Pediatric Radiology (2018) 48:1698–1708
https://doi.org/10.1007/s00247-018-4221-x

COMMENTARY

Pediatric radiology mission work: opportunities, challenges and outcomes

Summit H. Shah[1] · Larry A. Binkovitz[2] · Mai Lan Ho[2] · Andrew T. Trout[3] · Brent H. Adler[1] · Savvas Andronikou[4]

Received: 22 May 2018 / Revised: 11 June 2018 / Accepted: 25 July 2018 / Published online: 16 August 2018

Introduction

The lack of access to imaging studies and radiologic expertise is a global issue receiving increasing attention in the news media [1, 2]. The need for radiologists to apply their interpretive skills and interventional techniques to children in resource-poor areas is global, with major medical resource and disease discrepancies (Fig. 1). The desire to care for children with medical needs is a common impulse among pediatric health care workers. As aptly put by Shaywitz and Ausiello [3], "It is difficult to imagine a pursuit more closely aligned with the professional values and visceral instincts of doctors than the quest to improve global health." A recent survey noted that 72% of radiology residents had interest in doing such work, but only 4% of radiology residency programs offered elective international aid experiences [4]. In our discussions with other pediatric radiologists, it seems that this nearly universal desire to participate in global outreach efforts is often hampered by a lack of knowledge as to how to get started.

Efforts to close the gap between theory and practice have been undertaken [5], and the purpose of this paper is to provide the tools for pediatric radiologists who are interested in participating in global outreach efforts to act. The range of opportunities for pediatric radiologists to contribute to global outreach efforts is discussed in the paper's first section: on-site mission work, teleradiology, and virtual or on-site teaching and consultation. These include primary or secondary interpretations of examinations done at a remote site via teleradiology, on-site pediatric radiology at underserved areas (radiology mission work), and virtual and on-site teaching and consultation. In the second section the authors discuss many of the challenges that arise when considering global outreach in resource-poor areas based on their experiences. This includes practical issues of international travel with equipment, interactions with local health care workers, personal health and safety, and personal emotional and ethical challenges. Last, the authors present the outcomes that have been achieved through pediatric radiology outreach programs.

✉ Larry A. Binkovitz
binkovitz.larry@mayo.edu

[1] Department of Radiology,
Nationwide Children's Hospital,
Columbus, OH, USA

[2] Department of Radiology,
Mayo Clinic,
200 First St. SW,
Rochester, MN 55905, USA

[3] Department of Radiology,
Cincinnati Children's Hospital Medical Center,
Cincinnati, OH, USA

[4] Department of Radiology,
Children's Hospital of Philadelphia,
Philadelphia, PA, USA

Opportunities

Many pediatric radiologists have a strong desire to help the international community, but they face barriers that limit actual participation. First, the demands of their full-time job and responsibilities to their families and communities might limit time away to 1- or 2-week blocks. Second, they might not know how to go about researching organizations and finding specific opportunities that would be suitable for them. Finally, practicing radiology in remote areas requires expensive equipment, and radiologists might not know how to contribute without their CT scanners, technologists and picture archiving and communication systems (PACS).

International underserved communities

For many, the only global outreach activity they are aware of is traveling and working as a practicing radiologist in a remote resource-poor area, often at a great distance. These

