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● *Original Contribution*

ASSESSMENT OF POINT-OF-CARE ULTRASOUND TRAINING FOR CLINICAL EDUCATORS IN MALAWI, TANZANIA AND UGANDA

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Abstract—Integrating point-of-care ultrasound (POCUS) to enhance diagnostic availability in resource-limited regions in Africa has become a main initiative for global health services in recent years. In this article, we present lessons learned from introducing POCUS as part of the Global Health Service Partnership (GHSP), a collaboration started in 2012 between the U.S. President's Emergency Plan for AIDS Relief (PEPFAR), the Peace Corps and Seed Global Health to provide health care work force education and training in resource-limited countries. A cross-sectional survey of GHSP clinical educators trained to use POCUS and provided with hand-held ultrasound during their 1-y deployment during the period 2013–2017. The survey consisted of 35 questions on the adequacy of the training program and how useful POCUS was to their overall clinical and educational mission. Clinical educators engaged in a series of ultrasound educational initiatives including pre-departure training, bedside training in the host institutions, online educational modules, educational feedback on transmitted images and training of local counterparts. In this study 63 GHSP clinical educators who participated in the POCUS trainings were identified, and 49 were included at the study (78% response rate). They were assigned to academic institutions in Tanzania (n = 24), Malawi (n = 21) and Uganda (n = 18). More than 75% reported use of POCUS in clinical diagnoses and 50% in determining treatment, and 18% reported procedural application of ultrasound in their practice. The top indications for POCUS were cardiac exams, second- and third-trimester obstetric exams, lung and pleura, liver and spleen and gynecology/first-trimester obstetrics. The largest perceived barriers were lack of ultrasound knowledge by the clinical educators, lack of time, equipment security, difficulty accessing the Internet and equipment problems. We concluded that our multiphase POCUS training program has increased the utility, acceptability and usage of POCUS in resource-limited settings. (E-mail: hshokoohi@mgh.harvard.edu)

Key Words: **Point-of-care ultrasound, Africa, Global Health Service Partnership, Resource-limited countries, Education, Survey.**

INTRODUCTION

Point-of-care ultrasound (POCUS) refers to the use of ultrasound at the bedside of patients to aid diagnosis, guide procedures and monitor response to therapy. POCUS is becoming standard of care for diagnostic and therapeutic interventions in a variety of clinical settings in highly developed medical systems (Bellamkonda et al. 2015; Dietrich et al. 2017; McLario and Sivitz 2015; Moore and Copel 2011). In recent years there has been an increasing effort to integrate POCUS into clinical care provided in resource-limited settings (Becker et al. 2017; Bélard et al. 2018; Epstein et al. 2018; Henwood et al. 2017; Stanley et al. 2017; Vinayak 2017; Vinayak and Brownie 2018; Zaver et al. 2018). These efforts include initiatives to improve the relevance of ultrasound training programs enabling clinicians with a point-of care imaging modality.

Launched in early 2012, the Global Health Service Partnership (GHSP) is a collaboration between the President's Emergency Plan for AIDS Relief (PEPFAR), the

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Peace Corps and Seed Global Health to provide medical and nursing education and training in collaboration with host institutions in Malawi, Tanzania and Uganda (Kerry and Mullan 2014; Stuart-Shor et al. 2017).

In 2013, the ultrasound training was included as part of GHSP clinical educators' training with the hope of improving the quality of and transforming learning for the very diverse clinical environment with a wide variability in accessing imaging and diagnostic capabilities (Boniface et al. 2018). The GHSP POCUS program for clinical educators has four major components: (i) a pre-departure training during orientation in Washington, DC; (ii) on-site hands-on training in the host institutions; (iii) self-study online modules and educational materials; and (iv) online feedback on transmitted images (Boniface et al. 2018).

The GHSP has therefore presented us with the unique opportunity to train and monitor clinicians in the use of POCUS over an extended period in resource-limited settings. We report our experience of training, deploying and guiding GHSP clinical educators in the use of bedside ultrasound techniques and POCUS in their educational and clinical activities at several sites in Malawi, Uganda and Tanzania. We describe our model for training practitioners in the use of POCUS in low-resource settings and how we provided them with continuing oversight and practice-based improvement programs. We report on how and why POCUS was used at GHSP sites and outline barriers to use and acceptance. We hope that our process and findings will shed light on how POCUS can be used to improve delivery of care in resource-limited settings. The conclusions of this study will also guide educational activities supporting POCUS in resource-challenged settings.

