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# Physicians' clinical experience and perspectives following a pilot, blended learning, point of care ultrasound course in Ghana- a mixed methods analysis

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## Abstract

**Background** Point of Care ultrasound (POCUS) is rapidly gaining popularity in resource constrained settings. Optimising training is important to ensure safe and effective implementation. To expand POCUS expertise in Ghana, we co-developed and piloted a context specific, multi-disciplinary, blended learning programme, targeted at physicians of any grade or speciality providing acute care in the public health sector. In this retrospective mixed method study, we capture the "real world" experience of participants, using POCUS in their daily practice, as well as the barriers and enablers they perceived to implementation.

**Results** Eight emergency and internal medicine specialists and residents participated, working across three teaching hospitals, treating both general and specialist patients. They implemented each POCUS application taught, with cardiac indications, inferior vena cava (IVC) assessment, deep venous thrombosis (DVT) diagnosis, lung/pleural assessment and peripheral vascular access being most frequent at 3–6 times/week. An estimated 40% of patients could not have afforded any other diagnostic tests. They considered the pilot curriculum adequate for general practice and the majority of applications of low difficulty (71%). For cases sent for second opinion, they are self-reported that their findings were confirmed in 60–78% of cases. Perceptions about the relative advantage of POCUS over the usual approaches to diagnosing patients enabled implementation. Generally, they believed that POCUS improved their clinical decision making and that more certified training courses need to be run at lower cost to make them more accessible. All participants valued ongoing connections after training to ask for help and consolidate their skills. Continued evaluation and reflection on their POCUS practice to improve quality was unanimously reported as important, yet none had a formal system for this. The strongest barrier was access to equipment and maintenance. A lack of training opportunities and local mentors, and negative beliefs from other departments and hospital administration were further barriers.

**Conclusion** Our new blended learning curriculum met the needs of physicians caring for patients with general and specialist presentations, with strong reported positive experience of improved bedside diagnostic capabilities, especially for the large proportion of patients unable to afford or access alternative diagnostic tests. Their experience


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drives the need for further training and for solutions to current barriers of equipment availability, training costs and lack of quality assurance mechanisms.

**Keywords** Ultrasound, Implementation, Point of Care Ultrasound, Ghana, Low- and Middle-Income Countries, Curriculum

## Background

An estimated two thirds of the world's population still lack access to X-ray and ultrasound services even though they can resolve up to 70–80% of diagnostic problems [1]. Point of care ultrasound (POCUS) is increasingly recognised as a valuable extension to clinical diagnosis and intervention across low- and middle-income countries (LMIC) and is one of the 10 recommendations of the Lancet Commission on Diagnostics to widen access to diagnostics [2, 3]. It is particularly well suited to these settings because of easy access, relatively low cost, and portability. It can be operated single-handedly with very little consumable cost [4]. This has made it a promising tool for future investment and implementation is expanding rapidly. However, more evidence around impact on patient and health system outcomes, cost-effectiveness, training, and quality assurance is still needed to guide appropriate scale-up.

POCUS is increasingly popular with physicians in LMIC settings for all the above reasons [5, 6]. However, access to high quality and context relevant training remains a challenge. In Ghana, POCUS training in Emergency Medicine (EM)consists of ad hoc, week-long visits and/or virtual training courses by international EM faculty, focusing on the Extended Focussed Assessment with Sonography for Trauma (EFAST) application. There is no structured training targeted at medical students, other residency program candidates or general physicians working in regions where imaging services are constrained [7].

To address this deficit, a multidisciplinary team of physicians, radiologists and sonographers from Ghana and the UK co-designed and piloted a 7-month intensive POCUS curriculum for physicians from various speciality backgrounds (Appendix). This programme was delivered partly online through an e-learning platform and partly in person in two 7-day blocks of hands-on teaching. Scan logbooks with expert review supported the participants in between the hands-on training blocks. Summative clinical assessments and case presentations were used for certification purposes, in line with criteria developed by the Consortium for the Accreditation of Sonography Education (CASE) in the UK. The curriculum was co-created between Ghana and UK team members, based on the most common acute presentations and indications expected in general and emergency practice in Ghana, including basic cardiovascular, respiratory, renal, hepatic, urological and obstetric indications. As we were interested in capturing the "real world" experience of participants applying their new POCUS skills in their clinical practice, we designed this study to: a) evaluate the relevance of the selected learning outcomes in clinical practice to inform development of the training curriculum, b) identify barriers and enablers the participants encountered during implementation of POCUS and c) inform future studies on the clinical impact of POCUS implementation in Ghana and other similar LMICs.

