General Practitioners' Perspectives on Appropriate Use of Ultrasonography in Primary Care in Denmark: A Multistage Mixed Methods Study

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ABSTRACT

PURPOSE Researchers aimed to describe general practitioners' understanding of appropriate ultrasound use, to record actual scanning practices of early adopters in general practice, and to identify differences between attitudes and actual practice via a mixed methods analysis.

METHODS This study was part of a larger multistage mixed methods research framework exploring the use of ultrasound in general practice in Denmark. We used an exploratory sequential approach in the data collection with initial qualitative findings from an interview study applied to building a quantitative questionnaire utilized in a cohort study. In addition, we merged the qualitative and quantitative data using joint display analysis to compare and contrast the results from the 2 stages of the study.

RESULTS In the interviews, general practitioners described appropriate ultrasound use as point-of-care examinations with a clear purpose and limited to predefined specific conditions within delimited anatomic areas. They stated that general practitioners should receive formalized ultrasound training and be skilled in the examinations they perform. In the cohort study, general practitioners performed ultrasound examinations of anatomic areas with or without a defined clinical suspicion. Some performed ultrasound examinations for which they had no previous training or skills.

CONCLUSIONS We found a difference between the ideas about the appropriate uses for ultrasound in general practice and the actual use by early adopters in clinical practice. Our findings suggest a need for evidence-based guidelines to support general practitioners in choosing which examinations to perform and strategies for developing and maintaining scanning competency.

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INTRODUCTION

Point-of-care ultrasonography (POCUS) is performed by a frontline clinician and integrated into the examination of the patient.[1] Despite lack of evidence-based guidelines, POCUS use is growing in general practice,[2] although in Denmark, where this study was conducted, POCUS is not widely used. This may be an example of Rogers' diffusion of an innovation,[3] where the technology has been adopted by innovators and early adopters within the general practice community. Potentially, POCUS may lead to faster and more precise diagnoses and referrals.[4,5] Introducing a diagnostic test entails potential unintended harms, however: misdiagnosis,[6,7] over or underdiagnosis,[8] and overtreatment.[9,10] Point-of-care ultrasonography is used for a variety of conditions in general practice,[2,4] but general practitioners (GPs) cannot achieve the same breadth and depth of experience as imaging specialists. Hence, defining the boundaries of POCUS in general practice seems necessary to guide appropriate practice.

Clinical guidelines should be developed from a thorough evaluation of the actual use of POCUS in general practice and based on best available evidence,[11] but also include GPs' perspectives on the type of examinations and competencies needed. This complex issue calls for mixed methods research, where integration of qualitative and quantitative approaches enables a more complete understanding by drawing on strengths of both methodologies[12] with new inferences generated from their integration.[13,14]

Conflicts of interest: authors report none.

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Table 1. Participating Physician Demographics

Characteristic	Interview Stage		Cohort Stage	Overall Population[a]
	Nonusers (n = 11)	US users (n = 13)	US Users (n = 20)	GPs in Denmark (n = 3,402)
Age, y				
<40	2	0	2	...
40-50	1	6	14	...
51-60	5	4	3	...
61-70	3	3	1	...
Mean age, y	52.4	52.2	46.2	52.2
Gender, No.				
Male	7	11	14	1,605
Female	4	2	6	1,797
Experience as a general practitioner,[b] y				
<10	3	4	...	...
10-20	3	6	...	...
>20	5	3	...	...
Experience using POCUS in general practice, y				
<2	...	7	6	...
2-5	...	4	11	...
>5	...	2	3	...
Type of POCUS training, No.				
No training	4	0	0	...
Residency	6	1	0	...
Course	0	5	4	...
Course and residency	1	7	16	...
Practice community character, No.				
Urban	5	8	12	...
Mixed	5	5	6	...
Rural	1	0	2	...
Practice region, No.				
North Denmark region	3	2	4	301
Central Denmark region	4	4	3	807
Region of Southern Denmark	1	2	7	782
Region Zealand	1	0	2	460
Capital region of Denmark	2	5	4	1,052
Practice size, No. of patients				
<2,000	2	4	3	...
2,000-5,000	5	4	10	...
>5,000	4	5	7	...
Type of practice,[c] No.				
Partnership	9	9	17	...
Solo	1	2	1	929
Collaboration	1	2	2	...

