

White Paper Report of the 2012 RAD-AID Conference on International Radiology for Developing Countries: Planning the Implementation of Global Radiology

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The RAD-AID Conference on International Radiology for Developing Countries is a yearly forum addressing global shortages of radiology that contribute to health care disparity. In this paper, the authors present key issues and consensus positions related to the planning, analyzing, implementing, and monitoring of radiology in limited-resource areas on the basis of presentations at the 2012 RAD-AID conference, to advocate for (1) economic development to build health care capacity, (2) multidisciplinary educational strategies, (3) innovative epidemiologic and infrastructural solutions tailored to community needs, (4) advanced technical solutions leveraging the widespread use of wireless telecommunications and phone-based portable devices, and (5) improved dialog across radiology and public health institutions for coordinating global health strategies.

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

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INTRODUCTION

The scarcity of radiologic resources, inadequacy of radiology quality, and deficient access to imaging services in developing countries continue to be challenges in addressing health disparities. Quantifying the radiology gap remains difficult because of the complexity of measuring hardware, personnel, quality, and other components of radiologic services, but radiology shortages are estimated to affect 3.5 billion to 4.7 billion people [1]. Moreover, the roles of radiology in diagnosis, screening, staging, monitoring, preoperative planning, and postoperative care across health care specialties involving acute and chronic conditions make radiology essential in addressing health care disparities. Primary and tertiary care ser-

vices falter without adequate radiology access, lowering overall patient care quality and affecting public health issues.

Documenting some radiology shortages, the World Health Organization (WHO) Global Health Observatory reports equipment availability on the basis of surveys of United Nations member countries. Most countries in Africa report <1 CT unit per 1 million inhabitants, compared with Denmark's approximately 24 CT units per 1 million inhabitants. Nearly all African countries have <1 MRI scanner relative to Denmark's 14 per 1 million inhabitants [2]. This differential ratio of 14:1 to 20:1 between developed and developing countries is similar to the reported differences in medical personnel. For example, parts of Africa report approximately 1 doctor per 8,500 people (8,500:1), compared with 350:1 in the United States [3].

When defining health care disparity, we identify 3 components: (1) increased disease incidence or prevalence, (2) a population having decreased health care resources, and (3) higher morbidity and mortality relative to other populations in the world. Given the widespread

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roles of radiology in diagnosis and treatment, the increased disease burden resulting from inadequate imaging highlights the need to incorporate radiology planning into projects designed to relieve health care disparities.

In this paper, we analyze issues related to the planning, analyzing, implementing, and monitoring of radiology in limited-resource areas on the basis of presentations at the 2012 RAD-AID Conference on International Radiology for Developing Countries. This paper builds on the consensus perspectives reported in the 3 prior RAD-AID conference white papers [4-6]. We advocate for (1) economic development to build health care capacity in tandem with community economic progress, (2) multidisciplinary educational strategies for broad-based radiology capacity advancement, (3) epidemiologic and infrastructural solutions tailored to community health needs, (4) advancing technical solutions leveraging the widespread use of wireless telecommunications and portable devices, and (5) improved dialog across radiology and public health institutions for coordinating global health strategies.

ECONOMIC DEVELOPMENT

The importance of economic development for radiology resource deployment in developing countries stems from the significant range of capital costs required to implement medical imaging and the need for supplemental diagnostic and treatment resources to act on the radiology-based diagnoses. Organizing radiology outreach efforts necessitates assessment and planning at several levels:

- the enterprise level (such as the medical institution offering the radiologic service) viewed from a microeconomic perspective and
- the national or international macroeconomic perspective, accounting for such factors as international trade and governmental aid.

At the enterprise (microeconomic) level, the concern is risk versus resources, specifically, the risk of radiology enterprise failure in which the facility or service becomes nonviable with costs exceeding revenues versus resources for sustaining long-term radiologic services (capital, expertise, personnel, etc). For programs in developing countries, stakeholders have different degrees of risk tolerance and different capabilities for managing the stages of program development. During phases of initial outreach and startup, nonprofit or nongovernmental organizations (NGOs), driven by donations and volunteer staffs with low capital budgets, are well suited to ignore market risk in pursuit of their philanthropic missions. This nonprofit outreach stage establishes the foundation for a program in terms of analysis, local partner engagement, and program planning. This phase helps mitigate risk and dispel uncertainties regarding local culture and

community-based strategic challenges. Later, market considerations can be addressed in the medium term, in which investment risk from the private sector may be more suitable for corporations, allowing corporate planning and expertise to collaborate with NGO outreach in advancing the program. Some corporations driven by more philanthropic goals enter the early stages with NGOs to embrace the highest risk in the startup phase.

