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ORIGINAL ARTICLE

Diagnostic point-of-care ultrasound in medical inpatients at Queen Elizabeth Central Hospital, Malawi: an observational study of practice and evaluation of implementation

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Background: In less well-resourced settings, where access to radiology services is limited, point-of-care ultrasound (POCUS) can be used to assess patients and guide clinical management. The aim of this study was to describe ultrasound practice in the assessment of medical inpatients at Queen Elizabeth Central Hospital, Blantyre, Malawi, and evaluate uptake and impact of POCUS following the introduction of a training programme at the college of Medicine, Blantyre, Malawi.

Methods : A weekly prospective record review of sequential adult medical inpatients who had received an ultrasound examination was conducted.

Results: Of 835 patients screened, 250 patients were included; 267 ultrasound examinations were performed, of which 133 (50%) were POCUS (defined as performed by a clinician at the bedside). The time from request to performance of examination was shorter for POCUS examinations than radiology department ultrasound (RDUS) (median 0 [IQR 0–2, range 0–11] vs 2 [IQR 1–4, range 0–15] d, p=0.002); 104/133 (78.2%) POCUS and 90/133 (67.7%) RDUS examinations were deemed to have an impact on management.

Conclusion: Following the introduction of a training programme in POCUS, half of all ultrasound examinations were delivered as POCUS. POCUS was performed rapidly and impacted on patient management. POCUS may relieve the burden on radiology services in less well-resourced settings.

Keywords: Africa, echocardiography, Malawi, point of care ultrasound

Introduction

Ultrasonography has been categorised as 'essential' for improving patient care in low-resource health systems by the WHO.[1] Point-of-care ultrasound (POCUS) is a clinician-directed ultrasound examination performed at a patient's bedside for diagnostic or therapeutic purposes.[2] POCUS, in comparison with other imaging modalities, is low cost, requires less infrastructure and maintenance, avoids ionising radiation, is portable and is relatively easy to learn.[2] All of these qualities make POCUS particularly suited for resource-limited settings where other imaging modalities may be unavailable, impractical or expensive and patient transfer for radiology services may be burdensome or impossible.[3,4] Furthermore, POCUS is not limited by the time of day or extended waiting times compared with radiology department ultrasound (RDUS).[5,6]

POCUS protocols encourage systematic sonographic assessment to answer specific, usually binary, questions.[5] Previous studies have shown that even brief training improves clinicians' confidence in their POCUS ability and in their comfort in using this examination for clinical decision-making.[2] Studies in other limited-resourced settings have shown that generalist physicians, nurses and mid-level healthcare providers demonstrate

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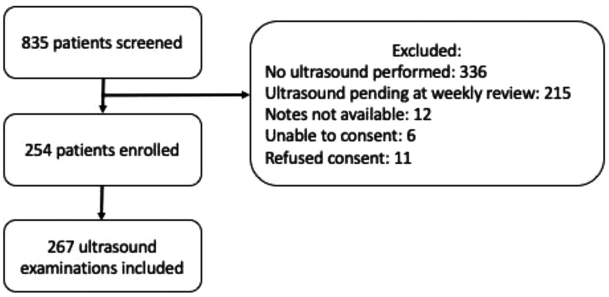

Figure 1. Study profile demonstrating the patients screened, excluded and enrolled from medical inpatients at Queen Elizabeth Central Hospital, Blantyre, Malawi.

excellent diagnostic accuracy after short, focused training sessions combined with follow-up evaluation and retraining.[7] Data from Malawian patients with a high prevalence of HIV and TB demonstrated that POCUS was a useful tool in a resource-limited setting, in particular to aid the diagnosis of extrapulmonary tuberculosis, but also other conditions such as heart failure, pneumonia, ectopic pregnancy and deep vein thrombosis.[4,8,9]

In Malawi, ultrasound examinations are mostly performed by staff of radiology units, usually radiology technicians. The quality of this service is variable as ultrasonography may not be part of the formal training for these technicians. In addition, services are often not available due to lack of staff, power outages or lack of equipment. POCUS can help overcome these shortages. However, evidence to inform the health system impacts of POCUS, such as training requirements and costs, and assurance of quality as well as real-life benefit to patients and health systems, is lacking.

In 2018, a training programme on POCUS was initiated in the Department of Medicine at the University of Malawi, College of Medicine (COM), in cooperation with the University of Hamburg. The aim of this programme was to sustainably introduce POCUS into the routine care of patients in the Department of Medicine at Queen Elizabeth Central Hospital (QECH, the teaching hospital of COM).

