A Practical Guide to Self-Sustaining Point-of-Care Ultrasound Education Programs in Resource-Limited Settings

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The value of point-of-care ultrasound education in resource-limited settings is increasingly recognized, though little guidance exists on how to best construct a sustainable training program. Herein we offer a practical overview of core factors to consider when developing and implementing a point-of-care ultrasound education program in a resource-limited setting. Considerations include analysis of needs assessment findings, development of locally relevant curriculum, access to ultrasound machines and related technological and financial resources, quality assurance and follow-up plans, strategic partnerships, and outcomes measures. Well-planned education programs in these settings increase the potential for long-term influence on clinician skills and patient care. [Ann Emerg Med. 2014;64:277-285.]

A podcast for this article is available at www.annemergmed.com.

BACKGROUND

In resource-limited settings, diagnostic imaging modalities are often constrained, frequently limited to plain film radiography. A number of articles have demonstrated the value of point-of-care ultrasonography in such settings. Point-of-care ultrasonography provides a low-cost, efficient method to aid in the diagnosis and management of many conditions in resource-limited settings, including maternal and peripartum care, heart failure, diarrheal illness, tuberculosis, and trauma. It can also decrease procedural complications. It allows one caregiver to perform, interpret, and act on a diagnostic test, which can save both time and resources.

Recent articles have described the use of point-of-care ultrasonography in Rwanda, Zambia, Liberia, Ghana, Haiti, and Tanzania. As ultrasound machines become more portable and affordable, coupled with increasing capacity to transmit digital images for remote review, the introduction of point-of-care ultrasonography may have a transformative effect on health care in resource-limited settings. As a result, there is increasing interest in delivering ultrasound education programs in low- and middle-income countries. However, there is little published guidance on how to establish effective and sustainable point-of-care ultrasound programs in resource-limited settings. In accordance with available literature and international experience of the authors, we aim to provide a practical overview of how to design and implement an ultrasound education curriculum leading to the establishment of a sustainable resource-limited setting ultrasonography program.

Our approach to program development is directed at achieving a transition from initial educational initiatives, likely supported by educators primarily from outside the training site, to the development of a stable, locally administered, point-of-care ultrasonography program with the capacity to provide training for other users in the resource-limited settings. This model has been used in a range of locations and disciplines of medicine and surgery. We emphasize the importance of beginning this process with a needs assessment to ensure a locally appropriate curriculum, and describe other core aspects of program development, including trainee selection, essential partnerships, equipment selection and maintenance, initial training implementation, competence assessment, research, funding, and logistics.

NEEDS ASSESSMENT

The critical first step to resource-limited settings program development is a thorough needs assessment, which ensures that new ultrasound programs will be tailored to local capacity and clinical requirements. Factors to consider include the patient population, prospective trainees, local and regional resources of the health care system, and identification of other stakeholders. Figure 1 illustrates an overview of the needs assessment process and pathways to program development.

Defining Objectives

The needs assessment for a point-of-care ultrasound program aims to define and prioritize clinical needs and anticipate the resources required to meet them. Unmet clinical needs and objectives can be determined by collecting...
information from stakeholders, including patients, clinicians, administrators, and government agencies. Needs assessment methods might include questionnaires, structured interviews, focus group discussions, direct observation of clinicians in their practice setting, and patient chart and health statistics review. Consulting with leadership from the hospital, health system, and
relevant specialties to help define need is recommended.²⁸,²⁹ Appendix E1 (available online at http://www.annemergmed.com) contains an example of a needs assessment tool developed by the lead author that has helped inform point-of-care ultrasound training program development in Rwanda, Colombia, and Brazil.³⁰-³²

Prospective Trainees

A central goal of needs assessments for point-of-care ultrasound programs is to better understand the target group of trainees and their local practice environment. Information about potential trainees’ experience with ultrasonography—didactic, practical, or self-taught—will guide curriculum complexity. This assessment should identify ultrasonographic and diagnostic imaging capabilities at trainee practice sites. Understanding whether point-of-care ultrasonography will provide an additional revenue stream may affect trainee interest. Language preferences and the need for interpreters or trainers proficient in the local language should also be considered. Specific ultrasound applications that prospective trainees anticipate being most relevant to their practice can be delineated, as well as perceived barriers to learning and using ultrasonography. Common barriers include lack of training, time or financial constraints on the part of trainees and teachers, insufficient continuing education and feedback, lack of machines, lack of local expertise for quality assurance and oversight, inadequate machine maintenance and repair, resistance from other specialty clinicians, and the absence of reliable electrical power or other ancillary supplies, such as ultrasound gel.