GP = general practitioner; POCUS = point-of-care ultrasonography; US = ultrasonography.

[a] Data available from the Danish Medical Association (PLO faktaark 2018).
[b] Becoming a GP in Demark requires a 6-year post-graduate specialization in family medicine. A few GPs may have been working or received training in other specialties before they entered family medicine training but there is no formal subspecialization of Danish GPs.
[c] Partnership practice is defined as a clinic owned and administrated by more than 1 GP. Solo practice is a clinic owned and administrated by just 1 GP. Collaboration practice is a clinic owned by 1 GP or several GPs, but administrated in collaboration with other GP clinics.

This study is part of a larger, multistage mixed methods framework[14] exploring the use of POCUS in general practice through several studies[2,15,16] (Supplemental Appendix 1). Using previously unreported data, this study aims to describe general practitioners' understanding of appropriate ultrasound use, record actual scanning practices of early adopters in general practice, and identify differences between attitudes and actual practice through a mixed methods analysis.

METHODS

Design

Prior to this study, data were collected using an exploratory sequential mixed methods approach[13] where initial qualitative findings from the interview stage[15] informed subsequent quantitative data collection in the cohort stage.[16] In this study, mixed methods integration was achieved through merging[13] as we gave equal emphasis to the qualitative themes from the interview stage and quantitative information from the cohort stage to compare and contrast the results[13] (Supplemental Appendix 1).

Setting and Participants

Denmark has a tax-financed health care system, where patients are listed with a GP.[17] The GPs provide primary health care in smaller clinics and act as gatekeepers for secondary health care. GPs have a post-graduate specialization in family medicine. They are self-employed and paid by the Danish regions through a combination of remuneration and fee-for-service. The use of gynecological/obstetric POCUS during hospital residency has been part of GP training for several years. General practitioners are not paid for performing POCUS in primary care, and relatively few GPs perform POCUS. Participants in the interview (n = 24) and cohort (n = 20) stages were recruited from the same population of GPs. Five GPs participated in both stages (Table 1).

Qualitative Interview Stage

From August 2016 through March 2017, we sampled and interviewed POCUS users and nonusers aiming for maximum

variation in the GPs' characteristics (Table 1).[15] Recruitment of both groups was done purposively, one at a time, based on the concept of information power,[18] and stopped when no new information emerged in the semistructured interviews. We used an interview guide, transcribed interviews verbatim, and analyzed text using Systematic Text Condensation.[19] The analysis included: developing an overall impression, identifying and sorting meaning units, condensing, and synthesizing. For the present study, we included the analytic themes "appropriate use of ultrasound in general practice" and "the need for regulations" (Supplemental Appendix 2).

Quantitative Cohort Stage

The prospective cohort study (Clinical trials registration number: NCT03375333) included 18 GP practices with 20 POCUS users and 574 patients.[16] The GPs were enrolled from January 2018 through July 2018. Each GP recruited patients examined with POCUS during 1 month. Data were collected during the consultation using an online registration before and after the use of POCUS. The GPs provided background information through a questionnaire at baseline. A POCUS skills assessment of each participant was completed 1 to 2 weeks before they enrolled patients, using an adapted version of the generic Objective Structured Assessment of Ultrasound Skills assessment tool.[20]

We conducted a subanalysis of individual POCUS users to examine the extent that they restricted their use of POCUS. Specifically, we looked at (1) the proportion of focused vs exploratory examinations and (2) the number of different anatomic areas evaluated. We further examined individual users' restrictions in terms of their own ultrasound competencies by calculating the proportion of ultrasound scans performed in anatomic areas in which (3) the GP had received formal training and (4) the GP had been assessed as skilled (Supplemental Appendix 3).

