

White Paper Report of the 2011 RAD-AID Conference on International Radiology for Developing Countries: Integrating Multidisciplinary Strategies for Imaging Services in the Developing World

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The 2011 RAD-AID Conference on International Radiology for Developing Countries discussed data, experiences, and models pertaining to radiology in the developing world, where widespread shortages of imaging services significantly reduce health care quality and increase health care disparities. This white paper from the 2011 RAD-AID conference represents consensus advocacy of multidisciplinary strategies to improve the planning, accessibility, and quality of imaging services in the developing world. Conference presenters and participants discussed numerous solutions to imaging and health care disparities, including (1) economic development for radiologic service planning, (2) public health mechanisms to address disease and prevention at the population and community levels, (3) comparative clinical models to implement various clinical and workflow strategies adapted to unique developing world community contexts, (4) education to improve training and optimize service quality, and (5) technology innovation to bring new technical capabilities to limited-resource regions.

Key Words: Radiology, developing countries, public health, residency education, international global imaging, economic development, radiology readiness, sustainability, technologists, radiology outreach, radiologic nursing

J Am Coll Radiol 2012;9:488-494. Published by Elsevier Inc. on behalf of American College of Radiology

INTRODUCTION

Radiologic services are scarce or nonexistent for most of the world's population. Recent reports from the World Health Organization (WHO) estimate that one-half to two-thirds of the world's population lacks access to medical imaging. On the basis of a recent global population census of approximately 7 billion people, this suggests a radiologic scarcity afflicting 3.5 billion to 4.7 billion individuals throughout the world. This disparity has

widened over time because of a relative lack of progress in less developed regions (Figure 1) [1].

With the widespread role of imaging in patient care for pulmonary disease, acquired immune deficiency syndrome, maternal-infant health, tuberculosis (TB), cancer screening and management, and trauma, this disparity of radiologic access translates into a significant contributor to overall health care disparity [2-5]. In addition to disparate accessibility of radiologic services, WHO also identifies large gaps in image service quality and deficiencies in radiologic service planning that exacerbate the radiology divide.

In this white paper, we describe and analyze multiple strategies for addressing the global radiology divide on the basis of presentations at the 2011 RAD-AID Conference on International Radiology for Developing Countries. Building on the growing consensus and data summarized in prior RAD-AID conference white papers [6,7], we advocate for ongoing multidisciplinary strate-

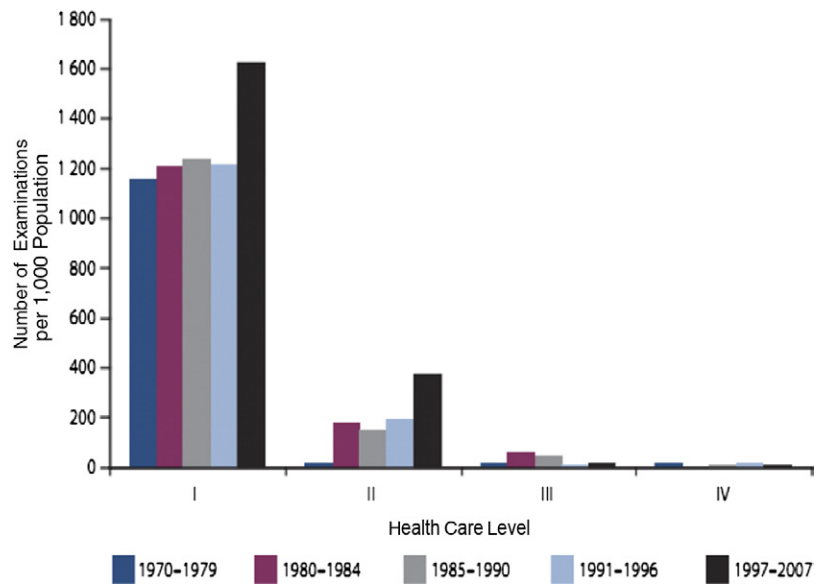
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Fig 1. Trends in the annual frequency of diagnostic medical and dental radiologic examinations per health care level (HCL). X axis: HCL I corresponds to >1,000 physicians per million population, HCL II to between 300 and 1,000 physicians, HCL III to between 100 and 300 physicians, and HCL IV to <100 physicians. This can also be interpreted as a range of country development, with HCL I representing highly industrialized countries and HCL IV poorly developed countries [1]. Reproduced with permission from the World Health Organization.



gies to arrive at innovative solutions for medical imaging, including (1) economic development for financial sustainability in enterprise planning, (2) public health mechanisms to address treatment and prevention at the community level, (3) comparative clinical models to implement various clinical and workflow strategies adapted to unique developing world community contexts, (4) education to improve training and optimize service quality, and (5) technology innovation to bring new technical capabilities to limited-resource regions. The RAD-AID conference advances this interdisciplinary agenda to address the complex task of improving radiologic service.

