Education in Global Health Radiology

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Introduction

Radiologists and radiology professionals have noted the gaps in diagnostic and interventional imaging access worldwide as documented by the World Health Organization (WHO) [1–3]. With the introduction of the United Nations' Sustainable Development Goals, the push for access to radiology in global health can be further justified by promoting good health (#3); quality education (#4); good jobs and economic growth (#8); industry, innovation, and infrastructure (#9); and reduced inequalities (#10)—all through partnerships for the goals (#17) [4]. Diagnostic and interventional imaging, as radiology is described by WHO, promotes global targets of reducing noncommunicable diseases (NCDs), increasing cancer imaging and treatment, and continued support for the goal of reducing and managing infectious disease [5, 6]. If "global health" focuses on issues that transcend national boundaries, emphasizes solutions that often require global cooperation, and is multidisciplinary, then the concept of radiology in global health, or global radiology, should consider this broader context of international partnership and collaboration [7].

In the context of global health, education is the effective transfer of knowledge so that it can be applied and translated to a healthcare professional's clinical practice [8–12]. The educational efforts of radiology professionals in high-, middle-, and low-income nations, as defined by the World Bank, combine to promote the advancement of radiology in global health. The integration of education in global health allows for human capacity building and strengthening partners bilaterally so that the field of radiology can more effectively address WHO target goals, like the reduction of NCDs, and United Nations'

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Sustainable Development Goals. Education can be used as a mode for sustainability and is critical for the advancement of radiology in global health.

There are several models in place for education in the global health setting with emphasis on radiology. This chapter discusses faculty exchanges, scholarly collaboration, partnership, formal education, online education as a tool, integration of global health concepts into radiology curricula, and socially responsible collaboration. This chapter is not an exhaustive collection of educational models, but it serves to demonstrate samples of potential pathways for educational exchange and advancement.

Faculty Exchanges and Scholarly Collaboration

Faculty exchanges are a well-established model for collaboration and international learning. Professional societies have opportunities for radiologists, physicists, technologists, and other health professionals to give presentations at national meetings or attend conferences internationally. These exchanges are part of the continuing medical education process. The Radiological Society of North America has an international visiting professor program. The American Roentgen Ray Society (ARRS), Radiological Society of North America (RSNA), and other international associations have opportunities for radiologist faculty exchange [13, 14]. Many radiology subspecialty societies have faculty exchanges also, and the concept can be applied to all parts of the radiology team. A similar program exists between the American Society of Radiologic Technologists (ASRT), Canadian Association of Medical Radiation Technologists (CAMRT), and College of Radiographers (CoR) [15]. The benefits of these faculty presentations at professional society meetings are the ability to reach a large audience and to impact practice based on new knowledge and up-to-date research [13–15].

With the advancement of technology and connectivity, the platforms for exchanging knowledge and information among colleagues have increased among high-, middle-, and low-income nations—for the entire global health community. There are examples of this in the medical imaging literature where there are regular contributions and even entire scholarly journals devoted to the topic of global radiology [12, 16, 17]. Access to up-to-date refereed content on radiology topics is necessary for the continued learning of health professionals regardless of their practice location. With that in mind, the World Health Organization launched Hinari in 2002. The program "provides free or very low cost online access to the major journals in biomedical and related social sciences to local, not-for-profit institutions in developing countries" [18].

In addition, radiologists and radiology professionals have integrated social media as a frontier of engagement with Twitter journal clubs, Tweet chats, and Twitter accounts for journals [19–21]. Kelly et al. note a positive association between impact factor and journal presence on Twitter [21]. Discussing journals and social media as modes of exchange is noted to demonstrate that the "locations" for collaboration and for the advancement of radiology in global health are becoming more robust. The field of radiology can leverage this increasing connectivity to discuss evidence-based medicine, healthcare policy, and global health with a broad reach. Faculty presentations at conferences, discussions of radiology in the context of global health, and access to peer-reviewed research on advancements in the field are all modes of educational exchange that support the goal of radiology's advancement in global health.