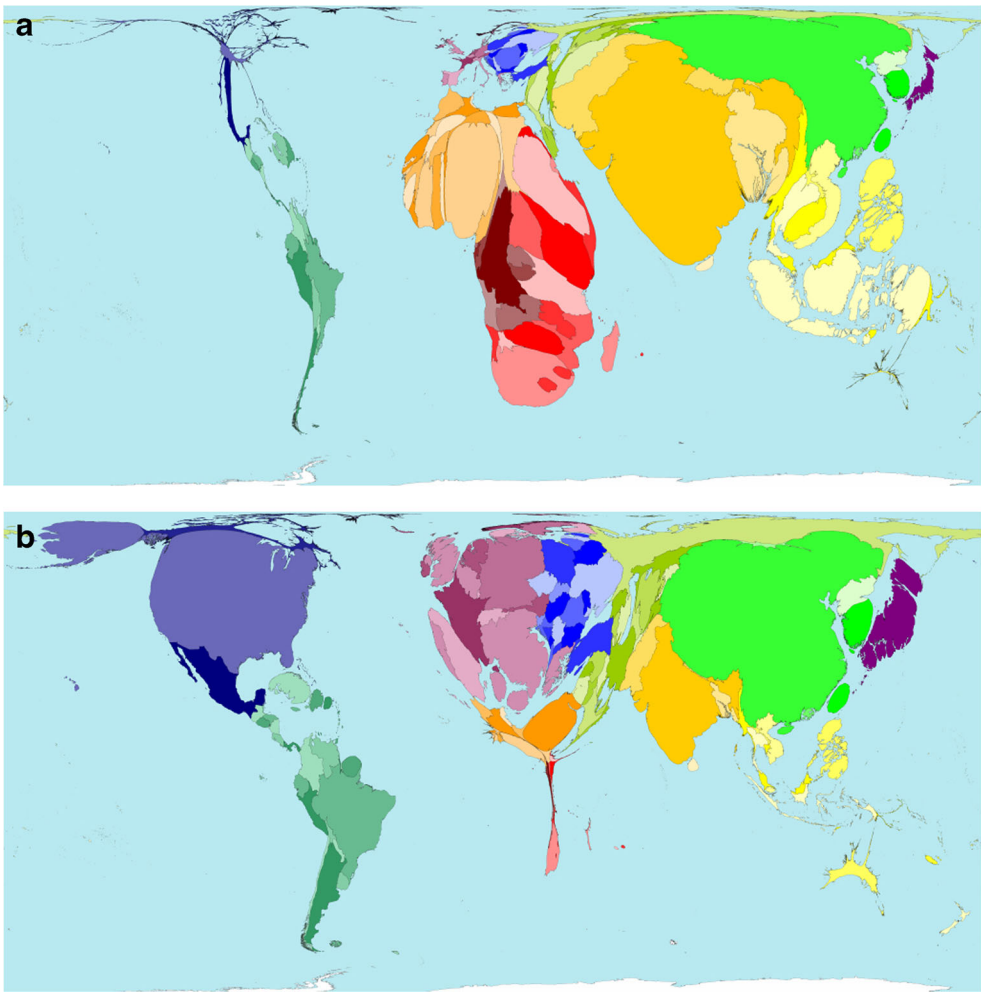

Fig. 1 Geospatial mapping demonstrates relative over-incidence of tuberculosis (TB) per capita compared to the reduced availability of physicians per capita. Countries' areas are expanded or contracted based on (**a**) relative excess of TB cases per capita and (**b**) relative deficiency of physicians per capita. Note bloated appearance of sub-Saharan Africa in (**a**), indicating relative excess of TB cases, and severe attenuation in (**b**), indicating markedly reduced physician numbers

experiences can have multiple benefits — immersion in another culture, gaining of perspective from other parts of the world, and potential additional travel in the country or region being served. There are many additional ways to contribute to global outreach efforts that can meet a radiologist's specific needs and talents (Table 1) [6–8]. By knowing the vast categories of opportunities possible, pediatric radiologists can take initiative and even suggest possibilities to organizations that do not have such programs in place.

One place to learn more about radiology-specific projects abroad and types of opportunities is RAD-AID, www.RAD-AID.org, a global non-profit that aims to improve radiology services for underserved populations around the world. RAD-AID projects begin with a radiology readiness assessment and emphasize education and sustainability. Currently, RAD-AID is active in 47 institutions within 30 countries. RAD-AID's pediatric-radiology-specific efforts include research and education initiatives, overseas mission work, technical innovations and multi-institutional conferences with activities in Laos, Malawi, Haiti, Nicaragua, Cape Verde, Bhutan, Nepal, Ghana, Vietnam and Ethiopia. Volunteer placements range from one to several weeks, depending on the location and objectives. RAD-AID also hosts an annual 1-day conference in Washington, DC, at the World Health Organization, which allows individuals to learn about current and future opportunities [9].

In addition to RAD-AID, numerous organizations are seeking and would benefit from participation by a pediatric radiologist. Opportunities are available through Doctors Without Borders (www.doctorswithoutborders.org), Radiologists Without Borders (www.rwborders.org) and Radiologists Across Borders (www.radiologyacrossborders.org). Unfortunately many opportunities are not well advertised and require initiative on the part of the radiologist. To help focus and guide the search, we recommend three major groups of organizations through which radiologists can find opportunities. First, universities or medical schools are an excellent resource for trips abroad. This frequently offers the opportunity to teach students and work in an interdisciplinary setting or travel as part of a carefully constructed team designed to fulfill a specific mission. For example, the pediatric radiologists at Children's Hospital of Philadelphia have been particularly active in global outreach in Ethiopia. Second, faith-based organizations that provide medical care,

Table 1 Opportunities for pediatric radiologists to contribute to global outreach

On-site opportunities
Interpreting radiology studies at a health care facility
Providing point-of-care ultrasound in a resource-poor setting
Completing a radiology readiness assessment (see RAD-AID)[a]
Providing in-person didactic lectures to trainees and practitioners
Hands-on teaching abroad
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
Improving informatics integration and optimizing radiology workflow
Home opportunities
Remotely interpreting studies (teleradiology) and performing over-reads
Hosting trainees from other countries
Conducting virtual lectures
Developing and contributing to an enduring radiology curriculum

[a] www.RAD-AID.org

such as Faith in Practice, faithinpractice.org are another great resource, especially for short-term medical trips. Most do not require endorsing a particular faith for participation. Although there might not be an established role for radiology on the trips the organizations have traditionally sponsored, the communities they serve can benefit greatly from portable ultrasound or interpretation of radiologic studies provided by a pediatric radiologist. This is especially the case with many of the rural clinics abroad at which a large percentage of the patients are children.

Discussion about mission opportunities with colleagues in pediatrics, family or emergency medicine can lead to partnerships with these clinical specialists on future trips, and these specialists might not have seen the benefits of radiology outreach first-hand. Last, direct contact with local practitioners can also yield opportunities. While it is often challenging to establish the line of contact, this form of communication often allows for needs and resources to be addressed directly and might lead to contacts with other organizations that have served the area. This type of search can be especially useful if there is a particular region where travel and work is desired and no organizations are known to be working in the area.

Teleradiology

For those looking specifically for teleradiology interpretation opportunities, several organizations are seeking pediatric radiologists. One is the Collegium Telemedicus (https://collegiumtelemedicus.org), which 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 study using a DICOM viewer downloaded to the computer, and responds with an interpretation. The communication tool also allows the radiologist to request additional clinical information. If a radiologist is not available and does not respond within a given time frame, the examination is automatically re-routed to another radiologist for reading. This takes little time to set up and the images can be reviewed from anywhere at any time. The World Federation of Pediatric Imagers (WFPI), WFPIweb.org provides several additional electronic resources, which will soon include recommendations for standardized pediatric imaging protocols across a variety of platforms [10, 11]. Partners in Health, www.pih.org, is another organization that offers onsite and teleradiology services.

