White Paper Report of the 2010 RAD-AID Conference on International Radiology for Developing Countries: Identifying Sustainable Strategies for Imaging Services in the Developing World

Rodney D. Welling, MD[a,b], Ezana M. Azene, MD, PhD[b,c], Vivek Kalia, MPH, MS[b,d], Krit Pongpirul, MD, MPH[b,e,f], Anna Starikovsky[b], Ryan Sydnor, MD[a,b], Matthew P. Lungren, MD[a,b], Benjamin Johnson, BA, MEd[b,g], Cary Kimble[h], Sarah Wiktorek[i], Tom Drum[j], Brad Short, MLA[k], Justin Cooper, MSE[l], Nagi F. Khouri, MD[c], William W. Mayo-Smith, MD[m], Mahadevappa Mahesh, MS, PhD[c], Barry B. Goldberg, MD[n], Brian S. Garra, MD[o], Kristen K. DeStigter, MD[p], Jonathan S. Lewin, MD[c], Daniel J. Mollura, MD[b]

The 2010 RAD-AID Conference on International Radiology for Developing Countries was a multidisciplinary meeting to discuss data, experiences, and models pertaining to radiology in the developing world, where widespread shortages of imaging services reduce health care quality. The theme of this year's conference was sustainability, with a focus on establishing and maintaining imaging services in resource-limited regions. Conference presenters and participants identified 4 important components of sustainability: (1) sustainable financing models for radiology development, (2) integration of radiology and public health, (3) sustainable clinical models and technology solutions for resource-limited regions, and (4) education and training of both developing and developed world health care personnel.

Key Words: Radiology, developing countries, public health, residency education, international global imaging, economic development, radiology readiness, sustainability, technology

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INTRODUCTION

Radiology plays an important role in many of the conditions targeted by public health programs, including maternal-infant health, cancer screening, HIV/AIDS, pulmonary infections, and others [1-6]. Although limited data make it difficult to precisely quantify access to radiology in the developing world, the World Health Orga-

[a]Department of Radiology, Duke University, Durham, North Carolina.

[b]RAD-AID International, Chevy Chase, Maryland.

[c]The Russell H. Morgan Department of Radiology and Radiological Science, Johns Hopkins University School of Medicine, Baltimore, Maryland.

[d]Johns Hopkins University School of Medicine, Baltimore, Maryland.

[e]Johns Hopkins Bloomberg School of Public Health, Baltimore, Maryland.

[f]Department of Preventive and Social Medicine, Faculty of Medicine, Chulalongkorn University, Bangkok, Thailand.

[g]University of California San Diego School of Medicine, San Diego, California.

[h]Project HOPE, Millwood, Virginia.

[i]Aperian Global, Boston, Massachusetts.

[j]Center for Entrepreneurship and Executive Development, Small Enterprise Assistance Funds, Washington, District of Columbia.

[k]American College of Radiology, Reston, Virginia.

[l]Engineering World Health, Durham, North Carolina.

[m]Brown University Alpert School of Medicine, Rhode Island Hospital, Providence, Rhode Island.

[n]Division of Diagnostic Ultrasound, Department of Radiology, Thomas Jefferson University Hospital, Philadelphia, Pennsylvania.

[o]Imaging the World, Charlotte, Vermont.

[p]Fletcher Allen Health Care/University of Vermont, Burlington, Vermont.

Corresponding author and reprints: Ezana M. Azene, MD, PhD, RAD-AID International, 2620 Spencer Road, Chevy Chase, MD 20815; e-mail: eazene@gmail.com.

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nization (WHO) reports that between two-thirds [7] and three-fourths [8] of the world's population has no or inadequate access to medical imaging [9]. To improve the accuracy of this estimate and emphasize the importance of radiology in health care throughout the world, the WHO initiated efforts to remeasure this technology disparity in 2010 [10] and has emphasized the importance of including technology development and planning in addressing the global health care disparity [8,11].

In this white paper, we analyze barriers to sustainably increasing access to radiology in the developing world as presented at the 2010 RAD-AID conference. We define sustainability as the ability to develop and maintain knowledge, equipment, skills, and other resources as part of an enduring radiology infrastructure that addresses the health care needs of a community by integrating with existing health care infrastructure. Sustainable radiology development can occur at any level, from a single clinic to an entire nation. We advocate that radiology sustainability for the developing world requires integrated strategies along 4 key multidisciplinary planes: (1) sustainable financing models for radiology development, (2) integration of radiology and public health, (3) sustainable clinical models and technology solutions for resource-limited regions, and (4) education and training of both developing and developed world health care personnel (Figure 1).

