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Challenges, opportunities and strategies of global health radiology in low and middle-income countries (LMICs): an excerpt review

Abstract

More than half of the world's population lack adequate radiology services according to the world health organization. However, radiology plays an important role in public health programs such as tuberculosis, trauma, breast cancer screening, and maternal-infant health. The purpose of our study is to identify challenges, opportunities, and strategies of global health radiology in low- and middle - income countries. The primary challenges confronting radiology in global health are inequality in access to services, injudicious use of existing resources, paucity of appropriate data to inform future strategic planning as well as the establishment and sustainability of radiology. Disparity in access provides increasing opportunity for building radiology infrastructure in region where it is absent or inadequate. To overcome these challenges, certain components of sustainability were identified as key strategies of global health radiology including economic development, clinical imaging models' implementation, educational approaches, integration of public health to radiology and technological innovation. Components of global health radiology initiative programs, should consider economic development, good clinical imaging models, education and collaboration of health professionals, the integration of radiology to public health and technological innovations as key sustainable strategies to implementation and optimization of radiology in low middle-income countries.

Keywords: global health, radiology, challenges, strategies

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Abbreviations: HICs, high income countries; LMICs, low–and middle–income countries; PACS, picture archiving and communication system; WHO, World health organization

Background

According to a world bank and world health organization (WHO) group report, at least half of the world's population lack access to essential health care services.[1] This has led governments and a growing number of nonprofit organizations and corporations committed to addressing this challenge in many parts of the world.[2,3] RAD-AID international is one of these non-profit organizations dedicated to improving and expanding radiology services in low – and middle – income countries (LMICs).[4] This effort is based on a long-standing estimate by WHO, that approximately half to two-thirds of the world's population has either nonexistent, sparse, or inadequate radiology.[5] The vast majority of the population with limited access to radiology services lives in LMICs of the world.[6-8] While the utilization of radiology has significantly increased in high-income countries (HICs), yet access to basic radiology services such as x-ray and ultrasound which can resolve between 70–80 percent of diagnostic problems remain a great challenge in LMICs.[5,9] This disparity in access is termed the "radiology divide" and is largely due to limited financial and human resources as well as lack of appropriate device procurement and planning.[10] In addition, disparity in access can impact health outcome and lead to higher rates of undiagnosed and untreated diseases like pneumonia, tuberculosis, cancer, trauma, and congenital abnormalities. Thus, the ultimate objective of any global health radiology initiative, is to optimize and reduce this disparity in access to radiology services and thereby converging health outcomes for health equity across countries, regions and populations.[11,12] In this article we identify challenges, opportunities, and strategies of radiology in global health initiatives in LMICs where resources may be scarce.

Global health radiology

The term global health is derived from the concept of tropical medicine, public and international health. Although these terms may appear similar and have overlapping definitions, however they differ in areas of emphasis. Global health is defined as an area for study, research, and practice that places a priority on improving health and achieving equity in health for all people worldwide. It emphasizes transnational health issues, determinants, and solutions; involves many disciplines within and beyond the health sciences and promotes interdisciplinary collaboration; and is a synthesis of population-based prevention with individual-level clinical care.[12] This definition of global health has been adapted in the specialized area of radiology known as global health radiology to clarifying the various roles and strategies that the radiology community is using to assist resource limited and impoverished communities in the developing world. Based on this definition, several components of global health became the characteristics that defines global health radiology as an area for;[13]

- Study, research, and practice of radiology for improving health and achieving worldwide health equity
- Application of radiology to transnational health issues for identifying determinants and solutions
- Multidisciplinary collaboration promoted across radiologic and nonradiologic medical specialties as well as outside the health sciences (such as economics, technology, engineering, business, and social science disciplines)

- Synthesis of population-based preventions with individual-level clinical radiologic service.