## Methods

### Study design

We conducted a retrospective study using a mixed method approach involving both qualitative (interviews) and quantitative (survey) processes of collecting data. We documented the clinical background and healthcare setting of the participants, compared the type and number of scans performed in daily practice with the course curriculum, captured the reported ease of the various applications, evaluated referrals for further imaging where information was available, and explored the physicians' experience of training and implementation of POCUS.

### Study site and population

The study was conducted remotely from the UK with participants in Ghana based at three public teaching hospitals (Ho, Cape Coast and Korle-Bu). We included all eight pilot course participants who completed the course and were using POCUS in their clinical practice from July 2021 to May 2022. No participants were excluded.

### Data collection

All data was collected between 30th May 2022 and 26th June 2022. All participants gave their written informed consent.

#### *Quantitative data*

Was collected data on demographics, clinical background and healthcare setting of participants, as well as their use of each POCUS application via an online Google Forms questionnaire (Appendix), with additional clarification given at interview.

#### *Qualitative data*

Collection was done through semi-structured interviews, conducted over Microsoft Teams. The audio-recorded interviews were conducted by a final year medical student (AP), trained in qualitative interview techniques. Qualitative data collection drew on the Consolidated Framework for Implementation Research (CFIR) [8]. We selected seventeen of the constructs which were most relevant to the POCUS intervention and distributed them across the five CFIR domains (Appendix). We drew on elements of the framework to design the semi-structured interview guide (Appendix).

### Data management and analysis

All documents and data are held securely on Worldwide Radiology's Google Drive, with password protected access to study authors only. All personal data was anonymised by providing each participant with a study ID. No information on individual institutions or patients was collected. Data on participant's clinical background and healthcare setting was categorised in tables. Quantitative data was reported as frequencies or proportions. Qualitative interview data was analysed using NVivo software package [9]. Data was analysed deductively, following broad descriptive themes, using a codebook developed from the CFIR codebook. We also inductively coded data using sub-themes generated from the data. We used an iterative approach to identify emerging themes that were explored further through later data collection.

Ethical approval was granted by the Ho Teaching Hospital Research Ethics Committee, Ghana, with Protocol ID number HTH-REC (17) FC_2022.

## Results

### Demographics, clinical background and healthcare setting of participants

Two female and six male physicians took part, ranging in age from 25 to 45 years. Half were consultants and half registrars from specialties including emergency, internal, critical care and gastro-enterological medicine. All had been purposely selected for the pilot course as potential future trainers. Each participant treats many general practice patients alongside specialist cases, and all had prior experience of working in peripheral clinics with limited access to imaging services. All carried out a teaching role for medical students and junior doctors. Six participants had some previous informal POCUS training.

### POCUS applications used in daily practice, compared to the course curriculum

All applications included in the course objectives were used in daily practice (Table 1). Cardiac and IVC assessment was used 5–6/week by the majority of participants, followed by DVT at 5/week, peripheral vascular access and soft tissue cellulitis 4/week, and lung and pleural applications 3–4/week. Half of participants used POCUS 3–4/week to assess kidneys and bladder. Other applications were used less frequently. As multiple applications may have been used in the same patient, this data does not represent the number of patients scanned. Patient populations in whom participants performed POCUS were reported as 55% emergency vs. 45% elective presentations, 85% adult vs. 15% paediatric, 86% inpatient vs. 14% outpatient and 74% public vs. 26% private hospitals.

