How Relevant Is Point-of-Care Ultrasound in LMIC?

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The trajectory of medical ultrasound has been marked by quantum decreases in size. In the 1950s, the first ultrasounds were performed using refrigerator-sized machines, with patients subjected to water immersion. Adoption of this technology across many medical specialties was hindered by machine bulk and cost, low-resolution still images, and a steep learning curve for image interpretation. Incremental changes in ultrasound technology through the 1970s and 1980s allowed machines to be moved on wheels, and eventually to sit atop a cart. It was not until the 1990s that an ultrasound machine capable of being transported in a backpack was invented, as a result of a Defense Advanced Research Projects Agency (DARPA) grant. As with other computer technology, ultrasound machines then rapidly grew smaller and more powerful, and a wider user base began adopting them for multiple types of medical applications.

By the 1990s, portable ultrasound machines were deployed in combat support hospitals, ambulances, helicopters, and a host of austere environments. Researchers described experiences using ultrasound on medical missions in remote Amazon jungle settlements, high-altitude environments in Nepal's Himalayan Rescue Association Clinic, and the International Space Station. A report from Guatemala in the aftermath of Hurricane Stan demonstrated that point-of-care ultrasound confirmed or ruled out emergent pathology in almost half of subjects evaluated. During the disaster relief effort following the 2010 Haitian earthquake, point-of-care ultrasound helped clinicians change management in 70% of cases, with nearly half of those decisions based on acute pathology identified examination.

On the basis of experiences such as these, the World Health Organization recommends increased use of ultrasound as a main diagnostic modality, especially in under-resourced environments. Ultrasound machine costs are generally lower than x-ray or computed tomography scan capital expenses, and ultrasound requires very little ongoing cost for consumables (such as gel), compared to the ongoing upkeep costs of these other modalities. Increasingly, ultrasound is being used in areas without easy access to imaging of any kind. Clinicians in the Lugufo refugee camp in Tanzania identified many tropical infectious disease manifestations on ultrasound. Midwives in rural Rwanda, Zambia, and Liberia have been trained in the use of focused obstetric ultrasound with the goal of identifying common and life-threatening complications of late pregnancy. In areas where maternal and fetal mortality are significant health concerns, accurate pregnancy dating, early identification of breech presentation, and proper placental position could significantly impact the care provided and save lives. Advances in telemedicine have enabled expansion in ultrasound use as well. Recently, health care workers in rural India underwent training in basic cardiac and thoracic ultrasound with the goal of transmitting images to physicians at major hospital centers for real-time interpretation.

Ultrasound has been described as a disruptive innovation by Harvard professor Clayton M. Christensen. The term, originally coined by Christensen in reference to disk drives, refers to an innovation that transforms a market "by introducing simplicity, convenience, accessibility, and affordability where complication and high cost are the status quo." Often, such innovations take the form of a narrow, niche market, overlooked by industry leaders, but as new users take hold, the new product can claim significant market share. In the case of ultrasound, traditional imagers such as radiologists, obstetricians, and cardiologists controlled a market marked by expensive, immobile machines whose images could only be interpreted by highly trained subspecialists within their respective fields. Hand-held ultrasound devices introduced an alternative concept of relatively inexpensive, easy-to-use machines that could generate images interpretable by a wider spectrum of clinicians at the point of care. Soon, concerns about smaller machines having inferior image quality compared to devices many times larger and more expensive were outweighed by evidence that rapid diagnostic decisions could be made with portable machines.

In the 1990s, emergency medicine physicians joined the ranks of clinician-sonographers and described ultrasound training as part of the core competencies for residency training in 1994. Surgeons used ultrasound for trauma at this time as well. A wave of intensivists, ophthalmologists, internists, and other specialists found utility in point-of-care ultrasound by the 2000s, and a 2011 article in the *New England Journal of Medicine* by Moore and Copel listed 24 specialties who had adopted the technology into common clinical practice. In 2013, the Agency for Healthcare Research and Quality published "Making Health Care Safer II," an update of its previous 2001 guidelines for best practices in patient safety. Among the top 10 practices in both publications was using ultrasound to guide central venous access. With mounting evidence that iatrogenic complications of many invasive procedures such as venous access, thoracentesis, paracentesis, and others can be mitigated with point-of-care ultrasound, hospitals are increasingly mandating training in ultrasound by clinicians. As of this writing, a number of medical schools have adopted ultrasound curricula as well, incorporating sonographic assessments of multiple organ systems along with traditional courses on physical examination and clinical reasoning.

Many authors have argued that ultrasound has become the stethoscope of the 21st century. Why then, do we not see

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ultrasound machines in the coat pocket of every clinician? Several factors play a role. The ultrasound machines are expensive, and even clinicians enamored with the promise of point-of-care ultrasound must make a financial decision weighing the increased diagnostic accuracy against increased cost. In addition, point-of-care ultrasound is still a new field relative to traditional imaging. Many older clinicians completed training long before ultrasound use was part of standard practice for their specialty. Still, others have yet to bridge the philosophical and practical gap between comprehensive imaging by a consultant and bedside physical examination. For many clinicians, point-of-care ultrasound exists somewhere in between. It can be a rapid, bedside diagnostic test replete with archived images and videos and appropriate interpretation in a medical record, or it can be used as an ophthalmoscope (or stethoscope), allowing clinicians to visualize structures without a permanent record of what was visualized. As many specialties codify guidelines on how point-of-care ultrasound should be incorporated into clinical practice, some common training, interpretation, and documentation standards should emerge.

This issue celebrates the power of hand-held ultrasound devices and makes an attempt to put together a comprehensive compendium for the use of ultrasound in bedside care. It is expected that not only would medical care personnel use ultrasound technology in the remote areas of resource-limited nations, but also that the expanding communication/transmission prowess would open novel opportunities for telemedicine in these parts of the world.

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