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**INTERPRETATIONS OF CHEST X-RAYS BY RADIOGRAPHERS AND GENERAL
PRACTITIONERS AT DISTRICT HOSPITALS IN THE CITY OF TSHWANE**

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LIST OF ABBREVIATIONS / ACRONYMS

Abbreviation / acronym	Meaning
AIDS	Acquired Immunodeficiency Syndrome
CEO	Chief Executive Officer
CT	Computerised Tomography
CPD	Continuous Professional Development
GP	General Practitioner
HIV	Human Immunodeficiency Virus
HPCSA	Health Professions Council of South Africa
PACS	Picture Archive Computer system
PHC	Primary Health Care
OPD	Outpatient Department
PTB	Pulmonary Tuberculosis
PWH	Pretoria West Hospital
RADS	Radiographer Abnormality Detection System
RCR	Royal College of Radiologists
SA	South Africa
TDH	Tshwane District Hospital
UK	United Kingdom
US	United States

DECLARATION

I declare that “Interpretations of chest X-ray images by radiographers and general practitioners at district hospitals in the city of Tshwane” is my own work and that all the sources that I have used or quoted have been indicated and acknowledged by means of complete references.

NAME: KHETHIWE MARGARET SETHOLE

SIGNATURE OF PRINCIPAL INVESTIGATOR:

A handwritten signature in black ink, appearing to read 'Kh Sethole', written in a cursive style.

DATE: 25th OCTOBER 2018

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ABSTRACT

The public health care system is at the core of transforming health services in South Africa. The effectiveness of patient service delivery in hospitals is highly dependent upon the ability to provide timely, adequate diagnostic radiography and an immediate radiology service, to support and influence patient management. A shortage of radiologists restricts continuity in radiology services and causes a delay in diagnosis, compromising the overall quality of service to patients.

The first point of entry to health services is at primary level through local clinics or primary health care hospitals. After clinical examination by general practitioners (GPs), many patients are referred for imaging to the X-ray department in district hospitals. A chest X-ray is one of the first-line diagnostic tools for GPs to diagnose, monitor treatment and predict the outcomes of many diseases. GPs are mandated to give reports on all chest X-ray images taken at district hospitals and they sometimes request image interpretation assistance from radiographers.

The aim of this study was to explore methods used by radiographers and GPs to perform image interpretation on chest X-ray images at district hospitals in the City of Tshwane.

A qualitative descriptive collective case study method with purposive sampling was used. Results showed that radiographers searched with a specific pattern of inspection and the GPs used a free global search by scanning X-ray images without a preconceived orderly pattern.

It was concluded that the methods used by both radiographers and GPs for chest image interpretations were not systematic in approach and that inter-professional communication was limited. No protocols were in place to promote communication.

Keywords: Image interpretation; general practitioner, method, primary health care, radiographers, radiologist

1 CHAPTER 1 - INTRODUCTION

INTRODUCTION

The aim of the first chapter is to orientate the reader to the study. It provides the background to the research problem – including the research questions, the overall goal, aim, and objectives of the study. These are followed by the demarcation of the study and highlights regarding the significance and value of the research. Subsequently, a brief overview of the research design and methods of investigation is presented. The chapter concludes with a layout of the succeeding chapters and a summative conclusion.

1.1 BACKGROUND OF THE STUDY

South Africa's (SA) major public health concerns currently are human immunodeficiency virus (HIV)/acquired immunodeficiency syndrome (AIDS), smoking-related diseases and tuberculosis. All of these are more prevalent in the African population.¹ The transmission rate of HIV/AIDS and opportunistic infections such as pulmonary tuberculosis (PTB) resulted in an increased demand for medical care in primary health care (PHC) hospitals in SA.²

The first point of entry to health services is at primary level through local clinics or PHC hospitals. After clinical examination by general practitioners (GPs), many patients are referred for imaging examinations to the X-ray departments in the district hospitals. The effectiveness of patient service delivery in hospitals is therefore highly dependent upon the ability to provide timeous adequate diagnostic radiography and an immediate radiology service to support and influence patient management. A shortage of radiologists restricts continuity in radiology services and causes delays in diagnosis. The overall quality of patient care service is thus compromised.³

A chest X-ray is one of the initial diagnostic tools used extensively by GPs to diagnose, monitor treatment, predict outcomes for many disease abnormalities and manage complications associated with PTB and HIV.

Chest X-ray images are challenging to interpret owing to a wide range of similar clinical features that have overlapping characteristics, atypical presentations due to several causes of the diseases and the broad spectrum of pulmonary diseases encountered in AIDS.⁴⁻⁵

Radiographers from Pretoria West Hospital (PWH), Jubilee and Tshwane District Hospitals (TDH) informed the researcher of incidents where GPs requested assistance from radiographers in identifying abnormal patterns on X-ray images. The researcher identified no specific method to assist radiographers with this type of image interpretation. Individual radiographers who rendered such assistance used different ways to communicate their findings. The expectation is that GPs should report on the images themselves and provide treatment based on this diagnosis. This study investigates methods used by radiographers and GPs to interpret chest X-ray images at district hospitals in the City of Tshwane.

1.2 PROBLEM STATEMENT

There are no radiologists on site in district hospitals in the City of Tshwane. Radiographers and GPs have limited training in image interpretation of chest X-ray images, which may result in incorrect diagnosis and thus affect service delivery. This study should therefore add value, alleviate the research gap in this area, and assist in the process of introducing radiographer interpretations to chest X-ray images.

1.3 RESEARCH QUESTION

What methods do radiographers and GPs use to perform image interpretation on chest X-ray images at district hospitals in the city of Tshwane?

1.4 AIM

Explore methods used by radiographers and GPs to perform image interpretation on chest X-ray images at district hospitals in the City of Tshwane

1.5 OBJECTIVES OF THE STUDY

- To describe the process of interaction between the radiographers and GPs during image interpretation of chest X-ray images.
- To explore methods used by radiographers to perform image interpretation on chest X-ray images.
- To explore methods used by GPs to conduct image interpretation on chest X-ray images.
- To explore strengths and limitations in the current methods of interpretation used by radiographers and GPs based on the standard recommended for non-radiologist reporting.

1.6 IMPORTANCE AND BENEFIT OF THE STUDY

This study was conducted to explore methods used by radiographers and GPs to perform image interpretation on chest X-ray images at district hospitals in the City of Tshwane. Strengths and limitations in the current methods used by both groups were evaluated according to the guidelines set by the Royal College of Radiologists in the United Kingdom (UK). The findings could be used to inform the scope of practice to include image interpretation on chest X-ray images for radiographers and continuous professional development (CPD) training in image interpretation of chest X-ray images for GPs.

1.7 RESEARCH PARADIGM

Polit and Beck, as cited by Brink et al⁶, describe assumptions as the basic principles that are accepted on faith, taken for granted or assumed to be true without proof or verification.⁶

1.7.1 Ontological assumptions

Ontological assumptions entail the philosophical study of the nature of reality.⁷ In this study the researcher assumed that there is a reality that can be formed by multiple

forms of evidence derived from the different perspectives and experiences of radiographers and GPs.

1.7.2 Epistemological assumptions

Epistemological assumptions concern the philosophical study of the relationship between the researcher and the participants.⁶ The researcher interacted with the participants to gather subjective evidence based on the individual views in the field and people's ability to explain their own reality in the context of the study.

1.7.3 Axiological assumptions

Axiological assumptions refer to the role of values and bias.⁷ The researcher used the process of reflexivity and bracketing to overcome biases. Reflexivity is the ability to do self-evaluation and identify personal experiences and biases regarding the research topic. Bracketing is a process of setting aside personal views and biases about the research topic so that they do not influence the final research report.⁸ In this study the field notes included the reactions, reflections and assumptions of the researcher.

1.7.4 Methodological assumption

The intentions of the social actors were uncovered through interaction between the researcher and participants. This is the process of research.⁷ The aim was to work towards a construction of the social context that is consistent with the experiences of participants. Methods employed included observational notes of the process, audio recordings and notes from interviews.

1.8 DELINEATION AND ASSUMPTIONS

The study did not look at the process of patient referral. The accuracy of reports on chest X-ray images was not evaluated. Only outpatient and casualty departments that refer patients for chest X-ray images were included in the study. Adult patients referred for a chest X-ray for the first time were included in the study. It assumed that methods used to interpret chest X-ray images by the participants were a true reflection of their daily reporting method.

1.9 RESEARCH METHODOLOGY

Qualitative research methodology using a collective case study approach was used. The study design was descriptive.⁹ A descriptive type of case study was selected to describe that which was observed in a real-life context.

Setting: District hospitals from the city of Tshwane were selected. These were TDH, PWH, and Jubilee Hospital. Each hospital has a fully operational imaging department with no radiologists on site. All the X-ray departments use computerised radiography technology; images are printed out and viewing boxes are still used.

Population: In a population of 68 participants working at the three hospitals, 28 were radiographers and 40 GPs from all three settings

Sample size: Thirty participants from all three settings were sampled. The sampling for this research was purposive, as the researcher had to look for participants that fitted the inclusion criteria. The sampling at all the sites was non-probability or convenient sampling, as the researcher had to interview and observe participants who were available on the day data was collected. Each setting had 10 participants, equally distributed between GPs and radiographers.

Data collection: The primary data was collected in two phases.

Phase 1: Making observations and taking field notes, using a checklist.¹⁰

Phase 2: Conducting interviews, with audio-recordings and writing memoranda for reflecting upon during the researcher's engagement with the collected data.⁹

Data collection tools: Observations were made using the checklist (see Annexure 2). During interviews, data collection tools were open-ended guided conversations to elicit information and to explore observed behaviour.⁹ Probing questions were asked to determine the sequence of events from different perspectives. Interviews and focus groups were audio-recorded. The audio-recorded data was transcribed. Data collected

underwent the three steps of coding, namely open, axial and selective, and was then categorised into themes linking it to the propositions.

1.10 DEFINITION OF KEY TERMS

Key words: Image interpretation methods, general practitioner, primary health care, radiographers, radiologist.

Image interpretation methods: are the methods that can be applied to assess chest X-ray images for competency. This enabled assessment of location sensitivity which is correct identification of area or location of abnormality and specificity of diagnosis.¹¹

A **GP** is a registered physician not oriented to a specific medical specialty but instead covering a variety of medical problems in patients of all ages. GPs provide routine healthcare, which includes physical examinations and immunisations, and they diagnose and prescribe treatment for different conditions, diseases and injuries.¹²

PHC is a system to promote healthcare to the population of SA delivered through the District Health System. A district hospital offers a range of in- and outpatient services. It is open 24 hours a day, seven days a week. Services rendered include a 24-hour emergency service and an operating theatre; diagnostic and therapeutic services include X-ray departments and basic laboratory tests.¹³

Radiographers are independent practitioners trained to produce high-quality diagnostic images, registered with the Health Professions Council of South Africa (HPCSA), after completing their community service.¹⁴

A **radiologist** is a registered physician who specialises in interpreting images of the body and producing the gold standard report to diagnose and treat medical conditions.¹⁵

1.11 RESEARCH PROGRAM OUTLINE

Chapter 1: The chapter presents the introduction, highlights the research proposal and provides an outline of subsequent chapters.

Chapter 2: The purpose of the literature review was to provide background in order to contextualise the research problem and the development of the questionnaires.

Chapter 3: The chapter describes the research design and methodology; the research design and the methods applied are discussed in detail.

Chapter 4: In the chapter the results of the study are presented in tables and figures.

Chapter 5: The chapter presents a discussion including a description and interpretation of the findings.

Chapter 6: Conclusions are drawn, and recommendations for further research are identified in this chapter.

1.12 CONCLUSION

The transmission rate of HIV/AIDS and opportunistic infections such as PTB resulted in increased demand for medical care in PHC hospitals. GPs refer many patients for chest X-ray examinations to the X-ray departments in the district hospitals. A shortage of radiologists causes delays in diagnosis. In district hospitals, GPs are expected to report on the images and provide treatment based on their diagnosis. Chest X-ray images are challenging to interpret because of a wide range of similar clinical features that have overlapping characteristics, atypical presentations due to several causes of diseases and the broad spectrum of pulmonary diseases encountered in AIDS. GPs sometimes request assistance from radiographers in identifying the presence of abnormal patterns on chest X-ray images. Individual radiographers render assistance using different ways to communicate their findings. A qualitative case study was conducted to explore methods used by radiographers and GPs to interpret chest X-ray images at district hospitals in the City of Tshwane.

2 CHAPTER 2 - LITERATURE REVIEW

2.1 INTRODUCTION

This chapter offers an overview of literature that outlines the recommended methods for non-radiologists to evaluate image quality and an approach to image interpretation to make informed comments on the abnormal patterns seen in chest X-ray images.

2.2 IMPORTANCE OF REPORTING CHEST X-RAY IMAGES

The object of diagnostic imaging is to demonstrate pathological processes beyond the scope of the clinical examination. To improve patient care, all chest X-ray images be reviewed at an early stage, that is, during admission; this should be done by a senior clinician and reported on by a radiologist at the earliest opportunity. It is important to have a systematic approach to interpretation of X-ray images when reviewing complex structures, such as the thoracic cage.¹⁶

A systematic approach to the interpretation of chest X-ray images eases the process of identifying abnormalities by improving the ability to evaluate and comment upon the relevant findings.^{17,18} The initial step in image interpretation is to make sure that the chest X-ray images taken are of good diagnostic quality. The second step is pattern recognition to identify abnormal patterns and the last is to describe the abnormal patterns. Del Ciello et al¹⁷ and Chand et al¹⁸ supported the use of a systematic image interpretation approach and the importance of obtaining good quality X-ray images to make a proper diagnosis.^{17,18}

To minimise interpretation errors of chest X-ray images, one requires knowledge of the normal anatomy of the thorax, common anatomical variants and the physiology of chest diseases. Analysis of X-ray images takes place in a fixed pattern, requiring evaluation of the evolution over time, knowledge of clinical presentation or history and knowledge of correlation with other diagnostic results, such as laboratory results for blood tests, or sputa tests, electrocardiograms and respiratory function tests.¹⁹

Chest X-ray images play an essential role in diagnosing the following pathology:

Communicable diseases such as PTB can present as acute pneumonia and pleural effusions in HIV-infected patients. In addition, complications of PTB could include lung cancer and abscesses. The typical radiographic findings of PTB are upper lobe infiltrates with cavitation and enlarged mediastina or hila lymph nodes, lung infiltrates and middle or lower lobe consolidations.²⁰

Trauma cases include piercing chest wall injuries; blunt trauma, including contusion; wounds from bullet shots; pneumothorax, haemo-pneumothorax and tension pneumothorax, as well as cardiac abnormalities. Trauma findings include contusions, fractured ribs, aortic artery ruptures and internal haemorrhages.²⁰ Chest X-ray findings should be in relation to the patients' history and the clinical findings.²¹

Cardiac abnormalities such as a cardiothoracic ratio greater than 50% on a posterior-anterior chest X-ray are representative of cardiomegaly.²²

2.3 SHORTAGE OF RADIOLOGISTS

Overcrowded emergency departments and staff shortages are becoming increasingly universal problems that hinder the facilitation of effective service delivery and management of patients.²³

Ideally, radiologists do the interpretation of X-ray images; the shortage of qualified radiologists is therefore of global concern. The effect of this global shortage of radiologists has been reported in well-resourced countries.²⁴ It has even greater significance in the government sector of low- and middle-income countries, such as SA. Statistics in 2015 estimated there were 650 registered radiologists in SA, which equates to 1.2 radiologists per 100 000 people in the population.²⁵ By contrast, the UK had approximately 3 000 registered radiologists with a ratio of 4.7 specialists per 100 000, while the European average was 10 per 100 000.²⁵

SA is facing a massive skills shortage in the field of radiology. The increase in demand for diagnostic imaging services is higher than the supply of radiologists.³ Because of the

limited resources and increased workload there is a delay in reporting conventional X-ray images.

In the UK, in response to evolving service needs, the scope of practice for radiographers was extended to include the interpretation of diagnostic musculoskeletal X-ray images. Radiographer reporting has expanded in scope beyond skeletal trauma to include chest image interpretation. There is a growing body of evidence that supports trained radiographers who can provide definitive clinical reports for chest X-ray images.¹⁶

2.4 CURRENT STATE OF IMAGE INTERPRETATION IN SOUTH AFRICA

In SA radiography forms an integral part of the health care process. A patient who reports to a health care facility might be referred to the X-ray department for necessary procedures, which will be performed by a radiographer. It is beyond the scope of practice of the radiographer to disclose x-ray results to patients.²⁶ Rather, the process generally entails that a radiologist writes a final X-ray report and sends this to the referring doctor, who will communicate the results to the patient. Etheredge²⁷ highlighted that SA radiographers find themselves in a precarious situation when no radiologist is available and they are faced with a request for assistance or an opinion from the referring GPs and even from patients.²⁷

Hlongwane and Pitcher²⁴ showed that the detection rate in acute fractures by radiographers trained in SA with five years' experience post-qualification was comparable to that of European Union radiographers with similar experience with no specific post-graduate training in radiological reporting. Experienced SA radiographers had an overall fracture-detection sensitivity (82.0% v. 81.1%, respectively) similar to that of experienced UK radiographers who had no additional training in trauma X-ray image interpretation. This suggests that the trauma-triage performance of experienced SA radiographers who have had no specific additional training is consistent with international norms.

Du Plessis and Pitcher²⁸ acknowledged that radiographers potentially fulfil important supportive and clinical roles in acute trauma-radiograph reporting, particularly in government hospitals. The acknowledgement was based on a study comparing the accuracy of acute trauma X-ray reporting between medical officers employed on short-term contracts and senior radiographers with more than 10 years of clinical experience. Results showed that the senior radiographers achieved 81.5%, a significantly higher reporting accuracy and sensitivity than the 67.8% accuracy of medical officers.²⁸

Van de Venter²³ explored the experiences of radiographers and medical practitioners during radiographer reporting in after-hours trauma units and found that radiographers can make a significant contribution to more holistic health care and positive patient outcomes by reporting on X-ray images in after-hours trauma units. Therefore, it is suggested that the regulatory regulations of the professional body be adjusted to extend the scope of practice for radiographers in SA.²³

There is international consensus that fracture-detection sensitivity in the order of 95% is required if radiographers are to fulfil a formal clinical role in trauma reporting. Loughran¹⁵ showed that training improved the sensitivity of radiographer fracture detection by approximately 15%, from 81.1% to 95.9%, notably similar to that of a radiologist at 96.8%. Hazell et al²⁹ demonstrated that additional, structured educational programmes in image interpretation and report writing improved radiographers' reporting accuracy to provide better quality comments in SA.