Challenges: practical, emotional and ethical

Practical challenges

Getting there (and back) safely

A common adage among mission workers is that a mission that results in injury, illness or harm to a worker is a failed mission, and this applies to radiology mission work. Primary considerations of personal safety when planning a mission trip include getting there and getting back safely. When working in low-resource or remote areas, be ready to be uncomfortable but not to accept situations where you are unnecessarily endangered. The most common cause of death for travelers in the developing world is motor-vehicle-related accidents, and this should be considered when making transportation decisions.

As a mission worker with expensive equipment, you could be viewed as a possible source of income for criminals in the developing world, either through robbery or kidnapping and extortion. Security of the mission workers needs to be a primary concern while planning a mission. Local law enforcement is sometimes inadequate, indifferent or non-existent, and private security might need to be considered. Where the potential for kidnapping is more than theoretical, one should consider purchasing kidnap and rescue insurance. The financial impact to one's family of going missing while on mission can be more severe than dying on mission. Insurance payouts sometimes require a lengthy waiting period before someone missing can be declared dead, and this can create considerable financial difficulty for the mission worker's surviving family.

As one of our spouses said prior to a recent mission trip, "Don't make me wish you were dead rather than just missing." The authors have used Lloyd's of London for kidnap and ransom insurance coverage, and other providers might be available. Knowing that you are covered by a ransom policy and disclosing this to your kidnappers might make you a more likely target of extortion once taken. It is important to note that many companies already have such coverage for their employees but do not disclose this to their employees for that reason.

For missions in remote areas, getting there is usually easier than getting back. With each leg of a journey to a remote mission site, facilities become more limited and less modern. Starting a travel day at O'Hare or Heathrow and finishing at the Moravian Mission at Ahuas, Honduras, or in a remote village in South Africa, for example, often requires multiple flights, the last one landing on a mud and gravel runway. The pilots will not take off on the final leg of the journey if the runway in Ahuas has been softened by recent rains. What if it rains the last night of your mission and the runway is unusable the next day when you are to depart? How do you get back? It is worth having alternative travel pre-planned such as using smaller planes or traveling overland or by water, shuttling the mission team to a larger airport. Having local currency and contacts is a must.

Staying safe and healthy

Personal health is also of primary concern, especially when traveling to the developing world. Country-specific travel advisories can be found at https://travel.state.gov/content/travel/en/traveladvisories/traveladvisories.html. Information regarding the need for immunizations, malaria prophylaxis and other health considerations is available at https://wwwnc.cdc.gov/travel/destinations/list/. There are many threats to the health and well-being of medical mission workers and these include infectious disease, trauma, sexual assault, excessive sun exposure and crime [12]. You or the organization you are traveling with should have an understanding of locally available medical resources and at least an idea of what you would do in the event of a serious illness or injury. When you get sick, not only might you feel miserable, but your ability to contribute to the mission could be limited and you could become a strain on mission resources.

The most common illness contracted while traveling is infectious diarrhea from ingesting contaminated water, which can come from unexpected sources. For example, vegetables and fruits washed with water can harbor *E. coli* or other pathogens. Bottled drinks could be stored in or served with ice made with tainted water, and bottles of water, often sold by street vendors, could simply be used plastic bottles refilled with contaminated water. In remote areas, many mission workers only eat fully cooked food, such as boiled vegetables, drink only boiled beverages, such as coffee or tea, and rely on grains, nuts and beans for dietary needs while avoiding meats, eggs and cheeses.

It is beyond the scope of this article to give specific medical advice and there are resources to address safety and health for the international traveler [13]. From personal experience, traveling with antibiotics, such as azithromycin (Zithromax, Pfizer Inc., New York, NY), and taking them at the first sign of gastrointestinal illness, has proved to be quite beneficial, helping to avert a failed mission. Others have routinely used antibiotic prophylaxis to reduce the likelihood of contracting infectious diarrhea.

Ultrasound equipment: getting it there and keeping it yours

With the advent of compact portable ultrasound units, the role of the radiology mission worker to resource-poor areas has become substantially more meaningful, allowing for 21st-century medicine, not early 19th-century. But traveling with a portable ultrasound unit can pose some challenges. The equipment is expensive, delicate and critical to your mission work. For individuals and organizations that do not have their own ultrasound units, the global health loan program through Sonosite is one source of equipment. With advanced notice, Sonosite (Fujifilm, Sonosite Inc., Bothell, WA) will at no charge ship a portable M-Turbo machine with any requested transducers before your trip abroad and provide a free shipping label for return after your trip. For more information, contact globalhealth@fujifilm.com. Additionally, RAD-AID might help to facilitate obtaining a US unit for on-site use.

Ideally the portable ultrasound unit never leaves your side. The most popular units (Sonosite; GE Healthcare, Waukesha, WI; Philips Healthcare, Best, The Netherlands) are small enough to be brought as carry-on luggage on most commercial planes. The overhead luggage bins and under-seat space might be too small for larger portable units on regional planes. Airlines and gate agents should be routinely notified prior to departure and at the departure gate that you are a mission worker traveling with an ultrasound unit. Often the flight crew will allow the unit to be stored in their closet near the front of the plane. Be aware that ultrasound gel is a liquid and technically would need to be checked. The authors have had Transportation Security Administration agents allow them to carry on several bottles of gel after special screening but this cannot be relied upon routinely. If the travel itinerary includes flight connections in the developing world, the luggage, including carry-on bags, might be left outside between flights. Keeping the ultrasound unit dry is critical and traveling with waterproof plastic bags or pouches is advisable.