### Reported ease of scan applications and self-reported confirmation of findings after radiology second opinion

Table 1 also summarises the reported subjective difficulty of the various scan applications, as well as the estimated percentage of patients participants referred for radiology second opinion and the estimated percentage of their POCUS findings that were confirmed by second opinion. Reasons to refer varied between participants, including requesting an expert second opinion or a formal confirmation of emergency POCUS scans as departmental policy. The participants estimated that 40% of patients they scanned would have been unable to afford the cost of any further diagnostic tests, including radiology, echocardiography or laboratory tests. Most applications were reported to be of low difficulty (1–3 on a scale of 1–10). Assessment of liver, kidney and adnexal lesions was rated as more difficult, as were features of bladder schistosomiasis (3.2- 5 on a scale of 1–10). For the 24/34 (71%) of applications that were rated of low difficulty, findings were confirmed in 60–78% of cases. Lower referral and confirmation rates were reported for IVC/fluid balance assessment (2.86% and 23.33% respectively) and suspected interstitial alveolar syndrome (52.5% and 33.3% respectively), consistent with the dynamic nature of these particular applications. Similarly, a low percentage of scans guiding interventions (aspirations and soft tissue foreign body removal) was referred, because successful interventions would not require referral. On average, aortic aneurysm assessments were rated of low difficulty, with 40% referral rate for further investigation. Only two participants used POCUS for a suspected ectopic pregnancy and viability and only one for other obstetric indications.

**Table 1** Estimated use of scan applications, subjective difficulty, and estimated percentage of POCUS findings confirmed after second opinion

| Pocus applications | Number of participants using this application | Average number of times per week they use the application | Subjective difficulty on scale 1 (very easy) to 10 (very difficult) | Estimated Percentage of patients referred for second opinion (%) | Estimated Percentage of POCUS findings confirmed by formal imaging (%) |
|---|---|---|---|---|---|
| Cardiac/Fluid balance | | | | | |
| **Pericardial effusion** | 8 | 4 (1–8) | (1–3) | 21 (0–70) | 58 (0–80) |
| **Cardiac function (gross LV function)** | 7 | 6 (4–10) | (1–4) | 50 (0-100) | 70 (0-100) |
| **IVC and fluid balance assessment** | 7 | 5 (1–10) | (1–4) | 3 (0–70) | 23 (0–20) |
| **Lung** | | | | | |
| **Pleural effusion** | 8 | 5 (1–8) | (1–2) | 18 (0–50) | 76 (0-100) |
| **Pleural aspiration and paracentesis** | 7 | 4 (1–8) | (1–2) | 3 (0–10) | 34 (0–90) |
| **Pneumothorax** | 6 | 3 (1–8) | (1–5) | 41 (10–100) | 78 (60–100) |
| **Pulmonary consolidation** | 6 | 4 (1–8) | (1–4) | 55 (10–100) | 70 (50–90) |
| **Covid Pneumonia** | 5 | 3 (1–7) | (1–4) | 62 (20–100) | 70 (50–100) |
| **Interstitial alveolar syndrome** | 3 | 4 (1–9) | (1–4) | 53 (0–80) | 33 (0–80) |
| **Urogenital** | | | | | |
| **Kidney size** | 7 | 4 (1–10) | (1–4) | 50 (0-100) | 69 (0–90) |
| **Hydronephrosis** | 6 | 3 (1–10) | (1–3) | 62 (0-100) | 72 (0-100) |
| **Urinary retention** | 5 | 3 (1–9) | (1–3) | 38 (0-100) | 73 (0-100) |
| **Kidney mass/calculi** | 4 | 3 (1–9) | (1–7) | 40 (0-100) | 50 (0-100) |
| **Bladder mass** | 4 | 3 (1–7) | (1–3) | 48 (0-100) | 60 (0-100) |
| **Bladder stones** | 4[a] | 5 (1–8) | (1–2) | 0 | 0 |
| **Bladder schistosomiasis** | 3[a] | 2 (1–4) | (3–4) | 44 (0–80) | 25 (0–50) |
| **Prostate enlargement** | 3 | 3 (1–8) | (1–4) | 50 (0–80) | 25 (0–50) |
| **Abdomen** | | | | | |
| **Aortic aneurysm** | 3 | 4 (1–8) | (1–5) | 40 (0–80) | 40 (0–80) |
| **Liver mass/abscess** | 5 | 3 (1–7) | (1–5) | 72 (0-100) | 78 (50–100) |
| **Liver schistosomiasis** | 2[a] | 2 (1–3) | (1–5) | 50 (50) | 60 (60) |
| **Gallbladder stones/cholecystitis**[b] | | | | | |
| **Free fluid**[b] | | | | | |
| **Vascular and soft tissues** | | | | | |
| **Deep Vein Thrombosis** | 7 | 8 (3–10) | (1–5) | 25.71 (0–70) | 73 (0-100) |
| **Soft tissue abscess** | 6[a] | 2 (1–8) | (1–5) | 55 (0-100) | 52 (0-100) |
| **Peripheral vascular access** | 6 | 4 (1–7) | (1–4) | 0 | 0 |
| **Cellulitis** | 5 | 4 (1–10) | (1–4) | 30 (0–80) | 64 (0-100) |
| **Abscess and lymph node aspiration** | 3[a] | 1 (1–2) | (1–5) | 36.67 (0–80) | 75 (60–90) |
| **Foreign bodies in soft tissue** | 2[a] | 4 (1–7) | (2–3) | 5 (0–10) | 40 (0–80) |
| **Gynecology and obstetrics** | | | | | |
| **Viability of intrauterine pregnancy** | 3[a] | 4 (1–6) | (1–4) | 40 (0–80) | 0 |