Classification of countries

The economy of the world is designated by the world bank into four groups based on the country's gross national income (GNI) measured in current United States dollars. These classifications are; high ($12,376 or more), upper-middle ($3,996 to $12,375), lower-middle ($1,026 to $3995), and low ($1,025) income countries. Examples of low-income countries include Ethiopia, Haiti, Rwanda etc. while the lower and upper middle-income countries incudes Ghana, Nigeria, Honduras, Kenya, Algeria, Brazil, China, Mexico etc.[14] The vast majority of people with inadequate radiology services lives in LMICs.[6-8]

The growing role of radiology imaging in global health

The role of radiology in global health has largely been shaped by limited available equipment, education and market changes. However, radiology continues to make great progress in addressing these limitations through increased outreach programs and short time deployment of its professionals from HICs to LMICs.[15] Also, radiology is an important component of many public health programs and in combating global burden of disease.[16] It provides essential support services and is critical to successful healthcare delivery in the rural areas. Plain X-rays and ultrasound which are relatively affordable are considered the minimum essential imaging modalities in any healthcare setting. It is believed that approximately 90% of all imaging needs in LMICs could be addressed by the provision of plain X-ray unit and a basic ultrasound machine.[17-19] These essential modalities play a role in deceasing maternal and perinatal mortality, diagnosis and management of tuberculosis, malignancy and cardiovascular disease as well as road traffic accidents.[16,20]

Challenges of global health radiology

The primary global challenges confronting radiology are inequality in access to radiology services, injudicious use of existing resources, large gap in image service quality, deficiencies in service planning, sustainability and the paucity of appropriate data to inform future strategic planning, policy, standards, and guidelines. The lack of relative progress in many LMICs have worsen the inequality.[7,16] A baseline country survey carried out by WHO about the type and number of highly specialized radiological equipment around the countries of the world sheds light on this. Although many countries did not provide data, but the information received from those who responded revealed the disparity in access to radiology services. The survey showed on average, around 54 percent of countries have at least one magnetic resonance imaging (MRI), 70 percent have at least one computed tomography (CT) scanner, 89 percent have mammography and 10 percent have PET scanner unit per 1 million populations (Table 1). But sometimes the differences are great. For example, only 14 percent of the respondent low-income countries have at least one CT equipment per million populations as opposed to 100 percent of responding HICs.[21] Similarly, in terms of radiology workforce, great disparity exists. For example, there are more radiologists working in four selected teaching hospitals in Boston, Massachusetts, than there are in West Africa according to a report. Additionally, in many resource deprived countries where imaging equipment are available, at least 40 percent of these equipment have been estimated to be not fully functional, often because they are donated at the end of their lives and getting replacement parts isn't possible.[22] The sustainability of radiology is also a challenge due to high cost of equipment and skill requirement of radiology services.[13,23] Sustainability in this context is 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. Key areas requiring sustainable strategies are; development of sustainable radiology financial models, sustainable clinical imaging models, sustainable solutions to information technology (IT), and education and training of healthcare personnel.[8] Lack of electricity, roads, or an information system to store images are non-medical related challenges confronted with radiology in global health.[22]

Table 1 Percentage distribution of specialized radiology equipment according to World Bank classification of countries

	MRI	CT	Mammography	PET
Low Income Countries	0	14	76	0
Lower Middle-Income Countries	30	60	79	4
Upper Middle-Income Countries	70	88	97	3
High Income Countries	92	100	100	29
Average	54	70	89	10
Total Respondent Countries	132	135	123	116

Source: world health organization

Challenges of safety and cultural sensitivity

Planning to engage in radiology outreach program in a resource low setting can come with personal challenges. One of these challenges is the safety and health of the worker as the foreign worker may be seen as a potential source of income by criminals either through robbery, kidnapping and extortion. Having a kidnap and rescue insurance is therefore considered important in areas where the potential is stronger. Workers may also be affected with infectious diseases, malaria, trauma, assault, excessive sun exposure and crime. Having understanding of your likely response in case of these emergency illness is useful.[24]

Electricity service can be unreliable and the working environment may lack basic accessories such as examination table, fresh sheet for each patient, paper towels and disinfectant. It is therefore important to confirm the usability of equipment, material support and staff. In many cases, improvisation may be necessary. Cultural sensitivity may also pose another challenge. For example, endo vaginal ultrasound may have a negative perception by the host community, despite its usefulness in female pelvic examination. But despite these limitations, it is imperative to create a work environment that provides for patient privacy, maximizes patient comfort and dignity and allows for good diagnostic studies to be performed.[24]