METHODS

Study setting

We conducted a qualitative and quantitative cross-sectional survey among 63 GHSP clinical educators trained to use POCUS and provided with handheld ultrasound during their 1-y period of deployment during the period 2013–2017. Data were collected and managed from self-administered questionnaires using Research Electronic Data Capture (REDCap) (Harris et al. 2009). REDCap is a secure, web-based application designed to support data capture for research studies, providing (i) an intuitive interface for validated data entry; (ii) audit trails for tracking data manipulation and export procedures; (iii) automated export procedures for seamless data downloads to common statistical packages; and (iv) procedures for importing data from external sources.

The study was conducted by investigators from the George Washington University (Washington, DC, USA) in collaboration with Seed Global Health (Seed) (Boston, MA, USA). The study was approved by the institutional review board of the George Washington University, and informed consent was obtained from all study participants.

Study participants and recruitment strategy

A total of 156 GHSP clinical educators were deployed between 2013 and 2017 across five countries (Malawi, Tanzania, Uganda, Swaziland and Liberia). Clinical educators were included if they (i) had participated at the ultrasound (US) training, (ii) had access to the Vscan after departure at their African institute and (iii) used US as part of their clinical or educational mission. At the time of this survey, only sites in Malawi, Tanzania and Uganda had US equipment and participated in POCUS training, and from this initial group of 156 GHSP clinical educators, 63 physicians and midwifes were assigned to sites with ultrasound equipment and participated in the POCUS training. These 63 clinical educators represent the target population for this study. Clinical educators who had not participated at the training or had no access to the US at the host site were excluded. Therefore, neither GHSP nurse educators (with the exception of midwife educators) nor GHSP physicians at sites without ultrasound were included in the POCUS training.

The GHSP clinical educators in this study were placed at academic institutions in Malawi (n = 21), Tanzania (n = 24) and Uganda (n = 18). These clinical educators spent 1 y in the host countries, and 20 of them extended their mission for an additional year (Table 1).

An online, cross-sectional survey was sent to 63 GHSP clinical educators who participated in the ultrasound training program between the years 2013 and 2017. Clinical educators who were still in-field were included in the survey and its analysis.

The ultrasound training

Over the course of two days during GHSP orientation in Washington, DC, clinical educators were presented with lectures on US application in limited-resource settings followed by hands-on POCUS training sessions with a volunteer-to-instructor ratio of 3:1 to 4:1. Two to four months after clinical educators' arrival, two authors (K.S. B. and H.S.) individually conducted onsite US training in the host countries for these same GHSP clinical educators and local counterpart faculty. These onsite training sessions typically included a review of the concepts for clinician-performed US, introduction to the ultrasound machine and its controls, the focused assessment with sonography for trauma/focused assessment with sonography for human immunodeficiency virus/tuberculosis (FAST/FASH) abdominal ultrasound exam (Heller et al. 2012), echocardiography, lung, renal/bladder and

Table 1. Clinical educators' characteristics (n = 49)

Characteristic	n	%
Medical specialty		
Family medicine	11	22%
Internal medicine	11	22%
Pediatrics	9	18%
Midwife	7	15%
Obstetrics/gynecology	7	15%
Emergency medicine	2	4%
Anesthesia	1	2%
Critical care medicine	1	1%
Years from completing residency		
<5	27	55%
6–10	5	10%
>10	17	35%
Years of providing service at the host country*		
2016–2017	23	47%
2015–2016	13	27%
2014–2015	12	25%
2013–2014	11	22%
Host countries		
Malawi	18	37%
Tanzania	18	37%
Uganda	13	27%
Number of scans before Global Health Service Partnership		
0	21	43%
20–40	14	29%
40–100	2	4%
100–1000	8	16%
>1000	4	8%
Site of practice in host country†		
Hospital	45	92%
Clinic	6	12%
Rural	15	30%
Urban	13	26%

* Some of the clinical educators served in multiple years for which the percentage is greater than 100%.

† Some of the clinical educators practiced in more than one site.

abdominal ultrasound in the classroom, followed by bedside ultrasound training and practice by clinical educators and their counterparts. Typically, during on-site hands-on practice, the instructor sonographer spent time rounding and scanning with the GHSP clinician educator and the local faculty counterpart. However, in multiple instances local faculty and trainees participated and were given the opportunity to practice ultrasound scans. Sites with midwives and obstetricians received focused training on gynecologic ultrasound and first- and third-trimester ultrasound, as well as other relevant topics. Clinical educators were also provided with online modules and educational materials; and they received online feedback on transmitted images from their independent scanning after their training.