Kelly et al³⁰ reported on the collaboration between medical practitioners and radiographers, stating that it improved the medical practitioners' accuracy of diagnosis in wrist and brain computerised tomography (CT), thus patient care management was improved. Patient management decisions made by junior medical practitioners were improved after introducing the collaboration with radiographers.

In SA, the only study that involved image interpretation of radiographers in image interpretation of chest X-ray images was conducted by Gqweta³¹. Gqweta reported that

junior medical practitioners that staffed PHC facilities and lacked knowledge to interpret X-ray images seemed to be the main driver why radiographers had to provide diagnostic opinions. He revealed that diagnostic radiographers at district hospitals in SA were able to identify abnormalities and were willing to give a verbal opinion about radiographic appearances on chest X-ray images. However, they lacked the ability to describe their findings accurately.³¹ No studies on interpretation of chest X-ray images by radiographers and GPs could be found on district hospitals.

If experienced SA radiographers were shown to be superior to medical officers in the interpretation of trauma X-ray images.^{23,28} Additional, structured educational programmes in image interpretation and report writing improved radiographers' reporting accuracy to provide better quality reports.²⁹ Investment in public sector radiographer training for the purposes of interpretation of chest X-ray images role extension may well be justified.

2.5 TRAINING OF GENERAL PRACTITIONERS IN IMAGE INTERPRETATION

Christiansen et al³² reported on the fact that Danish junior medical practitioners and medical students who received basic clinical education did not meet the minimum requirements for radiological diagnostic skills for interpretation of chest X-rays images. Mehdipour et al³³ found that in Iran both newly qualified practitioners and those with two to 25 years' experience failed to diagnose acute pathologies on chest X-ray images correctly. In Finland, Paakkala³⁴ proved that poor image quality was the primary source of errors made by less experienced doctors in interpretation of chest X-ray images for conditions such as cardiac insufficiency, as well as pathologic changes in atelectasis.³⁴

Eisen et al³⁵ in the USA showed that there was a need for a structured radiology curriculum for junior doctors aimed at the early post-graduate year levels, because after medical school, there was a stagnation in improving diagnostic imaging skills. Other researchers also recommended continual education training in image interpretation for practitioners with two to 25 years of experience.^{33,34,35} To provide interim reports,

Mehdipoor et al³³ recommended the use of electronic tools, such as the picture archive computer system (PACS) and teleradiology, for transferring chest X-ray images with acute pathologies to specialists radiologists.

The results of a comparative study by Du Plessis et al²⁸, conducted in SA among public sector junior medical practitioners and senior radiographers with clinical experience of more than 10 years, showed 67.8% accuracy for acute fracture detection and radiograph reporting by junior South African medical officers, and 80% by radiographers, while 95% accuracy is required for clinical practice. Du Plessis et al made two recommendations, confirming the international research findings. Firstly, they suggested that undergraduate radiology training in SA be re-evaluated in an attempt to equip newly qualified medical graduates better for accident and emergency unit clinical responsibilities in their first years of medical practice. Secondly, they pointed out a need among recently qualified South African doctors for continued professional training in plain X-ray interpretation.²⁸

A systematic approach recommended by Van Geel et al³⁶ to medical students being taught to interpret chest X-ray images promoted adherence to one specific sequence for viewing all images, resulting in complete coverage of anatomical structures.³⁶ Folio³⁷, like Chan³⁸, recommended a structured systematic approach using a mnemonic-based search pattern consisting of the ABCDEs. The search method included starting the search in the midline and working one's way outward or vice versa, ensuring that the same search pattern is followed on each and every examination.³⁸

According to Dur-er-sabi et al³⁹ there are training models available for GPs in the form of educational meetings, workshop seminars, group discussions, simulation laboratories and certification programmes. The impact of continued medical education, training and re-training helps to improve management and diagnostic decisions.³⁹

Instead of using lectures or instructional videos to teach students how to use a systematic approach, Hales and Pronovost,⁴⁰ and Marcovici and Taylor,⁴¹

recommended checklists as the criteria that are organised in a systematic fashion to ensure that all steps in a complex procedure are considered. Several authors^{42,43-44} have argued that checklists are potentially useful instruments to reduce diagnostic errors for clinicians of all levels of expertise, but in particular for inexperienced medical practitioners, and therefore, a checklist is a potentially important tool to improve radiology education in the medical curriculum.

2.6 TRAINING RADIOGRAPHERS ON INTERPRETATION OF CHEST X-RAY IMAGES

In the UK, Swinburne⁴⁵ prompted a debate on the potential for radiographers to develop and extend their role. Swinburne suggested extending the role of radiographers by means of teaching a pattern-recognition technique that would help them to distinguish normal from abnormal X-ray images and help improve job satisfaction. His definition of pattern recognition was that 'it allows an individual to identify whether a given situation is "normal" or "abnormal" without undergoing prolonged and complex training.' He raised the possibility of alleviating radiological workloads by training radiographers and expanding their role to incorporate preliminary image interpretation.

The UK is the leader in implementing radiographer image interpretation. A definition of pattern recognition according to Corr in collaboration with Peh et al⁴⁶ is; being able to recognise normal anatomical and physiological appearances on an X-ray image and the variations of appearances that may indicate pathology. Competency in pattern recognition requires expertise in medical imaging, knowledge of radiographic anatomy and normal variants to identify variations that may indicate pathology.

Hughes et al⁴⁷ provided tutorials on a systematic method of pattern recognition to interpret chest X-ray images for specific chest abnormalities, including atelectasis, pneumonia and pleural effusion. A pre- and post-tutorial assessment was conducted among radiographers who had no prior training in image interpretation. The tutorial assessment required radiographers to identify normal and abnormal chest X-ray images. On post-tutorial assessment, they had to apply the pattern recognition

approach they had been taught. The number of X-ray images incorrectly interpreted as normal decreased following the tutorial. The pattern recognition approach enabled radiographers to assess chest X-ray images adequately and to identify pathological conditions in a systematic manner. The post-tutorial training of an experienced radiographer improved the sensitivity and specificity of radiographers to 90% and 94% respectively. Hughes et al⁴⁷ recommended pattern recognition as a valuable technique that should form an integral part in developing and extending the role of radiographers.

Loughran¹⁵ ran an in-house training scheme in fracture reporting for radiographers. He demonstrated that, with structured training, radiographers could report with consistently high levels of diagnostic accuracy comparable with scores recorded for consultant radiologists. It also improved the retention of radiographic staff and improved patient service delivery.⁴⁸ These studies in the UK have shown that the transfer of some radiological reporting tasks from radiologists to radiographers potentially improved patient service, if well planned, well implemented and evaluated.⁴⁸

Following validation by the College of Radiographers in the UK in 2002⁴⁹, a postgraduate certificate, Clinical Reporting Adult Chest Programme, developed by Canterbury Christ Church University, was introduced and has been running annually since 2002.⁴⁹ According to Piper et al⁴⁹ the part-time work-based programme takes one year to complete and comprises postgraduate modules focussing on reporting adult chest X-ray images. Consultant radiologists are involved in the curriculum development, learning and teaching delivery, as well as the assessment stages. Students regularly attend university and assessments include a case study, a reflective essay, a record of a minimum of 750 practical reports, 150 of which are evaluated by a supervising consultant radiologist, and an objective structured examination. On completion of an accredited postgraduate education programme, this group of radiographers was found to have the ability to identify normal chest X-ray images and they could provide a report on the abnormal appearances to a high standard. Radiographers who have completed this particular programme are now reporting adult chest X-ray images in clinical practices, from a wide range of referral sources. In a survey conducted on UK X-ray

departments, over 10% of managers confirmed that chest X-ray reporting was undertaken by radiographers.⁴⁹

Reeves⁵⁰ acknowledged factors that had an impact on the abilities of radiographers to recognise abnormal patterns successfully. Optical illusions and normal variants were perceptual errors. To reduce these errors in the clinical environment, Reeves⁵⁰ recommended the presence of radiologists as mentors to provide practical guidance in the clinical environment to help radiographers implement an image interpretation approach learned in the classroom, to provide audits of the radiographers' image interpretation and to encourage radiographers to use reference books to learn more about normal variants. Training recommendations were that lecturers should emphasise the anatomy of the normal image and variants thereof.⁵⁰

McLaughlin⁵¹ recommended tutorials, lectures, short courses and CPD training sessions as essential training methods for chest X-ray image interpretation. Training included an introductory session, which covered radiographic anatomical knowledge, basic terminology and concepts that familiarised participants with a systemic approach to abnormality detection forces and patterns, established vocabulary and a model of writing a comment.⁵¹

The curriculum of radiographers in SA does not recognise postgraduate image interpretation programmes. Currently, there is inadequate formal postgraduate training in image interpretation for South African radiographers, which requires a review of the existing postgraduate courses.²⁸ Undergraduate training and education of diagnostic radiographers include pattern recognition in the curriculum, which according to Gqweta,³¹ prepares qualified radiographers to provide a verbal opinion; no formal training in image interpretation is included.²⁹ The Health Professions Act No. 56 of 1974 clause 10 (C) states clearly that a radiographer may only comment on X-ray images that he/she has performed and may only discuss the radiographic appearances with the referring practitioner. The radiographer may not perform duties that exceed his/her capacity of registration.²⁶

2.7 RESEARCH GAP IN HEALTH CARE NEEDS IN SOUTH AFRICA

A shortage of radiologists is a global concern.^{24,28} The current state of image interpretation in SA is that junior medical practitioners who are on short-term contracts staff district hospitals and are expected to interpret all X-ray images taken. The National Health Service in SA, the Department of Health, published 'The Charter of the Private and Public Health Sectors of the Republic of SA' that cited the need to use human resources available in the public sector effectively and efficiently.⁵² The Charter of the Private and Public Health Sectors of the Republic of SA identified a shortage of radiologists as a human resource problem that needs to be addressed.⁵² Extending the role of radiographers to include postgraduate training in limited plain X-ray reporting may help meet the demands of delivering a safe and reliable service in district hospitals. Wright⁵³ suggested that radiographers are ideally suited to this supporting role, since they have the responsibility for conducting the actual X-ray examinations.⁵³

There is a paucity of research in the field of image interpretation methods in SA.

2.8 PRINCIPLES OF IMAGE INTERPRETATION

The standard basic views taken to interpret a chest X-ray are posterior anterior (PA) and lateral projections done in the erect position. Other additional views of the chest are not relevant to this study. PA projection reveals two-dimensional structures in the chest area superimposed on one dimension. The lateral projection of the chest reveals areas that are situated behind the heart, which are not visible on the PA image, and localises lesions visible on the PA projection.⁵⁴

2.8.1 Viewing chest X-ray images

Viewing conditions and image presentations could affect the ability of the viewing medium to deliver sufficient spatial and contract resolution.⁵¹ When undertaking image interpretation it is important to view chest X-ray images from a distance of at least 1-2 metres, because the subtle differences in density of shadows with ill-defined margins

can be improved with minimisation.⁵⁵ Shea and Ziskin⁵⁶ mentioned that reading X-ray images at a fixed distance increases the risk of failure to detect abnormalities.⁵⁶ Viewing conditions influence image interpretations by improving the accuracy of diagnosis. Factors that are relevant to viewing are the luminance of display monitors or view boxes, as well as the ambient room illumination or the amount of light falling on the view box surface, for viewing analogue X-ray images. Clinical research has established that lesion detectability degrades when viewing conditions are not optimal. Five factors that contributed to poor radiograph reader performance are suboptimal illumination level, excessive pupil dilation, light scatter within the film, view box glare and improper ambient light level.⁵⁷ There are no globally accepted viewing box standards for radiography to ensure standardisation; the South African Directorate of Radiation Control⁵⁸ has developed guidelines suitable for local application.

2.8.2 Methods of image interpretation of chest X-ray images

According to Fraser⁵⁵, there were two methods of image interpretation of a chest X-ray: a direct search with a specific pattern of inspection or a free global search in which the X-ray images were scanned without a preconceived orderly pattern. Medical practitioners under training recommended the systematic approach. Experienced radiologists used the free global search.⁵⁵

McLaughlin⁵¹ reported on several image interpretation methods used by radiographers in different settings. One method uses a mnemonic-based search pattern consisting of the ABCDES. The ABCs system of radiological assessment was first introduced in 1995 by Nicholson and Driscoll and subsequently edited by Chan.³⁸ The system provided a simple and logical, easy-to-remember, systematic approach to searching for abnormalities on X-ray images. It has been adapted for different body systems and is not limited to plain film imaging only. The ABCDES systematic assessment for chest X-ray images includes image evaluation and pattern recognition and it stands for:³⁸

- A: Adequacy: The principles of chest X-ray quality is achieved by evaluating the quality of depicting positioning and technical accuracy, which includes anatomical inclusion, projection, rotation, inspiration or breathing, penetration and artefact,

following a systematic approach so that all aspects of the analytic process are considered.

- A: Airways, all lines
- B: Breathing
- C: Circulation
- D: Diaphragm
- E: Edges
- S: Skeleton, soft tissues.

The systematic assessment approach is preferred because it instructs readers in the appearance of radiological abnormalities and trains them to search for abnormalities by comparing them with the normal. The system requires knowledge of normal anatomy, its variance, the physiology of chest diseases and the ability to use correct terminology to describe the findings.³⁸

The role and importance of a good quality radiograph are to help the radiologists and the clinicians in the diagnosis of diseases and their management. Evaluation criteria are based on a systematic approach used for evaluating the quality of depicting the anatomical and physical details. Accuracy in positioning and technical factors affect the diagnostic value of images. It takes only 2-3 degrees of rotation or improper position to affect the appearance of chest x-ray images, leading to misdiagnosis of the heart. According to McQuillen⁵⁹, all chest X-ray images must undergo a criteria check to evaluate adequate image quality so that technical deficiencies are not mistaken for abnormalities. The evaluation criteria recommended for PA and lateral chest X-ray images, according to McQuillen⁵⁹, include searching X-ray images for adequacy of position, anatomy of interest, inspiration, collimation, exposures, identification, markers and the absence of removable artefacts. Both radiographers and GPs should check the X-ray images for adequacy. X-ray images that comply with all the evaluation criteria will be classified as optimal and then be ready for searching for abnormal patterns.⁵⁹

A study conducted by Kyei et al⁶⁰ on Ghanaian radiography students identified lack of knowledge of X-ray image exposure, image evaluation procedure and technique. To overcome this lack in image evaluation, students required basic knowledge of the evaluation of radiographic images. The mnemonic 'PACEMAN' was the criterion introduced as the image evaluation procedure. 'PACEMAN' stands for p- position; a- area; c- collimation; e- exposure; m- markers; a-aesthetics; n- name.⁶⁰

Hughes's⁴⁷ search strategy of a pattern recognition method involved a routine two-minute inspection of the chest X-ray carried out for detection and differentiation between abnormalities seen on initial inspection. The technique recommended a departmental 'checker'. The radiographic screening for technical acceptance assessed was in the context of the patient's clinical condition. Any removable artefacts, such as tubes, wires or catheters inspected, were for positioning of the tips of these lines. If an abnormality was seen on initial inspection, then an attempt was made to classify it into its pathological grouping, according to the given pathology groups. After the post-tutorial study, the radiographers were encouraged to comment on the significant appearances and to identify the pathology.⁴⁷

Folio's³⁷ other search patterns included starting on the midline and working one's way outward or vice versa. The key point is to have a systematic search pattern, which includes all aspects of the thoracic cage and ensures that a pattern is followed on every examination. This helps to avoid becoming overwhelmed, especially when there is a multitude of findings.³⁷ It is critical to develop and follow a logical search pattern to help define the underlying abnormalities and evaluate all aspects of the radiograph. Correlating findings with the patient's clinical status aids in providing a useful list of differentials. Continuous interdisciplinary communication with requesting GPs helps guide the work-up and management of patients.