Furthermore, frustration is likely to ensue as efforts are thwarted by clinicians who have been performing this work for years and don't see a role for a radiologist in the field, or by local health providers who are afraid that the technology might undermine their role in the community when you are gone. You might feel helpless as you identify diseases without treatment hope and also find yourself limited by the imaging technology you can bring on outreach. The sheer number of patients to be seen can be overwhelming. It is therefore important to remember that you have a skill set and expertise that is extremely valuable and not let the fear of not doing enough prevent you from doing anything at all.[24]

Opportunities for global health radiology

Propelled by global economic growth and attempts to curb inequality combine with trade and investment in LMICs, the number of people living in poverty (defined here as earning $1.25 a day or less) reduced from an estimated 1.9 billion in 1990 to 1.2 billion in 2010, with approximately 500 million people coming out from poverty from 2005 to 2010. Also, the number of countries classified as low income decreased by forty percent within that period. This has led to increasing opportunities for building radiology infrastructure. There is also a unique opportunity to help emerging radiology service providers on equipment acquisition and maintenance, educational training, and clinical diagnosis and management of diseases.[25]

Radiology health professionals can learn about different health care system and culture, and gain perspective from other parts of the world through on-site and off-site global health radiology outreach programs.[24,26] On-site outreach opportunities may involve the following:[24]

- Carrying out radiological procedure
- Image interpretation of studies
- Providing point of care ultrasound
- Completing a radiology readiness assessment
- Providing in person didactic lectures to trainees and practitioners,
- Hands-on teaching,
- Helping implement and set up new radiology technology and services,
- Assisting in the creation of radiology or radiology subspecialty training programs,
- Consulting on national policies related to radiology,
- Conducting quality-improvement projects (e.g., report and protocol standardization),
- Establishing public health initiatives and
- Improving informatics integration and optimizing radiology workflow within the host country.

While off-site opportunities on the other hand may involve:[24]

- Remote image interpretation by teleradiology,
- Hosting trainees from other countries,
- Conducting virtual lectures and
- Developing and contributing to an enduring radiology curriculum.

Finding the right organization with radiology specific project opportunities that will enable you engage and express your radiological skills in a more fulfilling way is critical when planning to undertake any radiology global health initiative. However, this decision has become easier with the continuing growth of nonprofit radiology outreach organizations and professional societies that have opened new project opportunities at country host sites.[3] RAD AID international have various radiology specific on-site projects opportunities in over 30 countries of the world. The organization which started in 2008 with few people, has now grown to include more than 10,000 volunteers from 100 countries, and 75 university-based chapter organizations. Each year, the RAD AID annual conference, brings together diverse organizations and individuals of many backgrounds to discuss current and future program opportunities. One fundamental strategy of RAD AID is the radiology readiness. It is a tool for systematic data collection that assess how imaging technology can be planned and implemented according to medical needs, infrastructure and personnel resources.[4]

Numerous medical organizations that provide opportunities for global health experience for radiology professionals through dedicated international healthcare and service are listed on Table 2. Unfortunately, many of these opportunities may not be well known and therefore require initiative on the part of the radiology professional. To help focus and guide the search, shah et al recommends three major routes through which radiology professionals can find opportunities. The first, is through universities or medical schools which offers the opportunity to teach students and work in an interdisciplinary setting or travel as part of a carefully selected team designed to fulfill a specific mission. Second, is through faith-based organizations that provide short term medical trips. Most do not require endorsing a particular faith for participation. Although these organizations may not be radiology specific outreach organizations, the communities they serve can benefit greatly from portable ultrasound or interpretation of radiographic images. Lastly, interaction with colleagues about mission opportunities in radiology can lead to partnerships for future trips. Direct contact with local practitioners can also yield opportunities.[24]