ECONOMIC DEVELOPMENT FOR GLOBAL RADIOLOGY

Radiology has a broad range of economic capital needs for implementation, from low-cost portable ultrasound to capital-intensive cross-sectional modalities such as CT, PET, and MRI, with diverse technologies in the middle of the economic spectrum such as radiography and mammography. Cost levels are further complicated by the range of data solutions, such as analog printed film (still prevalent in the developing world) and digital data storage via a PACS. Optimizing radiologic solutions for a given community or facility is paramount to achieve the highest clinical yield. Given the range of economic scale involved in planning radiology for the developing world, WHO has emphasized the need to improve radiology needs assessment and planning before implementing hardware, software, and personnel: “Health care technologies are seen as peripheral to health care planners The most important prerequisite . . . is that the potential recipient truly needs the . . . equipment and has the expertise and means to operate and maintain it” [8].

To address the need for robust economic planning, partnerships between leading business schools and radio-

logic service organizations have been initiated as a means to create comprehensive business plans for new radiologic services. One example is the partnership between RAD-AID and the Columbia School of Business via Columbia’s Pangea nonprofit assistance program. Volunteer MBA students traveled with RAD-AID’s radiologic service team to India in January 2011 to gather information and formulate a business plan that will provide mobile imaging and health care education to marginalized women in slums and rural regions. This program served as a follow-up to RAD-AID’s Radiology-Readiness assessment performed in northern India in 2010, which identified women’s health as a pressing unmet need [9].

The Wharton School of Business Global Consulting Practicum is another example of the integration of health and business professionals, offering a wide range of strategies to a variety of businesses and industries. As a model for nonprofit health care service advancement, the Wharton Global Consulting Practicum assisted Hope Village, a South African nongovernmental organization, to optimize efforts on behalf of orphans affected by acquired immune deficiency syndrome, thus improving the nongovernmental organization’s economic development and social impact [10].

Partnering radiology nonprofit outreach with academic business programs yields several key benefits to both the business and radiology professional communities: (1) it improves the strategic planning process for long-term economic sustainability, (2) it educates the business community about the vital role of imaging technologies in health care systems, (3) it educates radiology health care personnel on business practices and economic analytic tools, and (4) it generates cross-pollination of economic and health care ideas for innovation. On the basis of initial pilots of RAD-AID’s partnerships with

business schools, the aim is to deepen, replicate, and expand these collaborations with other academic business institutions for more robust business plan development in the future.

RADIOLOGY AND PUBLIC HEALTH FOR THE DEVELOPING WORLD

In contrast to care at the doctor-patient level, public health addresses the role of radiology at the community level to guide public policy and address epidemiologic challenges [11]. This is a key element of radiology in developing countries because radiologic service planning for underserved populations necessitates an in-depth understanding of a population's culture, disease patterns, and health care system. Tuberculosis is one example of radiologic scarcity broadly affecting public health efforts in the developing world, with 9.4 million new cases, 1.3 million deaths, and 9.7 million children orphaned by parental TB deaths annually [12]. Tuberculosis disease can be difficult to diagnose definitively. This is often due to the unavailability of bacterial cultures. Even when culture facilities are accessible, results are not available for at least 4 to 6 weeks because of the slow growth of *Mycobacterium tuberculosis*, which causes TB [3,13]. In addition, because young children cannot produce sputa and have a higher incidence of extrapulmonary disease, the sensitivity of cultures and new automated nucleic acid amplification methods is extremely low (<20%) [14-17]. Therefore, chest radiographs are regarded as a key component of diagnosis and treatment monitoring, particularly among pediatric patients and those infected with the human immunodeficiency virus. Because most TB cases are now in the developing world, the inadequate quality and scarcity of chest imaging significantly limits global public health efforts to control the disease [18]. As advanced imaging is developed and validated to better diagnose and monitor TB, the scalability of imaging will become an important component of disease control [19,20].

