as the score required to be skilled to perform POCUS. We choose a cut-off OSAUS of 24 as it corresponded to a score above average on each assessed dimension.

For each individual GP, we calculated the total number of examinations preformed in areas of application where the GP had an OSAUS score above 24, the total number of examinations performed within areas where the GP had an OSAUS score below 24, and the total number of examinations performed within areas where the GP's skills were not assessed at baseline.

The results in the baseline assessment of skills showed that only four GPs received an OSAUS score below 24: One GP in four out of six applications, one GP in two out of two application, one GP in one out of five applications, and one GP in one out of six applications. During the study, these four GPs performed between one and 57 POCUS examinations in areas where they had been found unskilled to perform the examinations. The remaining GPs performed examinations in which they were skilled. However, 17 of the GPs performed POCUS examinations that were not part of the baseline assessment.

Data measurement

We developed an online before-after POCUS registration tool based on the findings in the interview study. The registration tool was pilot tested in consecutive rounds involving first the research team and afterwards 5 GPs. Adaptions followed after each round according to the feed-back.

The final registration tool is available in the previous publication and in the clinical trials registration of the protocol. The registration tool was assessed through an online server (SurveyXact, Rambøll, Aarhus, Denmark) measuring the before and after POCUS registrations.

Study size

This study was an observational study aiming for a preliminary description of the use of POCUS in general practice. The proceeding studies (Appendix 3 reference 4 and 5) had shown that there was a large difference in the application of ultrasound in general practice and in the frequency of POCUS use. Hence, we were unable to calculate a specific sample size for this study. Based on the recruitment for the interview study (Appendix 3 reference 4), we estimated that around 75 GPs were using POCUS in Denmark at the time of this study. We expected that it would be possible to recruit 25% of these meeting our inclusion criteria. The interviews revealed that the participating Danish GPs were using POCUS 2-3 times a day. However, we expected that the online study registrations in this study would be challenged by the high workload in general practice and short consultations. Hence, the data collection for each participating GP was set to only one month to maintain the GPs' commitment to the registration of POCUS activity. We estimated that the GPs would include about 80% of the patients examined with POCUS corresponding to between 640 and 960 examinations during a full month. We estimated that this number of examinations would be sufficient to describe differences in the application of POCUS across GPs. As a results 20 GPs from 18 clinics were included and through the study period they included between 9 and 75 patients. Hence, data from 574 patients were available for analysis.

Statistical methods

Data were analyzed using STATA V.15.0 (StataCorp, College Station, Texas, USA) according to a predefined analysis plan published in ClinicalTrials.gov. (Clinical trials registration number: NCT03375333). As this was a first descriptive study, we opted to use only descriptive statistics. Data were collected as categorical variables on binominal, nominal or ordinal scales. These variables were reported using frequencies.

Ethics

All participating GPs and patients provided oral and written content to participate in the study. According to Danish law, no ethical approval was needed. Written confirmation of this was collected from the Regional Committee on Health Research Ethics. The study was approved by the Danish Data Protection Agency (2017-41-5273) and the Committee for Multi Practice Studies in General Practice (MPU-20-2016).

Appendix 3 references:

1. Andersen CA, Brodersen J, Davidsen AS, et al. Point-of-care ultrasonography in general practice affects patient care – a prospective observational study. BMJ Open 2020;10:e037664. doi: 10.1136/bmjopen-2020-037664

2. Andersen CA. The use of point-of-care ultrasound in general practice. [dissertation]: Aalborg University Denmark, Aalborg University Press; 2020

3. Tolsgaard MG1, Todsen T, Sorensen JL, et al. International multispecialty consensus on how to evaluate ultrasound competence: a Delphi consensus survey. PLoS One. 2013;8(2):e57687

4. Andersen CA, Holden S, Vela J, et al. Rathleff MS, Jensen MB. Point-of-care ultrasound in general practice: A systematic review. Ann Fam Med. 2019;17(1):61-69.

5. Andersen CA, Davidsen AS, Brodersen J, et al. Danish general practitioners have found their own way of using point-of-care ultrasonography in primary care: A qualitative study. BMC Family Practice. 2019;20(1):89.