**Table 1** (continued)

| Pocus applications | Number of participants using this application | Average number of times per week they use the application | Subjective difficulty on scale 1 (very easy) to 10 (very difficult) | Estimated Percentage of patients referred for second opinion (%) | Estimated Percentage of POCUS findings confirmed by formal imaging (%) |
|---|---|---|---|---|---|
| Placental position | 3[a] | 5 | 2 | 0 | 0 |
| Suspected ectopic pregnancy | 2 | 4 (1–6) | (2–3) | 25 (0–50) | 60 (60) |
| Uterine/adnexal mass | 2 | 4 (2–5) | (4–5) | 80 (80) | 50 (40–60) |
| Retained products/ missed abortion | 1[a] | | | | |
| Expected date of delivery | 1 | 1 | 5 | 0 | 0 |
| Multiple pregnancy | 1[a] | | | | |
| Foetal presentation | 1 | 6 | 1 | 0 | 0 |

[a] Participant did not complete all questions although they reported to use this application

[b] Data not available, due to omission on Google Survey

## Physician's experience of training and implementation of point of care ultrasound

We present our Qualitative results in five broad themes drawing on the CFIR domains that affect implementation of healthcare interventions (Table 2): (1) characteristics of the intervention; (2) outer setting; (3) inner setting; (4) individual characteristics; (5) process. For each of these, we describe the respective constructs, relevant for the POCUS intervention, their valence and strength, and how they affected the implementation. We have introduced a construct (hardware and software maintenance) within the characteristics of the intervention domain, which we found pertinent to POCUS intervention. There was a total of 17 constructs, out of which 14 positively influenced implementation while 3 negatively influenced implementation (Appendix and Table 2 ).

### Strong positive factors

We found perceptions about the relative advantage of POCUS over the usual approaches to assessing and diagnosing patients to be a strong positive factor. All participants were enthusiastic and in favour of POCUS and reported that it improved accuracy and speed of diagnosis in real time and allows tracking patient's progress by rescanning frequently thereby reducing the number of referrals made to radiology. Other advantages included procedures that would have been done blindly like drainage, biopsies, vascular access becoming more accurate with fewer complications. Patients did not have to be moved to the radiology department, requiring nursing time and equipment such as portable oxygen, and endangering unstable patients. Generally, participants felt that POCUS was scalable and were very keen to learn and to teach others. Most reported that the pilot training was "excellent" and adequate for their clinical needs. They believed that more training courses need to be run at lower cost to make them more accessible for the average Ghanaian doctor and several believed that it should be integrated into specialty training for all doctors. All participants had ongoing connections after completion of training with trainers to ask for help and feedback. Some participants suggested more external connections would enhance their skills and improve POCUS implementation. Participants reported a positive learning climate using a variety of resources and methods to continue education.

### Weak positive factors

Participants mostly reported POCUS being of low complexity. They reported challenges with learning and operating POCUS initially when they were inexperienced and lack of local senior input and low confidence in their ability. They also reported difficulties with indications that they don't practise frequently. Some commented on the difficulty with maintaining good ergonomics due to their setting (i.e. being in a cramped emergency bay), leading to back pain. A variety of networks and communication platforms were used to share POCUS images and videos for feedback. One participant did not feel they had the technical skills to upload images and videos of the POCUS to the group. Some reported communication and practical help being hindered by the dispersed layout of the hospital as people physically take a while to get from one department to another.