According to McLaughlin⁵¹, chest X-ray image interpretation is a challenging and skilful task because of the large variation in patient anatomy and the range of pathologies that can present on chest X-ray images. Different methods are used to interpret plain chest

X-ray images. Oken⁶¹ used PA chest X-ray images at baseline and then annually for three more years in screening for the presence or absence of lung cancer. Kok et al⁴⁴ designed a checklist as a tool to help medical students in the interpretation of chest X-ray images. Other methods included determining if images were normal or abnormal and in abnormal cases, giving detail on the position of the pathology. Savithri et al⁶² reported on the method of detecting nodules on PA and lateral chest X-ray images using computer-aided image interpretation systems.⁶² Stevens et al's⁶³ preliminary clinical evaluation method of interpretation entailed accurately localising and describing fractures in trauma cases⁶³

2.9 COMMUNICATION

The primary service of the diagnostic radiography department is diagnostic information. Radiography departments receive radiology request forms with patient history and request information from referring clinicians. The radiographers then take the X-ray images, which are interpreted in the corresponding clinical context, thus creating more information, and both the imaging and interpretation data are communicated to the referring clinicians, who can then inform patients and incorporate findings into clinical care. Effective inter-professional communication is intrinsic to safe health care and treatment.⁶⁴ The value provided to referring clinicians and to patients depends on how accurately and reliably the information flows through the process to the point of care. Radiography departments and practices, hospitals and other care providers must work together to establish communication standards. For two professionals to arrive at a common meaning, the individuals must share a common language. For frequently repeated simple interactions, communication standards in the form of protocols, procedures, and reports are the most appropriate option.^{64, 65}

According to Ellenbogen⁶⁵, standardisation of protocols, procedures, reports and checklists in radiology is best for patients and providers. Checklists in radiology provide a standard foundation for a sequential framework to meet operational requirements, allow mutual supervision and crosschecking, and serve as a quality control measure.⁶⁵

Communication difficulties that exist in health care sometimes arise from the hierarchy of power between different health professionals.⁶⁶ It seems that historical changes to radiography have set in place a restrictive, hierarchical professional structure in which radiographers now practise. A consequence of this structure is that autonomy within radiographer practice is discouraged by paternalism and subordination from medical colleagues. This is a characteristic of medical dominance, where the medical profession holds significant power and authority over other occupations. Whenever issues related to inter-professional boundary delineation come into question, such as radiographic image interpretation and communication of results, historical hierarchical relationships may influence and shape the way the interactions take place.⁶⁶

2.9.1 Radiographer abnormality detection systems

Radiographer abnormality detection systems (RADS) are a communication tool that allows radiographers to communicate to the referring GP or other health care professional their opinion on the status of the patient anatomy displayed on the X-ray images.⁶⁷ RADS are popular in the UK and now in some parts of Queensland, Australia.⁶⁸ Literature has reported the advantages of using RADS being not only to improve the diagnostic process, but having a positive impact on emergency management by supporting junior medical doctors in interpreting trauma X-ray images. Their use has been shown to decrease image interpretation errors made by GPs working in the emergency departments.^{67, 68}

To determine the clinical need for RADS, the following factors are considered: knowledge of the current level of image interpretation errors in clinical practice, timeliness of the current image reporting system. To identify if any potential 'gap' in communication exists between the GPs and imaging department. Could RADS address the "gap" and provide clinical support for implementing RADS. Radiographers need to assess whether the clinicians involved in managing patient treatment desire, or wish to accept, such communication from radiographers.⁶⁷

In the UK, undergraduate curricula for all radiographers provide them with knowledge of image evaluation as part of their professional role and this can form the basis of future educational development. However, this threshold knowledge is different across countries, regions and institutions.⁶⁹ An evaluation of current radiographer knowledge levels is essential to ensure the development of appropriate education programmes.⁶⁷

2.9.2 Types of RADS

RADS first introduced in the UK in the 1980s with the introduction of the red dot scheme to assist emergency department doctors in the correct interpretation of X-ray images. This initiative involves the radiographer affixing a red sticker to an X-ray image, as a 'visual cue', to communicate the abnormality identified to the referring doctor. The 'red dot' system was later found to have limitations related both to the absence of a red dot and inappropriate use because of not being used consistently. If there was no 'red dot' on a radiograph, it did not mean that there was no abnormality; not all radiographers used the system, which was therefore applied on a voluntary basis. With the 'red dot' system, the location or the significance of the abnormality cannot be indicated. To enhance the accuracy of X-ray interpretation, senior radiologists in the UK developed a series of lectures on chest radiographs and a protocol for red dot use. It was not a replacement of the radiologist's diagnostic report.⁷⁰

The College of Radiographers promoted radiographer role development into the middle ground between red dot and definitive reporting by encouraging the introduction of radiographer comments, or preliminary opinion. In this way, the radiographer can play a more proactive role in the diagnostic process by indicating verbally, or in writing, the nature of the abnormality identified, rather than just highlighting the X-ray image, over time evolving to the collective name of RADS. RADS have a comprehensive definition in the UK, concerning abnormality detection systems ranging from the 'red dot' to a brief written comment to the referrer.⁶⁸

The type of RADS used is dependent on service needs, the clinical environment, image evaluation skills and knowledge, and the confidence of the radiographers. Currently

three types of RADS are commonly used internationally: 'red dot', image triage and radiographer commenting or opinion.

Other abnormality detection systems include radiographer commenting or opinion systems. The comments can be verbal or written. Unlike the 'red dot' system that highlights an abnormal image but fails to specify where the suspected abnormality is, a commenting scheme that permits effective communication of the abnormality suspected by the radiographer. Radiographer detection and description amount to radiographer commenting.

Radiographer commenting systems identify whether an abnormality is present and include the provision of a written comment for consideration by the referring GP. The written comment that succinctly describes the location and type of potential pathology and number of abnormalities present is not as comprehensive as a radiology report. Inexperienced GPs staffing emergency departments may be supported by this system.^{67,70-71}

In the UK, legal impediments to radiographers performing medical image interpretation were removed by the statutory body for the profession of radiography in the mid-1980s. Studies showed that image interpretations performed by radiographers who received proper training were in agreement with reports of consultant radiologists and more accurate than those of non-radiological medical staff. Abnormality detection systems, used in trauma cases, expanded beyond the scope of skeletal trauma signalling to radiographer reporting, a skill acquired through postgraduate training.⁷²

2.10 ERRORS IN DIAGNOSIS OF CHEST X-RAY IMAGES

According to Singh et al⁷³ in the United States (US), factors contributing to radiological errors are poor image quality, inability to detect and recognise lesions, poor communication between radiographers and the referring practitioner, incomplete clinical history taken, absence of previous studies, the presence of abnormalities that went undetected, and inadequate room lighting for reading.

Diagnostic error in medicine is a major cause of patient harm, given the rate of missed, incorrect, or delayed diagnoses. Waite et al⁷⁴ reported on diagnostic errors in radiology made by those responsible for image interpretations. He categorised them into perceptual errors and interpretive errors. Perceptual errors were attributable to poor conspicuity of the target lesion on the image, reader fatigue, rush while performing interpretations, distractions such as phone calls, e-mails, and other internet-based distractions or interruptions and a phenomenon known as failure to search, whereby the finding of one abnormality on an image results in a second abnormality being overlooked.

Kim and Mansfield⁷⁵ separated their diagnostic error findings into categories by cause, namely:

- Error of faulty reasoning where pertinent findings detected and correctly interpreted as abnormal were attributed to a wrong cause that led to misdiagnosis. This type of error resulted from misleading clinical information or limited differential diagnosis.
- Error that resulted from lack of knowledge, where the findings were correctly identified on the image, but the diagnostic importance was missed because of the reader's lack of knowledge.
- Errors of prior examination, where findings that had been missed were identified in retrospect.
- Errors of miscommunication, where findings were correctly interpreted, but the message failed to reach the referring practitioner, owing to poor channels of communication.
- Errors caused by faults in radiographic technique, in which findings were not detected because of poor radiographic technique.
- Errors of prior examination, in which findings were missed because of failure to check old radiographic studies or reports that would have guided the practitioner to the correct diagnosis.

- Errors due to a faulty clinical history in which an inaccurate, incomplete, or misleading clinical history created bias that misdirected interpretation.
- Errors due to a wrong lead side marker being used, wrong patient and wrong type of procedure done.
- Error in which findings were missed because of failure to continue searching the X-ray images further after the initial abnormality had been discovered.

Brady⁷⁶ classified omission errors into three categories based on the fixation times on missed lesions, namely search, perceptual and decision-making errors. Search errors involve the reader allocating no time to the location of an abnormality. Perceptual errors involve the reader dedicating a short amount of time to the location of an abnormality, but not enough time to recognise the lesion. Decision-making errors involve the reader dedicating a longer amount of time to the location of a lesion/abnormality, but making an incorrect decision on its relevant identification.⁷⁵

2.11 METHODS TO ENHANCE ACCURATE IMAGE INTERPRETATION

Efforts are made to address the problem of diagnostic errors, especially errors of omission, which are perceptual in origin.⁷⁷ Most efforts focus on intensive education of in-training and retraining in continuing education, including unknown case reviews, training in pattern recognition, repetition and drills. Attempts to improve performance by adjusting work hours to limit fatigue mitigate pressure to keep up a rapid pace of work or reduce the number of interruptions and distractions in a workday.

The use of checklists has been shown to reduce errors of omission in a variety of fields, including critical care medicine and radiology. The use of checklists to reduce medical errors has been popularised in the book, *The Checklist Manifesto*.⁷⁸ The use of checklist, semi-structured and structured reporting in the interpretation of positron emission tomography/CT images has been standardised. A checklist that is well designed, not too lengthy, can reduce errors of omission by reminding the reader to take a second look at certain aspects, areas and features of the images, such is a checklist template out of the European Society of Radiology⁷⁹ which can be adapted to

suit the chest image interpretation done at district hospitals. The checklist can be placed near the reading station or be in the form of a standard set of blanks requiring data entry. A potential downside to the use of standardised reports is the risk that a clinician reading a standardised report under time pressure and focusing only on the segment of the report that matches the pre-test clinical concern may miss unexpected significant findings outside the specific area of clinical concern.^{43, 45-47, 79}

2.12 VOCABULARY FOR IMAGE INTERPRETATION

X-ray reporting or findings requires description of the pattern recognised on the X-ray images. The written report should use terminology that is widely understood and has a commonly agreed meaning among healthcare practitioners. The standardisation of terminology would benefit all parties. The present tense should be used to describe the findings. Relevant imaging findings should describe the following:⁸⁰

- Precise anatomical location using accepted anatomical terminology for the modality
- Size or extent
- Shape, where relevant
- Patterns of pathology, to name a few:
 - Consolidation - any pathologic process that fills the alveoli with fluid, pus, blood, cells (including tumour cells) or other substances resulting in lobar, diffuse or multifocal ill-defined opacities
 - Interstitial - involvement of the supporting tissue of the lung parenchyma, resulting in fine or coarse reticular opacities or small nodules
 - Nodule or mass - any space occupying lesions either solitary or multiple
 - Atelectasis - collapse of part of the lung due to a decrease in the amount of air in the alveoli, resulting in volume loss and increased density.

2.13 STANDARDS FOR IMAGE REPORTING

The Royal College of Radiologists (RCR) in the UK has provided guidelines and recommendations for reporting of imaging investigations by non-medically trained

practitioners.⁸¹ The standards define the aspects of radiological service and care that promote the provision of high-quality service to patients. Delegation of reporting to non-radiologist doctors applies to the interpretation of imaging studies relating to a body part by health professionals trained to interpret X-ray images. They should only work within their scope of practice and competence. GPs have the same initial undergraduate medical school and medical experience to interpret X-ray images as radiologists, but lack the formal speciality training in any imaging examinations. When image interpretation and reporting are delegated to GPs, team work is important to obtain immediate medical access to radiologists' opinion if required⁸¹.

Non-medically qualified reporters such as radiographers have not undergone medical training. Therefore, they will not appreciate the implications of clinical history, clinical examination and investigative test results, which may be relevant to interpretation of the imaging study. Thus, limitations from lack of medical knowledge and multi-modality radiological training must be borne in mind when deciding on the type of imaging study reporting that incurs minimal risk to patients. Delegation of reporting to non-doctors involves a single body system and modality or a yes/no answer to questions on the presence of abnormality. Teamwork is important to obtain immediate medical access to medical radiological advice and opinion rather than working autonomously.⁸¹

2.14 IMPORTANCE OF DUAL READINGS

There are three reasons for the dual reading of chest X-ray images. First, subtle lesions missed on the chest X-ray by the first reader may be picked by the second reader. Second, the clinician has the advantage of knowing the patient's history, physical and laboratory findings and is able to show the abnormality to the patient on the radiograph. Third, the non-radiology physician must gain sufficient experience of interpreting chest X-ray images in order to teach others. Multiple interpretations bring about improvements in accuracy, implications for patient care and additional costs.⁸²

2.15 CONCLUSION

The problem in SA as identified in literature is that there are no radiologists in district hospitals to interpret X-ray images and provide a report. The current state of image interpretation in primary care hospitals of SA is that junior medical practitioners, who are on short-term contracts, staff district hospitals and are expected to interpret all X-ray images.

Research identified this as a problem and recommended that radiology training should be re-evaluated in an attempt to equip new medical graduates better for accident and emergency unit clinical responsibilities in their first years of medical practice. Secondly, there is a need among recently qualified South African doctors for CPD in plain X-ray images, particularly interpretation.²⁸

The Health Professions Act No. 56 of 1974 clause 10 (C) states that a radiographer may only comment on X-ray images that he/she has prepared and may only discuss the radiographic appearances with the referring practitioner.²⁶ The UK recognised the potential for radiographers and others to comment on images as a means of alleviating radiological workloads in the face of the chronic shortage of radiologists in the 1990s. A recommendation was that training in the form of postgraduate degrees and/or short courses was necessary if radiographers were to perform image interpretation and continuing education units training for GPs.

Radiographers and GPs have limited training in image interpretation of chest X-rays. The problem that led to this study was that these professionals provide image interpretation of chest X-ray images within the limited scope of their training. Effective inter-professional communication is intrinsic to safe health care and this can be achieved by standardisation of protocols, procedures and checklist reporting in radiology.⁶⁵ Checklists in radiology provide a standard foundation for a sequential framework to meet operational requirements, allow mutual supervision and crosschecking, and serve as a quality control measure.^{40,78}

RADS are a communication tool that allows radiographers to communicate to the referring GP or other health care professional their opinion on the status of the patient anatomy displayed on the X-ray images.⁶⁷ Abnormality detection systems include radiographer commenting or opinion systems and the 'red dot' system, that highlights an abnormality in trauma cases. Radiographer commenting systems identify whether an abnormality is present and include the provision of a written comment that succinctly describes the location and type of potential pathology and number of abnormalities present; it is not as comprehensive as a radiology report. Inexperienced GPs staffing emergency departments may be supported by this system.^{67,70-71}

3 CHAPTER 3 - RESEARCH METHODOLOGY

3.1 INTRODUCTION

According to Mouton⁸³, research methodology focuses on the tasks and methods implemented during the research process. This chapter outlines the philosophical assumptions and also the design strategies underpinning this research study. The interpretive paradigm was identified for the framework of this study. In addition, this chapter discusses the research methodologies and design used in the study, including strategies, instruments and data collection and analysis methods, while explaining the stages and processes involved in the study. The qualitative case study research method selected was suitable to address the research question and problem statement for the study. Radiographers and GPs at district hospitals conducted the study to investigate interpretation of chest X-ray images.

3.1.1 Aim of the research

The aim was to investigate the methods used for interpretation of chest X-ray images by radiographers and GPs at district hospitals in the City of Tshwane.

3.1.2 Objectives

- To describe the process of interaction between radiographers and GPs during image interpretation of chest X-ray images
- To explore methods used by radiographers to conduct interpretation of chest X-ray images
- To explore methods used by GPs to conduct interpretation of chest X-ray images
- To explore strengths and limitations in the current methods of interpretation of chest X-ray images by radiographers and GPs based on the standards recommended for non-radiologist reporting from the RCR in the UK.

This chapter reviews the study's research design, setting and participant selection process, instrumentation, and the procedures for data collection and analysis.

3.2 RESEARCH DESIGN

Research design refers to the plan or strategy for conducting the research. According to De Vos,⁸⁴ qualitative researchers develop their own designs using one or more available strategies as an aid or guideline. This study was conducted using a qualitative, exploratory, and descriptive case study method of inquiry.⁴⁰ The qualitative case study research approach facilitates exploration of a phenomenon in its context, using a variety of data sources. This ensures that the problem investigated is not explored through only one lens, but rather a variety of lenses, which allows multiple facets of the phenomenon to be revealed and understood.⁸⁵

Case studies provide an opportunity for the researcher to gain a deep holistic view of the research problem; they facilitate description, understanding and explanation of a research problem or situation. According to Yin⁹, a case study design was considered when the focus of the study was to answer “how” and “why” questions; behaviours of those involved in the study could not be manipulated to cover contextual conditions relevant to the phenomenon under study. In this study the question was “how” radiographers and GPs interpret chest X-ray images, but the cases could not be considered without the context, which is the district hospitals and more specifically the X-ray department, casualty and outpatient departments (OPD) as the settings where the interpretations were taking place.

Yin⁹ and Stake⁸⁶ have recommended putting boundaries to all case studies. The boundaries indicate what will and will not be included in the scope of the research project. This is called binding the case. Suggestions on how to bind a case included time and place or time and activity. This study followed Yin’s binding by time and place as well as time and activity.⁹ The researcher was exploring the process of interaction between radiographers and GPs during image interpretation of chest X-ray images at selected district hospitals.

Yin⁹ categorised case studies as explanatory, exploratory, or descriptive and differentiated between single, holistic case studies and multiple or collective case

studies. Descriptive case studies describe different characteristics of a phenomenon in its context and identify differences between individual cases with a view to potentially generating a classified framework. A descriptive case study was selected to describe observations in real-life context.

For the purpose of this research, a collective case study design was used to evaluate current practices from groups of radiographers and GPs in the three district hospitals. Collective case studies are similar in nature and description to multiple case studies. The method allowed the researcher to analyse data within each setting and across settings and also to examine several cases to understand the similarities and differences between the cases. The collective design is robust and reliable, but it is time-consuming.⁹

3.3 PARADIGMS

Brink, van der Walt and van Rensburg⁶, described assumptions as principles that are accepted by faith, and assumed to be true without proof or verification. Ontology is the philosophical study of the nature of reality.⁷ There is an assumption that reality can be formed by multiple forms of evidence derived from the different perspectives and experiences of participants. Epistemology is the philosophy of the relationship between the researcher and the participants.

The philosophical paradigm applicable to this study is social constructivism, also called interpretive research. Interpretive researchers believe that reality consists of people's subjective experiences of the external world; thus, they may adopt an inter-subjective epistemology and the ontological belief that reality is socially constructed there is no single reality. Individuals in groups create reality. Reality needs to be interpreted to discover the underlying meaning of events or actions. The interpretive paradigm is underpinned by methodologies, such as interviews and observations, which rely on a subjective relationship between the researcher and subjects. Interpretive research focuses on the complexity of human sense-making as the situation emerges. The

interpretive approach aims to explain the subjective reasons and meanings that lie behind social action.⁸⁷

3.4 SELECTION OF PARTICIPANTS

3.4.1 Population

De Vos⁸⁴ defined a population as all elements in the universe of interest to the researcher that meet the criteria for inclusion in a study. In this study the population consisted of all radiographers and GPs rendering health services at casualty departments or OPDs at the selected district hospitals. A total population of 68 was identified, consisting of a staff establishment of nine radiographers from TDH, 13 from Jubilee Hospital and six from PWH, thus a total of 28 radiographers, and a GP population of 13 from PWH, 15 from TDH and 12 from Jubilee, thus a total of 40 GPs.

3.4.2 Sample

A sample is a subset of a larger set selected from the total population by the researcher to participate in a research project.⁸⁸ The responses of the sample may be used to estimate the way in which the entire population would have responded if all members of the population had been studied. Brink et al⁶ were of the opinion that the size of the sample in qualitative research depended on what the researcher wanted to know and on the purpose of the study. The total sample size from the three settings was N30 participants. The sample size was equally distributed to be five radiographers and five GPs from each one of the three settings.