In the long term, government provides the most stable pool of resources for health services. Governments facing political risk, such as losing reelection, being overthrown, and other forms of political disruption, as well as the economic risk of unsustainable deficits, are slow to support a program until the benefits are demonstrated and there is strong public demand for the service. Therefore, government is best suited to the long-term time horizon after NGOs and private sector work has established service benefits with proof-of-concept evidence in the form of successful pilot programs. Once government support is present, markets can expand to incentivize other private entrants, such as banks, insurance firms, hardware manufacturers, and software providers. Risk sharing (appropriately allocating risk among stakeholders) and the complementary capabilities and resources of these actors may enable radiology outreach programs by (1) having NGOs assume startup risk, (2) with short-term to medium-term collaboration from the private sector, and (3) long-term government contributions, thereby allowing a blend of market forces and political will to shape long-term development. This perspective on private-public partnership with complementary capabilities and risk sharing is represented in a strength-weakness-opportunity-threat (SWOT) analysis (Table 1).

RAD-AID is implementing this partnership approach in its Asha Jyoti ("ray of hope" in Hindi) program for women's health, in which a collaboration between an NGO (RAD-AID), the private sector (Philips Healthcare), and an Indian government hospital (the Postgraduate Institute of Medical Education and Research of Chandigarh [PGIMER]) defines complementary roles to provide a unique health initiative for indigent women in northern India. This program received recognition from the Clinton Global Initiative in 2012 in the Champions of Action session, on the basis of the Clinton Global Initiative's track record of espousing public-private partnerships for global challenges [7].

At the macroeconomic level, radiology outreach efforts fit in the broader context of international aid and the development of project funding. Ongoing debates about trade versus aid to lift populations out of poverty show that both actions have roles for alleviating poverty, as trade boosts commerce and aid provides security and necessities often not met by market forces. In the discourse on international aid, a distinction is drawn between *humanitarian aid* and *developmental aid*. Humanitarian aid consists of immediate, lifesaving mea-

Table 1. Analysis of strengths, weaknesses, opportunities, and threats demonstrating complementary capabilities and risk sharing in public-private partnerships for international radiology in limited-resource regions and developing countries

	Strengths	Weaknesses	Opportunities	Threats
Nonprofit (nongovernmental organizations)	Mission-based objective Volunteer staff and donors	Low capital resources Low efficiency	Outreach for partnerships Outreach for community acceptance	Community nonacceptance Limited potential donors
Private sector	Product/service expertise High efficiency; investment capital	Market risk exposure Cost pressure	New market development Early entrance to emerging markets	Low demand for products Market competition
Government	Long-term actor Authority and credibility	Need political support/consensus Slow response time for policies	New services garner public support New government services build local markets	Budget deficits Loss of political support

asures during a crisis, with protection and security playing predominant short-term roles for stabilizing risks. Developmental aid has a longer timeline and emphasizes sustainable capacity building to reduce poverty. Radiology addresses both contexts by providing acute care for disaster response and long-term health care infrastructure.

Foreign aid represents about 1% of the US federal budget, totaling \$48.16 billion in fiscal year 2011 and \$53.3 billion in fiscal year 2012 [8,9]. The past decade showed increased support for the Arab Spring, African health care, Iraq and Afghanistan, and the formation of new organizational entities, including the Millennium Challenge Corporation and the Office of the Global AIDS Coordinator. Other sources of international aid (government to government) include emerging market donors (China, Brazil, India) and Arab donors who favor supporting developing countries via trade partnerships for commercial development, direct government-to-government bilateral assistance, and subsidized regional and bilateral loans. The European Union and its member countries represent the largest source of foreign assistance, but recent budget and currency pressures have reduced international aid from European Union members.

An example of bilateral radiology capacity building is the relationship between the United States and China, enabling US and Chinese radiologists to collaborate in training and research to address growing educational demand and utilization of modernized tertiary care facility equipment in China. RAD-AID's partnership with the Chinese Congress of Radiology is strengthening RAD-AID's International Faculty Program by welcoming radiology educators at Chinese Congress of Radiology meetings. This type of program is similar to the RSNA's Committee on International Relations and Education, offering sponsored travel and educational opportunities for radiologists in the United States and overseas.

INTERNATIONAL RADIOLOGY AND PUBLIC HEALTH

A significant trend in international radiology is the increased focus on public health, particularly addressing poverty and poor health conditions in the developing world. Many public health programs, such as cancer, tuberculosis, and maternal-infant screening, rely on imaging. In 2012, RAD-AID signed a memorandum of understanding with the Pan American Health Organization, Regional Office of the WHO (PAHO/WHO), to place RAD-AID staff members in PAHO/WHO's Washington offices for onsite collaboration addressing radiology shortages via training and research [10]. The PAHO/WHO endorsed and adopted the RAD-AID Radiology-Readiness™ tool to collect and analyze data from Latin American and Caribbean radiology institutions. These assessments are essential in designing new strategies for radiology hardware, software, and personnel implementation. This cooperation opens avenues for radiology professionals in universities and private practices to work at the PAHO/WHO via RAD-AID membership.