**Table 2** Summary of domains and constructs

| Domain | Construct | Rating | Quote |
|---|---|---|---|
| **Characteristics of the intervention** | Relative advantage | Positive, strong | *"It also helps you track patients' progress. For example, if you have a pleural effusion that you have drained, you can come and rescan to see whether there is still enough or if it is totally gone so it also helps you track your patient and check if the patient has symptoms." ID3* |
| | Complexity | Positive, weak | *"I don't find it complicated. It is just normal now. I don't use the word easy because you can have patients in whom you won't get good views. But if you have the good views then I don't have issues with data interpretation anymore." ID4* |
| | Cost | Negative, weak, mixed | *"If we could make [POCUS training] more affordable for the ordinary Ghanaian doctor then we could have more people trained." ID5*<br>*"The on-call radiologist was about to take 3000 Ghanaian cedis to do that procedure but because it was done by the bedside, it was done for free." ID2* |
| | Hardware and software maintenance | Negative, weak | *"Someone donated [a cart-based] ultrasound machine…. It was not very good quality, but it was better than not having anything. It had a curvilinear probe…it wouldn't really work very well for some of the patients because the penetrance was poor" ID4* |
| | Perceived scalability | Positive, strong | *"For now, I think the delivery of the POCUS training is excellent. You are given full access to a platform with a lot of educational materials. Many virtual sessions are done for trainees and then the hands-on sessions come on which works very well." ID1* |
| **Outer setting** | Patient Needs & Resources | Positive, strong | *"Some patients, when we are using a probe on them, it seems like a high-tech thing, so they are like 'oh wow, they are using some high-tech imaging by the bedside'. They kind of have a lot more confidence in you as well." ID3* |
| | Cosmopolitanism | Positive, strong | *"I guess maybe there was another programme for DVT [diagnosis with POCUS]. …I think a German company. They are doing something with cardiology in Ghana. They have a wide range of things they are doing. They had a program for teaching people how to scan the lower limbs for DVT. I was part of that on a presenter level on an unofficial level and then there was an ongoing plan where they provided an ultrasound to the medical department with a linear probe specifically to scan swollen limbs for DVT." ID4* |

**Table 2** (continued)

| Domain | Construct | Rating | Quote |
|---|---|---|---|
| **Inner setting** | Structural characteristics | Negative, strong | *"The area where we see very urgent patients is almost always choked. The machine in that area is big. If you want to perform POCUS you have to look for space to place the machine." ID7* |
| | Networks and communication | Positive, weak | *"[Feedback on images sent on WhatsApp] wouldn't be immediate…it's not good if you immediately need to know what it is…it will take a day most of the time…it's not going to help you if they need an urgent opinion, it's just maybe for learning purposes." ID4* |
| | Culture | Negative, weak, mixed | *"The general radiology community in Ghana were not in support of POCUS. That was the initial part, but I think they realize what has been done so the perception is now different." ID1* |
| | Implementation climate: Relative priority | Positive, weak, mixed | *"Where I was before, I was the head of the emergency department. Most of the time having meetings with [administrators], explaining, bringing people on board who also didn't believe it. I would bring someone along who they trust a bit more." ID4* |
| | Implementation climate: Learning climate | Positive, strong | *"On my own I try to teach POCUS, assessing the IVC. That way I kind of reinforce what I have learnt, I don't forget it and keep on scanning." ID3* |
| | Team characteristics | Positive, weak, mixed | *"We don't always get calls from the nurses to scan but when you come in with a probe and fix things, they get super excited about it. The last time I did it, …one nurse was like "oh wow, this is what we have been waiting for. Now everyone can do nice stuff". It was a nice moment." ID5* |
| **Individual characteristics** | Knowledge and beliefs | Positive, strong | *"The interest is what drives the learning. At first, I didn't realise it was important but now I can do much more at the bedside with ultrasound. That has kept me wanting to know more." ID2* |
| | Self-efficacy | Positive, weak. | *"[At the beginning] Your confidence was low. You might find something and not be sure whether to take clinical action on it or not. Going forward over time, I got more comfortable with how to manoeuvre the probes." ID2* |
| **Process** | Executing | Positive, weak. | *"There isn't really a fixed scanning time. I sometimes like to just do it. So, if I am seeing the patient, I examine, I have my probe with me, I just take it out and then look and add all of that to make my decision, right. Only sometimes if you are in a group, say you are in triage with your team, it kind of takes time and all that so on days when I'm not alone, I might have to defer my scan to after we are done with rounds." ID5* |
| | Reflecting and evaluating | Positive, weak. | *"...before we send in an image to the [Whatsapp] page, because we know our colleagues will check and comment on these, we try to bring in the best image we can get." ID2* |