Purposive sampling is concerned with providing a sample of information-rich participants. The selection was based on experience and expertise regarding the phenomenon under study. The sample was based on the GPs who requested chest X-ray images and were willing to participate in the study and radiographers who were willing to participate in the study and had to perform chest X-ray images on the day data was collected. Purposive sampling was thus used to ensure that the knowledge gained

was representative of the population from which the sample was drawn, based on a specific purpose.⁶

3.4.3 Inclusion criteria

Polit and Beck⁸⁹ define inclusion criteria as a way of specifying the characteristics needed from a population.⁸⁹ The inclusion criteria for this study were:

Departments dealing with new patients: outpatient and casualty

Radiographers and GPs registered with the HPCSA

Interpretations of new chest X-ray images.

3.4.4 Exclusion criteria

The following exclusion criteria were applied:

Informed consent not signed

Audio consent form not signed

Inclusion criteria not met.

3.5 METHODOLOGIES

Methodological notes are reflections about strategies and methods that the researcher used during the study. Primary data collection entailed observations, field notes and interviews. The researcher played an essential role requiring creativity, sensitivity, flexibility and skill in using verification strategies, which determined the trustworthiness of the evolving study. Key elements considered to enhance trustworthiness, as promoted by Lincoln and Guba⁹⁰, were credibility, transferability, dependability and confirmability.⁸⁴

Research process

Data collection took place over a period of three months, from June to August 2017. The researcher visited the settings for the first time to deliver a letter requesting permission from the hospital's chief executive officer (CEO). After obtaining permission from the Research Ethics Committee of the University of Pretoria, the researcher visited

the settings again to obtain permission to conduct the study from the heads of the respective departments (HODs). The researcher engaged with the target population to understand their behaviour better and to build rapport and trust. Appointment dates to conduct the study in each of the settings were set. The HODs of each setting selected a date when most of their staff members would be present according to their work allocation. On the appointed day, the target population was re-oriented with regard to the topic and the purpose of the study and provided with the opportunity to participate in the study by signing a consent form.

The study unfolded in two phases, namely an observation phase and an interview phase.

To increase the credibility of the study, multiple methods of data collection were used to allow for data triangulation.⁸⁴ These techniques were method triangulation and data triangulation approaches. Method triangulation involved using observations, focus groups and individual interviews to collect data. Data triangulation involved different participants, radiographers and GPs as data sources within one study in subsets of five people, as well as time and space in the different departments.

3.6 DATA COLLECTION TOOLS

The research instruments used to collect data were observation checklists and semi-structured focus groups. The study unfolded in two phases, namely an observation phase and an interview phase.

3.6.1 Observations

Observations involve behavioural or environmental conditions observed at a site. Observations provide researchers with ways to check for nonverbal expressions, which are confirmed during interviews.⁹¹ Researchers may observe events that may be sensitive to discuss, and observe situations described in interviews. Observations range from formal to casual data collection activities and more than one observer was involved in this study. To increase the trustworthiness of the study, information was captured in real time to cover the context of the event. The goal of using observation as a method

was to develop a holistic understanding of the phenomena under study. The weaknesses were that observations were time-consuming and the behaviour of participants might change if they knew that they were being observed.⁹

Highly structured observations involve a checklist of behaviours of predetermined evidence for observation in the situation that will either support or refute a preconceived theory. To seek insight into the mind of a participant, observations are paired with additional strategies such as interviewing and document analysis, or surveys, questionnaires, or other qualitative methods that will add to trustworthiness. Finally, observations help to answer descriptive research questions, to build theory, or to generate or test hypotheses.¹⁰

Observation entails perceiving data through the sense of sight. The purpose of observations in this study was to observe the process and interactions between radiographers and GPs in their natural environment while interpreting chest X-ray images. Naturalistic observation involved observing individuals in their natural settings, making no effort to manipulate variables or control activities, but simply observing and recording. Types of observations are participant and non-participant observations, structured and unstructured observations, controlled and uncontrolled observations.

The researcher did not interfere with the normal running of the departments; both the GPs and radiographers explained some of the processes observed as the need arose. The researcher assumed the role of non-participant observer. The non-participant type of observation involved no participation of the observer in the activities of the participants. The observation was structured for the descriptive research design and unstructured for the exploratory research part.

The naturalistic structured observation included the actions decided upon in advance as presented in a checklist (see Annexure 2), where the observer followed the instructions in each section on the observation list to either tick the action observed and/or write

down the process as it unfolded while the observer watched the actions of the participants.

The unstructured observation included informal interviews, needed for action clarification. These included actions that required explanation. Focal sampling was used when conducting the observations; it involved observing one individual for a specified amount of time and recording all instances of that individual's behaviour.⁹²

3.6.2 Field notes

Note taking is the most commonly used and easiest method or technique to record observations, especially when actions to document observation are planned ahead of time. There are many styles of field notes, but field notes generally have a dual nature: descriptive, in which the observer attempts to capture a word-picture of the setting actions and conversations, and reflective, in which the observer records thoughts, ideas, questions and concerns based on the observations and interviews.

Field notes for this study were planned ahead of time. The researcher used Spradley's¹⁰ checklist idea as a guide during observations, but adapted it to suit this study (see Annexure 2).

Researcher checked the following activities while participants were under observation: Radiographers had to register all patients referred for imaging, provide chest X-ray images as requested, evaluate the X-ray images for adequacy in image quality, interpret X-ray images by identifying abnormal patterns, communicate results to the referring GP and send the patient back to the referring GP with X-ray image print-outs and comments, if available.

GPs were to view the X-ray images using adequate X-ray viewing light and subsequently evaluate and interpret them and write a report on the chest X-ray findings. The researcher ticked the activities as observed and explained.

3.6.3 Interviews

Observation preceded interviews. The purpose of the research interview was to triangulate data from other sources and to explore the views, experiences, beliefs and motivations of individuals on specific matters.³⁹ Interviews are appropriate where less is known about the study phenomenon and where detailed insights are required from individual participants. Interviews were a preferred data source for this study because they focused on the area of interest. All interviews were audio-recorded and transcribed verbatim to protect against researcher bias and to provide a permanent record. Interviews allowed participants to convey a situation based on their own perspective in their own words, based on their experiences.

Interviews were conducted in focus groups and individually. Focus groups involved small groups of five people engaging in collective discussion of the topic, guided by the pre-determined guiding questions.⁸⁵

Semi-structured interviews have the features of both structured and unstructured interviews and therefore use both closed and open ended questions. They offer the advantages of both methods of interview. In order to be consistent, the interviewer compiled a set of pre-planned core questions for guidance so that the same areas were covered with each participant. As the interview progressed, the participant was given the opportunity to elaborate or provide more relevant information.⁵² The interview guide comprised the following questions (also available in Annexure 3):

1. Give details of chest X-ray interpretation systems used in your department.
2. Give details of methods of image interpretation of chest X-ray images used by radiographers and GPs in this setting.
3. What were the perceptions of radiographers and GPs on image interpretation of the chest X-ray process at district hospitals?
4. Describe the workload caused by the interpretation of images.
5. What challenges were experienced during image interpretation of the chest X-ray images?
6. What mechanisms are in place to support image interpretation?

7. What training do you have in image interpretation of chest X-ray images?
8. What are the audits of practice undertaken to support participation of radiographers and GPs in chest image interpretation?

3.6.4 Audio recording

Hand-written notes were unreliable on their own, as some participants spoke very fast and the researcher may have missed some points. The audio-recording of the interviews made it easier for the researcher to focus on the verbal prompts. Present during the interviews for data capturing were the researcher, prompting and recording key points, and an assistant researcher who focussed on the audio recordings.

3.7 DATA COLLECTION

Burns and Grove⁹³ define data collection as the precise, systemic gathering of information relevant to the research purpose. It is important that the researcher be familiar with the data collection method used as well as its advantages and disadvantages. Interpretive researchers attempt to derive their data through direct interaction with the phenomenon being studied.⁶

Observation phase

Observations were performed following the checklist in Annexure 2. Data was collected from the first five radiographers who were involved in chest radiography on that day and had signed the consent form. The researcher followed the participants from the moment that the requested chest X-ray images were performed until the conclusion of the process. The researcher ticked all the activities done by the radiographers during the observation period. The processes checked included taking X-ray images, image evaluations, image interpretation by the radiographer and communication of the results to GPs. Participants were requested to explain the methods they were using to evaluate and interpret the chest image and how the results were to be communicated to the referring GP, as these could not only be observed; explanation was needed. The information noted on the observation form was based on participants' explanations. As Lincoln and Guba⁹⁰ noted, 'by describing a phenomenon in sufficient detail, one can

begin to evaluate the extent to which the conclusions drawn are transferable to other times, settings, situations, and people.⁹⁰ The careful construction and use of qualitative instrumentation, supported by probes or prompts for observation and field note checklists, were essential for ensuring transferability.

Interview phase

Focus groups were conducted at each setting according to the following:

Setting one: Focus group interviews with radiography participants were conducted in the tearoom. The researcher and the assistant researcher conducted the interviews. The assistant researcher is a graduate with a diploma in small business management. The researcher trained her on how to participate during data collection by recording the interviews on a mobile phone, creating a recorded audit trail. Audit trails are a study blueprint, outlining detailed procedural records maintained by the primary researcher.⁸⁴ The audit trail included guiding questions asked during the interviews in the order appearing in Annexure 3. Participants responded to the same question giving the answers in their own words until reaching saturation, which was when there was nothing more to say about the questions asked. The researcher then moved on to the next question. The interview took 30 minutes to complete.

Setting two: Focus groups were restructured, based on the results obtained from the preliminary analysis of setting one. The questions from Annexure 3 remained the same. Each group member was given an opportunity to respond to each question, and then the next participant would add new information; there were no repetitions. With this method, more information was gathered, and challenges experienced with the first group were eliminated. The time spent on gathering information was also 30 minutes.

Setting three: When the last group was interviewed, the department was very busy and to avoid disturbing the patient workflow, individual interviews instead of focus groups were conducted; each participant was interviewed immediately after observation. Five separate participant recordings were made. This method of individual interviews was more time-consuming for the researcher, but less disruptive to the workflow in the

department. The advantage of this method was that the information gathered contained many repetitions but was not contaminated by group dynamics. The verbatim transcriptions were also simplified. The time spent with each participant was 20 minutes. This included the time taken to explain the study and get the consent form signed.

Appointments were made with the HODs of the respective departments for the researcher to collect data from the GPs. Only one GP was unwilling to take part in the study, but the target number of participants was still reached. After explaining the study to the participants, the consent forms were signed. The researcher ticked all the activities carried out by the GPs during observation, based on the observation list in Annexure 2. The processes checked included image evaluations and image interpretations. Participants were requested to explain the methods they were using to evaluate and interpret the chest X-ray images and how the results were communicated to the patient; as these could not only be observed, explanation was needed, thus individual interviews were conducted with GPs at all settings. To avoid disturbance in patient workflow and causing a backlog for patients waiting for consultation, the individual interviews conducted took place inside the consultation rooms. GPs were asked to explain how they were conducting image interpretation of chest X-ray images. Interviews gave more clarity on the process of interpretation applied. The time spent with each participant ranged from 10 to 20 minutes.

3.8 DATA ANALYSIS

Data analysis in a qualitative case study is the search for meaning through direct interpretation of what is observed as well as what is experienced and reported by the subjects. The aim of analysis of qualitative data is to discover patterns, concepts, themes and meanings. Data collected was coded to create meaningful sequences that could be organised.⁷

Data analysis in this research followed a twofold approach. One, taken at the site during data collection, was called preliminary analysis; the second took place away from the site after completion of data collection for the whole study.⁸⁴ In the case study, data was analysed as it became available, and the researcher had to adjust the data collection process to accommodate unplanned distractions. Emerging results were used to shape and construct the next set of interviews.⁹

In this study non-participant observations generated data that was used to corroborate information gathered during participant interviews. Observations done required the researcher to use follow-up interviews to verify observations, a good method to triangulate or corroborate data gathered from interviews.

Creswell⁷ presents his approach as a linear, hierarchical process. He states categorically that there are five interrelated steps to be followed, but that these are not necessarily followed in the order they are given. The steps are as follows:

- Organise and prepare the data for analysis by transcribing interviews.
- Read through the transcription repeatedly to get a general sense of the information and its overall meaning.
- Coding of the data, the process of organising the data into information and writing a word that represents a category, is necessary. Coding includes a description of the setting or people. It should include a detailed discussion of several interconnecting themes.
- Then lastly, interpretation of the results is undertaken.

The first step: Transcription

Audio-recorded interviews were transcribed verbatim. Group interviews were transcribed independently and checked for accuracy by the researcher. The researcher transcribed individual interviews verbatim. Transcription was the initial point of secondary analysis, as it helped the researcher gain better understanding of the data and assisted in the development of the skills needed for the actual analysis process that followed.

The typed Word documents of the recordings were combined as one continuous document so that they could be analysed using thematic analysis. The two methods of analysing qualitative data applied were interpretive or thematic analysis and framework analysis. The framework analysis approach was adopted to examine findings with a pre-defined framework, which reflected the aims and objectives and had pre-determined interests. This approach allowed focusing on particular answers.⁹⁴ The second, thematic network analysis approach took a more exploratory perspective and organised all the data, allowing new impressions to emerge. Data was analysed using both the thematic and framework methods of analysis.⁹⁵

The second step: Coding

The researcher listened to the audiotapes, read, and re-read the verbatim transcripts to get a global understanding of the interviews and to become familiar with the data. The researcher randomly picked common words and phrases from the document and started analysing them one by one, until all the transcripts had been analysed and similar ideas or phrases had been selected. A code is a word or a short phrase that descriptively captures the essence of elements of the material. Initial coding involved an open coding method where a line-by-line analysis was used to assign text to codes. Open coding consisted of highlighting pieces of text that were relevant with coloured marker pens. Axial coding was done by grouping the highlighted codes according to relationships. Grouped codes were examined for establishment of patterns formed by themes. Similar themes were grouped together to form categories. From each category, a number of themes emerged. Discussions of the themes established will follow in the next chapter.

In this study, the categories adopted are based on the guiding questions in Annexure 3. The main categories are discussed in Chapter 4, with relevant quotations from the participants. The supplementary data (verbatim transcripts) presented are without corrections to grammatical errors, but colour-coded to facilitate audit trailing. All the participants answered the same questions, as reflected in Annexure 3.

The data collected from observations was organised, collated and quantified using a checklist guide that the researcher adapted from Spradley's checklist idea and results presented in tables and figures. Information collected from observations that was similar to data from interviews was coded and grouped into categories and merged to establish connections, taking due notice of connections; a thorough check was also done to ensure that the final categories covered all the data collected.

The third step: Interpreting results

Interpretation of results entailed building a valid argument for why particular themes were identified. A written account of the phenomenon under study is given. It is at this stage that constant referral to literature and its incorporation into the data analysis are ensured. This adds to the merit of the research by supporting the findings with previous research.

Data analysis consisted of examining, categorising, tabulating, testing and recombining evidence to draw empirically based conclusions. The key objective was to identify conceptual similarities and differences and to discover types, classes, sequences, processes, patterns or gaps⁹

According to Yin⁹, pattern matching is the core technique used for theory testing. Pattern matching is the technique that involves comparison of predicted patterns or effects with what was empirically observed and the identification of any variances or gaps. Analytical generalisation used previously developed theory and compared it with empirical case study results. Analytical generalisations were made to theory, but not to the population.

Explanation building was a special type of pattern matching, which aimed to analyse the case study data by building an explanation about the case. In this context, explaining refers to the process of building a set of causal links on how image interpretation of chest X-ray images was done by radiographers and GPs in district hospitals.

To complete the triangulation of the data, the patterns drawn from the data were compared with the templates extracted from McQuillen⁵⁹ and Chan³⁸, using the theory testing, pattern matching technique.

The fourth step: Presenting the data

The data analysis process culminated in the researcher's written reports in which the findings of the empirical research are discussed and conclusions are reached. This section explores and discusses the possibilities of applying qualitative content analysis as an interpretation method in case study research and thus tries to find an answer to the research question initially posed.

3.9 ASSESSING TRUSTWORTHINESS

The researcher played an essential role in the establishment of reliability and validity, employing her creativity, sensitivity, flexibility and skill in using the verification strategies, which determined the reliability and validity of the evolving study. Trustworthiness is the term used in a qualitative case study to ensure reliability and validity. Key elements to enhance trustworthiness are credibility, transferability, dependability and confirmability.⁸⁴

3.9.1 Credibility

Credibility relies on the trustworthiness of data collected through triangulation, peer debriefing and member checks.⁴³ The critical technique for establishing credibility in this study was the method of triangulation, where multiple methods were used to collect and interpret data about the phenomenon so as to converge into an accurate representation of reality. Peer debriefing was done to review and explore various aspects of the study and gain feedback on the data collected. A process of member checking where participants checked researcher's interpretations of the data was accurate. To add to the credibility of the study, information gathered was audio-recorded and notes were taken by the researcher and the assistant researcher.

3.9.2 Transferability

Lincoln and Guba⁹⁰ proposed transferability in qualitative research as synonymous with generalisability, or external validity, in quantitative research. Transferability implies providing readers with evidence that the research study's findings could be applicable to other contexts, settings, situations, times and populations.⁴³ Transferability requires that the original theoretical framework of data collection and analysis should be replicable and applicable to other settings.

3.9.3 Dependability

Dependability is analogous to reliability, which is the criterion for evaluating integrity in a study.⁴³ Dependability is the evaluation of the quality of the integrated processes of data collection, data analysis and theory generation. In this study, a major technique for assessing dependability was a dependability audit, in which two supervisors reviewed the activities of the researcher as recorded in an audit trail of field notes, audio-recordings and other reports, to see how well the techniques for meeting the credibility and transferability standards were followed. The audit trail associated with the study is easily accessible on request.

3.9.4 Conformability

Conformability captures objectivity, which accounts for individual bias.⁴³ All collected notes and audiotapes were kept in a well-organised and retrievable form so that they could be made available if required. Protocols for data collection were standardised. The researcher kept a log or "reflexive journal" where all problems were recorded, as well as ideas at various stages of the research, own reactions and values and their possible influence on the progress of the research. Reflexivity is the practice of reflecting upon the ways in which the research progress was influenced. Reflexivity and bracketing strategies were applied to control bias throughout the research process.⁹⁰

3.10 ETHICAL CONSIDERATIONS

Ethics are principles of proper conduct. These principles represent basic human norms and values. Every researcher should adhere to these principles in order to ensure the correct conduct with regard to subjects and participants in a study. Permission to conduct the study was obtained from all the CEOs and HODs at the district hospitals; see copies in Annexures 5, 6 and 7 respectively. Ethical approval to conduct the research was obtained from the Ethics Committee of the Faculty of Health Sciences, University of Pretoria, and reference number: 93/2017, before the study commenced.