Mixed Methods Merging Stage

We used joint display analysis.[21] First, we identified links between qualitative themes and quantitative constructs in relation to the (1) purpose of the examination, (2) anatomic area evaluated, (3) GP's ultrasound training, and (4) GP's ultrasound skills. Second, we organized and reorganized data in tables, developing different iterations as new understandings emerged. After developing 4 joint displays illustrating the order in the data collection, origin of data, and links between the 2 data sets, we interpreted the data collectively and drew meta-inferences from the 4 points of comparison.

RESULTS

Interview Qualitative Findings

Use of POCUS was described as appropriate and recommended for use in the context of general practice, but as something distinct from the traditional ultrasound examinations performed in secondary care. The GPs explained that POCUS should match the working conditions and patient encounters in general practice. As such, GPs talked about 4 dimensions of appropriate use of POCUS: the purpose of examination, the type of examination, the GP's training, and the GP's skills. Inappropriate use was described, not as the contrary, but as experimental or too extensive use, in which GPs exceeded their own abilities.

Both POCUS nonusers and users described general practice as a diverse field of medicine with the hallmark of unregulated subspecialization for GPs with areas of special interest. These GPs described the professional norm to be self-regulation guided by their moral responsibilities and awareness of their own competencies that entails providing patient care up to a certain level before referring patients to specialists.

Overall, nonusers described a clear distinction in scope between appropriate and inappropriate use of POCUS in general practice. In contrast, POCUS users defined appropriate use in less definitive terms and, for some, described appropriate uses were not in line with their actual use.

Purpose of POCUS in General Practice

All participants stated that POCUS in general practice should be used for focused examinations with a clear clinical purpose aimed to address specific clinical questions in symptomatic patients (Figure 1). Some participants even proposed that POCUS in general practice should be limited to rule-in examinations leaving it to imaging specialists to conduct detailed examinations and to rule out disease.

Nonusers described exploratory examinations motivated by the GP's curiosity or fascination with the technology as highly inappropriate. In contrast, POCUS users found some exploratory examinations appropriate as long as the GP exercised caution in drawing conclusions.

Application of POCUS in General Practice

The participants agreed that only some POCUS examinations should be performed by GPs, but they did not agree on which examinations. Some nonusers called for a restricted set of examinations that only included relevant and common conditions within a few anatomic areas. The POCUS users, however, talked about an individual's application with a stepwise addition of POCUS (Figure 2) resulting in a POCUS portfolio based on individual GP's interests, patient population, clinical routines, and competencies. Several of them opposed regulations limiting the use of POCUS in general practice as they feared their freedom to select applications in areas of interest would be reduced.

GP Ultrasound Training

All participants stated that appropriate use of POCUS required GPs to have ultrasonography knowledge obtained through formal training. They explained that some POCUS examinations would be easy to learn and master, while others would require more education and practice. They firmly believed that GPs could obtain the necessary competency.

Figure 1. Mixed methods findings on the purpose of POCUS in general practice.

Qualitative Stage		Qualitative Stage	Mixed Methods Merging Stage	Interpretation
Qualitative Findings Interview Study (12 Nonusers)	Qualitative Findings Interview Study (13 POCUS users)	Quantitative Findings Cohort Study (20 POCUS Users)	Meta-inferences	Implications for Practice

Descriptions of focused examinations

"I would think the rather simple clinical problems and also some acute problems as urinary retention or ascites plus/minus would be good."(GP9)

"The more complicated ones, well that's not for general practice. That's for the specialists at the hospital, while the simple conditions—those we can easily manage in general practice—and we should do that." (GP1)

"[Ultrasound examination in general practice should be] focused scans with primarily yes/no questions within completely defined areas. GPs shouldn't delude themselves into thinking that they can do everything, but they can use it [ultrasonography] as a very good tool the same way as they use other point-of care tests such as CRP, hemoglobin measurement – where you determine beforehand, what you want to use it for." (GP8)