Generally, people believed that POCUS made them better physicians and improved their clinical decision making (self-efficacy). There was acknowledgement that they have only done a foundational POCUS course and had limitations in their ability. They would frequently refer for further imaging if they needed a formal imaging report in the patient notes or wanted confirmation of their findings. In executing their work, all physicians carried out POCUS as part of an initial assessment of the patient if indicated and if possible. It was particularly useful in emergency situations. Most departments did not have to change infrastructure or staffing to execute POCUS implementation. Some aspects of execution such as privacy for the patient and sterile equipment for procedures were challenging. Reflection and evaluation on POCUS practice to improve quality was unanimously reported as important to the participants. None had a formal system for this. Feedback was gained from sending anonymised images to a WhatsApp group with participants and trainers, comparing with formal opinions from radiology and/or asking colleagues and seniors for feedback at the bedside. Many of them thought that quality assurance could be improved with a formal auditing system for images. For this, patient images need to be stored in their notes so they can be tracked to the diagnosis and physician. Others suggested a better mentoring system would be useful but did not specify what this would look like.

Participants reported that hospital staff including nurses were generally supportive of prioritising POCUS implementation after seeing the utility of POCUS firsthand and were enthusiastic to learn about it. Several of the participants held managerial roles and were engaged in stakeholder meetings and demonstrations promoting the utility of POCUS. Some participants argued for a national governing body for POCUS. In other cases, the administration was neutral or against POCUS implementation as they had other priorities and didn't see the need to invest in it. Administrators wanted to integrate it into a billing system of the hospital. The teams of the participants were broadly composed of doctors (both peers and seniors), nurses, radiologists, and students. Generally, members of the team such as medical officers not trained in POCUS are keen to learn and are trained by the participants. One participant said that nurses are happy with POCUS in general as it reduces transfers to radiology. However, another said that they were apathetic and had little interest in it as it fell outside their job remit. There was no mention of formalised referral systems to radiology after a POCUS scan.

#### Weak negative factors

The main resources for POCUS implementation are the machine (portable or handheld), ultrasonography gel and cleaning wipes. Participants described the cost of operating POCUS as being accessible to doctors in Ghana if the machines were provided. Procurement of POCUS machines was difficult in Ghana and one participant thought this may be because the companies selling the machines may have doubts about the Ghanaian doctor's ability to pay for it so are reluctant to sell them there. Others felt the cost of POCUS training to doctors was suggested to be a barrier to getting more staff trained. The POCUS machines used at the time of interview were either existing old equipment in their departments or handheld style probes, generally reported as easy to maintain with good training on cleaning, disinfecting, and storage. Some didn't have the recommended cleaning products but used alternatives suggested by the manufacturer's websites. Software for some handheld equipment is updated online but no one reported problems with this. Fixing breakages was difficult for most participants but they could ask their colleagues or send it off to an international contact for help. As the handheld probes communicate with the participants' phones, several participants reported the cables connecting the phone and handheld probe breaking when it was stored in the bag and having to be replaced. The culture of diagnosis before POCUS was just history and examination with costly additional tests from different departments. Including POCUS as a normal part of initial clinical assessment has been challenging due to barriers to training, the lack of mentors, equipment and beliefs of other departments and hospital administration. The hospital culture varies in its perception of POCUS from being useful to being a duplication of the radiology department's role, so a waste of resources. Most reported their hospital to be apathetic but would help implement POCUS if there were enough incentive and enough people wanted it. One participant reported that the radiologists in Ghana were initially opposed to the introduction of POCUS as they assumed it would take work away from them, but others said that they are supportive of POCUS because it reduces their workload.