Patient Population, Burden of Disease, and Health System Capacity

The needs assessment should identify hospital or health center resources and referral patterns. Consideration of the patient population served by the intended trainees, common presentations, local burden of disease, standards of care, and availability of medical and surgical resources is imperative. An effective point-of-care ultrasound curriculum focuses on identification of diseases that are common and treatable, and for which timely diagnosis can positively affect patient care. Conversely, teaching point-of-care ultrasound applications that would be only infrequently used in the local patient population may not be necessary. The entire catchment area of the healthcare system should be considered. The World Health Organization (WHO) Global Burden of Disease estimates or reports issued by a national ministry of health may be helpful in determining this information.³³

Programs must also consider how a point-of-care ultrasound application will intersect with local capacity and resources. The role of specific applications may change, depending on local treatment or referral options, and differ from application use in high-income countries. For example, without vascular surgery services, identifying a symptomatic abdominal aortic aneurysm may affect clinical reasoning but not trigger an algorithm leading to surgical repair. Detection of rheumatic heart disease with point-of-care ultrasonography may not prompt valve replacement but may increase diagnostic certainty and assist with optimizing medical management. Teaching applications with no local indication misuses resources. This underscores the importance of understanding the specific practice settings in which point-of-care ultrasonography will be used; the resources available have potentially unique implications for the curriculum, proctoring goals after training, and choice of equipment.

Key Partnerships

Early identification and collaboration with stakeholders at a potential training site is essential. This may require planning with trainees, representatives from other specialties that use ultrasonography, hospital leadership, and regional or national health authorities. This is similar to other practice environments in which changing the diagnostic paradigm may impinge on other specialties or norms. Specific individuals to involve might include graduate medical education leadership, administrators of professional development programs, clinical service directors, professional society leadership (eg, national ultrasound society), or officials in a department or ministry of health. Involving these stakeholders early in the planning process provides a platform for relationship development and for buy-in to increase.³⁴ Support and approval from partners beyond the trainee group is critical for program implementation and sustainability. In our experience, gaining such approval may require months to years of planning and negotiation.

EQUIPMENT

Acquiring and maintaining an ultrasound machine is potentially the most costly element of a point-of-care ultrasound program. Recognizing underused ultrasound machines represents one of the best opportunities to develop a training program. Alternatively, machine donations may be solicited from industry or charitable organizations that specialize in redistributing equipment; proposing a resource-limited setting educational initiative to machine manufacturers or distributors may afford them market exposure and insight in exchange for equipment.³⁴ Regardless of approach, it is imperative to ensure that prospective trainees have ongoing access to machines. As a physical and intellectual skill, point-of-care ultrasonography requires practice to ensure retention. Without this assurance, educational initiatives are unlikely to prove sustainable and may be an ineffective use of resources.

Machine Capability

If acquiring a new machine is an option, consider machine features, transducer selection, availability of ultrasound gel and cleaning supplies, and options for equipment service, safety, and storage. Training initiatives with access to existing machines may be at a significant financial and logistic advantage. However, a critical analysis of existing equipment should be made because outdated, damaged, or partially functioning equipment can be
an impediment to newly trained clinicians in establishing good ultrasound scanning practices. In particular, this machine survey should include an assessment of the transducers available because these may influence which applications can be included in the curriculum.

The capacity of machines to store images and save to external media or a network is vital if a remote image review is planned. The reliability of local power, battery life, and surge protection must be considered when choosing between plug-in versus portable battery-operated units. The anticipated practice environment may also influence machine selection. Hospital-based programs may prefer cart-based ultrasound platforms because these can be more durable and less prone to theft. Training programs for clinicians practicing in more remote or austere settings are likely to require smaller, more portable units.

Theft or damage to a machine may squander investments of labor and resources. Machines in low- and middle-income countries may also be diverted from their intended use for private gain. Program leadership must work with local practice administrators to determine how safe machine storage can be balanced with accessibility. Options might include placement in a highly visible area with consistent observation (such as an emergency or triage area), physically securing the machine, or storage in a locked room.