The aim of this study is to describe current ultrasound practice, both RDUS and POCUS, to evaluate the uptake of POCUS following training and to assess the impact of introducing POCUS as an alternative to RDUS, on patient management, among medical inpatients at QECH, Blantyre, Malawi.

Materials and Methods

Training programme

After an initial needs assessment, a curriculum for training was developed that covered indications for diagnostic and interventional ultrasound that fulfilled the following criteria: first, indications had to be common in inpatients treated in the Department of Medicine at QECH. Second, indications had to be easy to teach to users with little or no experience of POCUS. Finally, all indications had to answer clinical questions and have a direct impact on patient management. Protocols that were included in the training programme were focused assessment with ultrasonography for TB in HIV (FASH), chest ultrasound, echocardiography, abdominal ultrasound examinations (ascites, kidneys and bladder), compression ultrasound examinations for deep vein thrombosis, ultrasound guidance for fine needle aspiration of lymph nodes, ascitic paracentesis, pericardiocentesis and pleurocentesis.

The training was directed mainly at clinical staff involved in routine clinical care of inpatients on the wards of the medical department (consultants, registrars and clinical officers) but was also open to staff of attached outpatient clinics and surrounding hospitals. Due to limitations in training capacity, short-term staff (e.g. interns) were not trained. Participants did not require previous training in or experience of POCUS. By the completion of this study, 2 courses had been delivered to 26 participants and 2 refresher courses had been delivered to 16 participants. Of the 26 participants, 10 were involved in routine clinical care as medical registrars or clinical officers in the Department of Internal Medicine at the QECH. The training programme is described in more detail, including a description of the POCUS protocols, in the supplementary material (Appendix 1).

Study setting

This study was performed in the Department of Internal Medicine at the QECH, Blantyre, Malawi, a tertiary referral centre for the southern region (population of 7750 629).[10,11] All ultrasound

Table 1. The type of ultrasound examination performed and the proportion of each examination performed as point-of-care ultrasound scan (POCUS) in medical inpatients at Queen Elizabeth Central Hospital, Blantyre, Malawi

Type of ultrasound examination	Number of examinations performed, n	Percentage of total examinations performed, %	Number (percentage) of examinations performed as POCUS, n (%)
Abdominal	81	30	22 (27)
Echocardiogram	93	35	31 (33)
FASH	66	25	60 (90)
Chest	13	5	12 (92)
Vascular/DVT assessment	9	3	6 (67)
Others	5	2	3 (60)

DVT, deep vein thrombosis; FASH, focused assessment with sonography for TB in HIV.

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Table 2. Most common pathologies identified on ultrasound examination (POCUS and RDUS) in medical inpatients at Queen Elizabeth Central Hospital, Blantyre, Malawi

Pathology	Number (%)*
Abdominal ultrasound (N=81)	
No pathology reported	18 (22)
Free fluid/ascites	23 (28)
Pleural effusion	5 (6)
Hydronephrosis	3 (4)
Liver cirrhosis	3 (4)
Liver mass	9 (11)
Intra-abdominal lymph nodes	5 (6)
Splenomegaly	6 (7)
Echocardiogram (N=93)	
No pathology reported	17 (18)
LV impairment	30 (32)
RV impairment/dilatation	20 (22)
LV dilatation	26 (28)
Mitral valve disease	24 (26)
Pericardial effusion	14 (15)
FASH (N=66)	
No pathology reported	39 (59)
Pleural effusion	12 (18)
Pericardial effusion	11 (17)
Para-aortic lymph nodes	5 (8)
Splenic micro abscesses	5 (8)
Intra-abdominal free fluid	6 (9)
Chest ultrasound (N=13)	
No pathology reported	1 (8)
Simple effusion	6 (46)
Alveolar interstitial syndrome	2 (15)
Complex effusion	3 (23)
Consolidation	2 (15)
Alveolar interstitial syndrome	2 (15)
Vascular ultrasound (N=9)	
No pathology reported	6 (67)
DVT	3 (33)

DVT, deep vein thrombosis; FASH, Focused assessment with sonography for TB in HIV; LV, Left ventricular; RV, Right ventricular.
Pathologies identified on ultrasound examination in medical inpatients at Queen Elizabeth Central Hospital, Blantyre, Malawi.
*Percentages refer to the percentage of examinations of a given type with the particular pathology recorded. Multiple pathologies may have been identified in a single scan. Only the most common pathologies are reported.

examinations were performed for routine patient care as directed by the managing medical teams. POCUS examinations were performed using GE-Healthcare V-scan (GE-Healthcare, Chicago, Illinois, USA) and DP30 (Mindray, Shenzen, China) machines by the 10 clinicians that had recently undergone at least the 4-day introductory training course. Two experienced POCUS clinicians or a radiology technician provided supervision in case of uncertainty in the POCUS findings. RDUS examinations were performed by radiology technicians using a Mindray DC 30 and GE vivid Q-i for echocardiography. Data from ultrasound examination were used for clinical decision-making by the respective ward teams.