#### Strong negative factors

The lack of machines provided by the hospital dedicated to each ward has been a common suggestion for improvement of POCUS implementation by participants. They were generally happy to use their personal machines for lack of anything better but would prefer better machines that are not at their personal expense to operate. Some participants commented on the dispersed structure of the hospital forcing them to travel long distances between departments when called to practise POCUS or when transporting patients to radiology for formal imaging. Lack of space was an issue when using large ultrasound machines and not handheld probes.

## Discussion

This study confirmed continued uptake of POCUS by all participants 6 months after course completion. Participants estimated that 40% of patients would have been unable to afford any other investigations. This number suggests significant potential benefits of introducing POCUS more widely. However, good uptake does not equal proven positive impact on patient outcomes and prospective impact studies will be required. For example, a study evaluating the impact of POCUS in an Emergency department in Ghana reported improved diagnostic accuracy, but no impact on secondary outcomes including choice of treatment or 24-hour mortality [10]. On the other hand, our participants reported subjective clinical benefit, as did 96% of participants in a global survey on their perceived benefits of POCUS in LMICs [11]. Most POCUS applications in our curriculum were considered easy, including targeted liver scans. Pneumothorax was confirmed by formal imaging at a lower rate than expected (78%, as compared to commonly reported specificity of > 95%) [12]. This is likely because only equivocal cases will have been referred. For other applications, such as aortic aneurysm, schistosomiasis and adnexal pathology, confirmation rates were lower at 40–60%. This likely reflects the fact that these applications were included in the curriculum on a "nice to know" basis, as opposed to "need to know". POCUS training resources are severely restricted, and clinicians frequently aim to expand their POCUS skills independently [1, 3]. Performing a "nice to know" POCUS application, followed by referral for a formal scan, is one way of obtaining feedback, and most of the participants used this approach for learning. However, the modest confirmation rates also underscore the limited skills that can be achieved using this approach. They also reinforce the importance of getting a second opinion, whenever possible, and interpreting findings with caution. Overall, our curriculum appears relevant to participant's practice. A recent Delphi Consensus study in South Africa to determine ultrasound skills for Family Medicine and generalist practitioners included all applications also present in our curriculum [13]. A prospective evaluation of a similar curriculum for general physicians in 2016 in Rwanda also found that a similar range of applications was relevant to clinical practice [14].

This study also described barriers and facilitators with the implementation of POCUS in Ghana's public hospitals. The relative advantage POCUS gave them over routine clinical assessment in diagnosing their patients was a strong positive factor in their perception of this new diagnostic tool. Participants in this study reported that they felt adequately trained and had been able to practise and maintain their skills since the course. Interviews confirmed that the remote support via online platforms provided by the trainer team was one of the most valued components of this programme, as compared to short courses some had attended, with a desire to improve on the remote support format. The implementers considered POCUS as having accessible operating costs, being easy to maintain and less complex to implement, with hospitals teams keen to learn and support its implementation.

Our findings resonate with broader literature on health systems interventions in LMIC settings. The strong positive factor on the relative advantage of POCUS has also been reported in a qualitative study at a large teaching hospital in Kenya in 2020 and in a recent online survey including 241 respondents with experience of POCUS in 62 LMICs [11, 15]. In both, participants reported that they believed that POCUS improved clinical diagnostic accuracy. The majority (90%) of participants in these studies also were physicians working in tertiary or urban centres. A study in Nepal reported perceived usefulness and significance of POCUS among primary care physicians despite experiencing shortage of the equipment [16].

Experiences of our study participants also demonstrated that they had to cope with some challenges during the implementation of POCUS. Lack of access to functional equipment was the strongest negative factor. Handheld machines were considered relatively affordable and easy to maintain compared to larger departmental machines, but currently such POCUS equipment is self-funded, as part of the training programme. Market supply of affordable equipment is very limited in Ghana as companies are yet to seek regulatory approval for sales. Lack of Quality Assurance of POCUS practice more generally was also raised as a concern during interviews, with lack of image storage facilities quoted as a barrier to formally auditing POCUS practice. Some administrators indicated a desire to include POCUS into hospital billing systems. This will enable cost recovery, yet potentially negate one of the great benefits of POCUS as an extended clinical assessment tool for all patients. In some cases, the administration was neutral or against POCUS implementation as they had other priorities, highlighting the importance of proper patient outcome and health economic studies to appropriately position POCUS implementation among the many other competing health system priorities.