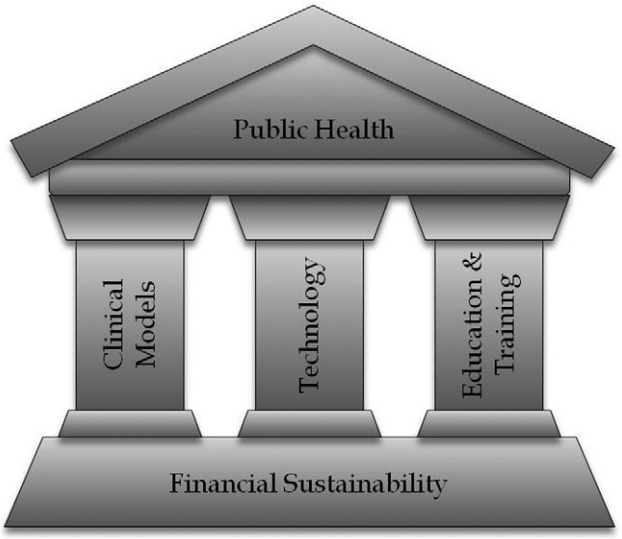

Fig 1. Graphic depiction of multidisciplinary strategy for developing radiology in resource-limited regions. Economic and financial resources are the foundation, supporting sustainable clinical model development, technology implementation, education, and training. Integration with public health programs completes the structure by amplifying and broadening the impact of radiology through disease prevention, screening, and surveillance.

SUSTAINABLE FINANCING MODELS FOR RADIOLOGY DEVELOPMENT

A major barrier to sustainable international radiology development is access to capital and financial resources. Although short-term radiology outreach efforts can help overcome both financial and technical obstacles, lasting financial solutions should be the goal. As previously described [12], one model of sustainable financing is the "radiology entrepreneurship" model, wherein local health care personnel are encouraged to develop sustainable, low-cost business models that incorporate realistic, "needed" medical imaging resources into the local health care economy. Microfinance loans and traditional small business loans have been discussed as potential sources of financing [13]. However, developing radiology infrastructure requires more capital than is typically provided by microfinance loans. Many small- to medium-sized developing world radiology projects cannot afford the interest rates, collateral, and shorter repayment term requirements of traditional local banks. At the other extreme, radiology development projects at the local or facility level rarely attract capital from investment banks and private equity funds in search of higher returns. Developing world radiology enterprises thus find themselves in a "missing middle," requiring more than a microloan but unable to access traditional credit markets.

Fortunately, institutions willing to extend credit to small- and medium-sized enterprises in the developing world do exist. One such institution, Small Enterprise Assistance Funds [14,15], is a nonprofit global fund management group that provides capital and technical assistance to small- and medium-sized enterprises in emerging markets. Similar to the "radiology entrepreneurship" model, Small Enterprise Assistance Funds promotes the development of "entrepreneur ecosystems" in which a network of local entrepreneurs provides the basis for investment in and management of middle-revenue enterprises. As previously described [12], the risk of mid-size loans could be mitigated by screening candidates and grouping radiology projects into larger pools to spread risk. Smaller microloans can be used to fund training and other less costly needs, thereby strengthening the creditworthiness of a site in the eyes of a larger "missing middle" investor.

A prerequisite step to financial sustainability is understanding in a systematic manner the resources and infrastructure necessary for deploying and optimizing radiology in a specific setting [11]. RAD-AID's Radiology-Readiness™ tool [16] provides an analytic framework for the structured assessment of local disease epidemiology, facility physical and technology infrastructure, clinical referral networks, access to medications and clinical consumables, availability and training of local health care personnel, availability of complementary laboratory testing, existing radiology infrastructure, and institutional financial health, among other areas. Since the last RAD-AID confer-

ence, the Radiology-Readiness™ tool has been used in multiple locations around the world as part of collaboration between RAD-AID and Project HOPE, including 4 sites in China, 3 sites in India, and 1 site in Haiti. An assessment was also performed at a site in Uganda as part of collaboration between RAD-AID and Imaging the World (ITW).

INTEGRATION OF RADIOLOGY AND PUBLIC HEALTH

The interconnectedness between radiology and public health is an important [17-19] but rarely investigated relationship with the potential to increase the health care impact of developing world radiology while elevating its importance in the eyes of local and national governments, which have a vested interest in the success of public health programs (and whose support is often a prerequisite to financial and regulatory sustainability). A search of the current literature revealed many core overlapping concepts between both radiology and public health, including but not limited to informatics, disease surveillance and screening, and radiation safety (unpublished data, Krit Pongpirul, MD, PhD, December, 2010). The role of radiology in public health is expanding [20] as more imaging studies and reports are stored digitally. These electronic files constitute a readily accessible reservoir of population health data that can play "a critical role in surveillance, prevention, and diagnosis of disease" [7]. Indeed, WHO refers to medical imaging as an important component in programs such as the Stop TB Partnership [21]. Radiology was also used as a tool for disease surveillance during the recent H1N1 influenza pandemic [19].