Study design

This study was a prospective observational review of records of ultrasound examinations performed for adult inpatients in the Department of Medicine during routine clinical care. The study was conducted across both male and female medical wards. There are 120 beds and approximately 400 admissions per month between the two wards. On a weekly basis from 1 October 2018 to 18 March 2019, a member of the study team reviewed the records of sequential patients on one half of each ward (Appendix 3, supplementary material). Any patient aged $\geq$16 y who had received an ultrasound examination was recruited after giving written informed consent. Patients aged $<$16 y or those unable to give informed consent (e.g. due to a reduced level of consciousness) were excluded. Initially, we planned to assess the use of POCUS for diagnostic and interventional use. However, as clinicians did not routinely record whether or not a procedure was guided, we restricted our analysis to the application of POCUS for diagnostic purposes.

Data collection

The medical records of enrolled patients were reviewed to extract demographic data and details of any ultrasound examinations performed from the radiology report (RDUS) or the medical notes (POCUS). Data were collected using electronic case reporting forms. Information collected included patient demographics, HIV status, the type of ultrasound examination performed, whether the examination was POCUS or a standard examination performed by the radiology department, the number of days between the examination request and the actual date of the ultrasound examination, indication and findings of ultrasound examinations.

Impact of ultrasound examinations on patient care

At the point of data collection, study investigators categorised the findings and impact of the ultrasound using a structured proforma. The findings in relation to the clinical indication were categorised as conclusive, supportive or inconclusive. The ultrasound examination was deemed to have impacted on patient management if, as a result of the findings, treatment was started, treatment was stopped, treatment was altered, further investigations were ordered, the information was used in decision-making for surgery or delivery, the patient was referred to another specialty, the information was used to discharge the patient or if the information resulted in palliative care initiation. A consensus expert decision was sought in equivocal cases and each entry was subsequently reviewed by a senior member of the study team. A detailed description of the process is presented in the supplementary material (Appendix 2).

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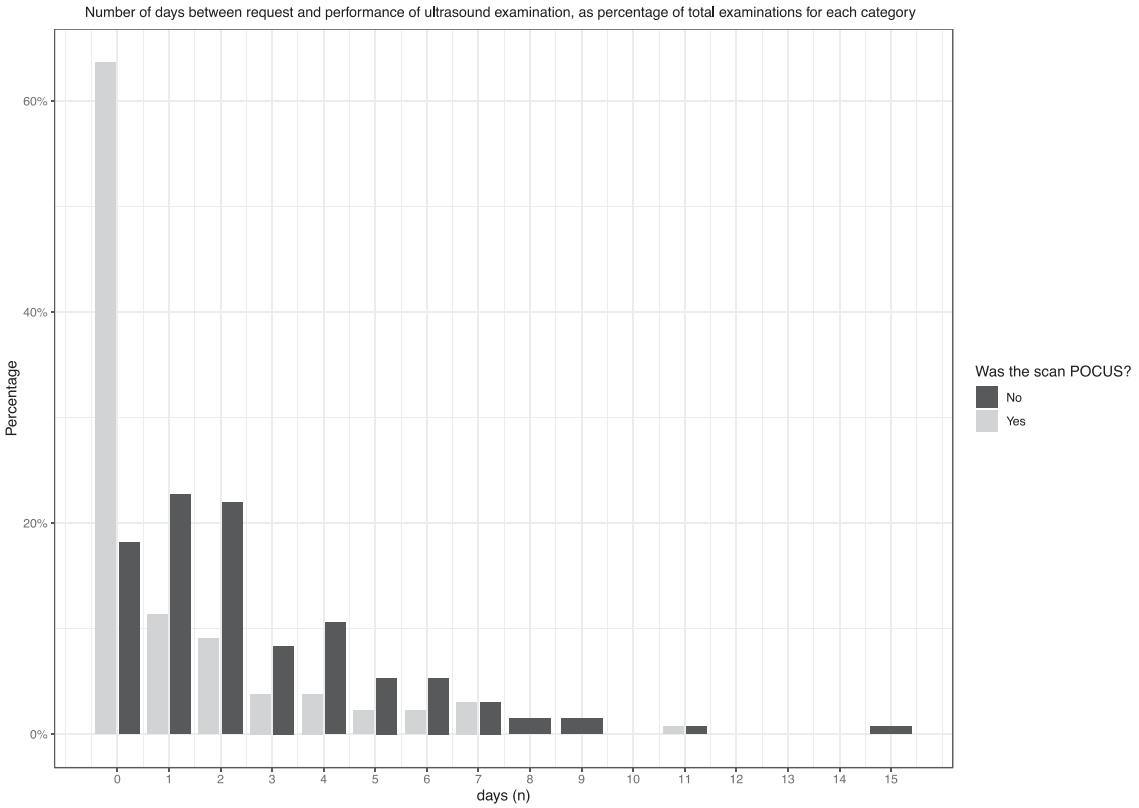