Supplemental Appendix 4

Elaboration of the procedures used in the mixed methods study

This Appendix elaborates on the mixed methods integration in the study. The content of this Appendix has been developed based on the methods described in a previous PhD thesis from Aalborg University (Appendix 4 reference 1).

This mixed methods study was built from three preceding and separate data collection processes (Appendix 4 reference 2-4). The mixed methods study and the preceding studies were connected in a larger multistage mixed methods framework described below and illustrated in Appendix 1. We followed the recommendations described in Best Practices for Mixed Methods Research in Health Sciences (Appendix 4 reference 5) while following the methods for integration described by Creswell et al. (Appendix 4 reference 6) and Fetters et al. (Appendix 4 reference 7-8). Pragmatism was chosen as the explicit worldview for the study, to allow for flexible and practical design decisions and selection of methods at each stage of the study based on the specific research question (Appendix 4 reference 9 and 10).

Review stage (The first data collection)

We set out to create a foundation of knowledge for the development of the succeeding studies within the mixed methods framework. First, we conducted a systematic literature review following the Cochrane recommendations. We aimed to include published clinical studies describing the use of POCUS by GPs and GPs in training. We searched the following databases: MEDLINE via Pubmed, EMBASE via OVID, Cinahl via Ebsco, Web of Science and Cochrane Register of Controlled Trials on May 12th 2016 and again on August 21st 2017 using the same search string (a combination of the keywords ultrasound and general practice using different thesaurus terms). Two reviewers independently screened the identified articles according to the research question and the inclusion- and exclusion criteria. Independently, two reviewers extracted data and assessed the quality of the articles using the Downs and Black quality assessment tool. Results were summarized in absolute numbers and narrative synthesis. This stage has been reported previously (Appendix 4 reference 2).

Interview stage (The second stage of data collection)

To further explore how GPs experienced the use of POCUS in general practice, we conducted a qualitative interview study as reported in greater detail in Appendix 2.

Cohort stage (The third stage of data collection)

To further examine how GPs used POCUS in general practice, we conducted a cohort study in office-based general practice in Denmark including POCUS experienced GPs as reported in greater detail in Appendix 3.

Mixed methods integration at the design level

For integration at the design level, we used an advanced framework described by Fetters et al. (Appendix 4 reference 8) as a multistage mixed methods design, which includes multiple stages of data collection. In our study, data were collected using an exploratory sequential mixed methods design. This enabled us to use the acquired knowledge from one study to inform the subsequent data collection and thereby increase the acceptance, relevance, and understanding of the measurement instruments used. We conducted a final stage entailing a mixed methods integrative analysis as we brought together the datasets from the

interview study and the cohort study. This final mixed methods integrated analysis enabled us to gain new insights and knowledge beyond the results of each stage and thereby enhance our understanding of the use of POCUS in general practice.

Mixed methods integration at the method level

Linking the methods of data collection and analysis has been described to occur through building when a dataset from one stage informs the data collection approach in the next stage (Appendix 4 reference 6). Mixed methods integration through building was achieved at two points. First, we used findings from the systematic review to develop an interview guide for the interview stage. Second, we used analytical themes from the conducted interviews to develop an online registration tool to be used in the cohort stage. Through this, we were able to develop outcome measures for measuring dimensions of appropriate use of POCUS.

We also achieved mixed methods integration through merging. In merging, two datasets a brought together for analysis and comparison (Appendix 4 reference 6). For this mixed methods integration through merging, we compared and contrasted themes from the interview stage with data collected in the cohort stage and equal valuing was attributed to the two datasets. Joint display analysis was the process used to achieve merging (Appendix 4 reference 7).

Joint display analysis procedure

Joint display analysis is a procedure used to analyze and integrate the qualitative and quantitative datasets. We used joint display analysis to give equal weighting to the results from the interview study and the cohort study by comparing and contrasting the results. Published joint displays of the mixed methods findings (See Figure 1-4 in the paper) are representations using a visual means that include the interpretation (also called meta-inferences) derived from the joint display analysis process.