Radiology can also play an indirect role in advancing public health through the pairing of radiology development projects with public health programs that do not necessarily involve imaging. For example, ITW partners imaging and public health outreach efforts in part to garner participation and support of local communities and governments. Imaging the World has reported pairings of HIV testing and immunizations with its ultrasound efforts.

Radiation safety is an obvious topic where radiology and public health overlap. Education and training in radiation safety may not be keeping pace with the growth and availability of medical imaging technology globally, creating the potential for a "radiation safety gap" [9]. Thus, there is a real need for experts in the field of medical imaging, specifically medical physicists and other radiation safety experts, to participate in international radiology development as consultants, educators, and planners. There are many ways in which the issue of global radiation safety can be addressed, including regional conferences and workshops, annual meetings, individual mentorship, Web-based learning modules, and, most important, site visits from radiation safety experts who can directly teach the principles of radiation safety to local health care personnel to whom other local health care providers can turn for guidance. WHO has outlined a basic operational framework for radiology in the developing world that includes general guidelines on radiology policy, quality, and safety [7]. This framework can be used as a starting point and checklist for developing a radiation safety program in developing nations.

SUSTAINABLE CLINICAL MODELS AND TECHNOLOGY SOLUTIONS FOR RESOURCE LIMITED REGIONS

Barriers to sustainable radiology in developing nations include the cost of repair and maintenance, unreliable sources of energy, inadequate access to adequately trained radiology health care personnel, limited patient transportation options, and patient fears. A careful assessment using a tool such as Radiology-Readiness™ should be performed to identify important barriers in a given location before developing a sustainable clinical radiology program.

One of the first models of durable, relatively inexpensive imaging equipment for sustainable radiology development is the WHO Imaging System for Radiology (WHIS-RAD). The WHIS-RAD minimizes moving parts by using a fixed source-to-image distance and fixed focused grid (Figure 2) [22,23]. WHIS-RAD units require only 2.3 kW of power, can be powered by a standard 230-V wall outlet or alternating current generator, and include batteries to compensate for unreliable power supply [23]. Thousands of WHIS-RAD x-ray units are now in use around the world.

Imaging the World's model for sustainable radiology involves the deployment of low-cost and durable portable ultrasound scanners that have very low power requirements and can be charged with solar energy [24]. Paramedical personnel and nurse midwives involved in maternal-fetal care are taught to perform ultrasound examinations using only external body landmarks [12]. These protocols are learned within a week by novice students. Images are stored as short cine clips encompassing the entire organ or anatomic region of interest. High-fidelity images are transferred to a netbook gateway, undergo compression, and are transmitted wirelessly across cellular networks, which are now widely available worldwide. The images obtained are of diagnostic quality and can be viewed remotely by an ultrasound expert who returns diagnoses via short service text messages, along with recommendations for treatment. Patients at the clinics where this service is offered are counseled about traveling to hospitals for definitive care. Ultimately, ITW's goal is that midwives and district hospital sonographers (who receive advanced ultrasound training through the program) operate independently, with ITW available for technical support, consultation on difficult cases, or volume overload.