On-Site Partnership Models

On-site partnerships are becoming increasingly common via university collaborations, professional societies, and nonprofit focus in global health. In any educational program, the initial step should be an objective assessment of needs with discussion between the stakeholders to establish roles, goals for learning, an assessment plan for that learning, and clear communication regarding expectations and next steps. Forming relationships with partner colleagues is critical and takes

time. As discussed at length elsewhere in this textbook, a useful initial assessment tool is the RAD-AID Radiology Readiness Assessment™ [22, 23]. Initial data collection should take into account the equipment available, current educational pathways of all stakeholders, staffing, related clinical services, supply chain, energy for powering imaging equipment, infrastructure, and available resources. The educational intervention should consider long-term sustainability, human capacity development, and a multidisciplinary approach to comprehensively address identified target goals.

Partners should review the needs assessment data together and approach the relationship as colleagues and peers. Each stakeholder brings valuable insight and experience into the program, and the partners should agree mutually on goals that are appropriate based on available partnership resources and initial assessment. Communication and cultural intelligence are critical as a foundation for moving forward. Caution is urged to avoid the framework that one stakeholder knows better than another; paternalism does not support the mission of equal partners [24]. According to Tedros Adhanom, the director general of the World Health Organization, "For any change to succeed, staff ownership of the change agenda at all levels is a must. External support can only complement" [25]. With the rationale that educational goals promote local human capacity, reduce the risk of dependency, and support collegial exchange of information, on-site partnerships with an educational emphasis can promote long-term sustainability. The on-site educational partnership is a long-term commitment between stakeholders. After the partnership is established, then objectives can be set to support the goals of the program. The following sections discuss examples of a bilateral partnership model and a multi-institutional partnership model.

Bilateral Partnership Model

The University of California Davis (UCD) radiology residency partners with the radiology residency at the Hôpital de l'Université d'Etat d'Haiti (University Hospital of the State of Haiti, HUEH). This relationship started when the UCD radiology residency director accompanied the American College of Radiology on an education outreach trip in early 2013. Based on initial assessment data, faculty at UCD and HUEH agreed to form a bilateral educational partnership centered on radiology residency education at both institutions.

Since 2013, UCD has conducted numerous weeklong radiology education trips, bringing UCD residents, faculty, and alumni to HUEH to teach radiology and pediatric residents. UCD's radiology residency program director, who is also the director of UCD radiology department's Global Education and Outreach, organized and led most of these trips. UCD faculty have also participated in two of RAD-AID's trips to HUEH. UCD residents apply to travel to Haiti as seniors. In preparation for the trip, they are expected to read portions *Radiology in Global Health: Strategies, Implementation, and Applications*, as well as a book about recent Haitian history. They prepare two interactive lectures and usually deliver them on 2 days, for a total of 5 or more hours, and they provide hands-on teaching. In addition to enhancing the Haitian residents' education, these trips provide a valuable opportunity to UCD residents as well as faculty, and these lectures complement those provided by visiting UCD faculty. UCD residents gain tremendous insight into how radiology is practiced in resource-limited environments and how healthcare systems function with different resources and diseases that are uncommon in the United States. They have the opportunity to recognize that despite the increasing reliance on CT and MRI in the United States, practitioners elsewhere make difficult diagnoses using radiography and ultrasound alone.

As an exchange, Haitian radiology residents travel to UCD for month-long observerships. This program was started in order to enhance their education with in-depth exposure to the expertise and the learning environment encountered at a partnership academic medical center. The Haitian observers are selected with the assistance of the residency director at HUEH. Efficacy of visits to HUEH and observerships at UCD is

assessed with pre- and posttests. Haitian observer visits to UCD have been limited to 1 month because longer visits to UCD Medical Center require detailed and expensive background and security checks. Successes of the partnership include increased educational opportunity for UCD and HUEH residents, targeted subspecialty education for HUEH residents with emphasis on modalities found in Haiti, and rewarding collegial relationships within the partnership.

Benefits of a partnership model include the opportunity for well-established relationships that can strengthen and grow over time. This model allows for some degree of simplicity, in that two partners can align and have clear communication regarding goals and objectives. The partners become invested in one another at the institutional and collegial level to ensure success and forward movement in the educational endeavor.