**Machine Support**

If program leadership can select a machine, an assessment of manufacturers’ history of durability, as well as their local infrastructure for technical support and repair, will be valuable. It is important to know who will own and care for the equipment within an institution. Ultrasonography may fall into disuse when novice users encounter even small technical problems or if technologists are not available for common repair issues. A local staff member should be identified to take responsibility for machine upkeep and security and to liaise with technical support. Acquiring machines with extended service packages, or knowing who services a machine, may be crucial to program success.

**TRAINING PROGRAM IMPLEMENTATION**

**Trainee Selection**

After data collection from a needs assessment and machine survey, planning for an ultrasound training program can begin. We find that prospective trainees often prove enthusiastic participants and that a local challenge to program implementation is securing official support from hospital or regional and national health system leadership. These local partners may wish to exercise substantial control over selection of a trainee cohort, and most steps to operationalize a training plan will also be contingent on their approval. Trainers may need to allow considerable time to secure this support.

Specific factors to consider during start-up include time and educational resources available to trainees. In particular, if trainees are in practice, it is important to secure sequestered time in which they will be free from clinical responsibilities and able to concentrate on ultrasound training. Providing learners with resources such as slide sets, image libraries, handbooks, and online references can be helpful because access to these materials may otherwise be limited.

In addition, program leadership should attempt to identify clinicians who are particularly interested in incorporating point-of-care ultrasonography in to their practice as potential ultrasound leaders. Strategic cultivation of “local champions” who will use point-of-care ultrasound regularly, and ultimately provide training to colleagues, will fuel the long-term sustainability of a program. We use this approach, commonly termed “train the trainer,” in our program development. These individuals may be recognized during the needs assessment or through referral from supervisors, or selected as a subset of the trainee cohort. Ideally, this group will include trainees from each training site or region. We target these potential trainers for additional education in advanced point-of-care ultrasound applications and the presentation skills, hands-on teaching techniques, and digital image management commonly used in ultrasound education.

Finally, planning may need to consider the projected stability of the trainee group. Information about health system and changes that might lead to relocations or disrupt the workforce is valuable. Local physician turnover, a common issue in many resource-limited settings, may challenge program continuity. It is optimal for trainees to be in a clinical setting in which they have the opportunity to practice and apply their newly acquired skills after the training program.

**Trainer Team**

A pool of experienced trainers is usually necessary to help with initial training efforts. If local ultrasound educators are available at a potential training site, we find it desirable to involve them as much as possible both to reduce the cost of external trainers and to foster the growth of the local ultrasound community. Some additional external trainers may be necessary. Ultrasound educators who have experience in resource-limited settings and fluency in the local language are ideal. A core trainer group composed of physicians with substantial experience in point-of-care ultrasound is best. However, there are additional applications (eg, advanced obstetric assessments, para-aortic lymph node evaluation, liver or splenic lesions) in which it may also be helpful to seek the assistance of obstetricians, cardiologists, radiologists, etc. A small number of ultrasound courses provide instruction in applications particularly relevant to resource-limited settings, and this can be helpful to prospective trainers.

Although it would be ideal to have a limited number of trainers on site continuously, funding and time constraints may require intermittent visits by groups of trainers during the course of a program. When training or follow-up is periodic, there should be an emphasis on frequent reinforcement of key concepts. Ongoing availability of trainers, even remotely, is an important element of providing continuity, troubleshooting, and consultation for challenging cases.
The optimal duration of training initiatives is not established and is currently under further investigation by the coauthors. Variables such as preexisting skills, curriculum content, and opportunity for practice and image review play a role. In our experience, substantive skill retention has been achieved in a 6-month training model.31

Curriculum

The curriculum should take a programmatic approach. Participants should not only learn basics of machine use, image acquisition, and interpretation but also program management components such as image storage, review, quality assurance, and machine maintenance. Devoting time to these aspects of an ultrasound program increases the likelihood of creating an enduring program.

The needs assessment can help define a clear and thorough scope of practice for the trainee audience. Topics relevant to local practitioners, their patients and health system should be selected for the curriculum (Figure 2). If trainees are drawn from more than 1 practice domain, it will be necessary to provide training in niche applications relevant to each group, in addition to the basic ultrasound skills needed by all. Trainees should acquire the core skills of point-of-care ultrasound training: anatomic knowledge, image acquisition and interpretation, and the ability to integrate interpretation with clinical decisionmaking.