Table 2 Medical organizations dedicated to international service and health care

S/N	Medical Organizations Dedicated to International Service	International Health Care Organizations
1	American Association of Physicists in Medicine	Doctors of the World
2	American Society of Clinical Oncology	Doctors Without Borders
3	American Society of Radiologic Technologists	East Africa Medical Assistance Foundation
4	American Society for Radiation Oncology	Health Volunteers Overseas
5	European Society of Radiology	Imaging 4 Change
6	International Atomic Energy Agency	Imaging the World
7	International Commission on Radiological Protection	International Health Volunteers
8	International Commission on Radiation Units & Measurements	Medical Imaging Partnership
9	International Society of Radiographers & Radiological Technologists	Pan American World Health Organization
10	National Council on Radiation Protection & Measurement	Physicians with Heart

Table Continued...

S/N	Medical Organizations Dedicated to International Service	International Health Care Organizations
11	Royal Australian and New Zealand College of Radiologists	Porting for Patients
12	Radiological Society of North America	Project HOPE
13	Radiological Society of South Africa	RAD-AID International
14	Royal College of Radiologists	Radiating Hope
15	Society of Interventional Radiology	Radiologists Without Borders
16	Society for Pediatric Radiology	World Health Organization
17	Society for Radiologists in Ultrasound	World Federation for Ultrasound in Medicine and Biology
18	World Radiography Educational Trust Foundation	World Federation of Pediatric Imaging

Source: https://www.acr.org/Member-Resources/Volunteer/international-outreach/Resources

Delivering basic radiology services in remote, low resource settings is often a challenge. Access to specialist opinions in particular may be difficult to obtain. In such setting, teleradiology is an important technology to deploy. It helps remote practitioners to obtain expert opinion even from around the world. Thus, teleradiology provides opportunities for those radiology professionals interested in remote interpretation of images. For example, collegium telemedicus allows radiologists to register and create an account on their website. Their system notifies radiologists by email when studies from various places around the globe request a pediatric radiologist interpretation. The radiologist then logs onto the system and views the clinical note, downloads the digital imaging and communications in medicine (DICOM) files, views the image and responds with an interpretation.[24,27]

It is noteworthy that, as investment in health technologies expands and medical imaging equipment becomes portable and affordable, opportunities for involvement in radiology global health programs will continue to increase.[23]

Strategies for global health radiology

Four major strategic issues have been identified as important components for implementation and most effective use of radiology in LMICs. They are; viable economic strategies, clinical imaging models, integration of radiology to public health, education and collaboration of health professionals and utilization of information technology strategies.[7,13]

Economic strategies

A viable financial and administrative support for radiology entrepreneurs is key to sustainability of radiology services due to the major setback in financial capital that radiology often faced in many LMICs. Although in the short term, radiology outreach had helped solved both technical and financial challenges, a lasting solution is required.[8,13] One of the economic strategies is "radiology entrepreneurship" through creation of effective business administration and leadership training together with financial loan support to radiology entrepreneurs. But, due to uncertainty in global financial establishments in the past years, microfinance institutions have become strong alternative source of financing local entrepreneurs by providing small loans.[13,25] The relatively high cost of radiology equipment presents a unique challenge, this is because radiology entrepreneurs require more than a microloan and are unable to access credit in traditional financial institution. Nevertheless, strategies to resolve this challenge requires screening candidates, grouping radiology projects into larger pools to spread risk, and using small microcredit loans for the purchase of supplies, training, and equipment repair.[8,13,25] Another economic strategy is to lower the cost of imaging equipment for deployment and use in LMICs as well as understanding of framework for successful utilization of these subsidized or donated equipment. One important tool that ensures optimization of radiology is RAD-AID's radiology readiness, which measures resources and infrastructure necessary for deployment of radiology.[7,8,13]

