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MINISYMPOSIUM

World Federation of Pediatric Imaging (WFPI) volunteer outreach through tele-reading: the pilot project in South Africa

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Abstract
Background Shortages in radiology services are estimated to affect 3.5–4.7 billion people worldwide. Teleradiology is a potential means of alleviating this shortage.
Objective This paper examines the practicality and sustainability of a pilot pediatric teleradiology project at the Khayelitsha District Hospital in sub-Saharan Africa. We analyze how this World Federation of Pediatric Imaging (WFPI) program fares against the global challenges described in the current literature facing these practice types.
Materials and methods A teleradiology pilot was developed to provide coverage to the Khayelitsha District Hospital after the district pediatrician requested assistance in interpreting radiographs. This program utilized a network of WFPI volunteer pediatric radiologists, direct JPEG conversion of digital radiographic images, and an e-mail delivery system of images, referral requests and teleradiology opinion. Data were collected retrospectively from referral cards and JPEG images of radiographs, as well as from the volunteer officer database.
Results A total of 555 referral cards and 1,106 radiographs were submitted for teleradiology opinion during the course of this pilot program; 74.6% of requests for image interpretation were chest radiographs and 14.2% of those were for the evaluation of tuberculosis. There were 40 volunteer teleradiologists from 17 countries; all spoke English, and 14 were bilingual (8 fluent in Spanish, 5 in Portuguese, and 1 in Italian).
Conclusion Teleradiology is a viable option to alleviate radiologist shortages in underserved areas, but there are many challenges to designing an adequate teleradiology system. The WFPI pilot teleradiology program can be considered a successful one.

Keywords Teleradiology · Pediatrics · Radiography · Outreach · South Africa

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Introduction

Radiology plays a key role in the diagnosis and management of diseases such as pneumonia, tuberculosis and human immunodeficiency virus (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 3.5–4.7 billion people worldwide [1]. Angola, for example, is a country with exceptionally high child mortality (160/1,000 for children younger than 5 years) and poor access to health care 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]. Many other sub-Saharan African countries do not have 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, a practice method known as teleradiology. Teleradiology allows image-sharing between organizations and across national borders [2]. It has been utilized for more than 30 years and is now being adopted as a means of practice in underserved areas, providing benefits such as improved access, avoidance of unnecessary patient travel, cost savings and improved outcomes from rapid reporting and earlier and more appropriate intervention [2–4]. 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 could 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.

This paper discusses 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 were lacking at the time of this study. Although it was not the objective of this study to assess the clinical effectiveness of the program, prospective analysis should be performed to ensure that our program has a positive impact. 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 e-mail for one secondary-level hospital in the Western Cape of South Africa that was not supported by on-site radiologic interpretation services. Data were 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 area of the City of Cape Town. It forms one of eight sub-districts within the Cape Town metropole. It is the Xhosa name for “new home” and 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% mixed European and African/Asian, and 0.5% white. Xhosa is the predominant language of the residents. The township has a very young population, with fewer than 7% of its residents being older than 50 years and more than 40% of its residents being younger than 19 years. Khayelitsha has a high mortality rate for children younger than 5 years (27 per 1,000 live births in 2012—data from City of Cape Town).

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 Médecins Sans Frontières. The clinicians are medical officers who are supervised by family physician specialists, a pediatric consultant (the district pediatrician) and emergency center specialists. 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 three times a week. In 2012 the Khayelitsha hospital admitted a total of 2,524 children to its pediatric service. The number of pediatric patients continued to increase in 2013, with 2,399 admissions during the first 6 months.

More than 10,000 radiographic 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 tele-reading program was developed after the district pediatrician requested assistance in interpreting radiographs.

The site was considered ideal for the tele-reading 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 radiographs are obtained with a modern computed radiography system. There are two senior radiographers and four other 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. While this manuscript was being prepared, there was 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 on-site radiographer and exported as JPEG images. They were then forwarded with the X-ray request form to the project control teleradiologist via e-mail, as attachments. An example of a referral card and an example of an anonymized JPEG image are shown in Figs. 1 and 2. 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 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 radiographs from the resuscitation room were forwarded as emergency referrals, and opinions on these radiographs were offered as soon as possible, even after-hours.