Any modern technological equipment can viewed as "valuable" and subject to being stolen, or in some countries seized by customs agents. It is important to be able to document that the US unit being brought into the country is yours and, when

departing at the end of the mission trip, was not purchased in the host country. A bill of sale might be useful. Upon arrival in the host country, be prepared to have the unit and anything packed with it inspected. A customs declaration form might need to be filled out. It is important to travel with documentation that the US unit is being brought into the country for temporary medical mission work. A cover letter with letterhead from the mission worker's home hospital or institution describing the mission in detail including dates, location and equipment being transported as well as a letter from someone in-country from the mission sponsor or hospital director including this information is also recommended. Be aware that the actions of custom agents might seem illogical; one of the authors had his hand-written cheat sheet with instructions for using the US unit confiscated in the host country.

The work environment

When preparing for a mission trip, confirm what, if any, local radiologic equipment will be available for use in country. Because the majority of radiologic equipment in the developing world comes from donations — much of it poorly or non-functioning (Fig. 2) [14] — it is critical to confirm the usability of the local mission-specific radiologic equipment and necessary support material and staff, such as darkroom supplies and film cassettes, as well as access to electricity, and if possible, the Internet. Viewing images on sheet film often requires a window for backlighting because view boxes are rarely available. If taking a portable ultrasound unit on mission, the radiologist needs to be very comfortable with the equipment and, at a minimum, have a means to communicate with his or her home institution or the manufacturer for technical support in the event of operational difficulties. Because electrical service can be intermittent and unreliable, it is advisable to have batteries that are sufficient for a day's work and can be recharged overnight. Converters are required for electrical outlets in many countries and power might be direct current (DC) rather than alternating current (AC).

The ultrasound work space is likely to lack an exam table and fresh sheets for each patient, and supplies such as paper towels and disinfectant might be limited or non-existent. Improvisation often becomes necessary. Desks or folding tables can be used as exam tables and a single cloth sheet might need to be used for every patient throughout the day. Cleaning the ultrasound probe between patients might be as basic as wiping the gel off with paper towels or a washcloth. Because of these limitations and possible cultural differences, many radiology mission workers do not perform endo-vaginal studies in low-resource rural areas, though the authors have found that the probe proves useful in other ways, such as for neonatal head ultrasound. For those who do perform endo-vaginal studies, condoms can serve as a low-cost probe cover and a container of bleach or other disinfectant wipes brought along can be used to clean equipment.

Despite these limitations, it is important to create a work environment that provides for patient privacy, maximizes patient comfort and dignity and allows for good diagnostic studies to be performed. Additionally, to the best extent possible, establish working conditions that are reasonably ergonomic for you as the practitioner. Long days providing ultrasound service places stress on the body and fatigue can build over the course of a mission. Temporary walls and blinds can be constructed using sheets, tarps, planks of wood or cardboard. Ambient light can be controlled with the same materials put over windows. Duct tape and clothespins are extremely versatile. Providing a place for parents and siblings to sit during the ultrasound examination, even on crates, conveys respect for their role in the patient's care. Access to drinking water for the patients is very important because many have walked great distances in the hot sun and might be dehydrated, and this can compromise transabdominal pelvic exams. The authors have found it efficient to have the patients begin drinking immediately once the need for a pelvic ultrasound has been established. It might be necessary to find ways to keep the ultrasound unit cool when working in a hot environment where there is no air-conditioning. Pre-arranging the availability of working fans should be considered (Fig. 3), and in extreme cases, placing the ultrasound unit on a tray of sealed bags of ice might be required.

Where language is a barrier to communication, an interpreter is ideal but not always available. Learning a few key phrases in the language of the patients can go a long way. It is

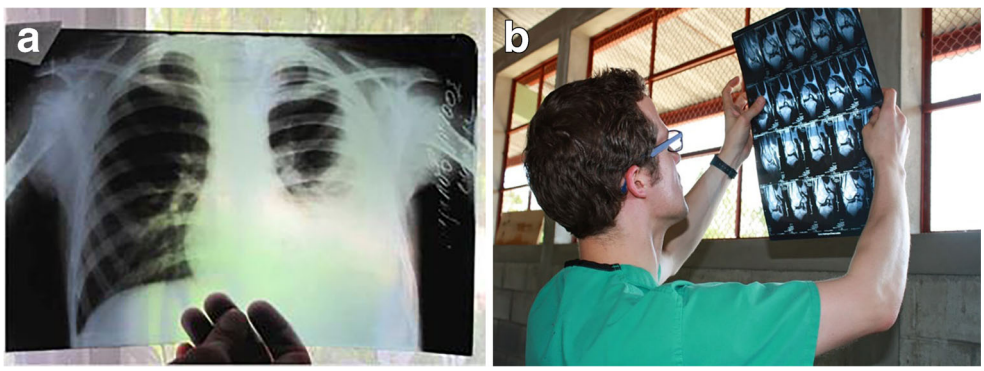

Fig. 2 On-site equipment and work conditions. **a** Patients might arrive with photographs of poorly exposed or developed radiographs for interpretation, often without knowledge of the findings. **b** Often view boxes are unavailable and natural light is sometimes the best way to view images

Fig. 3 Ultrasound examination area in rural Guatemala. **a** A fan used to cool a portable ultrasound unit, upper left. The exam bed is covered with a single sheet used for more than 50 patients each day. A roll of paper towels is the only supply available for cleaning the transducers between patients. Note the black ash particles that had settled on the bedsheet from sugar cane burning near the temporary clinic site. **b** A paper drape is taped in place covering the exam table and was used for the entire day. The school chair is used as a step stool and an empty box as a trash receptacle

important to confirm exactly what language your patients understand. On a recent trip to rural Honduras, one of the authors was confident in his Spanish language skills only to learn that most of the patients spoke the indigenous language Mosquito and had a limited understanding of Spanish.