Women's health is another significant public health issue affected by the radiology divide. Examples include osteoporosis, diagnosed by bone densitometry, and breast cancer, detectable by mammography and ultrasound [21,22]. Osteoporosis affects 200 million women worldwide and is a particularly widespread challenge in India, affecting 1 in 3 women [23]. RAD-AID has engaged public health and medical institutions in northern India to implement a mobile women's health outreach program. The mobile unit will offer screening for breast cancer, cervical cancer, and osteoporosis as well as targeted health education. The partnership will aid data collection on women's health, including barriers to engaging the health care system, obstacles to referrals, as well as patterns and rates of disease. This joint project aims to develop policies that will better incorporate radiologic services into public health programs [24].

To improve the interconnection between global radiology and public health, RAD-AID has also initiated a partnership with WHO. Initial efforts in Latin America are planned through WHO's Regional Office for the Americas, the Pan American Health Organization (PAHO). This pilot first aims to implement RAD-AID's Radiology-Readiness tool for participating Latin American and Caribbean hospitals through coordination with ministries of health, thus matching public health issues with optimized radiologic solutions.

The radiology divide is also significantly affected by human resource disparities. The developing world has a scarcity of radiologists and medical imaging technologists. According to Pablo Jimenez, MD, regional advisor on radiologic health for PAHO and WHO, "general practitioners often have to make [imaging] interpretations and unqualified staff [are] performing x-ray exposures." Poor educational curricula, insufficient radiology educators, and ill-defined credentialing tracks exacerbate this human resource deficiency.

EDUCATION EMPHASIZING MULTIDISCIPLINARY TRAINING

Educational resources are a vital element of international radiologic service implementation and sustainability because of the advanced skills required for image acquisition and interpretation. The need for improved educational strategies is 2-fold: (1) educating personnel living in developed countries to serve in limited resource regions and (2) educating local health care providers living in the developing world to improve the quality of radiologic service [25].

Educating the US radiology community focuses on radiology residencies and academic medical centers as well as continuing medical education credits necessary for maintaining board certification. Although other medical and surgical specialties have incorporated international training into residency curricula, diagnostic radiology has yet to officially adopt international service into program requirements [6,26-28]. Although there is a strong desire among radiology residents to participate in global service (as reflected by RAD-AID's published survey data [29]) and a steadily growing demand for the ACR's Goldberg-Reeder Travel Grant, the supply of interested residents greatly exceeds the opportunities for international radiology experience. The RAD-AID conference consensus advocates structured supervised learning experiences for radiology residents with clearly defined educational milestones and work deliverables. Recent revision of the residency curriculum to accommodate new timing of the ABR certification examination may avail opportunities to incorporate international training. Ongoing efforts must address concerns about (1) liability and insurance coverage of traveling residents, (2) mechanisms for effective supervision and teaching of residents while abroad, and (3) workflow and salary coverage for residents on leave for international rotations.

The radiology enterprise consists of a variety of skilled stakeholders with diverse expertise, including radiologists, radiologic technologists, radiology nurses, medical physicists, engineers, administrators, and IT specialists. Local health care personnel in low-income regions require training and educational materials developed through input from complementary professions. Consequently, the RAD-AID conference consensus advocates educational teams that blend specialized perspectives to create balanced strategies. Multidisciplinary teams have already been successfully implemented to improve efforts in CT dose reduction [30]. Given the importance of local health care personnel, translation of educational materials into culturally appropriate contexts and languages is also paramount. An example of this objective is RAD-AID's translation effort with WHO and PAHO of Radiology-Readiness for future assessments in Haiti and Latin America.

RAD-AID's new partnerships with the Association for Radiologic and Imaging Nursing and the American Society of Radiologic Technologists (ASRT) reflect the goal of skill-set integration and complement long-standing partnerships with the ACR, RSNA, and Engineering World Health [31]. Historically, each specialized knowledge source offered international training independently, but recent trends favor interdisciplinary educational efforts. One manifestation of this trend is the RAD-AID conference provision of continuing education credits (via ASRT partnership) to technologists attending the annual meeting. Continuing education credits to other constituencies may be provided for future conferences.