Point-of-care ultrasound curricula from high-income settings are not necessarily the default basis for curriculum design in a resource-limited setting. For example, ultrasonographic findings of tuberculosis, parasitic diseases, and HIV may be more important to teach in developing settings in which these diseases have increased prevalence. Recognition of a pericardial effusion, ascites, or para-aortic lymphadenopathy (eg, as part of the focused assessment with sonography for HIV-associated tuberculosis [FASH] examination) will have different clinical implications in low- and middle-income countries. Emergency medicine training programs in the United States provide little instruction in third-trimester obstetric ultrasonography, but in low- and middle-income countries, peripartum mortality may be one of the greatest causes of potential years of life lost, and instruction in third-trimester ultrasonography may be especially valuable.36,37 Fetal sex determination is an advanced application of ultrasonography and rarely necessary for obstetric care. In some resource-limited settings in which strong sex preferences exist, risks of identifying the sex may outweigh benefits, so including this in the point-of-care ultrasound curriculum should be carefully considered.38,39

Although the WHO has proposed a standardized diagnostic ultrasound curriculum, in current practice there is no standard.40 Program leaders may elect to implement a curriculum drawing on examples from other resource-limited settings, and the International Federation for Emergency Medicine is in the process of generating guidelines for point-of-care ultrasound programs in resource-limited settings. Standardized curricula may help ensure adequate rigor and depth for trainees and potentially allow certification from a national or international professional organization.

Assessment

Ongoing follow-up and assessment allows continual reinforcement of trainees’ skills and correction of mistakes. Evaluation of cognitive skills can be achieved through written tests, visual pattern recognition is best assessed by image review, and practical testing is necessary for evaluation of psychomotor skills. To demonstrate trainees’ progress, examinations may occur at the beginning, end, and intervals during the training period.

<table>
<thead>
<tr>
<th>Ultrasound basics</th>
<th>Soft tissue and musculoskeletal</th>
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<tbody>
<tr>
<td>- Machine introduction</td>
<td>- Abscess</td>
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<tr>
<td>- Knobology</td>
<td>- Cellulitis</td>
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<tr>
<td>- Basic physics</td>
<td>- Fracture</td>
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<td>- Probe selection</td>
<td>- Foreign body</td>
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<td>- Data entry</td>
<td>- Joint effusion</td>
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<td>Cardiac</td>
<td>- Pyomyositis</td>
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<td>- Pericardial effusion</td>
<td>- Obstetric</td>
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<td>- Ejection fraction</td>
<td>- Pregnancy location</td>
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<tr>
<td>- Valvular disease (rheumatic heart disease)</td>
<td>- Gestational age</td>
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<td>- Right ventricular dysfunction</td>
<td>- Fetal lie</td>
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<td>Lung</td>
<td>- Placental assessment</td>
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<td>- Pleural effusion</td>
<td>- Gynecologic</td>
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<td>- Pulmonary edema</td>
<td>- First-trimester emergencies (fetal viability, ectopic)</td>
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<td>- Pneumothorax</td>
<td>- Pelvic masses/abscess</td>
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<td>- Pneumonia</td>
<td>- Aorta</td>
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<td>- Abscess/cavitary lesions</td>
<td>- Aortic aneurysm</td>
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<td>Abdomen</td>
<td>- Aortic dissection</td>
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<td>- Hemoperitoneum</td>
<td>- Para-aortic lymphadenopathy</td>
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<td>- Ascites</td>
<td>- Vascular</td>
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<td>- Hepatic lesions</td>
<td>- Deep venous thrombosis</td>
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<td>- Splenic lesions</td>
<td>- Inferior vena cava</td>
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<tr>
<td>Renal</td>
<td>- Procedural and other</td>
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<tr>
<td>- Hydronephrosis</td>
<td>- Pericardiocentesis</td>
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<td>- Renal masses</td>
<td>- Thoracentesis</td>
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<td>- HIV nephropathy</td>
<td>- Paracentesis</td>
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<td>Gastrointestinal</td>
<td>- Arthrocentesis</td>
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<td>- Bowel obstruction</td>
<td>- Fracture reduction</td>
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<td>- Appendicitis</td>
<td>- Vascular access</td>
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<td>- Intussusception</td>
<td>- Nerve blocks</td>
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<tr>
<td>- Ocular</td>
<td>- Ocular</td>
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<tr>
<td>- FASH examination</td>
<td>- FASH examination</td>
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Figure 2. Potential ultrasound curricular topics.
Objective structured clinical examinations allow assessment of the trainee’s ability to perform an ultrasonographic application (see Appendix E2, available online at http://www.annemergmed.com, for a sample objective structured clinical examination developed by the authors that has been used in several US and international settings). Follow-up should assess not only trainee improvement but also relevance of the curriculum. Over time, some point-of-care ultrasound applications may prove more or less important for users. The curriculum focus may need to be altered for the remainder of the course or subsequent trainee groups.

