World Federation of Pediatric Imaging (WFPI) Volunteer Outreach through Tele-reading: A brief history and audit of a teleradiology pilot project in South Africa

Rachel Griggs, Savvas Andronikou, Raymond Nell, Natasha O'Connel, Amanda Dehaye, Maria Ines Boechat

Introduction:

Radiology plays a key role in the diagnosis and management of diseases such as pneumonia, tuberculosis and HIV. However, in underserved areas where these diseases are prevalent, there is often limited access to radiology services [1]. Shortages in radiology services are estimated to affect 3.5 to 4.7 billion people worldwide [1]. Angola, for example, is a country with exceptionally high child mortality (160/1000 for children under five years) and poor access to healthcare for the majority of the population. In 2011 the number of doctors in Angola was estimated at 1 for every 10,000 people with a tremendous shortage of general radiologists and an even greater shortage of pediatric trained radiologists [1]. There are many other sub-Saharan African countries, which have not a single radiologist in public service [2]. The lack of accurate radiologic interpretation, common to countries of sub-Saharan Africa, is considered a contributor to higher patient morbidity and mortality. This is compounded by the growing incidence of HIV/AIDS, tuberculosis and malaria in these countries [3].

Advances in technology, however, have led to a potential means of alleviating this shortage. Digital medical images and interpretations of these images can now be sent electronically from anywhere to anywhere in the world, in many cases circumventing the need for on-site radiologists. This method of practice is known as "teleradiology". Teleradiology allows image sharing between organizations and across country borders [2]. Teleradiology has been utilized for over 30 years and is now being adopted as a means of practice in underserved areas [2]. The benefits of teleradiology in underserved populations include improved access, avoidance of unnecessary patient travel, cost savings, and improved outcomes from rapid reporting and earlier/more appropriate intervention [3[4]. A change in diagnosis subsequent to teleradiology

consultation has been reported in up to 50% of cases [3]. Teleradiology has also been reported to improve the diagnosis of tuberculosis, especially in settings with a high burden of HIV infection [2].

More research is required, however, to optimize this method of practice. Better understanding of the efficacy, impact, and limitations of this relatively new practice may lead to even better outcomes. This paper examines a practice of teleradiology in Sub-Saharan Africa where HIV/AIDS and tuberculosis are prevalent in the pediatric population, and low-cost devices for teleradiology are used. In order to better delineate the global challenges facing these practice types and potential means of improvement, we also review current literature regarding other pilot projects of this type.

AIM:

To discuss the practicality and sustainability of the Khayelitsha District Hospital/WFPI volunteer teleradiology program, which utilizes JPEG radiographic images and e-mail in a low resource setting. We review potential influencing factors, such as:

1.) Program design, including methods of acquiring and delivering images and interpretations
2.) Referral load
3.) Types of referrals
4.) Volunteer demographics
5.) Technical, language and legal barriers
6.) Sustainability challenges

Data regarding clinical outcomes was lacking at the time of this study. Although it is not the aim of this study to assess the clinical effectiveness of the program, we agree that prospective analysis should be performed to ensure that a positive impact of our program exists. Data that could be assessed in a prospective study include: the proportion of all pediatric exams sent for teleradiology interpretation, reasons for teleradiology referral, elapsed time from teleradiology request to receipt of opinion by the requesting physician, number of interpretations requested but not responded to,

effect on patient management, volunteer teleradiologist workload, number of volunteers who left the project during the course of the pilot, and analysis of the image quality of the JPEGs.

MATERIALS AND METHODS:

Teleradiology services were provided by WFPI expert pediatric radiologist volunteers via email, for one secondary level hospital in the Western Cape of South Africa, not supported by on-site radiological interpretation services. Data was collected retrospectively from referral cards and JPEG images of radiographs, as well as from the data recorded by the control teleradiologist on the volunteer officer database. All referral cards were reviewed for the indication for imaging, patient age and gender, and type of radiographs requested. Radiographs were reviewed to determine the number and types of radiographs sent for interpretation. The volunteer database was reviewed to determine the number of volunteers involved, their spoken languages and their countries of origin.

Project site:

Khayelitsha is a partially informal township in the Western Cape of South Africa, located on the 'Cape Flats' of the City of Cape Town. It is the Xhosa name for "new home". It is reputed to be the largest and fastest growing township in South Africa. Khayelitsha has an estimated population of 406,779 (as of 2005), and extends a number of kilometers along the N2 motorway. The ethnic makeup of Khayelitsha is approximately 90.5% black African, 8.5% coloured and 0.5% white. Xhosa is the predominant language of the residents. Khayelitsha has a very young population with fewer than 7% of its residents being over 50 years old and over 40% of its residents being under 19 years of age.