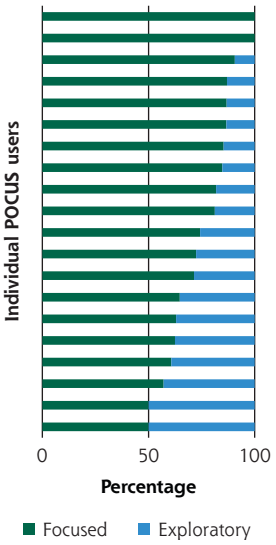
Descriptions of exploratory examinations

"We are not going to have sufficient training to perform full exploratory ultrasound examinations of the abdomen. That would be too much. It would require an extensive education. That is for the experienced doctors (.) When I think of ultrasound in general practice I'm thinking of the smaller things." (GP18)

"We should not be performing exploratory examinations like the ones we refer to at the hospitals – They will systematically look for everything – that's not for general practice."(GP12)

"I do sometimes extend my ultrasound examination, but as I have not received the specific training in doing so, I do it with a large amount of respect." (GP3)

Frequency of focused and exploratory ultrasonagraphy by individual GPs



In qualitative interviews, nonusers and POCUS users agreed that GP ultrasound examinations should be focused POCUS examinations aimed at answering clinical questions – confirming or disconfirming a clinical suspicion of disease.

In practice, the primary intent of POCUS users was to answer a specific clinical question, but GPs also performed exploratory POCUS without having a predefined condition to rule-in or rule-out.

Most GPs did not restrict their indication for performing POCUS to a single predefined clinical question. However, during exploratory examinations, they may answer several focused questions. Such examinations may be important on the frontline, where ruling in and out multiple conditions are necessary. Additionally, some explorative examinations may be performed to train ultrasound competencies.

Recommendations for GPs' POCUS use may benefit from listing POCUS applications that are relevant in a general practice setting and defined by a clear clinical purpose. Such recommendations may encourage GPs to restrict their POCUS use and exercise caution when moving beyond the recommendations.

GP = general practitioner; Nonuser = a GP who is not using POCUS; POCUS = point-of-care ultrasonography; POCUS user = a GP who uses POCUS.

Several nonusers, however, questioned whether competence could be maintained with the low frequency of POCUS use in general practice. Nonusers believed that GPs should restrict themselves to only perform POCUS examinations for which they had formal training. Users described individual learning strategies such as unstructured study and practice of scanning competencies as appropriate and an inevitable part of POCUS in general practice. While nonusers talked about restricting the application of POCUS in general practice to avoid required extensive or continuous training programs, users talked about continuous POCUS education including a constant addition of more applications (Figure 3).

GP Ultrasound Skills

All participants described how the appropriate scope of POCUS depended on GPs staying within the limits of their own abilities. The nonusers believed that GPs should only perform POCUS examinations for which they had sufficient skills and that GPs should be careful to not expand POCUS examinations into areas where they were not able to interpret the ultrasound images (Figure 4). The users agreed, but they also described cautious expansion of the application of POCUS to gain new skills.

Some users and nonusers described how appropriate use and GP skills could be secured through POCUS certification, but the majority of participants opposed this. Having to be certified to perform an examination in general practice was deemed nontraditional and they feared that agreeing to certification in one area of competence could lead to similar requirements in other areas.

Cohort Quantitative Findings

Focused vs Exploratory POCUS Examinations

The mean proportion of focused examinations was 75.4% (95% CI, 68.3-83.0) (Figure 1). Among the 18 GPs who reported performing exploratory examinations, the mean proportion was 24.5% (95% CI, 17.3-13.6). No demographic characteristics distinguished outliers or the GPs above and below average.

Types of POCUS Applications

POCUS use ranged from 2 to more than 8 different applications with gynecological/obstetric scans being most common (Figure 2). The GPs using POCUS for most applications were the GPs with the most extensive training, and the 2 GPs using only 2 applications had training from a previous hospital employment supplemented with 1 or 2 day-courses.

POCUS Applications and Formal Training

Five of the 20 GPs only performed POCUS within areas that they had previously received formal training (Figure 3). These 5 GPs were among the GPs with the fewest anatomic areas of application (2 to 4 areas). The other 15 GPs performed examinations outside anatomic areas where they had previously received training.