Ultimately, competence rests on the ability to accurately incorporate point-of-care ultrasoundography in patient care. Competence is not established solely by completing a given number of studies or training duration. An overall determination of competence is best derived from a mixture of knowledge testing, objective structured clinical examinations, direct observation, and image review.

**Quality Assurance**

Quality assurance is an essential element of any ultrasound program. It is required to evaluate operator competence and is imperative for patient safety. Initial oversight with quality assurance provided by remote experts may be necessary, but the ultimate goal should be to transfer quality assurance responsibilities to local users.

A process for quality assurance can be designed in concert with the educational curriculum. Program planning will have determined whether trainees will record their ultrasound studies. The infrastructure for image storage will have ramifications for the quality assurance process. Quality assurance based on digital images may require a secure “middleware” or cloud-based product to allow orderly image management and review.

Ideally, quality assurance will be provided continuously, although limited resources may dictate periodic review. Quality assurance can be performed at the site at which ultrasound is performed if there is sufficient local expertise, or remotely by external experts. Remote quality assurance can be achieved by a variety of transfer protocols, but the presence of reliable Internet connectivity is essential. If the process of transmitting ultrasonographic images is not feasible or time burdens clinicians, they may elect not to participate in the quality assurance process. As Internet access becomes increasingly common in resource-limited settings, remote quality assurance may become routinely achievable, although this places significant demands on distant quality assurance reviewers. If quality assurance is performed remotely or intermittently, there should be consideration of mechanisms for urgent feedback for interventions in case of important errors identified on review.

**RESEARCH**

Despite the potential of point-of-care ultrasound in resource-limited settings, few studies have investigated its effect on improving diagnosis or health outcomes. A smaller number have evaluated the effect of ultrasonography performed by a local clinician, rather than a visiting expert, or specifically assessed outcomes of ultrasound educational initiatives. Recent reviews have highlighted the importance of integrating outcomes research with ultrasound use in resource-limited settings and program development.

Point-of-care ultrasound use may be strengthened if educational initiatives are linked with research and self-assessment. Identification of research questions and study design can begin early in program development. Involving local partners at the outset may facilitate long-term goals of transitioning the research program to their direction.

Research in a resource-limited setting poses a variety of operational and ethical challenges. The research design and statistical methods may need to reflect that the subject of analysis in many point-of-care ultrasound studies is the operator, not the patient; this underscores the importance of a stable trainee cohort. Other challenges of conducting ultrasound research may pertain to limited infrastructure or the nature of research questions. For example, studies that call for remote review of images will hinge on adequate Internet connectivity and electrical power, and limited medical records may impede data extraction.

Given the scarcity of research on the subject of ultrasound training and use in resource-limited settings, research questions are ideally directed to the paramount questions of the field: what is the effect of a point-of-care ultrasound program on health outcomes and clinical decisionmaking? Is point-of-care ultrasonography cost-effective in resource-limited settings? What factors allow programs to become effective and sustainable?

**FUNDING**

The success of a point-of-care ultrasound training program is contingent on securing adequate funding. Implicit in the program design we advocate is the notion that short (1- to 3-day) courses without follow-up are incompatible with the goal of a self-sustaining program in a resource-limited setting. Even with trainers willing to dedicate time and effort to the project, long-term training programs may have significant costs for travel, lodging, and equipment. Before program implementation, financial resources should be sufficient to fund the costs of trainers and trainees participating in an initial course and relevant follow-up (Figure 3). Depending on the program, budgets may need to include the costs of temporarily relieving trainees from their clinical responsibilities (or funding individuals assuming their responsibilities), as well as their travel and housing costs.