Setting reasonable expectations — for colleagues and yourself

The impact of the pediatric radiologist on mission can be optimized when there is a health care team working together to identify which patients require imaging and integrating the imaging findings into a patient care plan. It is important for the referring medical providers to have reasonable expectations regarding what you can do for their patients and a clear understanding of your limitations. Discussions during the planning phases of a mission can improve efficiency and also help inform you as to the expected imaging needs.

At many resource-poor mission sites, the only radiologic modality available is the portable ultrasound you are bringing, so a sonogram might be ordered for indications typically requiring radiographs. For example, the authors have frequently been asked to use ultrasound to diagnose acute and healing fractures and dislocations. As discussed later in this paper, the absence of such discussions can result in "everyone being a patient who needs imaging," with *everyone* (including patients, their families *and* local staff and their families) wanting to benefit from the advanced technology you brought to the region. (The ethical implications of this are discussed later, as well.)

In our experience, your practice on mission is considerably broader than at home. In most settings, adults greatly outnumber pediatric patients and you are expected to be not only a *pediatric* radiologist but also to perform numerous adult exams, including obstetrical, breast and abdomen studies. If you plan to perform image-guided procedures, confirm the availability of lidocaine, suture material, aspiration or biopsy needles, drains, etc. A procedure for which a serious complication is more than theoretical should not be performed if there are no facilities or personnel to handle such complications. Additionally, tissue specimens should not be obtained without pre-arranged pathology support. It is possible to store and later send biopsy specimens for pathological evaluation in your home country, but the logistics of this, including international transportation of biological specimens, should be fully worked out in detail in advance.

With as many as 50 or more ultrasound exams to do each day on mission, it becomes necessary to limit the scope of each ultrasound study. In the absence of PACS, film printers or even medical charts at many mission sites, decisions regarding how imaging findings are documented and communicated to the referring health care team need to be made. Ideally, significant images should be reviewed with clinicians and surgeons directly, but this is frequently not possible. Storing images on the US unit's memory is possible but time-consuming and often not desired by the clinicians who only want your interpretations. Having an assistant who can record pertinent findings on a hand-written sheet and help direct patients into and out of the exam area is very desirable.

Being relevant clinically

Become aware of the imaging findings, especially ultrasound, of the indications and diseases that you are likely to see in the region where you are going. Infectious diseases, especially

TB, malaria and gastrointestinal worms, are ubiquitous in the developing world and awareness of the role of ultrasound in these diseases is important. There is a growing body of literature about the role of ultrasound in infectious and parasitic diseases, especially in TB, and this is discussed in the next section. Because maternal mortality is a leading cause of death in many resource-poor developing countries in women of child-bearing age [15], the decision to offer prenatal obstetrical ultrasound evaluations is not to be taken lightly; the need is ever present and the impact can be dramatic. Identification of breech presentation, twins or placenta previa can be life-saving if the mother-to-be can be referred to a hospital with sufficient facilities. Even in uncomplicated pregnancies, estimation of the due date can allow a family to appropriately plan for what may be a several-day walk to a clinic where a health worker can assist in the delivery rather than delivering unassisted at home. Prior to arriving on mission, discuss with the mission organizers or local health leaders what referral mechanism might be available for urgent or elective surgery, medical follow-up, or handling of image-guided biopsy tissue (if that is a service you can offer).

Last, it is important to realize that identifying certain pathologies that would have a major clinical impact at your home practice might have no impact in resource-poor settings. For example, identifying an advanced breast cancer with axillary adenopathy might not result in any medical intervention in many remote resource-poor areas of the world. The emotional impact of such situations is discussed in the "Emotional challenges" section of this paper.

Teaching effectively

In most resource-poor regions, you will probably not be teaching pediatric or general radiologists; instead you will be teaching general physicians, medical officers, radiographers, nurses and community health workers. Because the local physician staff often has relatively limited training, it is very easy to dismiss their radiology skills as inferior. However, often their knowledge of the imaging findings of infectious diseases will be far greater than your own. Your lectures and other teaching materials need to be geared to the population you will be teaching, their level of medical knowledge and the local needs. Regarding chest radiographs, interpretation of the findings of TB and, in many parts of Africa, human immunodeficiency virus (HIV)-related infections might be particularly relevant. The authors have found that many physicians want to be able to use ultrasound to diagnose pneumonia, even when radiographs are available, because it can help clarify difficult-to-interpret chest radiographs — such as when there is extensive opacification of a hemithorax — and can help guide drainage procedures. Health care workers with a basic understanding of anatomy and ultrasound can be taught how to evaluate for several key conditions such as hydronephrosis, hydrocephalus in the young infant, gallstones, long-bone fractures, breech presentation and placenta previa. Be aware that the teaching environment might be challenging, especially when using PowerPoint (Microsoft, Redmond, WA), because there might not be adequate facilities or appropriate shading for a computer-based lecture (Fig. 4).