Multi-institutional Partnership Model

Partnership educational models can also be multi-institutional. Kline et al. discuss an educational partnership with focus in Malawi as a "long-term collaboration between volunteers from five ACGME institutions, two European institutions, and a Malawian hospital—in affiliation with RAD-AID International." Based on initial assessment data, the partners agreed that "Human capacity development is a major focus with emphasis 1) on professional development opportunities for the Malawian medical officers, consultant radiologist, and radiographers in the form of targeted education on requested topics by [RAD-AID] faculty, staff, and trainees; 2) on providing funding for attendance by Malawian colleagues at regional radiology conferences within Africa; & 3) on a long-term goal of training additional radiologists for Malawi" [26].

Team members include radiologists, radiology residents, technologists, nurses, and medical physicists. Members that have participated provide reports and feedback on their objectives so that the next team has continuity and can continue to build the program. As noted by Kline:

> ...the radiology resident traveling to the site during 2014 collected part of the Radiology Readiness Assessment data on which the full program was established. She noted that because of workflow and resource limitations, radiographs typically leave the department without radiologist review and are interpreted by clinicians; therefore, it was decided—with the guidance of the Malawian consultant radiologist—1) to strengthen radiology services within the Malawian hospital's department of radiology and 2) to educationally support Malawian clinicians on radiology best-practices and appropriateness criteria. This initial trip report led to subsequent radiology faculty and trainees working with the Malawian radiologist and directly with Malawian internal medicine and pediatric clinicians. Additionally, an objective was incorporated to provide the Malawian consultant radiologist with opportunity for conference attendance on subspecialty areas [26].
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> In this way, each team passes information on objectives met and suggestions for process improvement so that the partnership continues in a sustainable manner. Based on the input and work of radiology residents and fellows within the context of the program, 1) sonography curricula have been developed for Malawian radiology professionals and clinicians from multiple departments, 2) CT protocols have been adjusted for dose optimization, 3) targeted education is provided on pediatric and trauma imaging, 4) feedback has resulted in process improvement among stakeholders, and 5) informatics & interventional radiology assessments have been completed. Team leaders return annually to conduct formal program assessment with in-country stakeholders. In this programmatic fashion, several institutions collaboration to achieve global health goals, and the involved radiology trainees make a lasting impact by their involvement to overall progress... [26].

The stakeholders of educational partnerships may include community health workers, radiology professionals, and clinicians from other services [27–30]. A benefit of a multi-institutional model in global health radiology is a shared distribution of resources required; success is not dependent on one sole partner. Additionally, communication among the involved stakeholders can avoid duplication and ensure the most effective use of partnership resources. Implementation of these programs should consider that the

"promotion, development, and expansion of high-quality, culturally sensitive global health education" are used to address "the health needs and human rights of populations around the world" [31]. With this target in mind, it is necessary to consider formal training as a result of on-site educational partnerships—as the next section discusses.

Establishing or Supporting Formal Education

The creation of residency programs for specialized care has been successful in other branches of medicine. In 2012, Anthony Charles, MD, MPH, and his colleagues from the University of North Carolina at Chapel Hill, Haukeland University Hospital in Norway, and the Department of Surgery at Kamuzu Central Hospital (KCH) created a surgery residency in Lilongwe, Malawi. When Charles began working at the site in 2007, there were only two Malawian consultant surgeons; the trauma registry and needs assessment demonstrated objectively that more surgeons were needed in the nation of 16 million [32]. A key point of this educational partnership is that the surgery residency at KCH is accredited by the College of Surgeons for East, Central, and Southern Africa so that physicians completing training are recognized as being educated formally. Surgery residents and faculty from the partners in Norway and the United States spend time in Malawi with their peers and learn about surgery methods; therefore, surgeons on both sides of the partnership experience education through the collaboration. An evaluation of the residency stated, "At the outset, a needs assessment revealed a substantial requirement to augment surgical capacity not through intermittent visits by overseas surgeons, but by the creation of a new surgery residency-training program...The creation of this program was based on several important principles: strong partnerships, locally relevant curriculum development, early program assessment, and substantial involvement of local partners for program leadership and accountability" [32].