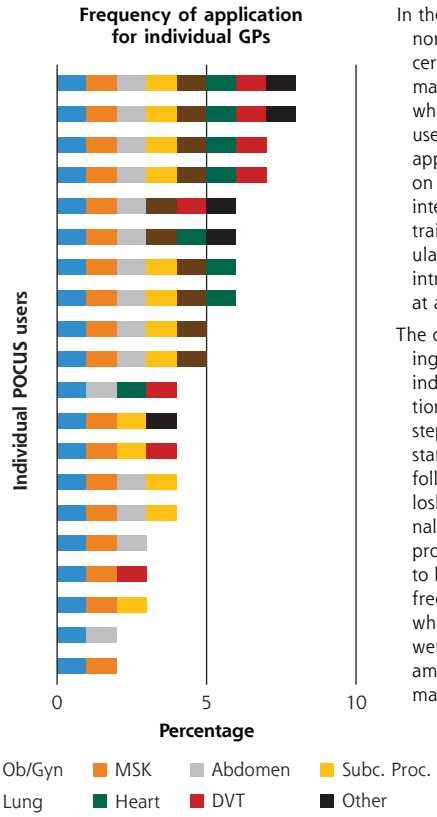
POCUS Applications and GP Skills

The users' ultrasound skills varied (Supplemental Appendix 4). Most participants, however, only performed ultrasound examination in anatomic areas where they were skilled (Figure 4). Four GPs performed POCUS examinations in anatomic areas where they had been assessed to be unskilled. No demographic characteristics distinguished these from the other GPs.

Findings From Mixed Methods Data Merging

In study interviews, nonusers and users all talked about normative use of POCUS. The nonusers exhibited a more rigid understanding of the boundaries of appropriate use, whereas the POCUS users had vaguer descriptions including accounts of deviating behavior. The cohort study confirmed such deviations. The mixed methods analysis revealed that although most POCUS users primarily scanned according to general perspectives on appropriate use, they also performed exploratory examinations and few restricted their use to limited anatomic areas of application. Most POCUS users performed examinations that were beyond their previous formal training and a few performed examinations in anatomic areas where they were unskilled (Figure 1-4).

Figure 2. Mixed methods findings for the anatomical areas of POCUS examinations in general practice.

Qualitative Stage		Qualitative Stage	Mixed Methods Merging Stage	Interpretation
Qualitative Findings Interview Study (12 Nonusers)	Qualitative Findings Interview Study (13 POCUS users)	Quantitative Findings Cohort Study (20 POCUS Users)	Meta-inferences	Implications for Practice
"Inappropriate use would be if you start scanning too much and use ultrasound for many areas and more comprehensive areas."(GP20) " I mean, there is no end as to what you can scan. We have to condense it and find out, which examinations are realistic for general practice – if we are to become ultrasound-supermen, well, then I think I've lost it." (GP21) "It would probably be a good idea to make sure that–well, if there was a group of things where we could use it and then we would be recommended to refer the rest on to specialists. That could be a way to make sure that we would have some routine in the things we examine, and that we were not using it [ultrasonography] to examine very rare conditions." (GP25)	"The application is going to depend on the individual doctor's skills and interests" (GP14) "Female doctors will have more gynecological patients while male GPs will use it [ultrasonography] for other applications" (GP4) "Well, you begin anywhere on the recommended list, and when your skills improve, you can include the next area. I didn't start off scanning the whole body, you know?" (GP5) "You build up [your competencies] as you go along and it could be in different directions depending on the individual GPs interests and possibilities" (GP12)		In the interviews, nonusers were concerned about too many applications, while the POCUS users thought the applications depend on the individual GP's interests, ultrasound training, patient population, and would be introduced one step at a time. The quantitative findings confirmed the individual application and revealed a stepwise approach starting with Ob/Gyn, followed by musculoskeletal or abdominal. Subcutaneous processes seemed to be the next most frequent application while heart and lung were most common among those GPs with many applications.	As generalists, GPs attend to a variety of clinical conditions, which supports the need for different applications of POCUS. However, some scans may be harder to master than others and some clinical conditions may be rare in a general practice setting. Restraint, eg, through a stepwise approach for GPs to implement POCUS in general practice, might address this. Although some of the users performed POCUS in >8 different areas, users focused on just a few simple clinical questions within each area. Hence, recommendations listing basic, advanced, and inappropriate POCUS use within each anatomical area of application may guide GPs in choosing examinations to use.