Organizing any radiology outreach efforts necessitates assessment and planning at microeconomic (enterprise) and macroeconomic (national or international) levels. At microeconomic level the concern is the risk of failure of radiology enterprise as costs often exceeds revenues and resources available for sustaining long-term radiology services. Different strategies abound to mitigate risk at various stages of program development. At the startup phase, nonprofit organizations driven by donations and volunteer staff with low capital budgets, are well suited to ignore market risk in pursuit of their philanthropic missions. Later, market considerations can be addressed in the medium term, in which investment risk from the private sector may be more suitable for corporations. In the long term, government provides the most stable pool of resources for health services. Therefore, government is best suited to the long-term time horizon after nonprofit organizations 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. At the macroeconomic level, radiology outreach efforts fit in the broader context of international aid and the development of project funding. Both trade and aid play important role in alleviating poverty.[28]

Clinical imaging models

Teaching the teachers model

Different clinical imaging models have been developed and tested in LMICs. One of this ingenious strategy is the "teaching the teachers model", The objective of this model is to provide a comprehensive educational program in medical ultrasound featuring didactic instruction and case reviews, observation in the clinical setting, hands-on training, and training in teaching techniques over a period of 12 weeks in the United States. Graduates trainees returned to their home countries and often establish affiliated ultrasound education centers. To date, there are more than 72 affiliated centers in 55 countries on 5 continents, each using this model to provide ultrasound training locally. Over 2,500 people have been trained through the affiliate centers worldwide.[13,29]

On-site direct guide model

A second clinical training model requires on-site direct guide within the countries. This model has been tested in Kwame Nkrumah University of Science and Technology in Ghana through the Sonographer Education initiative. As a result of this initiative, the first four-year bachelor's degree program in sonography in Africa was established. The first students were admitted in 2009 when the program began and since then the university have graduated students with current enrollment of over 100 students from Ghana and Nigeria.[13,30]

Combine clinical training with low cost adaptation model

A third model combine clinical training with low-cost adaptations for providing health care. In this model health personnel with no prior training in ultrasound or limited medical background are taught to perform limited ultrasound using visible or palpable external body landmarks and a low-cost ultrasound in rural areas. Images acquired during ultrasound are then store in form of a short video and compressed for transmission via cellular network for remote interpretation by ultrasound expert. The result of the reviewed and interpreted images is then sent back to both the rural clinic and the nearest hospital capable of providing definitive diagnosis and treatment.[13] These efforts decrease costs of rural radiology and leverage digital communications for referrals. Long-term sustainability of this model relies on local alumni of the program to train the next generation of practitioners.[28]

Application of teleradiology clinical model

A fourth clinical model uses teleradiology for imaging services. Teleradiology involves remote interpretation of digital images via electronic transmission of images and using picture archiving and communication system (PACS) to link radiologists is key for teleradiology.[25] This model provide opportunity for offsite remote image interpretation, yet it comes with challenges of implementation as there are shortages of imaging equipment, limited technical expertise for producing interpretable images, and little on-site experience in the use of teleradiology reports for clinical decision making.[13,28] There is also reluctance to implement teleradiology in many countries due to suspicion that outside interpretation lacks accountability, drains the local health care economy of necessary expertise, and distorts communication across health care providers when radiology personnel are physically absent.[25]

These clinical imaging models can be incorporated in a hub, spoke and wheel model. The hub is likened to a country's referral medical center capable of confirming and treating cases referred to them from the rural areas which constitute the wheel. The spokes represent the framework needed for effective flow of information and patient transport between the hub (referral medical center) and the wheel (rural health centers). Clinical support can be provided from developed countries when in need via teleconferencing, teleradiology, online education modules, and periodic on-site consultation.[7,13]

Integration of radiology and public health

Radiology is an important part of public health programs with great capacity to impact healthcare in LMICs. It is useful in disease surveillance such as during the H1N1 influenza pandemic, breast screening, diagnosis and management of tuberculosis (TB), radiation safety issues, and preventive care during maternal and perinatal ultrasound.[8,20,31,32] The association between radiology and public health is also seen in the area of radiology informatics where digital images combine with medical record provides rich metadata for public health applications.[33] 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.[7,8] Public health radiology necessitates the formation of multidisciplinary teams to integrate the skill sets of radiologists, radiologic nurses, and technologists. The emphasis on multidisciplinary staffing and collaboration with global health institutions moves radiology to the forefront of the international public health domain.[28]