If appropriate based on partnership assessment and if resources can support, then this type of initiative is possible for consideration in global health radiology. For example, if an assessment shows that an area has ample radiologic technologists, but no radiologist, then the long-term sustainable solution is the formal education of radiologists for this area and development of local human capacity. Several examples of on-site partnership with emphasis on formal training exist in radiology. During 2015, Dr. Teodora Bochnakova completed a Radiology Readiness Assessment™ at Georgetown Public Hospital in Georgetown, Guyana. A partnership was formed between in-country clinicians, the director of Latin America at RAD-AID International, and faculty from Northwell Hofstra. Partnership discussions found a major goal of the collaboration to be the creation of radiology residency training opportunities for physicians in Guyana [33].

Georgetown Public Hospital Corporation (GPHC) already had several residency programs which were built in collaboration with institutions based in the United States. The administrators and clinicians at GPHC felt that the radiology department had fallen behind in provision of service for the hospital. The Radiology Readiness Assessment™ revealed an overall lack of coordination for imaging services with workflow challenges that limited capacity and poor communication of imaging interpretation and limited human resources, specifically radiologists. The central solution to address these problems was identified by the hospital staff as development of a radiologist training program to eventually foster quality, capacity, and service development. Collaboration between Guyana Ministry of Health, Georgetown Public Hospital Corporation, University of Guyana, Northwell Hofstra radiology residency program, and RAD-AID International has resulted in an approved residency curriculum. The curriculum is planned over 3 years and focuses on imaging modalities available at GPHC. Currently, nuclear medicine

and MRI are not available but may be offered as fellowships after the initial training. Advanced IR is not currently part of the curriculum although the partners hope to incorporate basic image-guided procedures as warranted. Residents will spend a part of their training at Northwell Hofstra to build competence in physics, quality assurance, safety, and basic ultrasound performance. The remaining time will be spent at GPHC with on-site RAD-AID volunteer teaching radiologists and remote teaching conferences from Northwell Hofstra.

Curriculum design for this unique program began by collecting goals for each of the rotations at Northwell Hofstra. These were subsequently reviewed and modified to address the specific needs of the environment at GPHC based on initial assessment data. In addition, both formative and summative assessment models were incorporated to allow for continuing evaluation and improvement of the program and its residents. The Ministry of Health of Guyana and the University of Guyana were instrumental in guiding the process so that the program graduates will be recognized as specialists in the field of imaging by Guyanese standards. The residency directors and their administrative staff at Northwell Hofstra have examined the logistics to address issues from visas to housing and transportation to mentorship to provide a successful learning environment for the time at Northwell intended for the first year. The first class of residents started in 2018. Rwanda is another location in which a radiology residency has been established in this manner [34].

Another example of the integration of formal education in the context of global health is the training program of Engineering World Health (EWH). According to EWH, approximately 40% of critical medical equipment in low- and middle-income countries is in need of repair or replacement [35]. Donated and purchased equipment sits idle due to the lack of skilled biomedical engineering technicians (BMETs) who can install, maintain, or repair it. As a result, physicians and healthcare professionals are hampered in their ability to deliver care. EWH developed a training program for biomedical technicians in response to this dire need. The mission of the formal education is to build a local, sustainable, and trained workforce of BMETs in low- and middle-income countries to repair and maintain medical equipment [35]. Other examples of formal education implementation include creation of subspecialty fellowships, such as the pediatric radiology fellowship at the Addis Ababa University Department of Radiology in collaboration with the Department of Radiology at the Children's Hospital of Philadelphia, or the implementation of formal education for radiologic technologists, medical physicists, and other radiology professionals [34, 36]. The creation of these relationships should take into account the health systems and education systems of both parties involved. Appendices 1 and 2 provide additional examples.