DVT = deep vein thrombosis; GP = general practitioner; MSK = musculoskeletal; Nonuser = a GP who is not using POCUS; Ob/Gyn = obstetrics and/or gynecology; POCUS = point-of-care ultrasonography; POCUS user = a GP who uses POCUS; Subc Proc= subcutaneous processes.

DISCUSSION

This study revealed important differences between GPs' attitudes and their actual use of POCUS.

The sequential design of this study made it possible to explore and quantify the qualitative findings from the interviews. Comparison was limited, however, to the outcomes measured in the cohort study. Hence, other factors characterizing the extent of POCUS in general practice, for example, the scanning protocols used, were not explored.

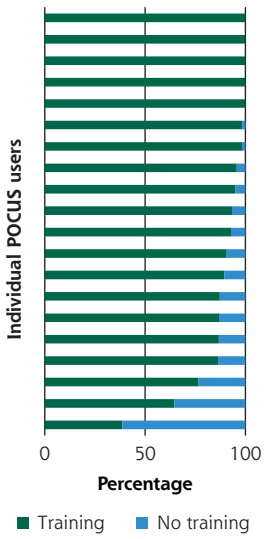
Generalizability of our results is limited by the low number of participants and self-reported outcomes. In addition, the studies were conducted in Denmark where POCUS is not widely used, and the users are most likely a select group of innovative GPs. The organization and regulation of Danish general practice, including the lack of fee for performing POCUS, differs from other countries.[17] This potentially limits external validity. The aim of this study, however, was to gain a deeper understanding on how POCUS is used in general practice when there are no guidelines or recommendations. Our findings included fundamental professional considerations for general practice rather than national organizational aspects of primary care. Furthermore, the GPs were not driven by financial incentives, but used POCUS because they found it relevant to their general practice. Hence, our findings are likely to be transferable and could, therefore, guide relevant POCUS use in other primary care situations and countries.

In the interviews, all GPs talked about appropriate use of POCUS as restricted use. Previous studies have pointed out the importance of regulation for other procedures used in general practice.[22,23] The lack of evidence-based clinical guidelines and regulations on POCUS in general practice may foster the opportunistic, individualized, and less restricted applications found in the cohort study. It remains unknown if this leads to negative effects on patient outcomes.

The POCUS users' deviation from fundamental professional considerations for appropriate use may be understood

Figure 3. Mixed methods findings for GPs POCUS training and competencies.

Qualitative Stage		Qualitative Stage	Mixed Methods Merging Stage	Interpretation
Qualitative Findings Interview Study (12 Nonusers)	**Qualitative Findings Interview Study (13 POCUS users)**	**Quantitative Findings Cohort Study (20 POCUS Users)**	**Meta-inferences**	**Implications for Practice**
Descriptions of GPs performing scans in areas with previous training		**Frequency of scan within the individual GPs previous training[a]**	In the qualitative findings, nonusers and users agreed that sufficient training is prerequisite to perform POCUS. Nonusers talked about requiring skills through formalized training, whereas users also talked about the appropriateness of self-study and practice to maintain or acquire new ultrasound skills. The quantitative results confirmed that most POCUS users performed scans where they had formal training. Even though many of the POCUS users completed a training curriculum that exceeded their actual practice, the majority also moved beyond their previous training in use of POCUS.	Some GPs may be highly motivated for using ultrasound and for achieving new ultrasound applications. These GPs may move beyond the limits of their previous training and search for knowledge outside formal training programs, eg, online or in networks of providers of ultrasound. Clearly defined curricula for training programs may create awareness about the skills achieved which may result in appropriate restraints. Future recommendations and guidelines must account for the learning curve to develop and maintain competence by suggesting continuous educational programs for GPs, mentorship, supervision groups, module-based courses, and recommendations from evidence-based educational sources.
"Of course It would be appropriate if I had some proper training in using it so that the quality would be okay"(GP23)	"Appropriate use will depend on the one performing ultrasound examination. Because they have to know the limits of their own abilities and they have to acquire knowledge and training within the areas that they wish to scan" (GP5)			
"Well, it is only fair that it is a requirement that you have had an education or been on a course, before you start using it" (GP18)				
Descriptions of GPs performing scans in areas with no previous training				
" [inappropriate use of ultrasonography would be] situations where people over-interpret their findings and go beyond their actual abilities." (GP9)	" It is appropriate that you are trained in the things you do - to be sure, that you can do it. Then you can try experimenting too, but if you do, you have to be aware that you are moving beyond." (GP3)			
	"I believe, you have to have some sort of maintenance or development [of your ultrasound competencies]. Otherwise, your skills and abilities will simply decline." (GP2)			