An important mechanism for respecting participant's autonomy in research is to seek their free, informed and on-going consent. Informed consent was obtained from all participants prior to the study. This included permission to use audio-recordings. See Annexure 4 for a copy of the consent form. The ethical principles adhered to in this study were beneficence, non-maleficence, respect and justice.⁴³

Beneficence as an ethical principle seeks to maximise benefits for participants in a study.⁴³ The findings in this study were intended to support the scope of practice to include chest X-ray image interpretation for radiographers and CPD in chest X-ray image interpretation for GPs. Thus, the study did not benefit the participants directly, but will contribute positively to a pool of knowledge required to build the professions of the participants.

The participants suffered no harm or maleficence. This ethical principle referred to the research not having a harmful effect on the participants or their communities. The autonomy of potential participants who chose not to participate in the study was respected. Confidential information obtained from participants was protected and respected. To ensure confidentiality, participant's identities were not recorded on the data collection sheet or in the audio-recordings. Participants were allocated codes and numbers according to their professions. GPs were cited as GP1 to GP15, and radiographers as R01 to R15 respectively. The ethical principle of 'respect for persons' was adhered to, as participation in the study was voluntary and all participants were free

to withdraw from the study at any time. There was no incentive or payment for those participating in the study. There was no risk of penalty or prejudicial treatment for not participating in the study.

3.11 CONCLUSION

A qualitative research methodology with a collective descriptive case study design was used.⁹ The method included research design, the methodology of collecting data, including data collection instruments, setting, population and sampling method, data analysis processes, adaptations and ethical considerations.

4 CHAPTER 4 – RESULTS

4.1 INTRODUCTION

This chapter will present the findings that emerged from the data analysis as described in chapter 3. All findings presented addressed the objectives of the study.

4.2 DEMOGRAPHIC INFORMATION

Table 1 shows that the sample in the study comprised N30 participants. The majority of the group were females, radiographers 67% and GPs 53%. The grouping in terms of age showed that the majority of participants were between the ages of 20 and 39 years. Only 20% of GPs were in the age group of 40 to 50 years and therefore had most experience, 10 years and above. A breakdown of the population in terms of work experience showed 53% GPs with experience of less than one year, includes those who have finished their community service the previous year, also in the study were those who were still doing their community service.

Table 1: Demographic distribution of all participants: n=30

		Radiographers Frequency: n=15		GPs Frequency: n=15	
Age in years:	20 -29	11	73%	6	40%
	30 – 39	4	27%	6	40%
	40 – 49	0	0	3	20%
Gender:	Female	10	67%	8	53%
	Males	5	33%	7	47%
Experience:	0/Community service	6	40%	8	53%
	(1-4 yrs.)	2	13%	0	0
	(5-9 yrs.)	6	40%	4	27%
	(10+ yrs.)	1	7%	3	20%

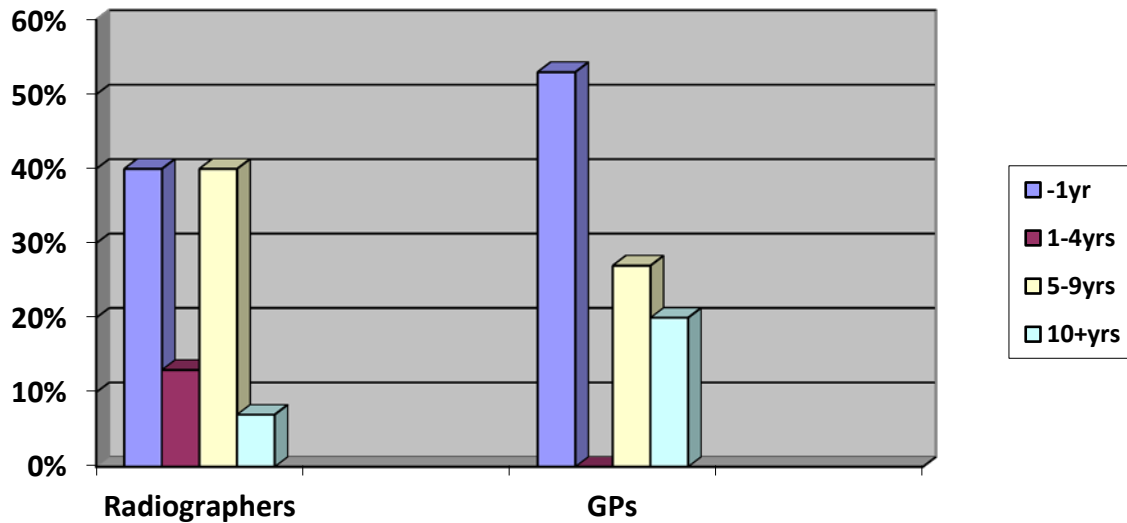


Figure 1: Demographic age distribution of the two professions

Figure 1 presented in the form of a bar chart indicates the difference between the two professions in terms of age indicating that there was more younger staff members in district hospitals

4.3 RESULTS OF THE OBSERVATION PHASE

The data collected from observations was organised, collated and quantified using the checklist seen in Annexure2 checklist. The results of the information are reflected in tables and figures.

Objective 1: To describe the process of interaction between the radiographers and GPs during image interpretation of chest X-ray images.

Table 2a indicated that the majority of radiographers, 67%, gave verbal opinions to communicate the chest X-ray image findings to the referring GPs when responding to requests for assistance. Radiographers gave an opinion on the site, area of interest, and the density of the abnormality.

Table 2b indicated that all GPs wrote their findings on the patients' files; 80% wrote down the diagnosis and only 53% added a description of the abnormalities seen on

chest X-ray images.

Table 2a: Methods of communicating chest X- ray image interpretation findings by radiographers

Activity performed	How findings were communicated		Radiographers frequency	%
Method of Communication	Verbal	Comment if requested	11	73
		Area of interest	10	67
		Image density	9	60
		Site of abnormality	10	67
	No communication		3	20

Table 2b: Methods of communicating chest X-ray image interpretation findings by GPs

Activity performed	How findings were communicated		GPs frequency	%
Method of Communication	Written	Write findings	15	100
		Describe pattern	8	53
		Diagnosis	12	80

Objective 2

- To explore methods used by radiographers to perform image interpretation on chest X-ray images.

Table 3 indicates all the technical areas, according to Mcquillen,⁵⁹ that should be evaluated by radiographers and GPs to obtain images of diagnostic value. Results showed that lateral views were done routinely by only 47% radiographers. The rest did them on request. Lack of evaluation was seen in anatomy of interest, breathing, exposures, patient identification, patient position and image orientation.

Table 3: Technical Image evaluation adapted from McQuillen⁵⁹

Image Evaluation		Radiographers		GPs	
		frequency	%	frequency	%
Views done:	PA:	15	100	15	100
	Lateral:	7	47		
AOI		9	60	7	47
Artefacts		3	20	0	
Breathing		5	33	2	13
Exposures		10	67	9	60
Identification		4	27	4	27
Position		7	47	3	20
Markers		1	7	0	
Orientation		0		3	20

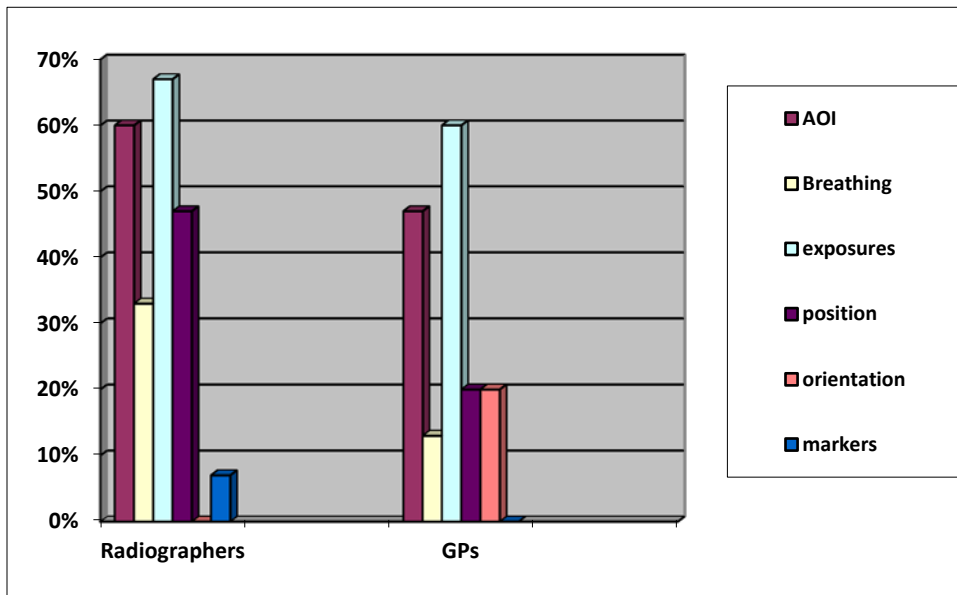


Figure 2: Technical Image evaluation results for the two professions.

Figure 2: Findings of Table 3 are presented in the form of a bar chart to indicate the difference between the two professions in following the technical chest X-ray image evaluation criteria.

Table 4: The results reflected in Table 4 were obtained by identifying the structures of the thoracic cage that were searched for abnormal patterns, following Chan's³⁸ ABCs system of chest X-ray image interpretation.

Table 4: Systematic ABC system image interpretation adapted from Chan³⁸

	Radiographers		GPs	
	Frequency	%	frequency	%
Artefacts(non-removable)	0		0	
Airways	4	27	7	47
Breast tissue	0		0	
Cardiac	5	33	10	67
Costo/Cardio phrenic angles	1	7	4	27
Diaphragms	0		5	33
Gas bubble	2	13	0	
Hila	0		4	27
Mediastinum	1	7	3	20
Lung tissue	5	33	12	80
Surrounding tissue	4	27	4	27
Skeleton	6	40	13	87

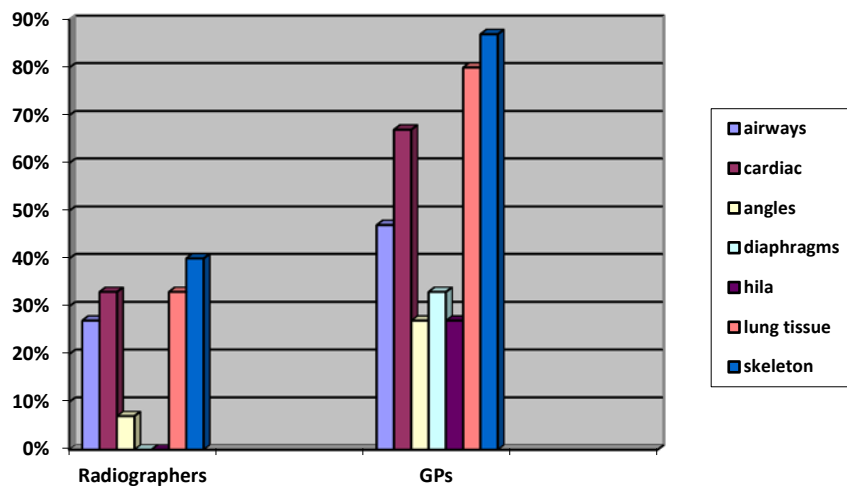


Figure 3: Systematic image interpretation based on Chan ABC system for the two professions

Figure 3: The findings of Table 4 are presented in the form of a bar chart to indicate the difference between the two professions in identifying structures of the thoracic cage that were searched for abnormal patterns.

4.4 RESULTS FROM INTERVIEWS

The evaluation of qualitative data obtained through focus groups and interviews of radiography and GP participants revealed four categories and their themes, which

formed the framework of data evaluation as listed in Table 5. The categories are methods of communication, methods of image interpretation, perceptions on image interpretation, challenges experienced during chest X-ray interpretation and mechanisms to support image interpretation.

Table 5: Framework of data analysis from themes to categories

Categories	Themes
Communication	Inter-professional communication
Methods used to interpret chest X-ray images	Image evaluation
	Systematic image interpretation
Challenges experienced during chest X-ray interpretation	Waiting time
	Equipment
Mechanisms to support interpretations of chest X-ray images	Colleagues
	Auditing of X-ray reports
Perception of participants on chest X-ray interpretation	Lack of experience led to misdiagnosis
	Lack of knowledge required training

4.4.1 Communication

Inter-professional communication

Participant's response to communication methods used in image interpretation.

PARTICIPANT R01: "Okay, normally ... you will put an arrow, I'm not sure if all of them knows what an arrow means, but we will put an arrow and make sure that it's bold, it's seeing that it's pointing somewhere, maybe there's a fracture or anything. Otherwise if it's a chest X-ray where you can't just point on a particular piece, you will call them and say I think something's not right."

“PARTICIPANT R03: So sometimes you’re just scared to tell that something is wrong on the image, depending on the doctor. If maybe there was a protocol for doctors to communicate with the radiographers ...”

Reflexivity

Reflexivity represents what the researcher observed before the study commenced. The researcher observed that there was minimal communication between GPs and radiographers. There was a communication breakdown in terms of views taken for specific cases. For example, lateral chest X-rays are to be taken only when an abnormality is seen on the PA. Not all the GPs were aware of this; some expected all chest X-ray images to have two views, while others did not even look at the lateral view when it was available (as reflected in Table 3).

Participant comments on protocols:

PARTICIPANT GP7: “I don’t know if the X-ray department have a protocol. I as a doctor expect them to have.”

At the time of data collection, no protocols were observed or reported to be in place.

4.4.2 Methods of chest X-ray interpretation

Image evaluation

Results of image evaluation responses obtained during interviews were the same as for the method followed and explained during observation (as reflected in Table 3). The participants searched for abnormalities in a random fashion. No specific, systematic approach was followed to evaluate the X-ray images.

Examples of responses made by some of the participants when asked to give details of image interpretation systems used in their department to interpret chest X-ray images are:

PARTICIPANT R01: “As long as everything that is needed is included on the image. And the second thing is to check the positioning because if the positioning is not well you can easily misinterpret it with the pathology. So if positioning is fine, it’s accurate, then the next step is to check the pathology.”

PARTICIPANT R04: “Another important thing having your left and right lead marker in position because you must interpret the left and the right.”

PARTICIPANT R12: “As observed – no systematic method in place.”

PARTICIPANT GP1: “We first evaluate the quality of the X-ray ... then you interpret it like I mentioned from outside going inside from the soft tissues, the bone and the lung tissues as well also looking at the cardio-phrenic angles and costo-phrenic angles ... then you will describe the abnormalities that you would see and then we would come up with a diagnosis from the abnormalities.”

“PARTICIPANT GP14: “The challenges are the technical factors because you find that you request an X-ray and it comes as a poor X-ray either ... underpenetrated or over-penetrated. ... And the other challenge we have is when we go and confront radiographers about why they are not doing all the views properly.”

Systematic image interpretation

The image interpretation methods used are to check abnormalities. These are the responses from some of the participants on the systemic approach of image interpretation:

PARTICIPANT R01: “I check the airways, check their bones and you check also their soft tissue, cartilage and stuff ... if everything is normal then you just state whatever is normal. Then after you state whatever is normal then you come to the abnormality. That’s when you come to see pathology ...”

PARTICIPANT GP3: "I'm going to talk for myself but yes I think there is a system because we do discuss X-ray images, an approach to X-ray images as part of a presentation to say this is what you look for, this is how you approach it but as to whether people are following the guidelines, that's a difficult one to say because people work as individuals and we don't really have time to monitor them and see if they are following the guidelines."

PARTICIPANT GP5: "For me I would say I was taught the system at school but I'm not really using the system. ... I think we need more classes for us to be able to focus on the system all the time if I'm being honest."

4.4.3 Challenges experienced during chest X-ray interpretation

Waiting time

Challenges involved were the time taken while waiting for the report.

"PARTICIPANT GP6: "Sometimes you find that you are unsure of what you see on the chest X-ray then you end up sending X-rays to (tertiary hospital) for reporting and the challenge is that it takes time, three to four days for the report to come back"

"PARTICIPANT GP2: "... bad quality X-rays if it was not properly taken then we have to send the patient back for a repeat X-ray."

Equipment

A regular programme of equipment maintenance in an imaging department is an important element of quality assurance.

PARTICIPANT G11: "Image interpretation does not increase the workload only when the monitors are not working or the proper printer not working, then it does affect on workload."

Supporting comment:

PARTICIPANT GP12: “Ja, the viewing boxes at night is not working, sometimes we use sunlight, so viewing images at night is a challenge.”

4.4.4 Mechanisms to support image interpretation

Colleagues

Results of the study showed that colleagues form a supporting pillar in image interpretations of chest X-ray images. Colleagues included are GPs, consultants or senior personnel supervising the junior or newly qualified doctors, radiologists and radiographers in the same hospital or at a tertiary hospital.

PARTICIPANT GP7: “I can honestly go to the X-ray department they are very helpful if I want to see the image on a system to make it darker/lighter they are very helpful there.”

PARTICIPANT R03: “... If you know this doctor always come and ask for assistance then you assist, telling them that ... it’s just my opinion, I’m not saying it’s a definite thing.”

PARTICIPANT GP9: “Ja colleagues and specialist hospitals are called and sometimes the radiographers themselves do help in image interpretation.”

A tertiary hospital provides specialist level services, for example a radiology service receiving referrals from regional and district hospitals, which is not limited to provincial boundaries.

PARTICIPANT GP14: “ ... uhm so far you’ll only rely on the one of us because if no one can help you in this hospital, you must phone (tertiary hospital) refer – always refer if you do not know what you are looking at. Use or follow the referral procedure.”

PARTICIPANT GP8: “ ... send for radiological report at (tertiary) hospital, takes long about two weeks sometimes, X-rays get lost you have to redo and re-send.”

Auditing

There should be regular audit of both unreported imaging investigations and of the time, it takes to issue a report. This is the best practice that forms part of a patient safety programme.