The survey

A 35-question survey was developed and used to query all GHSP clinical educators about their medical experience, experience using POCUS, the training sessions, their GHSP service and resources available at their local site. Additional questions surveyed their opinions of the most useful applications and most significant barriers in the use of POCUS at their host institution, as well as descriptions of these institutions and the clinical educators' previous ultrasound training.

An email containing a link to the survey was sent to each participant. The survey and collected data were hosted on REDCap. Data concerning previous ultrasound experience and the scale of POCUS use after the training sessions were obtained. GHSP clinical educators played a variety of roles within their host institutions, as is reflected in their responses; therefore, a comprehensive review of the use of POCUS in clinical practice across a range of diagnostic applications, as well as teaching activity, was included in the survey. Data collected were anonymous. To ensure anonymity yet allow for emails to non-responders, each clinical educator was given access to a personalized but de-identified online survey. Four email reminders were sent to non-responders over a period of 3 mo to encourage survey completion.

Data analysis

Surveys were completed by GHSP clinical educators who attended the US training during orientation in Washington, DC, and/or those who had attended the on-site US training. Clinical educators were not required to answer every question in the survey; therefore, the number of answers to survey questions varied and is presented in the findings. Qualitative data were organized in matrix format to compare and contrast responses. Descriptive statistical analyses such as frequencies and percentages were used for dichotomous and categorical outcomes.

RESULTS

Survey population

Seventy-eight percent of GHSP clinical educators (49/63) responded to the survey. The clinical educators' specialties include family medicine (n = 11), internal medicine and subspecialties (n = 11), pediatrics (n = 9), midwifery (n = 8), obstetrics and gynecology (n = 7), emergency medicine (n = 2), anesthesiology (n = 1) and critical care (n = 1). Twenty-three clinical educators were serving in-country at the time of the survey. The time between ultrasound training and completion of the survey was variable. Forty-seven percent of surveys were completed by clinical educators who had served in 2016–2017, 27% in 2015–2016, 25% in 2014–2015 and 22% in 2013–2014. In some instances, the clinical educators extended their services for a second year and are included in two categories; these numbers therefore add up to more than 100% (Table 1).

Ultrasound experience

Forty-three percent of clinical educators (21/49) reported that they had never performed an independent ultrasound scan before the GHSP training. Sixty percent (29/49) reported receiving US training during residency. Of those with independent US experiences, 33% (16/49) reported 20−100 independent scans, 16% (8/49) completed 100−1000 independent scans and 8% (4/49) reported having completed more than 1000 US scans independently (Table 1).

Forty-seven percent (23/49) of the GHSP clinical educators who participated in this survey attended both the orientation training in Washington, DC, and the training in their host country. Thirty-two percent (16/49) of clinical educators only participated at the POCUS training in their host country only, and 22% (11/49) had their training only during orientation.

Forty-four percent (22/49) of clinical educators agreed or strongly agreed that after participating in the orientation training, they felt more comfortable using POCUS to make patient care decisions. This number increased to 24 of 39 (62%) after hands-on training at their clinical site, reflecting both an increase in comfort level and a smaller pool of respondents who had in-country training sessions.

How often do they use POCUS after training?

Eighty-six percent (42/49) of the clinical educators agreed or strongly agreed that POCUS was a valuable addition to their institutions. Fifty-seven percent (28/49) of clinical educators used POCUS more than once a week, including 18 clinical educators who used ultrasound every day. These clinical educators' specialties included obstetrics/gynecology/midwifery (6), family medicine (5), internal medicine (4) and pediatrics (3). Twenty percent of clinical educators (10/49) reported using ultrasound more than once a week but less than daily, 24% (12/49) used ultrasound more than once a month and 10% (5/49) used ultrasound less than once a month. Four clinical educators reported never using US at their site. Of the 21 clinical educators who had performed no independent scans before this training, 5 reported using POCUS at their sites every day or nearly every day, 4 reported using US multiple times per week and all 21 reported some US use at their sites.

What are the indications for POCUS across sites?

Seventy percent of clinical educators (34/49) reported using POCUS very frequently or often in aiding diagnosis, 45% (22/49) used POCUS frequently or often in determining treatment, 31% (15/49) used POCUS in monitoring the clinical course of patients and 16% (8/49) reported frequent use of POCUS for the procedural applications. Most of the clinical educators used the Vscans for multiple purposes, and as a result these numbers add up to more than 100%.