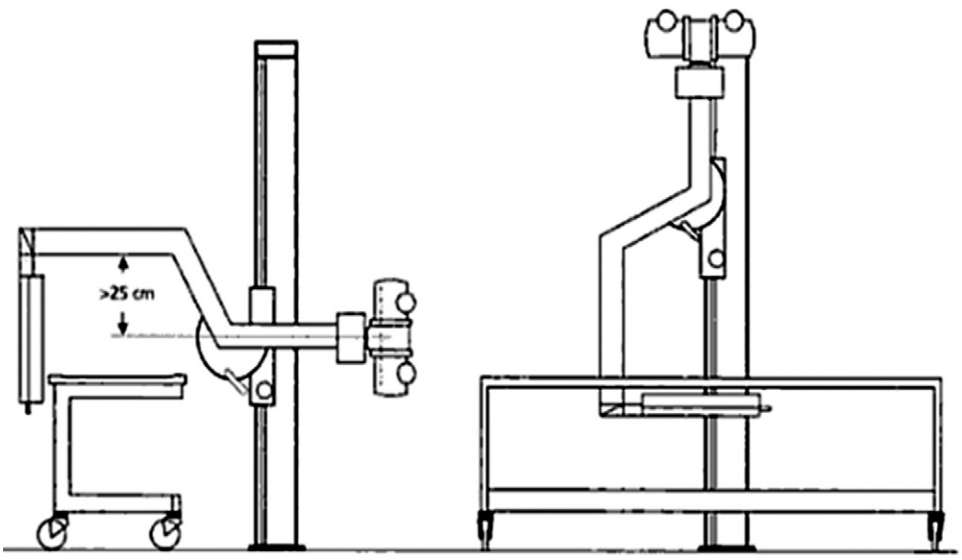

Fig 2. The World Health Organization Imaging System for Radiology "prone question mark" design [23]. Reproduced with permission from the World Health Organization.

One of the emerging technologies that has tremendous potential for the establishment of sustainable international radiology efforts is medical imaging clouds, so-called cloud PACS [25,26]. Cloud PACS is a software-as-a-service that supports image storage, retrieval, archiving, viewing, and so on, without the financial burden of equipment ownership, security, maintenance, backup, and management. It should be noted that cloud computing does have limitations, including a need for highly reliable Internet access and issues related to the transmission of patient data over the Internet. However, because of the potential resource savings and easy scalability, RAD-AID is in the process of adapting a cloud PACS solution as part of its technology education portfolio.

Transporting patients to and from medical facilities is another common barrier in the developing world, where rural patient populations are often far from the point of care and affordable transportation is not always available. Imaging the World addresses this problem by bringing portable ultrasound into the rural periphery and providing taxis to and from centrally located district hospitals as needed. RAD-AID is developing a mobile women's health care unit in Chandigarh, India, that combines preventative and diagnostic medical imaging (bone densitometry, mammography, and sonography) with clinical care (primary, gynecologic, and obstetric) and patient education. Partnership with a referral hospital to manage patients served by the mobile health unit is a critical component of this model. Moreover, patient education designed to teach preventative health care and debunk local myths and stereotypes about medicine is part of both ITW and RAD-AID mobile health care models. Partnering with local health education experts, such as Project HOPE, who understand and can adapt to local culture is essential for sustainability.

EDUCATION AND TRAINING OF BOTH DEVELOPING AND DEVELOPED WORLD HEALTH CARE PERSONNEL

Unless local knowledge and expertise are developed, inadequate supply of adequately trained radiology personnel will persist as a barrier to sustainability. Thus, planners should strive to include a holistic education plan as part of every radiology outreach effort. The objectives of training should be targeted to the specific needs of the local facility and its personnel, including, but not limited to, technical aspects of image acquisition, image interpretation, device maintenance and repair, workflow, and resource management, safety, and utilization criteria. Radiology business management and entrepreneurship training may also be needed. In academic centers, training in research design and development can be considered.

The multiple potential areas of training listed above underscore the need for a multidisciplinary approach and are why so many different fields were represented at the RAD-AID conference. A few examples of training programs offered by conference participants are listed in Table 1 [27,28]. The Radiological Society of North America (RSNA) publishes an online list of international radiology outreach resources [29].

In addition to the training programs listed for foreign personnel, several societies in North America have educational outreach programs. RSNA has an international visiting professor program whereby faculty members lecture in countries that request radiology information according to their needs. In addition, there are programs whereby foreign radiology residents are sponsored to visit the RSNA to learn about radiology academics. Educational material (journals, lectures, and syllabi) are made available to developing countries at no cost. The ACR

Table 1. Training programs for international radiology personnel

Organization	Description of Training Program
Small Enterprise Assistance Funds and Center for Entrepreneurship and Executive Development	Entrepreneurship and leadership training program.
Engineering World Health	Biomedical technician training program trains technicians in Ghana, Cambodia, Honduras, and Rwanda how to service medical equipment.
Jefferson University Research and Education Institute (JUREI) [27]	Teaching the Teachers; foreign physicians are provided 3 months of intensive training in hands-on ultrasound scanning, image interpretation, and teaching techniques. Upon returning home, many students develop JUREI-affiliated ultrasound education centers (currently 72 affiliated centers in 55 countries on 5 continents).
RAD-AID	Developing an online learning management system to provide training, testing, performance tracking, and certification in a readily accessible and collaborative educational environment for use by teachers, trainers, and learners in the developing world.
Radiological Society of North America	Derek Harwood-Nash International Fellowship: 6-week to 12-week fellowship at a North American institution targeted to international scholars 3 to 10 years out of training preparing for academic careers.
ACR	Free access to online ACR grand rounds to facilities in developing countries [28]

has also sponsored radiology residents and American radiologists to assist in education in different countries.