RAD-AID's 2010 Radiology-Readiness initiative in China, a collaboration between Project HOPE and RAD-AID, identified a great need for radiology education. This project began in 2011 with RAD-AID's support of radiologists presenting at the annual meetings of the Chinese Society of Radiologists. This model has expanded to include more subspecialty meetings of the Chinese Society of Radiologists and grand rounds presentations at leading urban hospitals, as well as efforts to improve and standardize the certification of radiology professionals throughout China. RAD-AID's China initiative has been published in the *Chinese Journal of Radiology*, which includes publication of US standards of radiology training for potential broader adoption in China [32]. Given that two-thirds of the world's poorest individuals (earning less than \$1.25 per day) live in middle-income countries such as India and China, this radiology outreach initiative aims to address health care disparities affecting a large population.

CLINICAL MODELS

The heterogeneity of cultural, geographic, economic, and health care contexts throughout the developing world necessitates the design and testing of multiple strategies for new imaging services. A successful radiology strategy in one region may or may not be adaptable to another community,

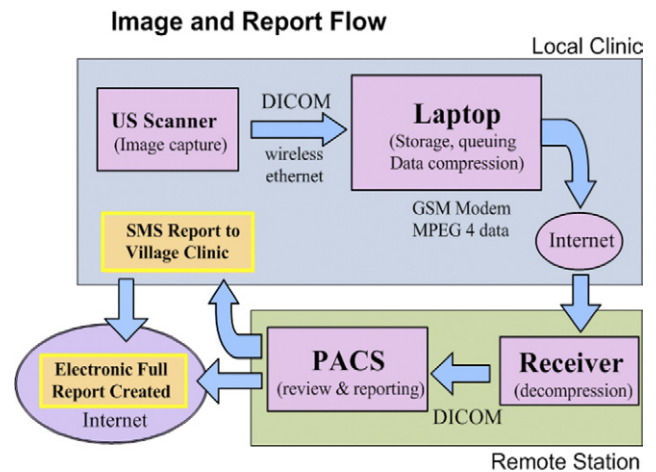


Fig 2. Imaging the World (ITW) data flow model for ultrasound (US) services in rural limited-resource regions showing transmission of Digital Imaging and Communications in Medicine (DICOM) images from scanner to laptop and PACS to generate report via short message service (SMS) to local clinic.

country, or region. Therefore, the RAD-AID conference encourages dialog to evaluate ideas from multiple perspectives and to incorporate differences in experience among international service volunteers.

Given ultrasound's high utility, versatility, and low cost, multiple models of ultrasound-based service have been implemented to assist developing countries [33]. One model provides direct onsite instruction in goal-directed, point-of-care ultrasound to physicians. The Physicians Ultrasound in Rwanda Education initiative, administered by emergency medicine physicians, has partnered with the Rwandan government to design educational programs that fit the needs of their health care system. A second model trains midwives for obstetric screening at the point of care, implemented by the University of Washington in Uganda. A third model provides direct instruction to sonographers. For example, a sonography curriculum leading to American Registry for Diagnostic Medical Sonography certification in Ghana was presented at the 2009 RAD-AID conference by Ann Polin. A fourth model provides direct onsite instruction to non-physicians in sonographic technique and interpretation, as presented by William Marks, MD, from pilot projects in Mali. A fifth model, initiated by Imaging the World in Uganda, trains personnel with little or no prior medical experience to perform regimented ultrasound protocol sweeps on the basis of physical landmarks with image transmission to a central facility for interpretation (Figure 2). Finally, offsite instruction to health care providers visiting the United States is exemplified by the Jefferson University Research and Education Institute in the Teaching the Teachers program, as led and presented by Barry Goldberg at the 2009 and 2010 RAD-AID conferences [34].

There are key similarities among these models that warrant attention and reflect radiology's progress in the devel-

oping world. First, these models place high importance on connected referral systems to further link care providers using ultrasound as a vital data point for triage. Second, these models emphasize peer education as a resource for replicating and transmitting knowledge among local personnel [35]. Third, these models often place clinical priority on maternal-infant health, with fetal ultrasound as a screening measure that may improve the management of obstetric deliveries [36]. This emphasis highlights radiology's role in the global public health issue of maternal-infant mortality. Fourth, these models all emphasize the participation and collaboration among diverse stakeholders for executing these objectives.