The Khayelitsha District Hospital itself is modern and attractive, very different from the original Khayelitsha clinic site, which is famous for its HIV treatment programs initiated by Medecins Sans Frontiers. The clinicians are specialized 'family physicians' serving as medical officers, and supervised by a pediatric specialist (the district pediatrician) and senior emergency room staff. The total bed number is 230 with 32 pediatric beds, 12 neonatal nursery beds and 10 KMC (kangaroo care) beds

for growing premature babies. There is also a 6-bed short stay pediatric ward in the emergency center. Pediatric outpatient clinics take place 3 times a week.

More than 10,000 X-ray examinations are performed at Khayelitsha per year. Approximately 1/3 of the exams are on pediatric patients. These exams include those performed on patients in the emergency department and in the resuscitation room. Prior to the WFPI pilot teleradiology project, only the requesting clinicians were interpreting these radiographs. The volunteer telereading program was developed after the district pediatrician requested assistance in interpreting radiographs.

The site was considered ideal for the telereading pilot because of the excellent clinical referral, the availability of new, well-maintained digital X-ray equipment, and the eager, well-trained radiographic staff with experienced leadership. The chief radiographers in the X-ray department played a key role, exporting the images and referral forms to the control teleradiologist.

Technical Radiography Services:

The radiology equipment comprises two X-ray rooms with new Shimadzu X-ray units for general and pediatric radiography. Digital X-rays are performed with a modern CR system. There are two senior radiographers and another four radiographers who are fully trained, but have no specific additional pediatric training and experience. Images are stored on a digital archive, but there is no PACS system. The X-ray images are transferred to CD for the referring clinicians. There is no on-site radiologist, nor was there any existing teleradiology service offered by the Ministry of Health.

Teleradiology Design:

Digital radiographs were anonymized by a responsible onsite radiographer and exported as JPEG images. They were then forwarded with the X-ray request form to the project control teleradiologist via email, as attachments. The control radiologist then distributed the cases to individual members of a volunteer team from the WFPI volunteer list, while keeping track of individual workload on an Excel database. Readers interpreted the assigned studies on their own personal computers, and their findings were considered as “expert opinion”. The teleradiologist’s opinion was

returned via e-mail, printed on-site and forwarded to the referring clinician. Pediatric X-rays from the resuscitation room were forwarded as emergency referrals and opinions on these x-rays were offered as soon as possible, even after hours.

Enlistment of Volunteer Telereaders:

Volunteer telereaders were enlisted via mass e-mail invitation through the founding member organizations of the WFPI and local South African Society of Pediatric Imaging (SASPI). Volunteers had to provide proof of qualification as radiologists, as well as proof of subspecialty training in pediatric radiology or an explanation of their expertise in pediatric imaging. Volunteers also provided proof of licensing in their own country. The volunteer database is held at the WFPI administrative headquarters and is updated regularly.

RESULTS:

Audits were performed to evaluate the following:

1) The type and range of indications for referral
2) Basic patient demographic information
3) The quantity and types of radiographs submitted for review
4) The burden of disease based on imaging referrals
5) Basic demographic information regarding the volunteers, i.e. countries of origin and languages spoken

Audit of Referral Cards and JPEG Radiographs:

A total of 555 referral cards and 1106 radiographs were submitted for teleradiology opinion during the course of this pilot program. Table 1 summarizes the data from this analysis. The majority of requests for image interpretation were on chest radiographs (74. 6%), and a fair number of those were for the evaluation of Tuberculosis (14.2% of all requests). Only 2.2% of studies had no or illegible indications, and only 11.9% of studies had no or illegible patient demographic information.

Audit of Volunteer Officer Database:

There were a total of 40 volunteer teleradiologists. All volunteers spoke English, but 14 were reported bilingual. Eight volunteers were fluent in Spanish, five in Portuguese, and one in Italian. Seventeen different countries of origin were reported. The largest number of volunteers was from the United States (12), followed by South Africa (8), and Brazil, China and India (4 each). Individuals from Columbia, Pakistan, China, Spain, the United Kingdom, Argentina, Bolivia, Cuba, Sri Lanka, Australia, Panama, New Zealand and Italy also volunteered.