Public health radiology necessitates the formation of multidisciplinary teams to integrate the skill sets of radiologists, radiologic nurses, and technologists. To strengthen technologist participation in international outreach, the American Society of Radiologic Technologists Education and Research Foundation (ASRT Foundation) partnered with RAD-AID to provide funded fellowship opportunities on RAD-AID teams, facilitating technologist efforts to improve training, research, and onsite clinical assistance.

Nursing is paramount in the public health domain to ensure patient safety during imaging procedures. The Center for the Rural Development of Milot Foundation, for example, has partnered with RAD-AID to offer radiology training for nurses. This will provide education on referrals, radiology study orders, and patient follow-up

that may help streamline imaging utilization in Haiti. The Association for Radiologic and Imaging Nursing has also contributed funding to RAD-AID to start a program analogous to the ASRT Foundation–RAD-AID partnership to sponsor nurse participation in RAD-AID.

The emphasis on multidisciplinary staffing and collaboration with global health institutions moves radiology to the forefront of the international public health domain. Another example is the PGIMER School of Public Health collaboration with Philips and RAD-AID to monitor the Asha Jyoti program. This will improve public health infrastructure and programming in northern India, to possibly serve as a policy model for women's health throughout India. RAD-AID has also joined the Global Health Track of the Clinton Global Initiative to advance worldwide philanthropic efforts.

CLINICAL DEVELOPMENT

Clinical innovation is vital to produce economic efficiencies in limited-resource regions. Marginalized patient populations requiring radiology may also lack familiarity with the health care system. Vehicle-based mobile imaging continues to engage underserved communities in the United States and abroad. For example, 26 of 75 counties in Arkansas (mostly rural) lack FDA-approved mammography. The University of Arkansas instituted the Mobile Mammography Program to provide breast cancer screening, with referrals for abnormal findings. The program's operations have screened >5,200 women, among whom 27 cancers and 11 high-risk lesions have been identified.

Similarly, RAD-AID, PGIMER, and Philips Healthcare implemented a mobile women's health program using a flat-bed truck platform, providing osteoporosis, breast cancer, and cervical cancer screening in one integrated design. Improving on the strategy of stand-alone mobile programs in developing countries, vertical integration through follow-up care at a local public hospital allows continuity of patient care. The program provides community education and strengthens local capacity through technical and clinical education for technologists and radiologists. Asha Jyoti completed its 6-month pilot phase, screening >500 women.

Clinical models addressing rural populations without vehicle-based approaches, such as Imaging the World, have trained paramedical professionals to perform ultrasound on portable units using anatomic landmarks and standardized protocols. Images are transmitted to tertiary care centers for interpretation, and results are communicated via multimedia messaging service cell phones to providers and patients. These efforts decrease costs of rural radiology and leverage digital communications for referrals. Long-term sustainability of this "teaching-the-teachers model" relies on local alumni of the program to train the next generation of practitioners.

Remote interpretation via teleradiology is challenging in limited-resource regions because of (1) complexity of digitally moving images and (2) limited image quality due to poor equipment quality and undertrained or understaffed technologists. It is preferable to train local experts for in-country teleradiology rather than outsourcing examinations because in-country capacity building is more sustainable. Nevertheless, teleradiology is a helpful element in medical care requiring diagnostic consultation.

EDUCATION

Education in international radiology can be viewed along two lines: (1) educating local personnel abroad to build health care capacity and referral systems and (2) educating personnel from advanced health care systems to assist limited-resource regions. Both forms of education are needed to integrate local and international efforts.

Educating local personnel includes technical execution of imaging and interpretation with onsite hands-on education and online didactic materials. For example, the ASRT Foundation partnered with RAD-AID to provide direct technologist imaging assistance and educational workshops [11]. To date, ASRT Foundation/RAD-AID fellows have worked in Haiti and India. The ACR has also initiated international training programs for radiologists in service to limited-resource regions.

Educating personnel in advanced health care systems to perform international work is critical for increasing the quality of outreach efforts as well as for building leadership capacity in US academic programs and residencies. Residents and students gain leadership skills from project planning, workshop design, and overseas clinical work where limited resources incentivize problem solving. Building grassroots capacity, RAD-AID has enabled residents, technologists, faculty and staff members, students, and other personnel at ACGME-accredited institutions in the United States to form RAD-AID chapters. Eleven institutions have formed chapters to date. Membership includes access to monthly webinars on international radiology, encourages project collaboration, and establishes project guidelines for resident training. Web tools and outreach are provided at <http://www.rad-aid.org>, which includes a list of project descriptions.