Funding sources might include institutions associated with trainers or trainees, grants or in-kind donations to individual participants, government, foundation or industry grants or donations. Instructors may be willing to provide their time and travel expenses. If the group sponsoring the training is organized as a nonprofit organization, it may be able to provide volunteers with a charitable tax receipt. Support from ultrasound equipment manufacturers or their local distributors may be particularly valuable for larger, centralized training courses with trainees who will need multiple ultrasound machines for hands-on practice.

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Resource-limited settings are emerging markets for low-cost ultrasound systems, and industry partners may be motivated to support training programs. Many funding agencies will expect that proposals include a plan to achieve financial and logistic independence.

LOGISTICS

If the training program is being delivered in a foreign country, planning will need to account for the accessibility and safety of the proposed site. Ground transportation may be affected by road conditions and weather, and choosing private or public transportation will modify cost, efficiency, and safety. Local government requirements for work, travel, and research must be addressed well in advance of implementation and may include medical licensing, work permits, visas, vaccination, and prophylaxis against local diseases.

Figure 3. Potential program costs.

<table>
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<tr>
<th>Initial</th>
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<tr>
<td>• Machine acquisition</td>
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<td>• Middleware image management solution</td>
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<td>• Training site</td>
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<td>• Facility rental</td>
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<tr>
<td>• Models</td>
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<td>• Ancillary supplies, eg, ultrasonographic gel, linens, power strips</td>
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<tr>
<td>• Trainers</td>
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<td>• Travel and lodging</td>
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<td>• If international:</td>
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<td>• airfare</td>
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<td>• visas, local medical licensing</td>
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<td>• immunizations and prophylaxis</td>
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<td>• travel insurance</td>
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<tr>
<td>• Trainees</td>
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<td>• Travel and lodging</td>
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<td>• Clinical replacement</td>
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<td>• Educational materials</td>
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<td>• Books, online resources</td>
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<tr>
<td>• Research</td>
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<tr>
<td>• Capital costs</td>
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<td>• Administrative support</td>
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<td>• IRB/regulatory application</td>
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<td>Ongoing</td>
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<td>• Machine maintenance</td>
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<td>• Electricity</td>
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<td>• Internet connectivity</td>
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<tr>
<td>• Cloud computing services</td>
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<tr>
<td>• Follow-up assessments</td>
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<tr>
<td>• Travel and lodging</td>
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<tr>
<td>• Longitudinal training</td>
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<td>• Quality assurance personnel time</td>
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If lodging and food for trainers and trainees will be provided for the program, this needs to be negotiated in advance of any programming. The location for the training program also deserves careful consideration; training can be provided at a centralized site, trainee practice settings, or a mixture of both. A central site allows consolidation of teaching effort and trainee networking but may constrain attendance; instruction at trainees’ clinical settings ensures they can learn on their institutional equipment, and trainers may tailor teaching to that practice. Local geography, program goals, and scope may dictate the best approach. We have successfully used a model with an initial centralized training, followed by practice site visits for reinforcement.30,31

Course organizers should also consider how to obtain patients or models for hands-on practice. Cultural norms may preclude employing members of the local community as models, performing educational ultrasonography on patients, or having trainees perform practice scans on other trainees. Therefore, a method for identifying individuals for hands-on practice should be in place.

CONCLUSION

We describe practical approaches to implementing a sustainable, resource-limited setting, point-of-care ultrasound training program. The issues detailed are not exhaustive but represent core factors to consider in program development and delivery. Needs assessments are a critical first step to identify the objectives of a training program and direct optimal resource allocation. Ensuring access to ultrasound machines, reliable power, and Internet access are important elements of a successful program. A curriculum relevant to local needs and practice patterns, with a plan for ongoing support and assessment, is necessary to engage trainees and foster sustainability. Quality assurance systems must be created to ensure competence and patient safety. Identifying funding sources, creating local partnerships, building a strong trainer team, and careful planning for logistic issues are all elements to success. Establishing a research agenda and program evaluation structure will help guide future educational initiatives and assist the sustainable growth of point-of-care ultrasonography in resource-limited settings.
of interest guidelines (see www.icmje.org). The authors have stated that no such relationships exist.