Emotional challenges

Participating in global outreach activities as a pediatric radiologist can be among the most professionally rewarding experiences of one's career. To have the opportunity to give your expertise to someone in need, to have it received openly, and to see the immediate positive impact of such an exchange can be deeply gratifying. To be welcomed with a standing ovation by the crowds of patients and families at the mission worksite each morning can be a humbling experience. To be able to teach fellow health care workers whose desire to help the sick and injured children of their country under extremely challenging and depressing conditions is a great honor. For many, experiences like these are self-reinforcing, leading to a desire to do more and give more. They can extinguish feelings of professional burnout that can come from feeling over-

Fig. 4 Lecture hall in Swaziland used during a *Médecins Sans Frontières* (Doctors Without Borders) training session with black trash bags duct-taped over the numerous windows to allow for better viewing of the projected images

burdened by the home practice. They can lead to new avenues of inquiry and research, drive a desire to develop new skills and expertise, and allow for the reconceptualization of one's professional role and identity.

However a pediatric radiologist might also experience many difficult emotions while on mission. You might be frustrated as your planning efforts are thwarted by clinicians who have been doing 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 and experience you wish to share with them might undermine their role in the community once you and your ultrasound unit are gone. You might feel helpless as you identify diseases in children who have no hope of treatment. Worse, you might find yourself useless, limited by the technology you can bring on mission, while clinicians have skill sets that allow them to directly care for patients. Having to use ultrasound in novel ways to provide your clinicians with meaningful information or for conditions that are outside your comfort zone can be frightening. The sheer number of patients to be seen can be overwhelming, and this can give rise to feelings of frustration and even resentment. Having to stop each day, when there are still many patients to see, can lead to feelings of guilt. Taking any personal time, even to eat or rest, can seem selfish. Leaving at the end of the mission, when there is so much left to do, can lead to feelings of hopelessness or self-doubt as you question your motivations and level of commitment.

It can be helpful to discuss such feelings with other team members. The authors believe it is important to acknowledge these feelings and be aware that they are common, normal and even healthy, reflecting an awareness of the global need for pediatric health care and the desire to help. Some mission teams include clergy or a counselor to help workers process some of these difficult feelings. It is 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. Ultimately, global outreach and mission work benefits both the patients and community served as well as the pediatric radiology mission workers.

Ethical challenges

As discussed, the desire to help children in need is universal, and the need is literally global. Because of the discrepancies demonstrated in Fig. 1, there can be the sense that because the need is great and motives of the mission workers are good, then their actions are right. Such thinking is narrow-minded and one-sided and can lead to interventions that are unnecessary, unsustainable or even harmful. Pediatric radiology mission workers must anticipate the ethical challenges that they might face and have a basic understanding of ethics to ground their ethical decision-making while on mission.

A discussion of ethical frameworks is beyond the scope of this article, but common to all ethical frameworks are universal moral norms and principles that include non-maleficence (do no harm), beneficence (do good), autonomy (patient self-determination), privacy (patient confidentiality), integrity (maintenance of professional standards), transparency (openness), trustworthiness and distributive justice (equitable societal resource allocation and burden). Ethical challenges arise when a medical intervention creates a conflict between these norms and can result from limited medical resources, insufficient interpretation services, differences in relative weight put on certain values, individual vs. community well-being, and different understandings of the medical facts [16]. To resolve such conflicts, mission workers must evaluate the effectiveness and necessity of the proposed actions, ensuring proportional and minimal infringement on these moral principles [17]. The competing principles need to be balanced by the involved parties (patients, families, local health care workers and, under certain circumstances, community leaders) with discussion of the relevant medical facts, the goals and values of the stakeholders (which might differ from one another) and the limitations of resources that might impact the possible interventions [18].

It might be asked whether ethical challenges exist for pediatric radiology mission workers who are simply performing and interpreting studies requested by the clinicians who are caring for their patients. The authors believe they do, and radiology mission workers should think about ethical challenges before and while they are on mission. Most pediatric radiologists likely do not work at institutions that put them in ethically compromising positions in their daily practice. However in resource-poor environments, often with language, cultural and other barriers, ethical challenges do arise. Several are discussed next.

Are you a dentist?

The first challenge a radiologist is likely to encounter in resource-poor areas can be expressed in the question "are you a dentist?" More specifically, "are you a dentist where there are no dentists?" This question asks, what is your scope of practice while on mission? How far beyond your routine scope of practice are you willing to go and how do you make that decision? For example, would you perform obstetrical ultrasound where Zika is endemic, where you have the only ultrasound machine and dozens of women show up for a screening ultrasound after being advised to do so by their minister during the sermon at church the day you arrive on mission *and* you have not performed obstetrical ultrasound in many years? The answer to this particular question goes beyond competency in obstetrical ultrasound. The radiologist should also evaluate whether and how such information would be used — would the patient be able to use the results

as she saw fit or would others in the community have access to the information and use it in such a way as to limit her autonomy?

Who is a patient? Who is a doctor? Who is your boss?

When advanced medical care becomes available for a limited period of time in a resource-poor area, human nature dictates that nearly everyone will want to put themselves in a position to benefit from that care. For portable ultrasound, the question is, does every patient need an ultrasound study? Will performing an ultrasound with little or no chance of providing meaningful information just so the patient can "experience advanced care" that is otherwise unavailable diminish the value of the mission or the perceived value of the local health care providers?