Education and training in the developing world is an essential component of sustainable radiology development. However, training health care personnel in the developed world is equally important, yet often overlooked. It is short sighted (maybe hypocritical) to assume that a radiologist, technologist, engineer, or other professional from the developed world has the knowledge and skills to develop, deploy, and participate in a radiology development project in the developing world. Overlooking such training probably contributes to the plethora of well-intentioned, but doomed to fail, attempts to increase access to medical technology in general and radiology in particular. For example, Engineering World Health, a US-based nonprofit organization, estimates that up to 59% of donated medical equipment in the developing world is not operational after 5 years. WHO cites "lack of user-training and . . . effective technical support" [9] as reasons why up to 70% of medical equipment in sub-Saharan Africa "lies idle." We suggest that the underlying problem is a lack of "donor training" in the components of sustainable radiology.

In addition to sustainability, other important instructional topics include local disease epidemiology, indigenous and endemic diseases and their imaging appearances, and cultural competency. Cultural competency training in particular is vital for volunteers traveling abroad, as it helps build the trust and credibility required for successful long-term collaboration. One in-depth cultural training resource presented at the RAD-AID conference is Aperian Global's GlobeSmart® Web tool [30].

Radiology residents, like medical trainees in general [31,32], have demonstrated interest in medically oriented developing world projects. The proportion of medical students who have completed a global health elective has increased significantly from 1980 (6%) to 2004 (22%), and the majority of US medical schools now offer international elective opportunities [32]. On the basis of a recent RAD-AID survey (submitted for publication) of residents in accredited US training programs, many residents are motivated to acquire global health imaging experience. The ACR Goldberg/Reeder Resident Travel Grant is one source of funding available to radiology residents for service in the developing world [33].

Interested radiology residents could form a core foundation for future sustainable international radiology efforts, suggesting the importance of implementing structured global health curricula and international elective rotations into residency training, as proposed by various groups [34]. However, recent data (submitted for publication) suggest that radiology residents perceive inadequate faculty support as a barrier to their involvement in international projects. Identifying faculty members willing to provide the oversight needed to ensure quality training and mentoring during these rotations may be challenging. As faculty members with an inclination to international service become involved with international radiology efforts, be it through onsite activities, providing Web-based lectures and seminars [35], or via teleradiology, departmental support at academic institutions will likely grow, as has been seen in other medical specialties [36-38].

Collaboration and communication among the growing community of people interested in radiology development in the developing world is facilitated by social media, which can also serve as a lead point for the dissemination of knowledge. These so-called Web 2.0 platforms use highly accessible and scalable publishing techniques to turn electronic communication into an interactive dialogue. One example of social media driving collaboration is the success of RAD-AID's Facebook, Twitter, and blog platforms, together visited by several hundred unique visitors per day from more than 110 different countries. Imaging the World reports more than 10,000 responses to its request for volunteer ultrasound experts submitted via Twitter at recent conferences. The ACR and RSNA also have very robust online communities with rapidly growing global Internet participation. These interactive Web-based social structures will be an important driver for global radiology efforts in education and clinical-model building.

CONCLUSIONS

This white paper of the 2010 RAD-AID conference presents a consensus perspective that sustainable solutions for international radiology development should interconnect financing, public health, innovative clinical radiology models, education of health personnel, and sustainable technology. Vital components of this multidisciplinary strategy include the following:

- Sustainable financing models as a prerequisite for establishing clinical, technological, educational, and public health efforts.
- Implementation of sustainable clinical and technological models to help maximize efficiency, minimize cost, and leverage local and nonlocal expertise, thus maximizing available financing.
- Education of both local and volunteer personnel, including residents, attending radiologists, technologists, and engineers, to sustain well-rounded global collaboration teams and develop local expertise and skill.
- Donor education in good donation practices that help prevent allocation of scarce equipment resources to locations where they are not needed, cannot be used, or cannot be maintained. A careful needs and feasibility analysis using a tool such as Radiology-Readiness is an important first step.
- Public health efforts to address population-based goals for health and safety, which can reinforce collaboration among institutional, local, regional, national, and international stakeholders. Integration of radiology with public health programs also encourages participation by nonradiology aid organizations and international bodies, such as WHO, with vested interest in promoting public health.
- Technology innovation and implementation are crucial drivers of sustainable global radiology, with new approaches emphasizing Web-based solutions for imaging as well as social media interconnectedness for consultation, result reporting, education, and volunteer and staff team building.

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