Publication dates: Received for publication July 30, 2013. Revision received December 16, 2013. Accepted for publication April 2, 2014. Available online May 27, 2014.

REFERENCES


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APPENDIX E1.

Ultrasound needs assessment tool

Name: ____________________________  □ Male  □ Female
Date: ____________________________

1. Primary clinical practice location:  □ capital city  □ other city □ town □ rural □ remote
2. Setting: □ district hospital □ private hospital □ private clinic □ rural clinic □ other________
3. Highest level medical training: □ physician □ nurse □ midwife □ med student □ other______
4. Specialty: □ general medicine □ surgery □ obstetrics/gynecology □ pediatric □ other_______
5. Years in clinical practice: □ < 1 year □ 1-5 years □ 5-10 years □ > 10 years
6. Check all imaging available in your setting: □ radiography □ ultrasonography □ CT scan □ MRI □ none
7. Can you obtain ultrasound studies at another facility?
   7a. □ no □ yes If yes, where? ________
   7b. If yes, how long does it take to transfer a patient and obtain the ultrasonography? ________
8. Have you ever used an ultrasound machine before? □ no □ yes
8a. If yes, total number independent ultrasound scans: □ 0-10 □ 10-20 □ 20-40 □ >40
8b. Please check all the types of ultrasonography you have done:
   □ trauma □ echocardiography □ OB first trimester
   □ OB second and third trimester □ liver □ gallbladder
   □ skin findings □ deep vein thrombosis □ kidney
   □ volume status □ bladder evaluation □ spleen
   □ nerve blocks □ procedures □ vascular access
   □ musculoskeletal □ abdominal aortic aneurysm
8c. Please list all the types of ultrasonography that you feel comfortable performing and interpreting independently: __________________________
9. Have you had formal instruction in ultrasonography? □ no □ yes
9a. If yes, total hours of all ultrasound lectures: □ 0 □ 1-5 □ 5-15 □ >20
9b. If yes, total hours of all ultrasound practical use: □ 0 □ 1-5 □ 5-15 □ >20
10. What is your interest level in learning ultrasonography? □ none □ low □ medium □ high
11. Over the next 3 to 6 months, how much time could you dedicate to learning ultrasonography?
   □ no time □ <4 hours per week □ 4-10 hours per week □ >10 hours per week
12. What are barriers preventing you from learning ultrasonography? (check all applicable)
   □ limited time □ no immediate financial incentive
   □ no machines □ no teachers □ no interest
13. In addition to hands-on teaching, do you have interest in learning by computer lecture?
   □ no interest □ low interest □ medium interest □ high interest □ not possible in my setting
14. From the list below, please write in, in order of importance, the top 3 potential types of ultrasonography in your practice:
   1. __________________________ 2. __________________________ 3. __________________________
   □ trauma □ echocardiography □ OB first trimester
   □ OB second and third trimester □ liver □ gallbladder
   □ spleen □ nerve blocks □ skin findings □ kidney
   □ volume status □ bladder evaluation □ deep vein thrombosis □ procedures □ vascular access
   □ musculoskeletal □ abdominal aortic aneurysm
15. Are you satisfied with formal ultrasonographic results you obtain in your practice now? □ No □ Yes
15a. If no, what are the issues?____________________
16. What percentage of time do you believe bedside ultrasonography will change patient management?
   □ no change □ < 25% of time □ 25% to 50% of time □ > 50% of time □ not sure
17. What interest do you expect your patients to have in bedside ultrasonographic availability?
   □ no interest □ low interest □ medium interest □ high interest □ not sure
18. What is the availability of the following types of surgery at your hospital?
   18a. general surgery: □ none □ yes during day, none at night □ yes, always
   18b. cesarean section capacity: □ none □ yes during day, none at night □ yes, always
   18c. vascular surgery: □ none □ yes during day, none at night □ yes, always
19. Please check all procedures that you perform yourself:
   □ vaginal delivery □ cesarean delivery □ chest tube
   □ pericardiocentesis □ nerve blocks □ thoracentesis
   □ paracentesis □ central venous lines
   □ incision/drainage □ general surgery □ lacerations
20. How many antenatal visits per week do you see? □ 0-5 □ 5-10 □ 10-20 □ >20
21. At your practice site, do you have reliable:
   a. power □ no □ yes
   b. Internet □ no □ yes
   c. telephone □ no □ yes
22. If you refer a patient for further care, can you follow up on their outcome? □ yes □ no
22a. If yes, how do you follow up?____________________
23. Can you start and manage patients receiving anticoagulation in your setting? □ yes □ no
24. Please feel free to include questions or comments on any questions in the space below:
Questions to be discussed in small focus groups or one-on-one with physicians/clinicians:

Point-of-care, clinician-performed ultrasonography is used to answer specific diagnostic questions.