Figure 2. Bar chart describing the number of days between ultrasound examination request and performance, according whether examination was point-of-care ultrasound (POCUS) or not in medical inpatients at Queen Elizabeth Central Hospital, Blantyre, Malawi. The percentage described is that of the total examination performed as either POCUS or RDUS.

Results

Patient demographics

Of 835 patients screened during the 22 weeks of the study, 254 were enrolled with 267 ultrasound examinations (Figure 1 and supplementary figure in Appendix 3). The median age of patients was 39 (range 16–94) y, 126 (50%) were HIV-positive and 129 (51%) were female.

Nature of ultrasound examinations performed

Overall, 133 examinations (50%) were performed as POCUS. FASH and chest ultrasound examinations were more often performed as POCUS examinations (90% and 92%, respectively), while abdominal scans and echocardiography were more often performed as RDUS (73% and 67%, respectively). Table 1 details the types of ultrasound examinations performed and the proportion of each type of examination performed as POCUS. The most common clinical indications for performing ultrasound examination were, for echocardiography examination: breathlessness (n=50, 53.8%), suspected biventricular failure (n=26, 30.0%) and stroke (n=12 12.9%); for abdominal examination: abdominal pain (n=25, 30.9%), abdominal swelling (n=23, 28.4%) and suspected extrapulmonary TB (n=17, 21.0%); for FASH examination: suspected extrapulmonary TB (n=59, 89.4%), weight loss (n=12, 18.2%) and cough (n=10, 15.2%); and for chest examination: breathlessness (n=9, 69.2%), suspected pleural effusion (n=7, 58.8%) and chest pain (n=3, 23.1%). Table 2 details the most common pathologies identified.

Delays from ultrasound examination requests to performance

The median time from an examination being requested to an examination being performed was 2 (IQR 1–4, range 0–15) d for RDUS and 0 (IQR 0–2, range 0–11) d for POCUS examinations (p=0.002). Figure 2 illustrates the delays between examinations being requested and performed for both POCUS and RDUS examinations.

Impact of ultrasound examinations

The findings documented in the ultrasound report in relation to the indication for the ultrasound examination were conclusive in 102, supportive in 153 and inconclusive in 10 (Table 3); 195/267 examinations were deemed to have had an impact on patient management (Table 4); 104/133 POCUS and 91/134 RDUS examinations were deemed to have an impact on management. Treatment was started following 60 examinations (22.5%), treatment was altered following 68 examinations (25.5%) and further investigations were ordered following 108 examinations (40.5%)

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(Table 4). For POCUS examinations, the impact on management occurred immediately following examination in 16/105 (15.3%) or on the same day as examination in 55/104 (52.9%), compared with 6/91 (6.6%) and 40/90 (44.4%) for the non-POCUS group.

Discussion

Our results demonstrate that in Malawi, following a short, pragmatic training intervention, with active ongoing supervision, POCUS is now widely used to assess medical patients. Half of all ultrasound examinations were performed as POCUS, with FASH and chest sonography almost exclusively performed as POCUS. Times from request to performance of an ultrasound examination for inpatients were significantly shorter when the examinations were POCUS. As POCUS is specifically intended to be performed by a clinician at the bedside, an important strength is that it can significantly reduce delays in diagnosis and treatment and enhance clinical care. The immediacy of POCUS has meant that its usage in emergency medicine and intensive care is well established in well-resourced settings to assess unwell patients, guide immediate treatment and facilitate safe invasive procedures.[12–16] POCUS in low-resource settings is increasingly well described and similar protocols are emerging to facilitate rapid assessment and support clinical decision-making.[5,10,17–20] While the majority of POCUS scans were performed on the same day as they were requested, the long delays observed in a proportion of POCUS scans may reflect the lack of immediately available POCUS-trained clinicians in some clinical areas.