Online Educational Tools

In conjunction with on-site visits based on initial assessment data, education can be supported by content via distance education. Many professional organizations and consortiums, such as Image Gently, Image Wisely, World Federation of Pediatric Imaging, and the RAD-AID Learning Center, have existing models for this type of delivery [37–44]. Global disparities in healthcare delivery are a complex problem of scarcity and unequal distribution of resources. The workforces in LMICs often have limited access to educational content or, in some locations, a lack of structured curricula to ensure competency. To achieve the goal of promoting radiology in global health, two initiatives have to work in parallel: (1) investing in infrastructure and technical resources for imaging acquisition and (2) investing in the education of the local healthcare providers.

The United Nations highlights the role of promoting education. This was reflected in the Millennium Development Goals and is now in the Sustainable Development Goals. Emphasis was placed on healthcare education during the WHO 2013 Global Health Professional's Forum [45, 46]. In this forum, healthcare educators

worldwide were called into action to utilize innovative teaching methodologies and communications advancements to increase human capacity development. Online learning management systems (LMS) have significantly facilitated distance-virtual learning, which is an appealing attribute for global education initiatives. These systems possess the versatility of course assignments, case presentations, quizzes with ease for grading, and discussion forums for in-depth analysis of topics while allowing learners to move at their own pace with monitored progress and the added benefit of cost savings [47, 48].

In order to succeed, online learning resources should:

- Follow sound educational framework and objectives.
- Integrate the entire healthcare team.
- Adapt to and supplement the existing educational program needs.
- Be relevant to the available healthcare resources.
- Be easily accessible.

Blended Educational Models

Recently there has been a call for a transformation in teaching methodologies to "change the way we teach" [49]. This change in education, including radiology education, employs the blended learning models. This instructional strategy entails several models of combined online courses and varying degrees of instructor oversight or face-to-face interactions [50]. These methodologies have been shown to engage "millennial learners" who are technology savvy and prefer a more learner-centered approach [51, 52]. The assigned online courses and activities promote active learning by providing control over the pace and order for some of the content while at the same time are very accessible for distance learning [50, 53].

In global health educational partnerships, the varying degrees of instructor oversight and face-to-face components can be timed with on-site teaching through coordination with local training programs. Delivery of safe, effective, and efficient radiologic services requires an integrated radiology healthcare team; therefore, to upscale these services, educational initiatives should target the entire team including radiologic technologists, radiology nurses, practicing physicians, trainees (medical students and residents), and IT personnel [54].

There are three common blended learning models which include:

- Supplemental Model: this model supplements in-person teaching. For example, prior to clinical trips, specific online lectures are assigned to learners, and then applied knowledge is tested with in-person case conferences or scheduled web conferences.
- Replacement Model: this model partially replaces in-person teaching. For example, certain topics are assigned as online lectures while restricting in-person teaching to hands-on training.
- Emporium Model: this model replaces in-person teaching. For example, in-country learners are given full access to educational content and allowing students the freedom to choose. This last model is especially relevant if direct learner supervision is conducted by in-country educators [55].

Applications in Global Health Education

Before integration of online learning tools, bandwidth and access availability should be evaluated as well as acceptance of online learning tools into the educational framework of a culture and system. To assess the feasibility of online delivery of radiology educational material, qualitative surveys to evaluate the experience, benefits, and limitations of this method can be delivered. Information technology indicators, such as web traffic, user log-in data, and individual progression through the content, can be monitored also. The integration of online educational programs is dependent on Internet accessibility, which may be

unreliable in resource-limited areas; however, ease of accessibility through mobile devices can often guarantee access to educational material [56]. Mobile-friendly development can be targeted for regions in which cellular phone access is reliable even if Internet LAN connections are not.

Online content should address fundamental topics in diagnostic and interventional services in a radiology department. The curriculum should be based upon existing published national and international societal practice parameters, accreditation guidelines, certification study guides, and published literature in radiology. Examples include the American Board of Radiology (ABR) Core study guide, the WHO World Alliance for Patient Safety Reports and Guidelines, the ACR Practice Parameters, and the ACR accreditation programs' requirements and guidelines. The online delivery allows for using multiple media, including presentations, selected peer review articles, online videos, or recorded lectures that are pertinent to each topic. Formative and summative assessments should be incorporated to examine variable levels of knowledge for the learners, including factual, conceptual, procedural, and metacognitive knowledge [57]. Clinical vignettes with relevant scenarios can be used for assessing higher-order learning and problem-solving skills. The development of interactive and tailored online learning resources is a useful educational tool for promoting global radiology education.