The following series of questions is designed to assess whether teaching certain bedside ultrasound applications will assist in your diagnostic capacity and whether it will change management for your patients.

In general, how would you handle the following conditions?

1. What would you do if bedside ultrasonography helped you confirm the presence of free fluid in the abdomen of a hemodynamically unstable trauma patient?
2. What would you do if bedside ultrasonography helped you confirm the presence of free fluid in the abdomen of a stable trauma patient?
3. What would you do if bedside ultrasonography helped you confirm the presence of a pneumothorax in a patient who presents with shortness of breath?
4. What would you do if bedside ultrasonography helped you confirm the presence of a large nontraumatic pleural effusion in a patient who presents with shortness of breath?
5. What would you do if bedside ultrasonography helped you confirm the presence of a pericardial effusion with early tamponade physiology in a patient presenting with shortness of breath?
6. What would you do if bedside ultrasonography helped you confirm the presence of dilated cardiomyopathy and a decreased ejection fraction in a patient with volume overload on examination?
7. What would you do if bedside ultrasonography shows free fluid in the pelvis and no evidence of an intrauterine gestational sac in a patient with diffuse lower abdominal pain who reports her last period was 2 months ago and has a positive pregnancy test result?
8. What would you do if bedside ultrasonography helped you confirm the presence of no fetal heart rate in a patient who is 12 weeks pregnant?
9. What would you do if bedside ultrasonography helped you confirm the presence of more than 1 fetus in a patient who is 38 weeks pregnant?
10. What would you do if bedside ultrasonography helped you confirm the presence of a low-lying placenta in a patient who is 39 weeks pregnant?
11. What would you do if bedside ultrasonography helped you confirm the presence of a nonvertex presentation in a patient who is in the early stages of labor?
12. What would you do if bedside ultrasonography helped you confirm the presence of an enlarged and irregular liver in a patient presenting with right upper quadrant pain and mild jaundice?
13. What would you do if bedside ultrasonography helped you confirm the presence of a liver abscess?
14. What would you do if bedside ultrasonography helped you confirm the presence of ascites in a patient with abdominal pain and a long history of alcohol abuse?
15. What would you do if bedside ultrasonography helped you confirm the presence of a liver hydatid cyst?
16. What would you do if bedside ultrasonography helped you confirm the presence of cholecystitis in a patient presenting with right upper quadrant pain and fever?
17. What would you do if bedside ultrasonography helped you confirm the presence of cholelithiasis in a patient presenting with recurrent episodes of epigastric pain, worse after eating?
18. What would you do if bedside ultrasonography helped you confirm the presence of splenomegaly in a patient with a history of night sweats and fever?
19. What would you do if bedside ultrasonography helped you confirm the presence of hydropnephrosis in a patient with severe right flank pain and no fevers?
20. What would you do if bedside ultrasonography helped you confirm the presence of a renal abscess?
21. What would you do if bedside ultrasonography helped you confirm the presence of an abdominal aortic aneurysm in a hypotensive patient with abdominal and back pain?
22. What would you do if bedside ultrasonography helped you confirm the presence of an aortic dissection in a patient with a history of hypertension who presents with syncope and abdominal pain?
23. What would you do if bedside ultrasonography helped you confirm the presence of a deep vein thrombosis in a patient with unilateral leg swelling and tenderness?
24. What would you do if bedside ultrasonography helped you confirm the presence of significant dehydration in a patient with sepsis?
25. What would you do if bedside ultrasonography helped you confirm the presence of significant dehydration in a patient with a history of dizziness after persistent vomiting and diarrhea?
26. What would you do if bedside ultrasonography helped you confirm the presence of a distended bladder in a patient who presents with no urine output for 24 hours?
27. What would you do if bedside ultrasonography helped you confirm the presence of a skin abscess in a patient with focal erythema, induration, and tenderness on their extremity?