This study demonstrates that both POCUS and RDUS scanning, within their respective indications, can yield useful findings and impact patient management. The high observed impact on management described is similar to other studies assessing the impact of POCUS in this setting.[5,21] Furthermore, these findings are comparable with a study from the same setting before the introduction of POCUS training, where 69% of scans were deemed to be useful in patient management.[11] In this study the findings and impacts on patient care were categorised; however, within each category the exact nature of the impact was not recorded. Furthermore, given the observational design of the study, it is not possible to determine whether the impact on management observed following an ultrasound scan could be solely attributed to the ultrasound examination or would have been different had the scan not occurred. Only limited conclusions can be drawn from this study relating to the findings and impact of POCUS on patient management. More comprehensive evaluation and research of the impact of POCUS on patient management and outcomes in the low-resource setting are required.

POCUS examinations may be performed by clinicians with relatively little training in ultrasound whereas a full RDUS requires specific expertise and a high level of training. The scope of the POCUS examination is limited to answering specific (and usually binary) questions. More subtle or complex findings are beyond the scope of POCUS. A potential downside to widespread POCUS uptake is that important pathology may not be appreciated, which might have been recognised with RDUS sonography. An example of this would be our categorisation of abdominal ultrasound examinations, where the POCUS protocol only covers a limited range of findings (ascites, kidney size and echogenicity and bladder masses) compared with RDUS. However, many common pathologies identified in this study fall within the scope of recognised POCUS protocols. The extent to which RDUS scans would have provided additional information that would have altered management compared with POCUS is beyond the scope of this study and would depend on the level of competence of the POCUS and RDUS examiners. In a health system with significant pressure on resources, POCUS can be used to obtain management-altering information and could relieve the burden on radiology services. This study supports the usage of POCUS as a 'first step' assessment in cases where radiological information is required, allowing more challenging cases to be referred for RDUS, while avoiding RDUS in cases where the answer has already been obtained from POCUS and additional information would not alter management any further. A case in point would be an abdominal examination in a patient with abdominal swelling. If the radiological question required by the clinician only relates to the presence/absence of intra-abdominal fluid, then POCUS would suffice. However, if the question relates to the aetiology of free fluid then POCUS is unlikely to suffice and RDUS may be sought.

A barrier to widespread POCUS uptake is training and ongoing supervision. Several studies have demonstrated that POCUS protocols can be reliably taught in a relatively short time, including in the low-resource setting.[3,8,9] However, data relating to long-term competence in POCUS following short courses are lacking. This study suggests that in an environment where training and

Table 3. Findings documented on the ultrasound report in relation to the indication for the ultrasound examination in medical inpatients at Queen Elizabeth Central Hospital, Blantyre, Malawi

	Findings on ultrasound (n, %):		
Type of examination	Conclusive	Supportive	Inconclusive
All examinations			
Abdomen (n=81)	16 (19.8)	59 (72.8)	6 (7.4)
Chest (n=13)	7 (53.8)	6 (46.2)	0 (0)
ECHO (n=93)	40 (43.0)	49 (52.7)	4 (4.3)
FASH (n=66)	30 (45.5)	35 (53.0)	1 (1.5)
POCUS:			
Abdomen (n=22)	7 (31.8)	15 (68.2)	0 (0)
Chest (n=12)	7 (58.3)	5 (41.7)	0 (0)
ECHO (n=31)	13 (41.9)	18 (58.1)	0 (0)
FASH (n=60)	25 (41.7)	34 (56.7)	1 (1.7)
RDUS:			
Abdomen (n=59)	9 (15.3)	44 (74.6)	6 (10.2)
Chest (n=1)	0 (0)	1 (100)	0 (0)
ECHO (n=62)	27 (43.5)	31 (50)	4 (6.5)
FASH (n=6)	5 (83.3)	1 (16.7)	0 (0)

ECHO, echocardiogram; FASH, focussed assessment with sonography for TB in HIV; POCUS, point of care ultrasound; RDUS, radiology department ultrasound.