Breast imaging models presented at the RAD-AID conference also illustrate the range of approaches that can be implemented in the developing world. Direct onsite multidisciplinary instruction in stationary mammographic facilities is advocated by Richard Hirsh, MD, of Radiology Mammography International, with project evidence from Asia and Latin America. RAD-AID's initiative in northern India uses mobile imaging linked with tertiary care center referral services to serve marginalized populations. Combining screening interventions and targeted health education can potentially improve health care for women living in slums and rural regions in a cost-effective manner [37].

Although numerous other models and projects are under way throughout the world, the examples presented at the 2011 RAD-AID conference provide solutions to personnel shortages and educational challenges that remain major barriers to international radiologic service. These solutions will be further discussed, refined, and optimized in the future.

TECHNOLOGY INNOVATION

The role of technology innovation is paramount in radiology's international outreach, because novel technologies can improve quality, optimize connectivity, and decrease cost of services. Examples of technology innovation include imaging services and educational platforms used to support personnel. The continuing proliferation of third-generation cell networks, broadband Internet, and Wi-Fi present new opportunities for digitally connecting radiology facilities in the developing world. Imaging the World, for example, advocates a unique image compression technique to facilitate ultrasound transmission to remote diagnostic centers. Moreover, RAD-AID advocates cloud-based PACS for low-cost image storage that can also facilitate interinstitutional consultations, educational case rounds, and direct radiologic service.

The proliferation of smartphone technologies allows new opportunities in imaging. Brian Choi, MD, of George Washington University, presented a model for smartphone-based echocardiography at the 2011 RAD-AID conference. More than 80% of cardiovascular deaths occur in low-income and middle-income coun-

tries, where echocardiography is scarce and could be lifesaving [38–40]. The pilot was performed in Honduras and tested the transmission of echocardiograms via Secure Socket Layer 128-bit pipeline to iPhone or iPod devices (Apple Corporation, Cupertino, California) using the mVisum application (mVisum, Inc, Camden, New Jersey), which demonstrated 90% interpretation concordance relative to workstation-based interpretation [41].

Technology-based solutions for training and education are also an important source of radiology outreach for limited-resource regions. This observation has been reported by WHO and RAD-AID's Radiology-Readiness assessments. Education and training of technologists is a particular area of need and has underpinned recent partnership efforts between RAD-AID, ASRT, and the ACR. RAD-AID presented collaborative efforts to implement an online learning management system for technologists, radiologists, and nurses in the developing world. The World Radiography Educational Trust Fund presented an ASRT-funded project that embedded PDF files, interactive point-of-care applications, and electronic textbooks onto mobile electronic devices, which provide Internet-based solutions and digitized texts for technologists who would not otherwise have access to these vital references. RAD-AID is also in the early stages of advising the PAHO/WHO Virtual Campus program on using radiologic resources for educating public health personnel in the developing world.

CONCLUSIONS

This white paper of the 2011 RAD-AID Conference on International Radiology for Developing Countries presents a consensus perspective on multidisciplinary approaches to sustainable radiology in the developing world by integrating economic development, public health programming, clinical model testing, educational strategies and technology innovation. Key themes of the conference include the following:

- Partnerships among radiology nonprofit organizations and academic business institutions can improve international health service planning via integrated teams of health care and business professionals.
- Clinical model implementation, such as ultrasound and breast imaging, can be tailored to the specific needs of communities with limited resources to optimize infrastructure and integrate these models to existing referral and treatment systems.
- Links between public health programs and radiologic service organizations, such as the collaborations between WHO and RAD-AID, potentiate the contribution of high-quality medical imaging to global health issues, such as cancer screening, maternal-infant health, osteoporosis, women's health, TB, and acquired immune deficiency syndrome-related disease.
- Education of personnel in the developed world and dissemination of training to developing countries

continues to be a key objective of international radiologic service efforts through Internet-based and onsite mechanisms.

- Technology innovations continue to improve connectivity through third-generation cellular phone networks, advanced digital PACS, smartphone-based image interpretation, and learning management systems to strengthen radiologic capacity in developing countries.

ACKNOWLEDGMENTS

The 2011 RAD-AID Conference on International Radiology for Developing Countries was funded in part by the Gatewood Foundation (Baltimore, Maryland), hosted by the Russell H. Morgan Department of Radiology at Johns Hopkins Hospital in Baltimore, Maryland, and received general program support from the staff members and volunteers at RAD-AID International (<http://www.rad-aid.org>).

APPENDIX

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