GP = general practitioner; Nonuser = a GP who is not using POCUS; POCUS = point-of-care ultrasonography; POCUS user = a GP who uses POCUS.

[a] All GPs had all participated in formalized training in the use of POCUS. Ten GPs had participated in musculoskeletal POCUS courses, 3 in abdominal courses, and 2 in gynecological/obstetric courses. Fifteen GPs had participated in an extensive 12-month POCUS course targeting general practice. Nine of these GPs had also taken additional courses. Finally, 5 GPs had previous experience with using more advanced ultrasonography in a hospital setting; 2 in cardiology and 3 in gynecology.

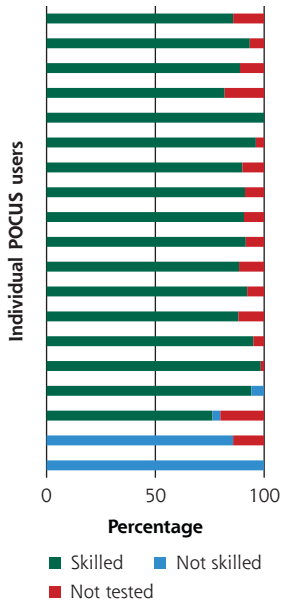
with Rogers' theory of diffusion of innovations.[3] According to Rogers, early adopters, like the GPs in this study, are innovators, who venture into new areas, adapt new technology, and have a willingness to take risks. Later adopters of technology tend to wait for recommendations and be less adventurous.

A few attempts have been made to guide GP use of POCUS,[5,24,25] but evidence from in-hospital settings does not account for the different epidemiology of illnesses in general practice (especially the low pre-test probability of disease), or national differences in primary care organization and working conditions. Applications for rare conditions such as ocular ultrasound for detached retina[24] or chest ultrsasound for pneumothorax,[25] and applications that require extensive training, such as, cardiac ultrasound,[4,5] have been recommended for GPs. This and previous studies,[2,16] however, suggest that such applications may not be very useful in general practice. Other medical specialties[26,27] have listed suitable POCUS applications and defined the purpose for POCUS with a clinical question. Some guidelines have defined a scanning protocol that includes the extent of the examinations.[28,29] Such guidelines may reduce the individual applications of POCUS revealed in this study and create awareness of basic, advanced, and discouraged applications of POCUS.

Our findings confirm that achieving and maintaining POCUS competence requires continuous use and practice. A recent review[30] described skills assessments after short training programs for GPs, but how busy GPs will be able to maintain and develop their skills over time is an area ripe for scientific investigation. Reports have emphasized visual knowledge in relation to skills development[31,32] and international recommendations for continuous training under supervision.[6,33,34] In countries like Denmark, however, opportunities for supervision are sparse, frequency of POCUS use is low,[2,16] and no skills assessment or accreditation is required.[5] This study showed that some GPs do not have the recommended skills despite having participated in POCUS training.