DISCUSSION:

Before we review the feasibility of our own pilot program, we think it pertinent to review the many factors that may influence the success of any teleradiology program providing care to an underserved area.

Barriers to the Practice of Teleradiology:

Barriers to the implementation of teleradiology services across national borders include technical factors, language barriers, and legal issues [5]. Poor sustainability is another potential hindrance to the success of teleradiology.

Technical Barriers: One major challenge of teleradiology is quality control. For teleradiology to be effective, it must be ensured that there is no reduction in the quality of radiology services provided [5].

A major technical consideration for many countries is low bandwidth, slow internet connection and high internet service charges [3]. Areas of the developing world continue to have data transmission speeds of 10 kbps vs. the 1 mbps available in developed countries [6]. Because of these ongoing bandwidth limitations, image compression is vital, particularly for rural regions where infrastructure is highly variable. Advanced image compression techniques have been tested successfully by Imaging the World in Uganda [6].

Although JPEG compression beneficially decreases image file size, this in turn leads to poorer image quality. Nonetheless, several studies have demonstrated that JPEGs

obtained by digital photography of radiographs using limited image compression are sufficient for diagnosis in most instances, and that discrepancy rates between radiologists are the same whether JPEG images or higher quality X-ray images are being interpreted [2].

Screen-film X-ray (still in use in many African countries) image quality is affected by numerous factors such as poor equipment, inadequate materials and the intrinsic nature of the screen-film technology [1]. Many telereading programs use screen-film images converted into digital files via digital cameras, scanners, or specialized digitizers. The Ethiopian telereading program found that taking photographs of x-ray pictures with a regular camera, using natural light on a white glared window, produced good quality images, and this was proposed as good solution for areas where light boxes are not available and where a stable power source is an issue [3]. Such systems are feasible, but there is limited opportunity to improve the image quality if the primary x-ray is poor [1].

Digital technology, as compared to screen-film x-ray, is ideal for low-resource countries. It is simpler to use, obviating the need for development and processing, has less inherent artifact, and also simplifies the practice of teleradiology as images can be directly electronically converted to JPEG format [1].

Effective transmission of images to the teleradiologist is another technical consideration. Simple e-mail consultations (such as used in our project) have proven effective, useful and acceptable [3]. Use of email for telemedicine has been utilized by the Swinfen Charitable Trust over the first six years of operation, successfully [4].

Another technical consideration that may affect the success of a teleradiology program is the simplicity and user-friendliness of the involved software. This is a lesson learnt from the failed Ethiopian project [3].

Language Barriers: Language is cited as a potential barrier to the efficacy of teleradiology [7]. Language barriers may arise when obtaining informed consent by the patient for sharing medical records and images. Language barriers may also prevent teleradiologists from understanding key information such as the referral

indication as well as prevent the requesting physician from understanding the reader's interpretation. One solution to this problem is to utilize volunteers from all over the world, such as was done in our pilot with the WFPI, where multiple volunteers with multiple language skills are available.

Legal Barriers: When delivering any care across borders, there is uncertainty about the liability of health professionals [7]. In the Netherlands, for example, a medicolegal claim can be made against the teleradiology provider [5]. The medicolegal implications of opinions exchanged by email, such as those of the WFPI, are potentially important and these interactions should be stored in a database from which they can be retrieved [7]. Implementation of sustainable cross border teleradiology therefore requires strong co-operation between radiologists, societies of radiology, healthcare administrators, politicians and relevant authorities [5]. Additional concerns arise regarding confidentiality of medical information on the web [7].

Sustainability Issues:
Successful telemedicine applications must be sustainable (i.e. they must be adopted into everyday practice and continue to function with high activity levels after any pilot funding runs out) [4]. The Ethiopian case study shows that the success or the failure of a telemedicine practice does not only rely on technological factors, but also on e-governance, an enabling policy environment, and effective human resource management and capacity building [3]. Collaboration of radiologists who are familiar with the resources available locally and with the health conditions seen most often in the population of interest is very important.

Many telemedicine applications have been tested in small-scale studies, but most of them have failed to survive beyond the initial (funded) research phase [4]. Successful telemedicine applications exist but they are generally still run by local telemedicine champions and funded on an ad hoc basis [4].

To advance sustainability, programs should facilitate local training and capacity building, rather than solely relying on external support [1]. Academic institutions and charities also play an important role in initiating links between experts and local figures championing for improved health [7].

Evaluation of the Success of our WFPI Program:

For a program such as ours to be successful, it must provide care to an underserved population in a cost-efficient way that surpasses the many existing technical, legal, and language barriers, leading to improved outcomes, and shows promise for sustainability.