Clinical educators cited 14 different applications of POCUS that were most applicable in their clinical and teaching practice. The applications included trauma, cardiac and volume status, lung and pleural, first-trimester gynecology and obstetrics, second- and third-trimester obstetrics, liver, gallbladder, spleen, skin and soft tissue, musculoskeletal, ocular, deep vein thrombosis, abdominal aorta and kidney and bladder. Forty-five percent (22/49) of clinical educators stated that cardiac ultrasound was the top indication for ultrasound at their site (Table 2).

In response to identifying the top five clinical indications, the clinical educators most frequently listed cardiac US (40/49, 83%), followed by second- and third-trimester obstetrics exams (30/49, 63%), lung and pleura (28/49, 58%) serving as a replacement for chest X-ray, liver and spleen (20/49, 42%) and gynecologic and first-trimester obstetric exams (21/49, 44%) (Table 3).

Did clinical educators use POCUS to teach local health care providers?

Thirty percent (15/49) of the clinical educators reported very frequently and 20% (10/49) reported often using ultrasound to teach students and registrars in their institutions. Twenty-seven percent (13/49) reported sometimes using US for teaching (Table 3).

What are the main challenges for the use of POCUS?

Clinical educators were asked what they considered to be the greatest challenges to the use of POCUS. The most common perceived barrier reported was the lack of

Table 2. Frequency of point-of-care ultrasound use after training for clinical, teaching and research purposes

Ultrasound application	Frequently (>75%)	Often (50−75%)	Sometimes (25−49%)	Rarely (<25%)	Never (0)
Making clinical diagnoses	56%	20%	13%	9%	2%
Determining treatment	16%	34%	27%	7%	16%
Monitoring clinical course	7%	30%	16%	30%	19%
Procedural applications	7%	11%	20%	27%	34%
Educating colleagues	11%	23%	30%	7%	7%

Table 3. Clinical educators' role in teaching ultrasound (n = 40)

Teaching activity	n	%
To whom did you teach ultrasound?		
Physicians	19	46%
Registrars (residents)	20	49%
Medical students	27	66%
Clinical officers	17	42%
Nurses or midwives	10	25%
Clinical officer students	9	22%
Nursing students	4	10%
Other health care workers	1	2%
How many health professionals did you teach to use ultrasound?		
1–10	23	58%
11–20	10	25%
21–30	3	8%
>31	4	10%
How confident are you on continuity of ultrasound use after your departure?		
Very confident	12	29%
Somewhat confident	9	22%
Neutral	7	17%
Not very confident	10	24%
Not at all confident	3	7%
What are the most important indications for ultrasound training?		
Cardiac	33	83%
Second- and third-trimester obstetrics and gynecology	25	63%
Lung and pleura	23	58%
Liver and spleen	22	56%
First-trimester obstetrics and gynecology	18	44%

US knowledge (35/45, 78%), lack of time to scan (25/45, 44%), equipment security (being concerned about losing the device at the clinical site) (20/45, 44%)], Internet connection and technical assistance (for obtaining feedback on images) (16/45, 36%) and equipment problems (15/45, 33%). Three participants reported no barriers to using ultrasound at their sites. Of the 4 clinical educators who reported never using ultrasound at their site, 3 reported that lack of access to equipment was a barrier, and 1 reported that lack of US knowledge was a barrier (Table 4).

DISCUSSION

A survey of GHSP clinical educators who underwent a multiphase ultrasound training and had served as clinical educators in sub-Saharan Africa suggest that an innovative POCUS educational activity focusing on capacity building among GHSP clinical educators and local POCUS "champions"—clinicians who dedicated extra time to learning to use ultrasound as well as teach others—resulted in a successful program implementation. Survey responses indicate that the program increased US knowledge and skills among clinical educators, increased diagnostic utility of bedside US and provided an opportunity to enhance clinical teaching and improve on a sustainable partnership between the United States and institutions in the host countries. This program has created a meaningful way of enabling faculty to provide improved clinical care across a variety of specialties by bridging the gap caused by lack of access to medical imaging, especially cross-sectional imaging, in resource-limited hospitals.

Before the ultrasound training provided during orientation and on-site, 21 clinical educators (42%) had not performed a single independent US scan. However, after receiving the training, all 21 were using US at their sites. Of all survey participants, only 4 reported never using ultrasound at their sites, and 3 of these reported difficulties accessing functional ultrasound equipment. This suggests that intensive, time-limited but focused trainings along with remote technical assistance can provide clinicians with the knowledge and support to use ultrasound for certain indications in resource-scarce settings. In addition, the preparation of clinical educators who will work in the developing world should emphasize cardiac, pulmonary and liver and spleen US imaging and interpretation. Among those who are involved in maternity care, including midwives, and training in the use of POCUS, targeted second- and third-trimester applications are a priority. Eighty-six percent of responding clinical educators reported POCUS was very valuable to their host institutions. This opinion is supported by the number of clinical educators who used ultrasound at their sites and the relative lack of other imaging modalities.