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Table 4. The impact of ultrasound examination in medical inpatients at Queen Elizabeth Central Hospital, Blantyre, Malawi

	Impact on management (n, %)*				
Type of examination	Treatment started	Treatment altered	Further investigations ordered	Referred to another specialty	Palliative care initiated
All examinations:					
Abdomen (n=81)	8 (9.9)	18 (22.2)	39 (48.2)	4 (4.9)	3 (3.7)
Chest (n=13)	5 (38.5)	2 (15.4)	2 (15.4)	2 (15.4)	0 (0)
ECHO (n=93)	30 (32.2)	27 (29.0)	24 (25.8)	0 (0)	1 (1.1)
FASH (n=66)	13 (19.7)	17 (25.8)	42 (63.6)	1 (1.5)	0 (0)
POCUS:					
Abdomen (n=22)	3 (13.6)	8 (36.4)	9 (40.9)	2 (9.1)	1 (4.5)
Chest (n=12)	4 (33.3)	2 (16.7)	2 (16.7)	2 (16.7)	0 (0)
ECHO (n=31)	15 (48.4)	7 (22.6)	7 (22.6)	0 (0)	1 (3.2)
FASH (n=60)	12 (20.0)	17 (28.3)	37 (61.7)	1 (1.7)	0 (0)
RDUS:					
Abdomen (n=59)	15 (25.4)	10 (16.9)	30 (50.9)	2 (3.4)	2 (3.4)
Chest (n=1)	1 (100)	0 (0)	0 (0)	0 (0)	0 (0)
ECHO (n=62)	15 (24.2)	20 (32.3)	17 (27.4)	0 (0)	0 (0)
FASH (n=6)	1 (16.7)	0 (0)	5 (88.3)	0 (0)	0 (0)

ECHO, echocardiogram; FASH, focussed assessment with sonography for TB in HIV; POCUS, point of care ultrasound; RDU, radiology department ultrasound.
*Percentages refer to the percentage of ultrasound examinations of a given type with the particular impact recorded. Ultrasound examinations may have had impact on treatment in multiple categories. Not all ultrasound examinations had an impact on treatment.

ongoing support are available, POCUS is able to meet a substantial part of the overall requirement for ultrasound imaging in comparable patient cohorts. Further research is required to determine if POCUS education can be rolled out sustainably in low-resource environments and if ongoing training needs can be met.

Several additional limitations to this study must be recognised. First, the study was not designed to assess the accuracy or quality of either POCUS or RDUS examinations in this setting. We did not analyse who performed POCUS examinations or whether examinations were supervised. The experience and competence of POCUS performers may substantially impact upon the quality of information obtained from each examination, but that was beyond the scope of this study. This may limit the generalisability of the results to other low-resource settings or to disciplines where training programmes and supervision in POCUS are not established or where radiology services are more readily accessible. Weekly sampling may have underestimated the proportion of patients receiving ultrasound examinations, and as POCUS examinations were performed faster, the true proportion of examinations performed as POCUS compared with RDUS may not have accurately been captured. While one of the most important indications for POCUS is guidance of procedures, and this is one of its main uses in our department, our study design using routine data from medical records did not allow us to capture data on this. While procedures were recorded in the notes, information on whether they were performed with ultrasound guidance was often missing. Finally, the observational nature of this study does not allow for assessment of impact on patient outcomes.

Conclusions

This study supports the inclusion of POCUS in the assessment and management of medical patients; however, it is essential that evaluation of outcomes, feasibility, cost-effectiveness and sustainability of POCUS are assessed by further research to inform strategic health system planning in low-resource settings.

Supplementary data

Supplementary data are available at *Transactions* online.

Authors' contributions: ET, BK, EJ, SJ and JM facilitated point-of-care ultrasound training and rollout. FL, DD, AJK, EJ, ET, LG, SJ, JM and BK conceived and designed the study. FL, DD, VN, ET and BK implemented the study and collected data. AJK, FL, TP, DD, EJ and BK analysed the data. FL, DD, TP and AJK drafted the manuscript. FL, DD, AJK, EJ, TP, ET, LG, VN, SJ, JM and BK revised and approved the manuscript.

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Competing interests: EJ is cofounder and Director of Worldwide Radiology, a UK-registered charity, delivering not-for-profit, point-of-care ultrasound training in low-resource settings. All other authors declare no conflicts of interest.

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Ethical approval: Ethical approval for the study was obtained from College of Medicine Research and Ethics Committee (COMREC), Blantyre, Malawi, on 8 September 2018 (P.06/18/2419).

Data availability: The data underlying this article will be shared upon reasonable request to the corresponding author.

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