Our program did provide care to an underserviced population. Forty radiologists from 17 different countries, speaking 4 different languages, volunteered to provide expert radiology opinion. This was done without added travel or cost to the patient. During the course of our pilot, 1106 radiographs, which would have otherwise been solely interpreted by the requesting family physician, were submitted for the opinion of specialty trained pediatric radiologists. A fair number of those submissions were for the evaluation of Tuberculosis (14.2% of all requests).

With regard to how our program faired against technical barriers, although an analysis of our image quality and email system was not performed, we used similar methods to those proven successful in other pilot programs. In addition, a major factor in choosing the Khayelitsha District Hospital for the WFPI pilot program was the availability of digital imaging, which reduces the risk of inadequate image quality.

The WFPI pilot also used a network of multinational, multilingual telereaders, as a means to prevent language barriers. As a means of preventing legal issues, all images and referral requests used in our project were anonymized.

To ensure sustainability of this program, an institutional 'buddy system' is being tested in conjunction with Stanford University. Stanford has agreed to take responsibility of providing expert of opinion to Khayelitsha hospital, making use of residents supported by attending radiologists. The intent is to provide ongoing assistance to the underserved area as well as provide training material for the supporting institution, a symbiotic relationship. WFPI hopes to encourage other university hospitals to engage in such buddy systems.

Limitations:

This report is mainly a practicality study and evaluation of referral practice. It did not aim at evaluating either the impact of teleradiology on health outcomes or the quality of imaging or reporting in this pilot program.

Conclusions:

Although teleradiology is a viable option to alleviate radiologist shortages in underserved areas, there are many challenges to designing an adequate teleradiology system. We believe that we may have achieved a successful teleradiology program in our WFPI pilot, utilizing a network of multinational WFPI volunteer telereaders, direct JPEG conversion of digital radiographic images, and an email delivery system of images, referral requests, and expert teleradiology opinion. Our program provided care to an underserviced population by allowing submission of 1106 radiographs (which would have otherwise been solely interpreted by the requesting family physician) to a network of forty multinational, multilingual expert radiologists. This was done without added travel or cost to the patient. Our system was also designed in a way to prevent the many technical, language, and legal barriers described in the current literature. Additionally, an institutional “buddy system” has been developed to ensure the sustainability of the program. Prospective analysis is in order to evaluate the clinical impact of the program.

Table 1: Summary of Audit Findings of the Teleradiology Pilot program

	Number	Percent of Total
Data Regarding Patient Referrals:		
Referrals with no Provided or Illegible Indications	12	2.2
Referrals with Incomplete/Illegible Patient Demographic Information	66	11.9
Referrals Mentioning Tuberculosis (TB) in the Indication (positive TB contact, known TB, or concern for TB)	79	14.2
Data Regarding Submitted Radiographs:		
Chest Radiographs	825	74. 6
All other Radiographs, including those of the Abdomen and Extremities	281	25.4

References:

1. Zennaro F, Oliveira Gomes JA, Casalino A, Lonardi M, Starc M, et al. (2013) Digital radiology to improve the quality of care in countries with limited resources: a feasibility study from angola. PLoS One 8: e73939.
2. Coulborn RM, Panunzi I, Spijker S, Brant WE, Duran LT, et al. (2012) Feasibility of using teleradiology to improve tuberculosis screening and case management in a district hospital in Malawi. Bull World Health Organ 90: 705-711.
3. Shiferaw F, Zolfo M (2012) The role of information communication technology (ICT) towards universal health coverage: the first steps of a telemedicine project in Ethiopia. Glob Health Action 5: 1-8.
4. Zanaboni P, Wootton R (2012) Adoption of telemedicine: from pilot stage to routine delivery. BMC Med Inform Decis Mak 12: 1.
5. Ross P, Pohjonen H (2011) Images crossing borders: image and workflow sharing on multiple levels. Insights Imaging 2: 141-148.
6. Mollura DJ, Mazal J, Everton KL, Azene EM, Collaros P, et al. (2013) White paper report of the 2012 RAD-AID Conference on International Radiology for Developing Countries: planning the implementation of global radiology. J Am Coll Radiol 10: 618-624.
7. Saliba V, Legido-Quigley H, Hallik R, Aaviksoo A, Car J, et al. (2012) Telemedicine across borders: a systematic review of factors that hinder or support implementation. Int J Med Inform 81: 793-809.