In evaluating two aspects of ultrasound training—(i) pre-departure training during orientation and (ii) on-site training at the host African institutes, we found that more than half of clinical educators reported a lack of confidence in performing ultrasound after the first training. This could very well be explained by the time constraints during orientation and competing agenda of other important topics to address before departure (coursework in tropical/infectious disease and human immunodeficiency virus/tuberculosis treatment, procedure updates and pre-departure human resource topics, insufficient time for hands-on practice, priority of learning and adoption of other skills before departure and the learning curve required from learning to practicing ultrasound). We also noticed that a smaller number of GHSP clinician educators received both pre-departure and in-country training sessions and that a significantly higher percentage of those receiving in-country training reported comfort in clinical decision making. Finally, some of the respondents (obstetricians) who already had extensive experience and the training session may not have found any significant impact on their already significant comfort level with using ultrasound to make clinical decisions.

Barriers to ultrasound use identified in previous studies, such as equipment security and self-reported

Table 4. Challenges and barriers in integrating POCUS into patient care (n = 49)

Barrier	Always	Frequently	Sometimes	Rarely	Never
Equipment					
US machine broken	2%	2%	0	7%	89%
US machine lost or stolen	2%	0	0	4%	94%
Upload cable missing or broken	7%	0	2%	4%	87%
Inadequate battery life	2%	2%	22%	28%	46%
Difficulty charging	2%	0	11%	26%	61%
Lack of US gel	2%	17%	33%	20%	28%
Inability to clean US machine	4%	0	15%	30%	50%
Ultrasound knowledge					
Lack of knowledge using POCUS	11%	20%	36%	27%	7%
Lack of knowledge interpreting images	21%	30%	25%	16%	9%
Logistics					
Lack of time	9%	24%	36%	24%	7%
Liability concerns	2%	2%	2%	20%	73%
Difficulty with documentation	2%	0	16%	31%	51%
Inability to darken room	0	2%	16%	36%	47%
Lack of patient privacy during scans	7%	13%	22%	22%	36%
Patient refusal	0	0	2%	22%	76%
Resistance from hospital administration or co-workers	0	4%	2%	13%	80%

POCUS = point-of-care ultrasound; US = ultrasound.

lack of knowledge, were also found in this study. Given that a third of clinical educators reported lack of Internet access as a barrier to using US at their sites (presumably by preventing the sharing of ultrasound videos with distant mentors), this may reflect the importance as well as the challenges of virtual assistance in programs such as this. GHSP clinical educators reached consensus on the need for and the high-yield applications of this POCUS integration.

Lessons learned and recommendations

Integrating POCUS into the GHSP is unique, and its pre-departure trainings allow GHSP clinical educators to familiarize themselves with the concepts, basics and ultrasound indications. Furthermore, in-country one-to-one training is providing an optimal environment for bedside training in their host countries. Moreover, the program is structured in a way that they can apply what they learn to various clinical applications, such as diagnostics and procedural and clinical management. Training the host country counterparts and local trainees is also contextualized, and GHSP clinical educators continue to implement POCUS training relevant to their field of clinical practices. Key features of the program include the intentional pairing of the GHSP and African clinicians in partnering and implementing the program, emphasis on continuity of onsite training and a sustained commitment over time. POCUS also enhances clinical teaching and provides an opportunity for sustainable partnership between institutions and personnel in the host countries and those in the United States.

This innovative approach in East Africa has been successful in delivering imaging resources to meet the needs of those clinicians and institutions. Challenges, such as comprehensive training and providing ultrasound devices, are being addressed. It is therefore recommended that this program be replicated in other institutions in African countries and that regional collaboration be strengthened in the establishment of such programs.

CONCLUSIONS

A survey of GHSP clinical educators who underwent a multiphase POCUS training suggests that the educational program increased POCUS knowledge and skills among clinical educators, increased diagnostic utility of POCUS, provided an opportunity to enhance clinical teaching and has led to a sustainable partnership between the United States and institutions in the host countries. This educational program, and the materials developed to support it, can serve as a resource for academic institutions and organizations participating in clinical care and education in resource-limited communities.

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Conflict of interest disclosure—The authors declare that they have no competing interests.

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