Socially Responsible Global Collaboration

Voluntourism

Educational initiatives should be approached as long-term partnerships and collegial collaborations. The act of voluntourism, or a short-term volunteer trip, can be dangerous and potentially harmful to local economies [58–60]. In a discussion of voluntourism for orphan care, Maya Wesby of *The Wilson Quarterly* speculates, "A more suitable long-term solution would be to provide parents with the resources and knowledge to care for their children, or investing in a more permanent educational infrastructure, rather than focusing solely on short-term necessities...These examples reveal the core danger of voluntourism: It creates a dependency between host communities and Western societies rather than the infrastructure needed for sustainable self-reliance" [61]. The goal of educational partnerships should be bilateral agreement among stakeholders based on initial joint assessment and feasible objectives that promote human capacity development locally. *The New York Times* author, Jacob Kushner, claims, "Unless you're willing to devote your career to studying international affairs and public policy, researching the mistakes that foreign charities have made while acting upon good intentions, and identifying approaches to development that have data and hard evidence behind them — perhaps volunteering abroad is not for you" [62]. These deep systemic challenges should be considered during partnership establishment.

In the context of bilateral and multi-institutional partnership models, shorter time commitments under the leadership of consistent key stakeholders can be implemented to complete objectives and can create an effective educational model. Sending teams to transcribe images, obtain images, or do procedures in an LMIC is not a sustainable solution to the gaps in radiology in those locations. The critical factors for sustainability are focusing on education as a model (rather than completing clinical services for a site), having measurable objectives to evaluate transfer of knowledge and competence, and having agreement among the key stakeholders about what educational topics are relevant in the context of the partnership based on initial assessment data.

Bioethics and Cultural Competency

The discussion of voluntourism, education, and sustainability emphasizes the importance of bioethics in global health radiology education. When establishing a partnership, the integration of ethics is essential and ranges broadly from ensuring

that involved radiology residents are following the guidelines of their accrediting organization (ACGME or other national equivalent) to ensuring team safety to following IRB procedures for educational assessment. The bioethical tenets of nonmaleficence, beneficence, autonomy, and justice apply in global health radiology, and a partnership culture should be fostered in which stakeholders feel comfortable discussing dilemmas and issues [63]. *The Journal of Business Ethics* suggests two potential frameworks for creating a culture of ethics: (1) one led by the leadership to create an established organizational ethics or (2) another through which leadership promotes individual self-assessment in a broadly managed framework [63]. The integration of a process to support the open discussion of ethics should be based on the stakeholders in the educational partnership and their agreement.

Also, stakeholders should learn about the cultures and customs of their partners. One bilateral benefit of educational and collaborative international exchange is finding that there is more than one correct process. The process for dictating images and radiologist/clinician workflow that is appropriate for one partner, based on resources, may not be appropriate for the other partner. Communication styles vary among cultures, and understanding these differences and being able to shift to be respectful of your partners are critical—as communication is the foundation of partnership [24].

Learning from Failure

As in the fields of business and organizational science, educational partnerships should look at failures as opportunity for learning and reassessing to decrease the probability that mistakes will be repeated. Arino and de la Torre document "a longitudinal case study of the interaction between two partners to a failed international joint venture" and conclude "that positive feedback loops are critical in the evolutionary process, that relationship quality is both an outcome and a mediating variable, and that procedural issues are critical from the start in fostering a climate for positive reinforcement and the building of mutual trust and confidence in the relationship" [64]. An agreed-upon means for feedback, mutually established processes, and time spent building relationships were primary findings in their discussion. As an example, some partnerships may require formal feedback meetings based on cultural styles, and other partnerships may depend on informal discussions for stakeholder assessment. It is better to ask upfront which feedback style is most appropriate so that these conversations are productive [24]. In 2011, David Damberger reflected on the open culture created at Engineers Without Borders for discussion of failure and error. Cross-organizationally, the engineers are encouraged to "publically admit, scrutinize and learn from their missteps" [65]. The take-away being that these concepts should be applied to global health educational initiatives; organizations and partnerships must continually self-assess, seek systematic improvement, and document progress.