Emory University's program in Ethiopia is one example of residency-based international radiology education [12]. Prior RAD-AID white papers indicated that approximately 1% of radiology programs offer international health rotations [13], with more recent data showing between 4% and 10% [12,14]. This rise is promising but still represents a shortfall compared with other specialties, 25% to 70% of which offer international training to residents [12]. We hope that the rising number of RAD-AID chapters and interinstitutional

curricular development will yield more residencies offering global health education.

International education has 4 complementary forms: (1) onsite lectures, (2) onsite hands-on demonstrations, (3) online learning management systems (LMS), and (4) collaborative case reviews. These formats are complementary because onsite training is vital for relationship building and hands-on feedback for imaging techniques, while online learning provides curricular structure and quizzes measuring participants' learning. Consequently, RAD-AID launched its LMS, available free of charge in the developing world, providing online learning to complement onsite teaching. The LMS is available to partner organizations seeking to provide online learning materials to their overseas personnel and local staff collaborators.

Online education is surging. Companies such as edX, Udacity, and Coursera are offering massive open online courses, with some courses registering hundreds of thousands of users [15]. Although this format has been available for many years, particularly in medical education, the recent rise of online learning is providing new opportunities for influencing international radiology education. Key challenges include (1) providing quality control of course content, (2) enabling free access in developing countries, (3) applying criteria of course completion for certifications and credit, and (4) incentivizing instructors while containing costs.

TECHNOLOGY FOR INTERNATIONAL RADIOLOGY

Implementing technologies is important for addressing radiology shortages. The lack of image interpreters in rural areas warrants image transfer so that experienced staff members can provide interpretations. The imaging systems most relevant to this need are Internet based for PACS integration, but areas of the developing world continue to have slow data transmission speeds (10 kbps vs 1 mbps available in developed countries) with variable cost, quality, and broadband coverage.

Important considerations for radiologic IT implementation include (1) limiting bandwidth use, (2) avoiding the constant use of network connections (cloud-based applications may be suboptimal for some areas), (3) planning for frequent Internet downtime or restricted bandwidths, and (4) addressing electrical grid limitations using low-cost software and hardware with easily replaceable components. Because of ongoing bandwidth limitations, image compression is a vital piece of this strategy, particularly for rural regions where infrastructure is highly variable. Image compression techniques tested by Imaging the World in Uganda include MPEG-4 Part 2, DivX or XviD, offering higher performance over JPEG 2000 and JPEG, with H.263 or MPEG-4 Part 10 (AVC) and Dirac offering twice the compression of MPEG Part 2, and more improvements expected from H.265 due in

2013. Although there is high availability of cellular phone networks, variable in-network reliability requires software for addressing shortages of bandwidth and downtime, using methods such as automatic restarts, dynamic packet sizes, retransmission of lost data for failures, and remote monitoring of networks. Hardware to support and back up these wireless transmissions is also essential, including physical transport of CDs or DVDs to the reader ("sneakernet").

Widespread use of smartphones and tablets throughout developing countries often leapfrogs wired infrastructure to use wireless and portable applications before using stationery PCs. For example, Kenya leads the world in wireless banking, as more and more Kenyans use cell phones [16], and similar gains in tablet-based education are occurring [17]. Therefore, prioritizing the accessibility of applications via wireless platforms is essential. This accelerated use of wireless technologies in the developing world provides opportunities for international radiology [18]. For example, RAD-AID's LMS is built to be compatible with tablets and smartphones because standard PC-based Internet browsers would exclude many potential users in the developing world. The RAD-AID Knowledge Manager Application is an example of a smartphone application that manages clinical data, PubMed searches, and journal articles, thus portably organizing radiologic information. Going forward, non-profit and philanthropic organizations will need to prioritize smartphone-based strategies to accommodate these global trends replacing PCs with lower cost portable technologies.

CONCLUSIONS

Since 2009, the 4 annual RAD-AID conferences have been forums for international radiology in service to the developing world, discussing economic development, education, clinical innovation, public health, and technology. The 2012 RAD-AID conference presented key themes as follows:

- Economic development for global radiology can incorporate microeconomic (enterprise and facility) and macroeconomic (national and international) perspectives for planning sustainable strategies.
- Radiology's economic and public health strategies for limited-resource regions can achieve synergistic efficiencies by partnering the complementary capabilities and resources in risk sharing among nonprofits, NGOs, governments, and private-sector entities.
- Education for international radiology aims to address (1) clinical and technical skills of local health personnel in developing countries and (2) project implementation skills of radiology professionals in the United States and other advanced health care systems, using multidisciplinary teams to accomplish productive global collaborations and knowledge exchange.

- Clinical innovations continue to evolve in portable imaging technologies, vehicle-based health care systems, and teleradiology, for optimizing radiology in limited-resource regions.
- Technology innovation for radiology in the developing world encourages portable wireless technologies designed to accommodate unstable bandwidth, electrical grid limits, and frequent Internet downtime.

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