Mission work brings together medical workers of various backgrounds and training. The clinic or hospital being served should require documentation to ensure that all workers are actual professionals. However, local training requirements might be less stringent or not enforced and non-licensed individuals are sometimes viewed or pass as physicians. To what extent is the radiologist obligated to perform studies requested, or to teach the local physicians how to use the ultrasound equipment and perform ultrasound-guided procedures? If the radiologist on mission feels the local practitioner will not be able to safely and competently use the information made available to them or the new skills that may be taught to them, should the radiologist refrain from teaching? Last, your presence will raise the prestige of the clinic or institution you visit, and your services are sometimes bartered behind your back for favors unrelated to the patients you believe you are caring for. The local politics and economy will be impacted by your visit and care needs to be taken.

Who are you responsible to while on mission? Ideally, as a caregiver, your ultimate responsibility is to the patient because "the patient's interests are the only interests to be considered." However, there may be competing interests and obligations among those of the clinic/hospital, the mission organization, physicians caring for the patient and the patients themselves. The radiologist should also evaluate whether and how the imaging findings will be used.

Are your actions paternalistic? Are they sustainable?

Paternalism has been classically defined by medical ethicists as actions imposed upon a patient or population against their expressed wishes or without their informed consent. More broadly conceived paternalism results when actions by outside agents foster dependency and diminish self-sufficiency by reducing the perceived effectiveness of local health care workers or by reducing local efforts at developing a medical infrastructure. Paternalism can result from the implied greater expertise of mission workers compared to local providers. This is especially likely in remote resource-poor areas with limited health care infrastructure. Mission workers are outsiders who arrive on planes, arrive in groups, bring advanced technologies, bring medical resources unavailable to local health care workers, and think they know what the community needs. To minimize this, mission workers need to understand that true helping means being humble, and serving rather than dominating. It is difficult to document negative impacts of mission work and it is hoped that the good vastly outweighs the potential bad. An important strategy is to involve local health care workers and community members at the start of planning to identify problems, local resources, potential solutions and difficulties (cultural, societal or governmental). Be aware of previous attempts to address similar problems and reasons for successes or failures. Follow-up communication with remote-site physicians might fall short after you return home. Setting up teleradiology support can be very difficult and if promises are unfulfilled, subsequent outreach efforts are likely to be met with skepticism.

Are you volunteering or voluntouring?

Last, pediatric radiology mission workers need to self-reflect on why exactly they are there. They travel to remote areas, often at great expense. The desire to see more of the region served is natural. Knowledge of the broader region might help inform the goals of the mission work and its implementation. It is important for radiologists to ask themselves how to balance mission work with tourism. Why am I going? Why not just send cash? What does my presence add? How do I minimize my negative impact? Can I build relationships that last beyond the mission?

Outcomes

The benefits of pediatric radiology global outreach efforts are substantial, even life-saving, as recently documented. Wakjira and colleagues [19] demonstrated the effectiveness of an educational program teaching ultrasound-guided hydrostatic intussusception reduction to radiologists in Ethiopia. Prior to the education program, intussusception was treated primarily with surgery and, in the absence of access to a surgeon, was fatal. The authors reported an 87% success rate with ultrasound-guided hydrostatic reduction, thus changing the management of this common condition and improving outcomes.

The value of point of care ultrasound (POCUS) in pediatric TB, especially in demonstrating mediastinal lymphadenopathy [20] and extrapulmonary involvement [21], has been established. Vast improvements in film quality and interpretation have also been demonstrated following global outreach efforts [22–24], which include the introduction of digital

platforms and teleradiology consultations [22, 25]. While the need for and benefits of teleradiology are well known [26], it is important to note that teleradiology efforts can be very difficult to sustain. Internet access is inconsistent because remote hospitals might not have computers or Internet access. There is often no technical support and malfunctioning digital equipment can take weeks to be repaired. The local medical workers might have to use their own devices and incur personal out-of-pocket data usage expenses. The turnaround time might be too slow for over-reads to be clinically useful.

Advances in pediatric radiology training have also resulted from outreach efforts. Working with local radiologists in Ethiopia, pediatric radiologists from the Children's Hospital of Philadelphia have begun to "teach the teachers," helping to support pediatric radiology training in the radiology residency program at Addis Ababa University by establishing a 2-year international pediatric radiology fellowship. This fellowship includes a combination of on-site teaching in Ethiopia, Internet-based learning modules and international pediatric radiology rotations at Children's Hospital of Philadelphia and Weill Cornell Medical College [27]. Additionally, an annual 1-day pediatric radiology continuing medical education (CME) course has been developed and has been attended by virtually all of the countries' pediatricians, pediatric surgeons and radiologists [27].

The need for a pediatric radiology textbook to address the needs of radiologists in resource-poor regions has been recognized and efforts to make access to pediatric radiology literature are underway [28]. Furthermore, there is increasing awareness and sponsorship of global radiology research/education programs in developed countries. Radiology residency programs are increasingly joining global health organizations and offer elective rotations with structured curricula and dedicated mentorship [29–31].

Conclusion

Pediatric radiologists can participate in global outreach efforts in numerous ways. Local, remote and virtual opportunities provide a wide variety of options for us to contribute toward efforts to improve the health of children worldwide. Numerous such projects have been reported. In order for these efforts to be meaningful and effective, awareness of the practical, ethical and emotional challenges pediatric radiology mission workers face is essential while planning and performing such work.

Acknowledgments Sonia Watson, PhD, and RAD-AID assisted with editing the manuscript.