PARTICIPANT GP14: “ ... never had anyone to tell us of any audits that were done, maybe they do it and not tell us. They never come to us and say look we have seen your X-ray report.”

PARTICIPANT R14: “They come and observe and they check if you are wearing dosimeters, they check if we put notices for patients for the radiation danger signs.”

4.4.5 Perceptions on image interpretation

Lack of experience leads to misdiagnosis

The GPs and radiographers' perception is that image interpretation of the chest X-ray images in district hospitals is not properly done. Participants perceived that doctors working at district hospitals are mostly junior or community service doctors with no experience in image interpretation.

These are comments by participants on lack of experience:

PARTICIPANT GP8: “I don't think it is appropriate sometimes we see X-rays that we are not sure of. We diagnose wrongly. I do not think it is done adequately. It requires a person with experience.”

PARTICIPANT GP15: “EISH – OK Ja interpretation can be done better for now. Here we are mostly junior doctors, uhm so if you find a complex X-ray case you turn to ask your colleagues for help.”

PARTICIPANT R12: “Eish ... Perceptions of interpretation of chest? I would say I don’t know. It is quite difficult for radiographers to tell the doctors what is on the X-ray because in district hospitals most of the doctors are community service and are without experience”

Participant GP13: “Ja ... sometimes you find it is a complicated chest like you could see that it has cavitation, there is a mediastina shift you know it has scarring, sometimes it is difficult to conclude what is happening, is it one condition or multiple conditions?”

PARTICIPANT GP10: “ ... oh yes I think that is the issue of subjectivity and unnecessary treatments being given. I can quantify that because when, for example a casualty doctor looks at the X-ray, he makes an interpretation, admits the patient to the ward, the next day we will have some blood results and you will see that the results do not necessarily show the infection that was interpreted on X-rays and antibiotics was started based on that interpretation.”

PARTICIPANT GP7: “ ... so that is the problem especially in casualty. On a very busy day, honestly, we rush through the images and sometimes you do miss hairline fractures or something like that because of the rush and even with chest because you quickly looking for major things you might miss other things and the patient will come back after a week with deterioration and when you compare them now the abnormality has already started on the other side. ... Most of the time we are able to see PTB changes on chest X-rays. Actually you see them later in the ward if you look at the X-rays that it is not typical PTB but it’s something like interstitial lung disease and other abnormality other than PTB.”

Knowledge and training

All participants perceived that they lacked knowledge on how to evaluate and interpret chest images in a systematic way. It was the radiographers’ perception that GPs lacked knowledge of identifying different views done (supine and erect)

for chest X-ray images and the indications thereof. Only PA projections were considered for diagnostic purposes (as reflected in Table 4: views done). Lateral projections were not considered, even when they were available.

Some doctors could not differentiate between a normal image and an anatomical variant and there were those who could not differentiate between images taken in the erect or supine position. Views requested were not always in line with the clinical history of the patient. Justification of radiographic examinations is the practice of evaluating requested X-ray examinations, to assess for clinical merit and appropriateness based on clinical history and patient information. Before the radiographer applies ionising radiation to the patient, the acceptable and ethical practice of radiography should involve reviewing whether the benefits outweigh the risks associated with the requested examinations.⁹⁶

These are comments by participants on lack of knowledge:

PARTICIPANT R04: "Some doctors don't even know the difference between erect and supine chest X-ray because they will ask for an erect in a bedridden patient knowing very well that you cannot do an erect chest X-rays on a bedridden patient. So that is another thing. I don't know if ... they can tell the difference between erect and supine."

PARTICIPANT R01: "Image interpretation in district hospital ... is very poor, looking at the knowledge that most of the doctors have, especially on chest X-rays, they tend to request for PA only. When the printer is not working and we are not able to print images, doctors sometimes come to the X-ray department to check the images on our monitors and they only ask to see the PA ... one image is not good enough for diagnosis. So, they only look at the PA ... they don't even go to the lateral to check whatever they're seeing on the PA is there on the lateral as well. So, I think it is not adequate."

PARTICIPANT R01 “...So when he comes, he can’t really differentiate between an abnormality and a variantSo that’s how I feel they should do training as well.”

“PARTICIPANT R13: “Ok. I think we should get better knowledge we should get better educated to report X-rays, for example here in our district hospital the GPs here are more or less on the same level (in chest interpretations) as us, if not, we (radiographers) are above them in reporting (identifying abnormal patterns). So most of the doctors, especially the ones who are fresh from school never know what is happening unless you give them a clue, so I think the district hospital radiographers should get better knowledge and we should be given permission, I would say to guide them (new doctors) on the diagnosis.”

All participants reported that formal training on image interpretation was given during their undergraduate training.

PARTICIPANT GP13: “ ... last training was in medical school. As of now you use your experience.”

PARTICIPANT GP9: “ ... besides undergrad and internship training someone who is not specialised in radiology is self-taught if I can call it that.”

PARTICIPANT R04: “Yes, we were trained but it was 10 years back I can’t remember but if you think it is ABC as well. It sounds familiar.”

4.5 CONCLUSION

The data collected from observations was organised, collated and quantified using a checklist and the results of the information were presented in tables and figures. Information collected from observations that was similar to data from interviews was coded and grouped into categories and was merged to establish connections. A thorough check was also made to see that the final categories covered all the data

collected. Results from observations were tabled and the themes that emerged from the interviews formed the framework of data analysis presented in Table 5.

5 CHAPTER 5 - DISCUSSION

5.1 INTRODUCTION

In this chapter, the results from the observations and from the interviews that were analysed were used to discuss the objectives of the study, namely:

- To describe the process of interaction between the radiographers and GPs during interpretation of chest X-ray images
- To explore methods used by radiographers to conduct interpretation on chest X-ray images
- To explore methods used by GPs to conduct interpretation on chest X-ray images
- To explore strengths and limitations in the current methods of interpretation of chest X-ray images by radiographers and GPs based on the standard recommended for non-radiologist reporting.

5.2 OBJECTIVE 1:

Describe the process of interaction between the radiographers and GPs during interpretation of chest X-ray images.

5.2.1 Inter-professional communication

By observing the process of interaction between the radiographers and GPs during interpretation of chest X-ray images, the researcher observed communication methods used by the radiographers when responding to requests for assistance from the GPs in image interpretation of chest X-ray images. The majority, 67%, of radiographers (see Table 2) indicated that verbal comments were the preferred method of communicating chest X-ray findings to the referring GPs. These results were in line with Gqweta's³¹ findings; the majority of radiography participants in his study indicated willingness to provide verbal opinions to referring clinicians about radiographic appearances on chest X-ray images. Current legislature allows a verbal comment to the referring practitioner.²⁶

Only 7% of radiography participants reported that if an abnormality was identified on the X-

ray image, they called to inform the GPs of the findings. The majority of radiography participants regarded calling the GP who referred the patient as a waste of time, because the caller has to trace the doctor while other patients are waiting, thus patient waiting time would be compromised.

Twenty percent of radiography participants did not communicate their findings; this resonated with the findings of Renfrew et al's⁹⁷ series, where 10% of the patients were victims of communication errors, such as failure to alert referring clinicians of important findings. In the study, lack of communication occurred firstly because of lack of standardisation on protocols and procedures.⁶⁵ Individual radiographers implemented RADS communication in an ad hoc way on their own initiative. RADS are established communication strategies for intervention to reduce errors in diagnostic image interpretation in the clinical setting. Snaith et al⁶⁷ supported the statement that lack of standardisation in communication processes and practices alongside the adoption of technology increases the potential for diagnostic error and miscommunication.

Secondly, lack of communication could be due to some GPs' negative attitude to radiographers. This finding is similar to the description in a study by Squibb et al⁶⁶, which indicated autonomy in radiographer practice being discouraged by paternalism and subordination from medical colleagues. This is a characteristic of medical dominance, where the medical profession holds significant power and authority over other occupations. Inter-professional boundary delineation influences and shapes the way interactions take place in areas of radiographic image interpretation and communication of results.

Example: *PARTICIPANT R03: "To avoid trouble sometimes you keep quiet ... because you know you're not accredited to do reporting ... Then sometimes you know this doctor won't even say anything because whatever I say will just tell you who do you think you are. is the attitude of doctors that you get. So you end up keeping quite because of their attitude."*

5.3 OBJECTIVE 2:

To explore methods used by radiographers to conduct interpretation on chest X-ray images.

Radiographers used Fraser's⁵⁵ (paragraph 2.8.2) direct search with a specific pattern of inspection following a routine inspection of the chest X-ray carried out for detection and differentiation between abnormalities seen on initial inspection. If an abnormality were present on initial inspection of the PA, then a lateral projection would be performed. During interviews, the radiographers explained the process used for searching abnormal patterns and the explanation was similar to the Hughes et al⁴⁷ (paragraph 2.8.2) search strategy of pattern recognition method. The search method involves searching for adequacy in the position of the patient and identifying the presence of abnormal patterns on the chest X-ray images.

5.3.1 Image evaluation

Mcquillens's⁵⁹ (paragraph 2.8.2:) image evaluation is an evaluation criterion to check for adequate image quality so that technical deficiencies are not mistaken for abnormalities. Accuracy in positioning and technical factors affects the diagnostic value of images.⁵⁹ According to Kyei⁶⁰, Ghanaians use an evaluation system similar to McQuillen's⁵⁹ evaluation criteria, with the acronym 'PACEMAN', which stands for p- position; a- area; c- collimation; e- exposure; m- markers; a-aesthetics; n- name. It is easy to remember and thus helps plan for the required training needs and influences the curriculum policy.

Yin's⁹ pattern matching was the core procedure used for theory testing. Pattern matching involves comparing two patterns in order to determine whether they are the same or whether they differ. Results after pattern matching showed a deficiency in the process of image evaluation by all the radiography participants for the purpose of classification if the image was optimal or sub-optimal. Results showed that the radiography participants' evaluation criteria were incomplete; technical aspects inadequately evaluated were patient position by 47%, insufficient projections by 47% and breathing technique or inspiration by 33% (see Table 4). These findings are similar to those of Del Ciello¹⁷ in Italy that found that the technical aspects that contributed to

poor image quality were inadequate patient positioning, insufficient projections and movement. Chand et al's¹⁸ findings in Nepal showed that of a total of 1101 chest X-ray images done, 47.7% did not meet the image evaluation criteria owing to inadequately arrested inspiration in 34.8%, inadequate penetration in 24%, rotation in 21.8%, anatomy of interest not being covered in 3.8% and incorrect position in 14.7%. Therefore, the most important fault was due to inadequately arrested inspiration during chest X-ray examination and a minor cause of faults was anatomical cut-off. Silva et al⁹⁸ in Brazil obtained results that demonstrated that incorrect patient positioning, underexposure and overexposure were the main technical failures encountered in conventional chest radiography that contributed to radiographers' poor image quality affecting interpretation, and to increased patient radiation dose due to repetition of chest examinations. History has shown that technical deficiencies are a common occurrence among radiographers. These technical errors can be corrected by applying corrective measures and repeating the X-ray examination.

Comment on technical factors:

PARTICIPANT GP14: " ... the challenges are the technical factors because you find that you request an X-ray and it comes as a poor X-ray either ... underpenetrated or over-penetrated."

5.3.2 Systemic image interpretation by radiographers

The findings showed that the approach used by radiography participants to conduct interpretation of chest X-ray images was not systematic. Radiography participants practised the little that they could remember from undergraduate training and approached the interpretation of chest X-ray images with some trepidation.

The results of this study showed that neither radiography nor GP participants were systematic in the interpretation approach they used. That resulted in failure to evaluate some structures that formed part of the chest anatomy (see Table 1). After pattern matching Chan's³⁸ ABCs system assessment (paragraph 2.8.2:) approach with the searching approach used by radiographers, it was found that the following structures had

been omitted from evaluations: hila, soft tissue around the chest, diaphragms and angles or pleura, as reflected in Table 4 .

Importance of being systematic in image interpretation

By applying a systematic interpretation approach, complete assessment of chest X-ray images is simplified in order to identify abnormal patterns not only of the lung parenchyma, but also of other structures and systems around the chest. Table 4 indicates all the structures that should be evaluated on chest X-ray images for identification of abnormal patterns Raouf et al⁹⁹ suggested that medical practitioners must make a concerted effort to practise reading plain chest X-ray images themselves first without reading the radiologist's report. Confidence in making this determination can only be acquired if they read hundreds of normal chest X-ray images following the same systematic approach each time.⁹⁹ The medical practitioners may then discuss the findings with their radiology colleagues. Looking at the lateral projection may shed light on 15% of the lung that is hidden from view on the PA view. According to Chan³⁸, a systematic approach facilitates familiarity with the normal features, making other views easier to interpret.

Williams¹⁰⁰ emphasised the use of a systematic approach known as the ABC technique that maintains consistency and accuracy in describing and commenting on trauma X-ray images and can thus be used for teaching and auditing. Other researchers⁹⁹⁻¹⁰⁰ agree with the researcher that the systematic method emphasises all structures that must be included with every chest X-ray case. It is also a checklist for those who have experience but are not entirely comfortable with their ability to analyse the image. If the X-ray is analysed in a systematic fashion, the information provided could be processed in seconds.

5.4 OBJECTIVE 3:

To explore methods used by GPs to conduct interpretation on chest X-ray images.

5.4.1 Image evaluation

It is important for all GPs to have an initial review approach to evaluate chest X-ray images for technical adequacy, even if the radiographers have already passed the chest X-ray. As discussed in paragraph 2.8.2, the four important technical factors considered to define a technically adequate chest X-ray are exposure, inspiration, rotation, position, patient identification and a correct anatomical marker.

It is standard practice that chest examination includes both PA and left lateral views to be able to make a diagnosis. Two views are required to demonstrate if a chest abnormality is on the left or right side of the patient as seen on a PA view and to confirm the exact location of the abnormalities seen on the PA, a lateral view will show if the abnormality seen is more to the anterior or posterior. If for any reason the chest X-ray is not done PA, then the chest X-ray orientation should be labelled as supine or AP to inform the X-ray image reader that there may be a magnification factor to be taken into consideration during diagnosis. As reflected in Table 3, only 20% of GP participants checked the chest X-ray orientation prior to image interpretation.

The results indicated that the GPs used a free global search method of image interpretation; they rapidly checked for obvious abnormalities within the first few minutes of image viewing for identification of major features of lesions.⁵⁵ This study showed lack in the initial review of chest X-ray images by the GP participants (see Table 3). An ideal situation is that all GPs involved in chest ray interpretation should evaluate the chest X-ray images for adequacy prior checking for abnormal patterns in order to obtain the correct diagnosis.

Paakkala³⁴ in Finland also found that poor image quality was the primary source of error made by less experienced doctors in the interpretation of conditions such as cardiac insufficiency and inflammatory changes in chest X-ray images. In the US, Singh⁷³ reported poor image quality as one of the factors contributing to radiological errors. Pintoa et al¹⁰¹ reported on exposure factors that influence the ability to detect lesions to diagnose lung cancer.

Kurtz et al¹⁰² advised that to avoid perceptual errors, interpretation of images should only take place when diagnostic quality in terms of both exposure and patient position is adequate. With reference to Berlin¹⁰³, in one case against him, a pulmonary nodule was missed during image interpretation because X-ray images were overexposed and not suitable for diagnostic purposes.

5.4.2 Systematic image interpretation by GPs

Once the initial review confirms that the image is adequate, pattern recognition occurs. The search method used by junior doctors and other allied health professionals includes starting the search for abnormal patterns in the midline and working one's way outward or vice versa. The key point is to have a systematic search pattern, which includes all aspects of the chest X-ray and ensures that a pattern is followed on every examination. This helps to avoid becoming overwhelmed by a multitude of findings.

Results obtained after pattern matching showed structures omitted in the evaluations were diaphragms, hila, soft tissue around the chest and the costo- and- cardiophrenic angles (see Table 4). According to Berbaum et al⁹⁷, lack of adequate medical knowledge results in omission of abnormalities embedded in soft tissues around the chest. These include thoracic lesions that might be identified during an abdominal examination or pleural, pulmonary, and mediastina lesions incidentally encountered during a radiological study of the spine, thoracic bones or shoulder girdle.

5.5 OBJECTIVE 4:

To explore strengths and limitations in the current methods of interpretation of chest X-ray images by radiographer and GP participants based on the guidelines recommended for non-radiologist reporting.

The RCR is a registered organisation in the UK, which exists to advance science and the practices of radiology (see Annexure 1)⁸¹ by giving guidelines and making recommendations on reporting X-ray findings after interpretation of imaging

investigations by non-radiologist medically qualified practitioners. The current situation in SA is that all GPs who are requesting chest X-ray images should provide a report in writing on the chest X-ray findings. According to the recommended guidelines for non-radiologist reporting, the findings of this study showed strengths and limitations in the following themes:

5.5.1 Challenges experienced during chest X-ray interpretation

Waiting time

Standard 1: An individual appropriately trained to interpret that particular investigation should report imaging investigations within an agreed time. Currently, all the GPs involved in chest X-ray image interpretation have undergraduate training only. None is adequately trained to interpret chest X-ray images. Complicated cases are sent to tertiary institutions for radiology reporting, thus reports take a minimum of three to four hours and in some instances days or longer, because of the complexity of services provided by various levels of hospitals. SA has a “National policy on management of patient waiting time in outpatient departments”,¹⁰⁴ which states that the average patient waiting time for services per visit at a district hospital is estimated to be two hours and the total time, in hours, spent by a patient per visit to a hospital should be three hours.

Responses of participants on waiting time

PARTICIPANT GP2: “It can take long depending on how busy the radiologist is but in my case it actually took about four hours to get the radiologist report”.

PARTICIPANT GP6: “ ... sometimes you find that you are unsure of what you see on the chest X-ray then you end up sending X-ray images to (tertiary hospital) for reporting and the challenge is that it takes time three to four days for the report to come back ...”

Equipment

Standard 3: Providers of health care and hospital trusts should provide sufficient resources, in terms of personnel, infrastructure and equipment. There are no

radiologists on site in district hospitals in the City of Tshwane. GPs, both experienced and newly qualified, have to report on chest X-ray images. Results in terms of equipment, viewing conditions and image presentations revealed inadequacy. The study showed that viewing boxes were not working in two of the three settings, and GPs reported that they had to use electrical lighting in the room at night and sunlight during the day for reading X-ray images. Optimum viewing conditions facilitate identification of radiographic details with the advantage of decreasing the need for retakes, patients' costs and radiation dose. Viewing boxes facilitate optimal viewing conditions, thus enhancing accurate interpretation of conventional radiographic images. Studies by Nyathi¹⁰⁵ have proved that non-optimal viewing conditions affect the ability to detect low-contrast lesions. According to Singh⁷³, in the US, factors contributing to radiological errors included inadequate room lighting for viewing and reading X-ray images.