There is a need for studies to explore skill acquisition strategies for GPs, identify which competences are needed, and determine how GPs can develop competence and maintain skills over time.

Figure 4. Mixed methods findings about GPs POCUS skills.

Qualitative Stage		Qualitative Stage	Mixed Methods Merging Stage	Interpretation
Qualitative Findings Interview Study (12 Nonusers)	**Qualitative Findings Interview Study (13 POCUS users)**	**Quantitative Findings Cohort Study (20 POCUS Users)**	**Meta-inferences**	**Implications for Practice**
Descriptions of GPs performing POCUS scans in which they are skilled		**Frequency of scans within areas where the individual GPs were skilled[a]**	In the qualitative findings, both nonusers and POCUS users describe the need for restrictions to be sure GPs POCUS are within areas of the GP's skill, as individual judgement is not sufficient.	Ultrasonography is a highly operator-dependent examination. To gain and maintain POCUS competencies, GPs should have formal training and perform the ultrasound examination regularly.
"I think it is important that when you scan, you have tried it before, so you know the structures and know how it is supposed to look like [on the POCUS images]." (GP20)	"You could start with 5 things and when you are certain that you can perform those 5 things, you can move on to 10 things. In that way you can be certain that you can perform the things you do." (GP 12)		Several participants were against certification of GPs and many GPs talked about the need for continuous POCUS training to ensure quality.	An evaluation of GPs POCUS competencies, in following a training program may be needed to secure sufficient training, overall quality, and to help the GPs' self-insight.
Descriptions of GPs performing POCUS scans in which they are not skilled			The quantitative results show that most GPs are skilled in the examinations they perform. However, 2 GPs were not sufficiently skilled in any of the examinations they performed. These 2 GPs were found in our sample but this finding cannot be interpreted as 10% of GPs in Denmark are using POCUS to conduct examinations in which they lack the skills to perform.	As this study has shown, continuous training programs and quality assurance may be needed to ensure GPs competencies over time.
"The big risk with ultrasonography is that we don't stop where we should stop." (GP1)	"It is a powerful tool you're holding in your hand and you should respect that. You should not be scanning all sorts of things, you should stick to the things you're skilled in and the things where you need to practice – then you have to tell the patients that's what you're doing. (GP8)			
"If this [POCUS] is to be implemented in general practice, there will have to be clear guidelines and restrictions because we [GPs] are just as different as all other people; some will be very good at sensing the limits of their abilities, while others do not and they feel confident that their POCUS scan would always be good enough." (GP22)				

GP = general practitioner; nonuser = a GP who is not using POCUS; POCUS = point-of-care ultrasonography; POCUS user = a GP who uses POCUS.

[a] Skills were assessed using an adapted version of the generic Objective Structured Assessment of Ultrasound Skills assessment tool (Supplemental Appendix 2).

Developments in ultrasound technology provide new diagnostic opportunities for primary care physicians and this study may carry implications beyond POCUS. Despite scant evidence, the POCUS use in general practice is increasing.[36] Given the discrepancy between the GPs' perspectives on appropriate use and their actual practice, efforts to guide GPs venturing into POCUS use are needed. Patients seem to appreciate the use of POCUS,[37,38] but questions remain regarding the reliability and diagnostic accuracy of a GP POCUS scan[30] and the challenges of evaluating and monitoring technology based in the community.[39,40] Until data is available for developing evidence-based guidelines[11] about appropriate and inappropriate POCUS use in general practice, interim experience-based recommendations based on basic ethical clinical principles, eg, primum non nocere (first, do no harm), may guide and encourage prudence among GPs (Figures 1-4).

Including the 4 dimensions of appropriate use of POCUS described in this study in future guideline development[11] and research strategies may help determine the normative boundaries between appropriate and inappropriate use of POCUS in general practice. Hence, future research should focus on exploring diagnostic precision of different GP-performed POCUS examinations and patient prognosis following POCUS use in general practice.

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Key words: family practice, general practice, primary health care, point-of-care systems, ultrasonography

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Supplemental materials

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