Compliance with ethical standards

Conflicts of interest None

References

1. Silverstein J (2018) Most of the world doesn't have access to X-rays. The Atlantic https://www.theatlantic.com/health/archive/2016/09/radiology-gap/501803/. Accessed 14 May 2018
2. Pan American Health Organization/World Health Organization (2012) World Radiography Day: two-thirds of the world's population has no access to diagnostic imaging. https://www.paho.org/hq/index.php?option=com_content&view=article&id=7410&Itemid=1926&lang=en. Accessed 14 May 2018
3. Shaywitz DA, Ausiello DA (2002) Global health: a chance for Western physicians to give-and receive. Am J Med 113:354–357
4. Lungren MP, Horvath JJ, Welling RD et al (2011) Global health training in radiology residency programs. Acad Radiol 18:782–791
5. Review Committee for Diagnostic Radiology (2014) Guidelines for international rotations in diagnostic radiology. Accreditation Council for Graduate Medical Education (ACGME). https://www.acgme.org/Portals/0/PFAssets/ProgramResources/420_Guidelines_for_IntlRotations_in_DiagRad.pdf. Accessed 14 May 2018
6. Strouse PJ (2014) Outreach in pediatric radiology. Pediatr Radiol 44:635
7. Annam A (2014) International outreach and trainees: how to get involved — and why it's worth the effort. Pediatr Radiol 44:711–712
8. Nievelstein RA, Owens CM, officers of the European Society of Paediatric Radiology (2014) Outreach in paediatric radiology: European activities. Pediatr Radiol 44:674
9. Mollura DJ, Soroosh G, Culp MP, RAD-AID Conference Writing Group (2017) 2016 RAD-AID conference on international radiology for developing countries: gaps, growth, and United Nations sustainable development goals. J Am Coll Radiol 14:841–847
10. Prabhu SP, Dehaye A (2014) World Federation of Pediatric Imaging envisions web site as a tool to share and disseminate top-notch educational material to a global audience at a minimal cost. Pediatr Radiol 44:690–691
11. Sorantin E (2014) Platforms for tele-reading: history and lessons learned by the World Federation of Pediatric Imaging. Pediatr Radiol 44:692–694
12. Johnston N, Sandys N, Geoghegan R et al (2017) Protecting the health of medical students on international electives in low-resource settings. J Travel Med 25(1):1–9
13. Brunette GW (ed) (2018) CDC yellow book 2018 — health information for international travel. Centers for Disease Control and Prevention, Atlanta
14. World Health Organization (2010) Barriers to innovation in the field of medical devices: backround paper 6. http://apps.who.int/iris/bitstream/handle/10665/70457/WHO_HSS_EHT_DIM_10.6_eng.pdf;jsessionid=348B0929529A5CDBBD41762B54B79252?sequence=1. Accessed 14 May 2018
15. Girum T, Wasie A (2017) Correlates of maternal mortality in developing countries: an ecological study in 82 countries. Matern Health Neonatol Perinatol 3:19
16. Roberts MJ, Reich MR (2002) Ethical analysis in public health. Lancet 359:1055–1059
17. Childress JF, Faden RR, Gaare RD et al (2002) Public health ethics: mapping the terrain. J Law Med Ethics 30:170–178

18. Wall AE (2012) Ethics for international medicine: a practical guide for aid workers in developing countries. Dartmouth College Press, Hanover
19. Wakjira E, Sisay S, Zember J et al (2018) Implementing ultrasound-guided hydrostatic reduction of intussusception in a low-resource country in sub-Saharan Africa: our initial experience in Ethiopia. Emerg Radiol 25:1–6
20. Moseme T, Andronikou S (2014) Through the eye of the suprasternal notch: point-of-care sonography for tuberculous mediastinal lymphadenopathy in children. Pediatr Radiol 44:681–684
21. Belard S, Heuvelings CC, Banderker E et al (2017) Utility of point-of-care ultrasound in children with pulmonary tuberculosis. Pediatr Infect Dis J 37:637–642
22. Semakula-Katende NS, Andronikou S, Lucas S (2016) Digital platform for improving non-radiologists' and radiologists' interpretation of chest radiographs for suspected tuberculosis — a method for supporting task-shifting in developing countries. Pediatr Radiol 46:1384–1391
23. Kosack CS, Spijker S, Halton J et al (2017) Evaluation of a chest radiograph reading and recording system for tuberculosis in a HIV-positive cohort. Clin Radiol 72:519.e1–519.e9
24. Hlabangana LT, Andronikou S (2015) Short-term impact of pictorial posters and a crash course on radiographic errors for improving the quality of paediatric chest radiographs in an unsupervised unit — a pilot study for quality-assurance outreach. Pediatr Radiol 45:158–165
25. Monteiro A (2014) Worldwide pediatric radiology network (RADPED) in Brazil: growth of telemedicine and the global exchange of knowledge. Pediatr Radiol 44:672–673
26. Griggs R, Andronikou S, Nell R et al (2014) World Federation of Pediatric Imaging (WFPI) volunteer outreach through tele-reading: the pilot project in South Africa. Pediatr Radiol 44:648–654
27. Darge K, Debebe T, Renjen P, Jaramillo D (2014) Working to grow pediatric imaging in the developing world: Children's Hospital of Philadelphia outreach in Ethiopia. Pediatr Radiol 44:670–671
28. McHugh K, Ward L (2014) A paediatric radiology text for resource-poor settings? Pediatr Radiol 44:707–708
29. Pool KL, Culp MP, Mollura DJ, Suh R (2018) A structured global health training program for radiology residents. J Am Coll Radiol 15:334–339
30. Wood MF, Lungren MP, Cinelli CM et al (2014) Global health imaging curriculum in radiology residency programs: the fundamentals. J Am Coll Radiol 11:968–973
31. Zener R, Ross I (2017) Global health imaging in radiology residency: a survey of Canadian radiology residents. Can Assoc Radiol J 68:348–356