Fig. 1 An anteroposterior chest radiograph submitted for referral during the course of our teleradiology project in Cape Town, South Africa. The image was anonymized prior to submission to World Federation of Pediatric Imaging to maintain patient privacy

Enlistment of volunteer tele-readers

Volunteer tele-readers were enlisted via mass e-mail invitation through the founding member organizations of the WFPI and local South African Society of Paediatric Imaging (SASPI). Volunteers had to provide proof of qualification as a radiologist, 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 in France and is updated regularly.

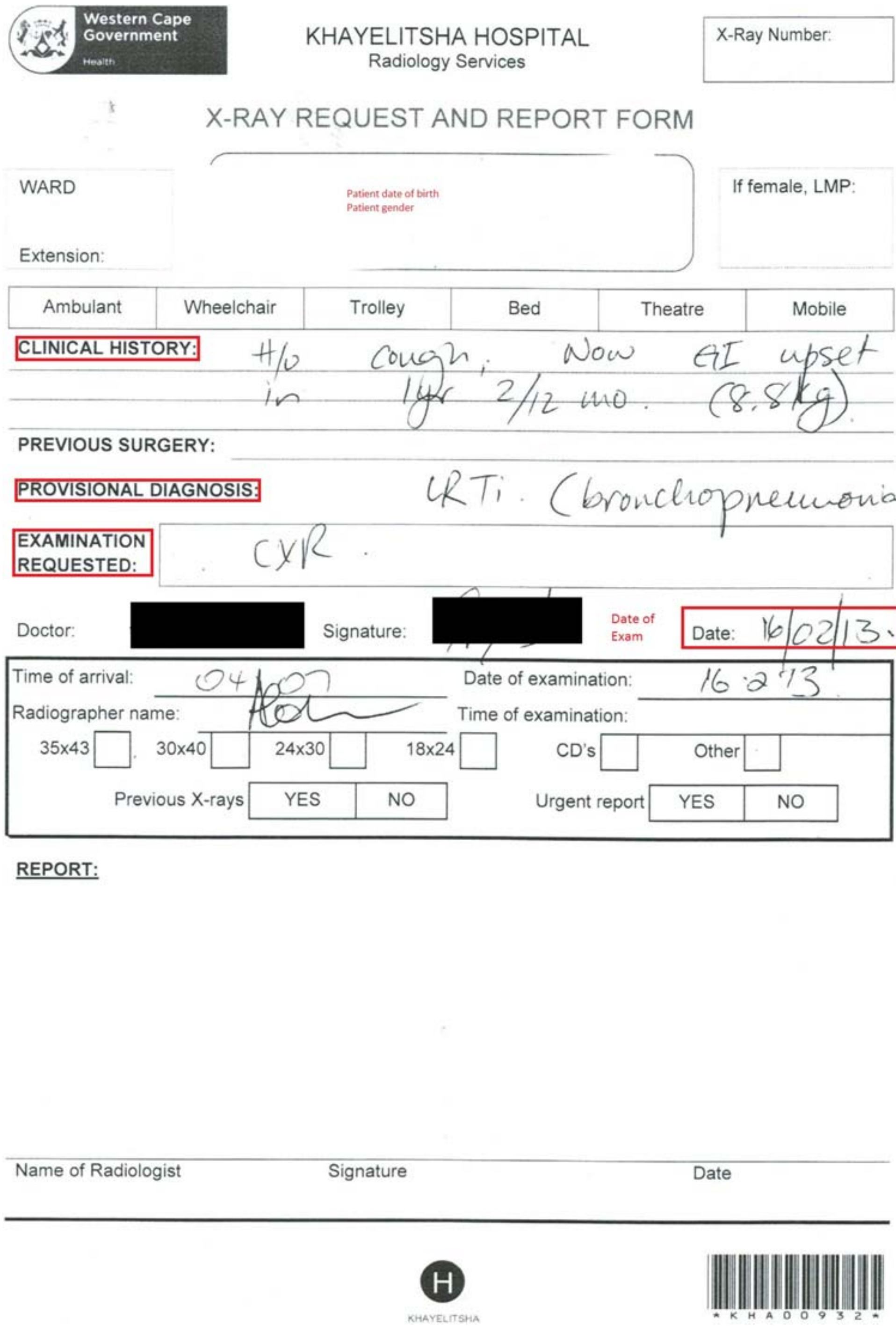
Results

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 1,106 radiographs were submitted for teleradiology opinion during the course of this pilot program (July 26, 2012–March 3, 2013). Table 1 summarizes the data from this analysis. The majority of requests for image interpretation were on chest radiographs (74.6%),



Western Cape Government Health

KHAYELITSHA HOSPITAL
Radiology Services

X-Ray Number:

X-RAY REQUEST AND REPORT FORM

WARD

Extension:

Patient date of birth
Patient gender

If female, LMP:

Ambulant	Wheelchair	Trolley	Bed	Theatre	Mobile

CLINICAL HISTORY: H/o cough, Now GI upset in 1yr 2/12 mo. (8.8kg).