Curricula for Global Health in Radiology

As more radiologists, technologists, physicists, nurses, and radiology professionals recognize the importance of radiology in global health, there is opportunity for joint education and collaboration. If pursuing an on-site partnership model or a partnership that establishes or supports formal education, then stakeholders in those organizations or collaborations, regardless of professional scope, benefit from a structured framework within which to operate for their long-term initiatives [66, 67]. General public health and global health educational opportunities are available, such as the MD/MPH degree combination or graduate degrees in public health or global health.

Because of the special considerations in radiology for technology and equipment, curricula are being created with emphasis specifically on radiology in the context of global health. Recommendations for global health electives and project experiences for radiology residents include global and public health education,

targeted travel medicine education, basic imaging proficiency, and consideration for practice attitudes and accountability. Additional global health curricula place emphasis on ultrasound education of radiology residents because of its prevalence as a modality in LMICs [68–70]. This structure and need can be applied to other professional scopes, as is evidenced by the ASRT's Medical Relief Readiness educational product which is targeted for technologists traveling abroad in educational or disaster relief capacity [71].

Other organizations, like RAD-AID International, offer learning opportunities, like the Certificate of Proficiency in Global Health Radiology, which is a facilitated online learning experience for a multidisciplinary cohort with mentorship for project planning and implementation. This cohort echoes the Koplan definition of global health [7]. From 2015 to 2018, cohorts have included healthcare professionals from Australia, Cameroon, Canada, Egypt, Germany, Guyana, Ireland, Kenya, Malawi, the United Kingdom, the United States, and Seychelles. The certificate of proficiency is open to an international cohort with two annual scholarships for participants in LMICs. Also, cohorts have included consultant/attending radiologists, health informatics specialists, primary care physicians with interest in future radiology training, radiologic technologists, radiology registrars/residents, and sonographers. The multidisciplinary interaction and exchange provide a unique learning environment.

A sample of competencies covered by the cohort include (1) *radiology's context in global health* including broader implications of interactions, concepts of resource accessibility versus availability, and implications of economy and infrastructure; (2) *socially responsible global collaboration* including cross-cultural intelligence, communication, responses to failure, and legal and ethical considerations; (3) *partnership and educational* structures including the importance of initial assessment and continuous assessment to measure impact; and (4) *radiology-specific issues* including sustainable approach to equipment and technology issues (such as addressing supply chain, warranty and maintenance for equipment, stakeholder agreement), the role of education in human capacity development, and the usefulness of multidisciplinary approach for holistic success [72, 73]. These competencies are applied in the context of professional scope: How would these topics apply to a breast imaging radiologist, an interventional radiologist, a medical physicist, a radiologic technologist, a sonographer, a nurse, and other professional specialities? How would they apply to the team and partnership as a whole?

Training and student variants of this curriculum have been used via a combined RAD-AID and Columbia College of Physicians and Surgeons Global Health Radiology Clerkship for medical students, a combined RAD-AID and UCLA Global Health Radiology Clerkship for medical students, and a self-directed tutorial for radiology residents [73]. Regardless of the source of global health curriculum or framework, it is helpful for stakeholders to have education and knowledge about the context of global health and radiology's role internationally when moving forward to establish educational partnerships.

Conclusion

In summary, radiology is a critical field in the advancement of global health, and education is a method of achieving sustainable progress. Faculty exchanges, scholarly collaborations, partnership models, formal education, online educational platforms, and global health curricula are some educational tools that are used in global health. Regardless of the type of model used, educational goals and objectives should be based on initial assessment data and address the appropriate needs. Curricula should be established in partnership with all stakeholders and with consideration for ethical best practices, continuous evaluation and improvement of the program, and open communication among stakeholders.

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