Our study confirms key perceived barriers reported in the studies in Kenya and the global online survey [11, 15]. The study by Kagima found resource scarcity as one of the limiting factors to POCUS implementation including maintenance and safety of the equipment. In contrast, our study has identified costs for operating and maintaining POCUS equipment as weak negative factors if the machines are provided to doctors. A further study on perceived barriers to ultrasound use in developing countries identified insufficient ultrasound equipment and the need for developing distant learning or telesonography training programmes [17].

This study has several limitations. Data was collected retrospectively and scan numbers, scan types and referral data were estimated. This may have led to recall bias. Prospective, systematic follow up of any referrals for further investigations will provide more accurate insight into the quality and appropriateness of POCUS scans. Data on free fluid in the abdomen and gallbladder applications, which are common POCUS applications, was not collected, due to an error in the survey. More importantly, participants were selected specifically for their interest in POCUS and in becoming future trainers. This will have influenced their enthusiasm in adopting POCUS in clinical practice and may have created bias in their estimation of clinical benefit. Future participants of mandatory curricula may be less enthusiastic, show worse performance and have more negative perceptions around implementation, as reported in interviews with clinicians in Kenya who were not yet trained and who reported mixed enthusiasm and more scepticism [15]. This evaluation was performed by a member of the health partnership delivering the training programme. While we employed rigorous interview techniques and the interviewer was not involved in course design or delivery, nor had any prior contact with participants, this may still have impacted on their ability to freely share negative perceptions. Finally, our findings, like those from the study in Kenya and the recent global survey, are strongly biassed towards the experience of mostly tertiary level, urban physicians, and specialists. In Ghana, their practice includes caring for general practice patients, and they are well placed to evaluate the curriculum from a general practice physician's perspective. However, our findings on implementation and experience of POCUS cannot be generalised to other staff cadres or to lower-level healthcare settings. Despite these limitations, obtaining quantitative estimates of "real life" POCUS applications, along with information on barriers and enablers, will inform urgently needed prospective studies on patient and health system outcomes, will improve training models and can guide distribution of scarce resources.

## Conclusion

In this pilot study amongst eight physicians in Ghana, POCUS was deemed to be a useful adjunct to the clinical exam and may offer a useful solution to bridge the gap in diagnostic imaging for patient in LMICs. This resonates with the experience of many of their colleagues in similar resource restricted health care settings. The essential components of the pilot curriculum were utilised well, with ongoing mentorship being particularly highlighted as beneficial to build confidence across a broader scope of practice. Their experience drives the need for further training with strong communities of practice and for solutions to current barriers of equipment availability, training costs and lack of quality assurance mechanisms.

### Abbreviations

| | |
|---|---|
| LMIC | low- and middle-income countries |
| POCUS | Point of care ultrasound |
| CASE | Consortium for the Accreditation of Sonography Education |
| EM | Emergency Medicine |
| IVC | inferior vena cava |
| DVT | deep venous thrombosis |
| EFAST | extended focussed assessment with Sonography for trauma |
| CFIR | Consolidated Framework for Implementation Research |
| WWR | Worldwide Radiology |

## Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12909-024-06250-z.

Additional file 1. Course curriculum.

Additional file 2. Quantitative questionnaire.

Additional file 3. Qualitative evaluation tool (from CFIR criteria).

Additional file 4. Qualitative interview framework.

Additional file 5. Graphic representation of Qualitative Data.

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### Authors' contributions

YAA, AB and EJ were involved in curriculum development and delivery of the original programme. YAA and EJ established ethical approval. AP, FL and EJ designed the study. AP conducted interviews and questionnaire data. •AP: study design, data collection, analysis and write up •FL: study design, data collection, analysis and write up •YAA: ethical approval, editing •AB: editing •EJ: curriculum design, study design, data collection, analysis and final manuscript. All authors read and approved the final manuscript.

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### Data availability

Additional data and materials is available in the Appendices and on request from the authors.

## Declarations

### Ethics approval and consent to participate
Ethical approval was granted by the Ho Teaching Hospital Research Ethics Committee, Ghana, with Protocol ID no HTH-REC (17) FC_2022.

### Consent for publication
Consent has been obtained from all subjects and authors for publication.

### Competing interests
The authors declare no competing interests.

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