PREVIOUS SURGERY:

PROVISIONAL DIAGNOSIS: LRTi. (bronchopneumonia)

EXAMINATION REQUESTED: CXR.

Doctor: [redacted] Signature: [redacted] Date of Exam Date: 16/02/13.

Time of arrival: 04h07 Date of examination: 16.2.13

Radiographer name: Time of examination:

35x43 30x40 24x30 18x24 CD's Other

Previous X-rays YES NO Urgent report YES NO

REPORT:

Name of Radiologist Signature Date

KHAYELITSHA

KHA00932

Fig. 2 A referral card submitted alongside a radiograph to the volunteer teleradiologist. Highlighted on this document are the patient age and date of birth, date of examination, clinical history, provisional diagnosis and requested examination

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 40 to 50 teleradiologists available at any one time on the volunteer list. All volunteers spoke English, and 14 reported being bilingual. Eight volunteers were fluent in Spanish, five in Portuguese, and one in Italian. Eighteen 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 Colombia, Pakistan, China, Spain, the United Kingdom, Argentina, Bolivia, Cuba, Sri Lanka, Australia, Panama, New Zealand and Italy also volunteered.

Table 1 Summary of audit findings of the teleradiology pilot program

	Number	Percentage of total
Patient referrals (n=555)		
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
Submitted radiographs (n=1,106)		
Chest radiographs	825	74.6
All other radiographs, including those of the abdomen and extremities	281	25.4

Discussion

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

Barriers to the practice of teleradiology

Obstacles 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 for effective teleradiology is quality control. For teleradiology to be effective, the standard quality of radiology services provided must be ensured [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 successfully tested in Uganda by the organization Imaging the World [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 radiographic images are being interpreted [2].

The image quality of screen-film radiographs (still in use in many African countries) is affected by numerous factors such as poor equipment, inadequate materials and the intrinsic nature of the screen-film technology [1]. Many tele-reading programs use screen-film images converted into digital files via digital cameras, scanners or specialized digitizers. An Ethiopian tele-reading program found that taking photographs of radiographs 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 in which light boxes are not available and 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 radiograph is poor [1].

Digital technology, as compared to screen-film radiography, 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 because 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 those used in our project) have proved to be effective, useful and acceptable [3]. Use of e-mail for telemedicine has been utilized by the Swinfen Charitable Trust over 6 years of operation, successfully [4].

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

Language barriers

Language is cited as a potential barrier to the efficacy of teleradiology [7]. Language barriers can arise when obtaining informed consent from the patient for sharing medical records and images. Language barriers can also prevent teleradiologists from understanding key information such as the referral indication and can 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 program, for which multiple volunteers with multiple language skills were 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 medico–legal claim can be made against the teleradiology provider [5]. The medico–legal implications of opinions exchanged by e-mail, 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 cooperation between radiologists, societies of radiology, health care 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 play an important role in initiating links between experts and local figures championing for improved health care [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, leads to improved outcomes, and shows promise for sustainability.

Our program did provide care to an underserviced population. Between 40 and 50 radiologists from 18 countries and representing 4 languages volunteered to provide expert radiology opinion during the course of the pilot program. This was done without added travel or cost to the patient. During the course of our pilot, 1,106 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 e-mail system was not performed, we used similar methods to those that proved 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 tele-readers, 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 opinion to the 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 reciprocal systems.

Limitations

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

Conclusion

Although teleradiology is a viable option to alleviate radiologist shortages in underserved areas, there are many challenges to designing an adequate teleradiology system. We have achieved a successful teleradiology program in our WFPI pilot, utilizing a network of multinational WFPI volunteer tele-readers, direct JPEG conversion of digital radiographic images, and an e-mail delivery system of images, referral requests and expert teleradiology opinion. Our program provided care to an underserviced population by allowing submission of 1,106 radiographs (which would have otherwise been solely interpreted by the requesting family physician) to a network of 40 multinational, multilingual expert radiologists. This was done without added travel or cost to the patient. Our system was also designed 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 needed to evaluate the clinical impact of the program.

Conflicts of interest None.

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