1. The qualitative and quantitative data were analyzed and prepared for the mixed methods merging of the data as described in Appendix 2 and 3.
2. We discussed the underlying meaning of the data and identified linkages between the qualitative themes and quantitative outcomes in relation to: 1) the purpose of the examination, 2) the area of application, 3) the GP's previous ultrasound training and 4) the GP's ultrasound skills. The aim of this discussion was to ensure that the linked qualitative and the quantitative data were addressing the same constructs.
3. We then discussed how data could be presented and organized in tables in relation to order, label and linkage, by drawing-up several preliminary models in a continuous reflective process.
4. The analytical results of qualitative and quantitative data were then prepared for presentation in tables and inserted into a joint display template.
5. Through discussion, the joint displays models were organized and reorganized, a process that involved developing different iterations of the joint display models as new understandings emerged. Different presentations of the qualitative and quantitative results were inserted in the tables and discussed in this process, e.g. the first versions of the joint displays included analytical paraphrases of the qualitative findings including descriptions from both POCUS users and non-users, while later versions were changed to include separate findings from POCUS-users and non-users, and to include individual quotes instead of paraphrases. The aim of this process was to ensure direct linkage between the two datasets and a visual presentation with respect to methodological considerations and nature of the different data.

6. After developing the final four joint displays sufficiently illustrating the order in the data collection, the origin of data, and the linkage between the two datasets, we compared the data collectively and drew meta-inferences, that is, interpretations across both types of data for each of the four domains of comparison. The results were described and inserted into the joint displays.

Mixed methods integration at the interpretation and reporting level

In multistage mixed methods frameworks, integration at the interpretation and reporting level, can occur in a staged approach, if the results of each stage are analyzed and published separately(Appendix 4 reference 8). We used this staged approach for reporting the systematic review(Appendix 4 reference 2), and some of the findings from the interview study (Appendix 4 reference 3) and the cohort study (Appendix 4 reference 4) with only brief mention in these articles of the mixed methods integration used to develop the interview guide and the online registration tool. The sheer volume of data, and the fidelity to systematic literature review procedures, the phenomenological approach, and the cohort study, justified separate publication. The merging of the different types of findings in joint displays provided insights beyond the previous study findings(Appendix 4 reference 11).

Appendix 4 references

1. Andersen CA. The use of point-of-care ultrasound in general practice. [dissertation]: Aalborg University Denmark, Aalborg University Press; 2020

2. Andersen CA, Holden S, Vela J, et al. Rathleff MS, Jensen MB. Point-of-care ultrasound in general practice: A systematic review. Ann Fam Med. 2019;17(1):61-69.

3. Andersen CA, Davidsen AS, Brodersen J, et al. Danish general practitioners have found their own way of using point-of-care ultrasonography in primary care: A qualitative study. BMC Family Practice. 2019;20(1):89.

4. Andersen CA, Brodersen J, Davidsen AS, et al. Point-of-care ultrasonography in general practice affects patient care – a prospective observational study. BMJ Open. 2020;10:e037664. doi: 10.1136/bmjopen-2020-037664

5. Creswell J, Klassen A, Clark VP, et al. Best Practices for Mixed Methods Research in Health Sciences: Office of Behavioral and Social Sciences Research (OBSSR); 2011: doi:10.1037/E566732013-001.

6. Creswell JW, Clark VLP. Designing and conducting mixed methods research. 3rd ed. Thousands Oaks, CA, USA: SAGE Publications; 2018.

7. Fetters MD. Mixed methods research workbook - activities for designing, implementing and publishing projects. Thousand Oaks, CA, USA: SAGE Publications; 2020.

8. Fetters MD, Curry LA, Creswell JW. Achieving integration in mixed methods designs-principles and practices. Health Serv Res. 2013;48:2134-2156.

9. Creswell JW. RESEARCH DESIGN qualitative, quantitative and mixed methods approaches. 3ed. Thousand Oaks, California: SAGE Publications; 2003

10. Morgan DL. Integrating qualitative and quantitative methods: A pragmatic approach. Thousand Oaks, California: SAGE Publications; 2014.

11. Guetterman TC, Fetters MD, Creswell JW. Integrating quantitative and qualitative results in health science mixed methods research through joint displays. Ann Fam Med. 2015;13(6):554-561.