Education and collaboration of healthcare personnel

Education is critical for the advancement of a sustainable strategy in global health radiology and should be part of a holistic plan for any radiology initiative in LMICs. It involves education of health professional in LMICs as well as HICs. In LMICs, it involves educating local radiology health professional in quality image acquisition and interpretation, while educational training of personnel living in HICs is done to enable them serve in LMICs.[8,28] Educating health care personnel in HICs to perform international work is critical for increasing the quality of outreach efforts as well as for building leadership capacity in academic programs and residencies.[28] Any training should be carried out based on prior needs assessment. The fourth sustainable goal of the United Nations promulgated in 2015 is promoting quality education. There are several models in place for education in the global health setting with emphasis on radiology. These includes; faculty exchanges, scholarly collaboration, partnership, formal education, online education as a tool, integration of global health concepts into radiology curricula, and socially responsible collaboration. Education promote local human capacity, reduce the risk of dependency, and support collegial exchange of information.[7,8,20]

Faculty exchanges and scholarly collaboration provides opportunity for shared knowledge among radiology health professional groups through meetings, conferences, workshops, symposiums that transcend across national boundaries. Partnership may be bilateral or multi-institutional. Unlike bilateral partnership success in multi-institutional partnership is not dependent on sole partners. In any on-site partnership it is necessary to consider formal educational training. In addition to on-sited training, education can also be supported via distance learning.[20]

International education has four complementary forms: onsite lectures, onsite hands-on demonstrations, online learning management systems, and collaborative case reviews. Online education is surging and the rise provides new opportunities for influencing international radiology education. However, key challenges include providing quality control of course content, enabling free access in developing countries, applying criteria of course completion for certifications and credit, and incentivizing instructors while containing costs.[28]

In term of collaboration, radiology department by nature is multidisciplinary, composed of health professionals, including but not limited to radiologists, radiologic technologists, trainees, medical physicists, nurses, etc. Therefore, the need for interprofessional collaboration is essential for integration into radiology global health initiatives based on WHO initiatives which seeks to integrate interprofessional education to support collaboration.[23] For any international radiology outreach program, it is important that stakeholders established goals to address gaps in radiology access after initial assessment. Then, a mutually agreed-upon plan can be implemented with measurables deliverables. The professional roles within the radiology team should be represented when planning. By understanding the professional scope and role of all members,

the stakeholders can more effectively proceed with working toward improving human capacity, infrastructure, supply chain, and other needs.[23]

Information technology strategies

The application of digital imaging such as picture archiving and communication system (PACS), teleradiology, and electronic reporting in LMICs is a very useful strategy. Non-digital imaging used in many LMICs are likely to become obsolete in the near future due to lack of replacement parts, as the use of digital imaging in HICs becomes a standard in their healthcare system. The numerous advantages of teleradiology which provide opportunity for remote image interpretation for example has led to an increasing effort to deploy and test digital imaging solutions in LMICs. For example, the increasing global bandwidth over the past years has supported the growth of teleradiology, although there are gaps in bandwidth between countries which reflect also the gap in access to medical imaging. Data storage is a key strategic element in optimizing radiology service through information and communication technology (ICT). Already there are efforts to provide a secure, low cost decentralized PACS for storing radiology studies for facilities in LMICs.[13]

Other strategies for global health radiology initiatives includes the use of mobile (vehicle-based) imaging with scheduled visits, temporary clinical sites (such as refugee camps and triage centers) with limited imaging and referral of patients for advanced imaging at tertiary centers when clinically necessary, and non-imaging clinical triage sites referring patients to other facilities for radiologic services.[25]

Conclusion

Radiology in global health initiatives is very critical in reducing disparities in access to radiology. Components of radiology in global health initiative programs should consider a viable and sustainable economic strategy, designing and testing of good clinical imaging models, integration of radiology to public health programs, enhance interpersonal education and collaboration of health professionals, and the utilization of information technology strategies.

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Competing interests

The authors declare that they have no competing interests.

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