Comment on viewing:

PARTICIPANT GP12: "Ja, the viewing boxes is not working, sometimes we use sunlight so viewing images at night is a challenge."

5.5.2 Mechanisms to support interpretation of chest X-ray images

Colleagues

Standard 7: Health care organisations should have mechanisms in place to support interim reporting of images. Study results showed that the mechanisms to support interim reporting of chest X-ray images in the hospitals were by colleagues, which included all GPs, radiographers and consultants in the same district hospital.

Support from radiologists was available only at tertiary hospitals; these are at different locations from the district hospitals and the time taken to get a radiologist X-ray report ranged from a few hours to a few days. According to Wright⁵³, junior doctors are exposed to the risk of misdiagnosis if unsupported by other health care professionals. He recommended that radiographers are ideally suited to this role, having the responsibility for conducting the actual X-ray examination.

Mehdipoor et al³³ recommended the use of electronic tools, like the PACS system and teleradiology, for transferring the chest X-ray images with acute pathologies to specialists radiologists, sited away from the setting, but the study settings included in this study still used conventional printing of images.

Comment on the support available:

PARTICIPANT GP14: "... uhm so far you'll only rely on the colleagues around because if no one can help you in this hospital, you have to phone ... refer ... always refer if you do not know what you are looking at. Follow the referral procedure."

Auditing

Standard 6: There should be regular audits at least once a year of all X-ray images, reported and unreported imaging investigations and the time it takes to issue a report. The study showed that no audits were done for either the reported or unreported imaging investigations at all the settings.

This study could be the initial step in a project to improve the quality of image interpretation of chest X-ray images. Auditing is a practice that forms part of a patient safety programme, safeguards against misdiagnosed cases going undetected and could reduce the number of unnecessary chest X-ray images performed in general practice. Woznitza¹⁰⁶ also suggested that regular audit, which incorporates case note review and discrepant reporting in a multidisciplinary setting, contributes to safe practice.

5.5.3 Perception of participants on chest X-ray interpretation

Lack of experience leads to misdiagnosis

The GPs' and radiographers' perceptions are that image interpretation of the chest X-ray images in district hospitals are not done correctly. All participants perceived that the GPs working at district hospitals are mostly junior or community service GPs (see figure 3) with no experience in chest X-ray interpretation. Adequate knowledge of normal anatomy and pathologies is required to reach an accurate

and timely diagnosis. This study showed junior doctors often to be lacking in knowledge and experience in the following areas:

- An approach to systematically interpreting chest X-ray images
- The ability to differentiate normal anatomical variants on chest X-ray images from abnormal ones
- The ability to differentiate supine from erect views
- The diagnosis of complicated cases
- The ability to check abnormalities on lateral images rather than making a diagnosis based on what they saw on the PA views only.

As reported by Pintoa¹⁰¹ and Shah¹⁰⁷, the lateral chest X-ray image plays an important role in lung cancer because it reveals the lung neoplasm retrospectively better than on the frontal projection. These results are comparable to those of Quekel¹⁰⁸, which indicated a 2–4% detection rate for lung cancer on the lateral radiograph compared with the frontal chest radiograph.

Comments made by participants regarding lack of experience:

PARTICIPANT GP10: “The issue is that I see a lot of discrepancy in various medical officers when interpreting X-rays. There is no kind of a way, no system of doing it and because of that we have a lot of the wrong diagnosis being made and antibiotics given unnecessarily because of subjective interpretations made by medical officers.”

PARTICIPANT GP10: “... oh yes I think that is the issue of subjectivity and unnecessary treatments being given. I can quantify that ... a casualty doctor looks at the X-ray, he makes an interpretation, admits the patient to the ward, the next day we will have some blood results and you will see that the results do not necessarily show the infection that was interpreted on X-rays and antibiotics was started based on that interpretation.”

The participants reported on cases of misdiagnosis of chest X-ray images due to a lack of knowledge in applying a systematic approach to interpreting chest X-ray images.

The finding is similar to that of a study done by Paakkala³⁷ in Finland, that poor image quality was the primary source of errors made by less experienced doctors in interpretation of pathologic changes in chest X-ray images. The primary source of error that caused inaccurate and untimely diagnosis was knowledge deficiency in terms of poor image quality, image interpretation approach not being systematic and lack of knowledge of normal anatomy and pathologies.

Reflection

Radiographers' perception, especially those with more than five years of experience, was that they were more knowledgeable than GPs when it came to identifying abnormalities such as pneumonia on chest X-ray images. GPs, on the other hand, thought that they did not need radiographers to help with chest X-ray interpretations, as they spent more years training for their qualification, so they knew more.

Example:

Participant R12: "... when the doctor asked what did I see? I told the GP, I think this is pneumonia based on what I saw. So I could not understand why the doctor went and intubated a patient diagnosed with pneumonia, so now the challenge you face is that when you are helping, do they actually appreciate your help? Do they take what we say seriously?"

Lack of knowledge requires training

All participants perceived that there was lack of knowledge on how to evaluate and interpret chest X-ray images in a systematic way. The majority of participants confirmed that their training on chest X-ray interpretation was done during their undergraduate training. The results of the study showed that there were three areas in which participants lacked knowledge of image interpretation of chest X-ray images. First, evaluation of image quality was poor. Poor image quality may cause

image interpretation errors, where technical deficiencies might be mistaken for abnormalities. Secondly, lack of knowledge of applying a systematic approach to interpreting chest X-ray images resulted in the omission of structures during evaluation and lastly, communication between radiographers and the referring practitioner was poor.

These study findings agree with findings in other countries, which support lack of knowledge of medical practitioners. According to Christiansen³², Danish junior medical practitioners and medical students who received basic clinical education did not meet the minimum requirements for radiological diagnostic skills for interpretation of chest x-rays. Mehdipour et al³³ in Iran added that both newly qualified and experienced practitioners failed to diagnose acute pathologies on chest X-ray images correctly.

Reflection

Radiographers were excited to take part in the study. They reported on cases that were not properly managed where they could have helped the GPs with interpretation, not only on chest X-ray images but on trauma cases as well. They also complained about patients who were X-rayed several times because the GPs could not decide on the correct diagnosis for the patient even when the X-ray images were of good quality.

PARTICIPANT R02: “Yes. There is a lot because most of the time doctors will bring a patient for an X-ray and then they see something, that’s because they’re not sure what they are seeing is. That patient will end up coming for X-rays three or four times in a week because they really have no idea what they’re seeing on that image. So we end up repeating the X-ray, redoing it, supine, erect, supine, erect for the rest of the week ...”

When asked about any training they had in image interpretation, the answer was:

PARTICIPANTG13: “... last training was in medical school, as of now you use your experience.”

All the participants agreed that they needed more training in chest X-ray interpretations.

Example:

PARTICIPANT GP9: "I think I could with just continuous education to remind ourselves more ..."

Participant R14: "I think ... generally we are not that bad but ... maybe we (radiographers) need a refresher course or training together with doctors because sometimes ... we find that both of us we are not sure what is happening in the chest X-ray."

5.6 CONCLUSION

In this chapter, the objectives of the study were discussed, themes that emerged from the interviews and observations were used to explain and address the objectives of the study and the current methods of interpretation of chest X-ray images were matched with the standards recommended for non-radiologist reporting to identify the strengths and limitations in the current methods of interpretation.

5.7 STRATEGIES TO ENHANCE QUALITY

Opportunities for scrutiny of the project by colleagues, peers and academics were welcomed. Feedback offered to the researcher was implemented, which was to reduce the number of objectives for the study and to refine methods, develop a clearer explanation of the research design and strengthen arguments in the light of the comments.

Ensuring that the same research process generates the same essential findings often depends on external audits. An institutional research colleague from another institution reviewed all of the research procedures and findings to generate alternate perspectives on the study and to develop truthfulness.

Frequent debriefing sessions were conducted between the researcher and her superiors through discussions. The vision of the investigator was widened as the supervisors brought to bear their experience and perceptions. These collaborative sessions were profitable to the researcher, since alternative approaches were discussed, drawing attention to flaws in the proposed course of action. The meetings also provided a sounding board for the researcher to test her developing ideas and interpretations, and probing from others helped the researcher to recognise her own biases and preferences.

6 CHAPTER 6 – CONCLUSIONS, LIMITATIONS AND RECOMMENDATIONS

6.1 INTRODUCTION

The final analysis of the research conducted is presented in this chapter. Limitations identified and recommendations put forward are based on the final analysis. The discussion of the research process was guided by the purpose of the study, namely to explore methods used by radiographers and GPs to perform image interpretation on chest X-ray images at district hospitals in the absence of radiologists.

After clinical examination by GPs, many patients are referred to the X-ray department for chest X-ray images. The effectiveness of patient service delivery in district hospitals is therefore highly dependent upon the ability to provide a timeous, adequate diagnostic radiography and radiology service to support and influence patient management.

The shortage of radiologists restricts continuity in radiology services and causes diagnosis to be delayed and the overall quality of patient care service is thus compromised. Radiographers perform chest X-ray images as requested by the referring practitioners and therefore GPs have to interpret and report on these chest X-ray images. Both these groups of professionals have limited training in image interpretation of the chest. The study was conducted to explore the methods used by radiographers and GPs to conduct image interpretation on chest X-ray images at district hospitals in the City of Tshwane.

6.2 CONCLUSIONS

Based on the findings of this study, the study objectives defined in 1.6 may be as follows:

To describe the process of interaction between the radiographers and GPs during image interpretation of chest X-ray images.

The findings of this study (see Tables 2a and b) showed that the inter-professional communication used by the majority of radiographers to communicate abnormalities detected on chest X-ray images was verbal comments indicating the area and/or anatomical site, but not describing the abnormal patterns. Some radiographers did not even communicate their findings because of perceived negative attitudes of some GPs regarding radiographers' ability to identify abnormal patterns on images.

To explore methods used by radiographers and GPs to conduct image interpretation on chest X-ray images.

Using the Yin⁹ pattern matching technique seen in Tables 3 and 4, which involved the comparison of predicted and empirically observed patterns for the identification of any variances or gaps, gaps in image interpretation of X-ray images identified were found to be an inadequate image interpretation approach and inadequate image evaluation. The study showed that some radiographers and GPs did not evaluate X-ray images for the following technical factors: part position, inspiration and rotation. Thus, image quality was inadequate, resulting in X-ray images that were sub-optimal for identification of abnormal patterns, owing to technical deficiencies or pathology (see Table 3). The image interpretation approach was not systematic, as some structures forming the thoracic cage were not evaluated for pathology (see Table: 4).

To explore strengths and limitations in the current methods of interpretation used by radiographers and GPs.

SA has a "National policy on management of patient waiting time in outpatient departments"¹⁰⁴, which estimates the ideal average patient waiting time for services per visit to a district hospital as two hours and the total time, in hours, spent by a patient per visit to a hospital as three hours. Participants reported a waiting time of four hours or longer to get the radiologist's report.

Viewing boxes used to facilitate optimal viewing conditions, enhancing accurate interpretation of conventional radiographic images, were not working in two of the three

settings, and GPs had to rely on electric lighting in the room at night and sunlight during the day for reading and presentation of X-ray images.

Demographic results showed that the majority of participants in the study were young, between 20 and 39 years old, 100% of radiographers and 80% of GPs respectively. In terms of work experience, more staff members were newly qualified, with experience of less than one year, including those doing community service (see Figure 1).

The participants, both radiographers and GPs, perceived that the junior doctors working at district hospitals had limited knowledge and experience of interpreting chest X-ray images.

Since the doctors working in district hospitals were junior medical practitioners, the health care organisations did put mechanisms in place to support interim reporting of images. The support is in the form of colleagues and consultants available in the hospital during crises.

No audits were conducted for either reported or unreported imaging investigations in any of the settings included in this study.

Results showed that all participants received training during their undergraduate training. Radiographers reported that after training they did not use the image interpretation systems so they tended to forget them. The GPs did not comment on the approach, but had no specific method to search for abnormalities.

In conclusion, radiographers and GPs adopted no systematic approach to interpret chest X-ray images. Inter-professional communication was limited. No protocols were in place to promote communication.

6.3 LIMITATIONS

The main limitation affecting the methodology was experienced during interviews with radiographers. In the first and second settings, data could be collected using group interviews, whereas in the last setting, individual interviews had to be conducted because the X-ray department was too busy to allow for group interviews.

It was challenging to interview all radiographers at the same time. Capturing all spoken words posed a challenge because some participants spoke very fast and sometimes there was more than one participant speaking at the same time. The audio-recordings done by the assistant researcher captured all the words spoken.

The researcher found that some participants dominated the interview, overshadowing the quiet ones. Other participants decided to agree with the topic under discussion without expressing their views in full; in some instances, sentences were not completed. The researcher sensed some competition among the participants during the interviews. Group interviews required a longer time to execute, since the researcher had to give the participants enough time to explore all areas concerning the question under discussion. Until there was no new information coming out from the participants, when information saturation has been reached. The advantage of group interviews was that participants bounced ideas around a group and stimulated one another's ideas. One started the sentence and others completed it and added more information on the topic under discussion. The researcher gathered more information in a short space of time, but transcribing the audiotaped information took longer.

6.4 RECOMMENDATIONS

The following are recommendations based on the research findings:

6.4.1 Inter-professional communication

The purpose of radiography in performing X-ray images accurately is dependent on the information from referring clinicians. The information is supplied through X-ray request forms with patients' clinical history and the examination requested. The radiographers

take X-ray images, which are interpreted in the corresponding clinical context, thus creating more information and both the imaging and interpretation data are communicated to the referring clinicians and then to patients and incorporated into clinical care.

Effective inter-professional communication is intrinsic to effective and safe healthcare.⁶⁴ The value of communication to referring clinicians and to patients is dependent on the accuracy and reliability of the flow of information to the point of care. Radiography departments, practices, hospitals, and other care providers must work together to establish communication standards. The present study found that there was poor communication between radiographers and GPs. Snaith⁶⁷ supported the statement that the lack of standardisation in communication processes and practices alongside the adoption of technology increases the potential for error and miscommunication. The researcher recommends standardisation in communication processes and practices, in terms of protocols and procedures.

6.4.2 Training for radiographers

Skills and education development is required to implement RADS. Radiographer commenting has the potential to improve timely diagnosis and management of patients in emergencies and in clinical practice settings where delays between image capture and comprehensive radiological reporting occur.⁷¹ Commenting in the clinical environment requires the usage of precise and concise medical terminology and pathology description.

McLaughlin⁵¹ recommended tutorials, lectures and short course training sessions as useful training methods for chest X-ray image interpretation. The researcher recommends that the training methods suggested by McLaughlin⁵¹ be used to train radiographers in image evaluation and systematic chest X-ray image interpretation. Training should include introductory sessions, which will cover image evaluation criteria, radiographic anatomical knowledge, basic terminology and concepts that familiarise

participants with a systemic approach to abnormality detection forces and patterns in the chest X-ray, then establish vocabulary and a model of forming a comment.

6.4.3 Training for GPs

The image interpretation approach of GPs was not systematic and not all structures forming the thoracic cage were analysed adequately for identification of pathology. GPs were lacking knowledge in concepts that familiarised participants with a systemic approach to detection of abnormal patterns in interpretation of chest X-ray images. Training is recommended for both newly qualified and experienced practitioners through CPD workshops. Training should focus on improving systematic methods of image interpretation used to perform image evaluation and to check image quality prior to systematically searching all structures of the thoracic cage for the presence of abnormal patterns.

6.4.4 Checklist template

The results of the study showed that some structures were omitted from the images and not evaluated for the presence of abnormal patterns (see Figure 4). Even though it was not one of the objectives of this study, the researcher would recommend the use of a chest X-ray interpretation checklist, which might be standardised for all district hospitals. The suggested template based on the results of this study was adopted from the template of the European Society of Radiology⁷⁹ and adapted to suit the chest image interpretation done at district hospitals.

The suggested template would consist of a checklist that is well designed, not too lengthy and can reduce errors of omission by reminding the reporting GPs to take a second look at certain aspects, areas and features of the images. The checklist would have three sections, the patient demographics and image evaluation sections completed by the radiographers and a last section containing all the structures of the chest, which should be evaluated by the GPs for the presence of any abnormalities and the abnormal patterns identified. These will then be described and the conclusions

reached will constitute the X-ray findings. The checklist will be in the form of a standard set of blanks requiring data entry, kept in all relevant departments. The template compiled by the researcher is shown in Table 6 below.

Table 6: Recommended image interpretation checklist: chest X-ray images

Demographic information:					
Patient's name					
X-ray number					
Date of service					
Patient's date of birth		Age:			
Patient's gender		Male	Female		
Indication(s) for examination:					
Completed by radiographer		Erect	Supine	Decubitus	
	PA				
	Lateral				
	AP				
	Oblique				
	Other				
	Image evaluation	Position			
		Inspiration			
		Rotation			
		Marker			
Description of findings	Pattern recognition	Airways: trachea			
		Bony structures			
		Circulation:	Heart size:		
			Mediastina position		
			Mediastina contours		
			Hila		
		Diaphragms			
		Edges/Pleura			
		Lung tissues			
Soft tissue					
Name			Signature		

6.4.5 Equipment

A regular programme of equipment maintenance in an imaging department is an important element of quality assurance. The researcher recommends that viewing boxes should be kept in a clean condition and be uniformly illuminated. Fluorescent tubes should be replaced every 18 to 24 months as recommended. Since X-ray departments are now incorporating electronic equipment, digital radiography using the picture archive system is recommended to save on costs incurred for purchasing conventional equipment and storage space. Going digital has the advantage of being able to communicate with tertiary hospitals by sending and receiving X-ray reports from radiologists more quickly.

6.4.6 Regular audits

The researcher recommends regular audits at least once a year of all reported chest X-ray images. The unreported images are audited for proper image quality and the waiting time should be improved. Medical radiological practices, procedures and results should be examined against recommended standards for good medical and radiological procedures, with modification of practices, where appropriate, and the application of new standards, if necessary.

6.4.7 Scope of radiographers

Demographic information has shown doctors working in district hospitals were mostly newly qualified practitioners with experience of less than one year (see Figure 1). The study has shown that these participants lack the skills to interpret chest X-ray images adequately. Many patients from PHC are referred for chest X-ray images in district hospitals. A chest X-ray is one of the first-line diagnostic tools for GPs to diagnose, monitor treatment and predict outcomes for many diseases. GPs are mandated to give reports on all chest X-ray images taken at district hospitals and they sometimes request image interpretation assistance from radiographers.

For the purpose of this study, the researcher recommended that the scope of practice for radiographers should be extended to include chest X-ray image interpretation. Post-

graduate training is required to equip radiographers to be able to assist in identifying abnormal patterns in chest X-ray images. This study emphasises the need for training both classes of professionals in image interpretation, using the recommended checklist template or any other standardised checklist.

6.4.8 Summary of recommendations

The researcher recommended that the scope of practice for radiographers be extended to include chest X-ray image interpretation to be able to assist newly qualified GPs in identifying abnormal patterns on chest X-ray images. Inter-professional communication should be improved by standardisation of communication protocols in terms of the RADS system to be used. The participants also need post-graduation training workshops to improve their ability to evaluate and interpret chest X-ray images adequately and use systematic image interpretation approaches. A checklist should be used after training workshops and audits should be done every six to 12 months to evaluate the interventions. To improve viewing conditions, quality control of the equipment has to be carried out regularly.

Reflection

Participants expect to see change brought about by recommendations from this study's outcomes. The researcher was welcomed at all the settings by radiographers and GPs. The GPs were willing and ready to be part of the study and to share their frustrations concerning poor imaging and the 'I don't care' attitude of some radiographers.

6.4.9 Suggestions for further studies

This study may serve as the baseline for auditing the image interpretation systems approach for radiographers and GPs in the district hospitals in the City of Tshwane. The results obtained from this study indicated that there is a need for training both radiographers and GPs in image interpretation of the chest. It would be beneficial to train the radiographers and GPs together in the implementation of the checklist and to improve inter-professional communication.

Secondly, the results of the study identified the knowledge gaps in chest image interpretations. The knowledge to fill the gaps may be used to structure the curriculum for training the radiographers and GPs in image interpretation of the chest for implementation in these settings. Further studies should be done to audit the ability to evaluate and interpret chest X-ray images systematically after training. The results of the audit could inform further work in other parts of SA.

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LIST OF ANNEXURES

ANNEXURE 1

Standards for the reporting of imaging investigations by **non-radiologist** medically qualified practitioners.⁸¹

Standard 1: Every imaging investigation needs to be reported within an agreed time by an individual appropriately trained to interpret that particular investigation.

Standard 2: All imaging investigations need to be accompanied by a formal, permanently recorded report that covers the whole of the examination.

Standard 3: Commissioners, providers of healthcare and hospital trusts need to provide sufficient resources, in terms of radiologists, information technology (IT) and infrastructure, to achieve the standards outlined in this document.

Standard 4: Where interpretation of radiological investigations is delegated to non-radiologist medically qualified practitioners, hospitals and healthcare providers are jointly responsible for ensuring the expertise of the practitioners and for obtaining their agreement to provide a record of the result of each investigation.

Standard 5: All practitioners who interpret imaging investigations should include their name, professional status, grade, position and medical registration number when reporting an imaging investigation.

Standard 6: There should be regular audit (at least once a year) of both unreported imaging investigations and of the time it takes for a report to be issued.

Standard 7: Healthcare organisations should have mechanisms in place to support interim reporting of images by non-radiologist doctors in training and other non-radiologist consultants.

ANNEXURE 2:

Observation field notes checklist¹⁰

Participants demographics	Radiographer (standard 5) Age: Gender: Professional status: Position:	GP (standard 5) Age: Gender: Professional status: Position:
Space: the physical place	Hospital: x-ray Casualty OPD	Hospital: Casualty OPD
Activity: a set of acts participants must do: (Tick what participants do)	Register patient Provide chest x-ray Evaluate image Interpret image Report on x-ray Communicate results Send back to referring GP Other	Register patient View x-ray Evaluate image Interpret image Report on x-ray Give final report Other
Object: a physical thing that is present (tick if available)	(standard 2) Request form Chest x-rays Chest x-ray report	(standard 2) Request form Chest x-rays Chest x-ray report
Events: a set of activities that participants carry out. (indicate how it is done)	Taking chest x-ray Evaluate Interpret Report Communicate results Sending back to referring GP Other	View x-ray Evaluate Interpret Report Final report Other
Goals: (note down the process of doing)	Image evaluation method Image interpretation method Final reporting method	Image evaluation method Image interpretation method Final reporting method
Time:	(standard 1) Arrival time for x-rays Departure time	(standard 1) Arrival time after x-rays GPs final report time
Reflection: researcher's personal response		

ANNEXURE 3

Interview guiding questions

1. What are your perceptions of the image interpretation of the chest x-rays process at district hospitals?
2. Describe in detail methods of the image interpretation of chest x-rays used by radiographers and GPs in this setting.
3. Discuss the workload caused by the interpretation of images.
4. Discuss other challenges experienced during image interpretation of the chest (<i>standard 4</i>)
5. Discuss details of image interpretation systems used in your department to interpret chest x-rays
6. Are there any mechanisms in place to support you in image interpretation? (<i>standard 7</i>)
7. Describe the training you have in image interpretation of chest x-rays.
8. Is any regular audit of practice undertaken to support participation of radiographers and GPs in chest image interpretation? (<i>standard 6</i>)

ANNEXURE 4:

PARTICIPANT'S INFORMATION & INFORMED CONSENT DOCUMENT

Study title: Interpretations of chest x-rays by radiographers and general practitioners at district hospitals in the City of Tshwane.

Sponsor: Researcher

Principal investigators: Mrs KM Sethole

Institution: University of Pretoria

Daytime and after hours telephone number(s): Daytime numbers: 012 354 1165/
After hours: 083 226 2100

Date and time of first informed consent discussion:

dd	mm	yyyy	Time
----	----	------	------

Dear Participant number:

Dear Dr / Mr / Mrs. date of consent procedure/...../.....

1) Introduction

You are invited to volunteer for a research study. This information leaflet is to help you to decide if you would like to participate. Before you agree to take part in this study, you should fully understand what is involved. If there are any questions, not explained in this leaflet, do not hesitate to ask the researcher. You should not agree to take part unless you are completely happy about all the procedures involved.

2) The nature and purpose of this study

The study will be conducted to investigate Interpretations of chest x-rays by radiographers and general practitioners at district hospitals in the City of Tshwane. Strengths and limitations in the current methods used by both groups will be evaluated against the current standards set by the Royal College of Radiologists that may be used in future studies as guidelines to develop a model for chest x-ray interpretation suited to the need of radiographers and GPs working in district hospitals. The benefits of the findings will be used to support the scope of practice to include chest x-ray interpretation for radiographers and promote continuous professional development in chest x-ray interpretation for GPs. The Royal College of Radiologists is a registered charity that exists to advance science and the practice of radiology. The document standards and recommendations for reporting and interpretation are contained in a document for guidance of imaging investigations done by non-radiologist who wish to interpret images. The standards are applicable to the South African settings because they are not regulations; they define aspects of radiological services that promote good quality service to the patient.

3) Explanation of procedures to be followed.

A qualitative research methodology with a case study approach will be used.

The study design will be descriptive. The study will be conducted at the following hospitals: Tshwane district hospital, Pretoria West district hospital and Jubilee district hospital. Each hospital has a fully operational imaging department with no radiologists on site.

The primary data will be collected in two phases. Phase 1: Observation and taking notes will be done from the moment that the requested chest x-rays are done by the radiographers. It will be continued when the x-rays are sent back to the referring medical practitioner for interpretation in order to diagnose and prescribe a

management plan for the patient. The researcher will not interfere with the normal running of the departments. The purpose of the observation is to establish information on the radiography service provided, details of the image interpretation methods used by radiographers and GPs and the type of system used to interpret chest x-rays

Phase 2: Interviews will be audio-recorded. GPs will be individually interviewed immediately after observation and radiographers will participate in a focus group interview. Interviews will be conducted in the respective departments. The radiographers and GPs will be requested to provide factual information relating to the radiography service provided, details of the image interpretation methods used by radiographers and GPs and the type of systems available for use to interpret chest x-rays, as well as any education to support participation in image interpretation. The participants will be allowed to comment on issues relating to image interpretation in their hospitals. The researcher will take notes during the interviews where necessary. Present during the interviews will be the researcher and an assistant researcher.

4) Risk and discomfort involved.

There are no risks or discomfort involved.

5) Possible benefits of this study.

The benefits of the findings will be used to support the national outcry to extend the scope of practice in radiography to include chest image interpretation for radiographers in SA.

6) I understand that it is my choice to participate in this study.

7) I may at any time withdraw from this study.

8) Has the study received ethical approval? Yes protocol number: 93/2017 dated 30th March 2017

This protocol was submitted to the Faculty of Health Sciences Research Ethics Committee, University of Pretoria (telephone numbers 012 3563804 / 012 3563084) and written approval has been granted by the committee: Ethics Reference No.: 93/2017. The study has been structured in accordance with the Declaration of Helsinki (last update: October 2013), which deals with the recommendations guiding doctors in biomedical research involving human subjects. A copy of the Declaration may be obtained from the investigator, should you wish to review it.

9) Information: If I have any questions concerning this study, I should contact:

Ms KM Sethole at telephone number: 012 354 1165 or cell: 0832262100

10) Confidentiality

All records obtained for the purpose of this study will be regarded as confidential. Results will be published or presented in such a fashion that participants remain unidentifiable.

11) Consent to participate in this study.

I have read the above information before signing this consent form. The content and meaning of this information have been explained to me. I have been given the opportunity to ask questions and am satisfied with the answers. I hereby volunteer to take part in this study where data collection tools include observations, taking notes and interviews, including audio recordings made during the interview.

I have received a signed copy of this informed consent agreement.

..... Participant number Date
..... Participant signature Date
..... Investigator's name Date
..... Investigator's signature Date
..... Witness name and signature Date

Annexure 5

Permission to conduct a study at Tshwane District Hospital

To: Chief Executive Officer/Information Officer
Tshwane District Hospital
Dr Soe

From: The Investigator
Department of Radiography,UP
KM Sethole

Re: Permission to do research in the Department of Radiology and in Outpatient Departments

Mrs KM Sethole is a researcher working at the University of Pretoria, School of Health Care Sciences, and Department of Radiography. Permission is requested to conduct a study in the x-ray Department and outpatients departments of Tshwane District Hospital that involves access to radiographers and medical practitioners.

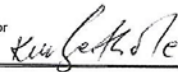
The title of the study is: Methods used by radiographers and general practitioners to interpret chest x-rays at district hospitals in the city of Tshwane.

The researcher request permission to investigate how radiographers and general practitioners conduct image interpretation of the chest x-rays.

Personal identity of the participants will be protected by citing them only according to their careers; hospital names will not be used.

I undertake not to proceed with the study until I was granted approval from the Faculty of Health Sciences Research Ethics Committee, University of Pretoria.

Yours sincerely
Signature of the Principle Investigator



Permission to do the research study at this hospital and to access the information as requested is hereby approved.

Chief Executive Officer
Tshwane District Hospital

Dr S. Nkomo



Signature of the CEO

Hospital Official Stamp

Annexure 6

Permission to conduct a study at Pretoria West District Hospital

To: Chief Executive Officer/Information Officer
Pretoria West District Hospital
Dr Moswane

From: The Investigator
Department of Radiography,UP
KM Sethole

Re:

Permission to do research in the Department of Radiology and in Outpatient Departments.

Mrs KM Sethole is a researcher working at the University of Pretoria, School of Health Care Sciences, and Department of Radiography. Permission is requested to conduct a study in the x-ray Department and outpatients departments of Pretoria West District Hospital that involves access to radiographers and medical practitioners.

The title of the study is: Methods used by radiographers and general practitioners to interpret chest x-rays at district hospitals in the city of Tshwane.

The researcher request permission to investigate how radiographers and general practitioners conduct image interpretation of the chest x-rays.

Personal identity of the participants will be protected by citing them only according to their careers; hospital names will not be used.

I undertake not to proceed with the study until I was granted approval from the Faculty of Health Sciences Research Ethics Committee, University of Pretoria.

Yours sincerely
Signature of the Principle Investigator



Permission to do the research study at this hospital and to access the information as requested is hereby approved.

Head of Department
Pretoria West Hospital

pp Dr Maabisa
N.L. MADIBA

pp Maabisa
Signature of the HOD

Hospital Official Stamp



Annexure 7

Permission to conduct a study at Jubilee District Hospital

To: Chief Executive Officer/Information Officer
Pretoria West District Hospital
Ms DL Magano

From: The Investigator
Department of Radiography,UP
KM Sethole

Re:
Permission to do research in the Department of Radiology and in Outpatient Departments.

Mrs KM Sethole is a researcher working at the University of Pretoria, School of Health Care Sciences, and Department of Radiography. Permission is requested to conduct a study in the x-ray Department and outpatients departments of Jubilee District Hospital that involves access to radiographers and medical practitioners.

The title of the study is: Methods used by radiographers and general practitioners to interpret chest x-rays at district hospitals in the city of Tshwane.

The researcher request permission to investigate how radiographers and general practitioners conduct image interpretation of the chest x-rays.

Personal identity of the participants will be protected by citing them only according to their careers; hospital names will not be used.

I undertake not to proceed with the study until I was granted approval from the Faculty of Health Sciences Research Ethics Committee, University of Pretoria.

Yours sincerely
Signature of the Principle Investigator

Permission to do the research study at this hospital and to access the information as requested is hereby approved.

Head of Department
Jubilee Hospital

Dr MOUJE

[Signature]
Signature of the HOD



ANNEXURE 8

Protocol No. 93/2017

Principal Investigator(s) declaration on the storage of research data and/or documents

I, the principal investigator, Mrs KM Sethole, of the study titled: Interpretations of chest x-rays by radiographers and general practitioners at district hospitals in the City of Tshwane; will be storing all the research data and/or documents referring to the above-mentioned study at the following address: Steve Biko Academic Hospital; Department of Radiography; Level 5; Bridge E; Room 51139

I understand that the storage for the above-mentioned data and/or documents must be maintained for a minimum of 15 years from the commencement of this study.

START DATE OF STUDY: 2017

END DATE OF STUDY: 2018

UNTIL WHICH YEAR WILL DATA WILL BE STORED: 2033

Name: Mrs KM Sethole

Signatures: 

Date: 30 September 2018

ANNEXURE 9

The Research Ethics Committee, Faculty Health Sciences, University of Pretoria complies with ICH-GCP guidelines and has US Federal wide Assurance.

- FWA 00002567, Approved dd 22 May 2002 and Expires 03/20/2022
- IRB 0000 2235 IORG0001762 Approved dd 22/04/2014 and Expires 03/14/2020.



UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Health Sciences Research Ethics Committee

26/10/2017

Approval Certificate Amendment

(to be read in conjunction with the main approval certificate)

Ethics Reference No: 93/2017

Title: Interpretations of chest x-rays by radiographers and general practitioners at district hospitals in the City of Tshwane

Dear Mrs Khethiwe Sethole

The Amendment as described in your documents specified in your cover letter dated 2/10/2017 received on 3/10/2017 was approved by the Faculty of Health Sciences Research Ethics Committee on its quorate meeting of 25/10/2017.

Please note the following about your ethics amendment:

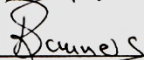
- Please remember to use your protocol number (93/2017) on any documents or correspondence with the Research Ethics Committee regarding your research.
- Please note that the Research Ethics Committee may ask further questions, seek additional information, require further modification, or monitor the conduct of your research.

Ethics amendment is subject to the following:

- The ethics approval is conditional on the receipt of 6 monthly written Progress Reports, and
- The ethics approval is conditional on the research being conducted as stipulated by the details of all documents submitted to the Committee. In the event that a further need arises to change who the investigators are, the methods or any other aspect, such changes must be submitted as an Amendment for approval by the Committee.

We wish you the best with your research.

Yours sincerely


Dr R Sommers, MBChB; MMed (Int); MPharMed; PhD
Deputy Chairperson of the Faculty of Health Sciences Research Ethics Committee, University of Pretoria

The Faculty of Health Sciences Research Ethics Committee complies with the SA National Act 61 of 2003 as it pertains to health research and the United States Code of Federal Regulations Title 45 and 46. This committee abides by the ethical norms and principles for research, established by the Declaration of Helsinki, the South African Medical Research Council Guidelines as well as the Guidelines for Ethical Research: Principles Structures and Processes, Second Edition 2015 (Department of Health).

☎ 012 356 3084 ✉ deepeka.behari@up.ac.za / fhsethics@up.ac.za 🌐 <http://www.up.ac.za/healthethics>
✉ Private Bag X323, Arcadia, 0007 - Tswelopele Building, Level 4, Room 60, Gezina, Pretoria

ANNEXURE 10

UNIVERSITY OF PRETORIA PLAGIARISM POLICY AGREEMENT

The University of Pretoria places great emphasis upon integrity and ethical conduct in the preparation of all written work submitted for academic evaluation.

While academic staff teaches you about referencing techniques and how to avoid plagiarism, you too have a responsibility in this regard. If you are at any stage uncertain as to what is required, you should speak to your lecturer before any written work is submitted.

You are guilty of plagiarism if you copy something from another author's work (e.g. a book, an article or a website) without acknowledging the source and pass it off as your own. In effect you are stealing something that belongs to someone else. This is not only the case when you copy work word-for-word (verbatim), but also when you submit someone else's work in a slightly altered form (paraphrase) or use a line of argument without acknowledging it. You are not allowed to use work previously produced by another student. You are also not allowed to let anybody copy your work with the intention of passing it off as his / her work.

Students who commit plagiarism will not be given any credit for plagiarised work. The matter may also be referred to the Disciplinary Committee (Students) for a ruling. Plagiarism is regarded as a serious contravention of the University's rules and can lead to expulsion from the University.

The declaration which follows must accompany all written work submitted while you are a student of the University of Pretoria. No written work will be accepted unless the declaration has been completed and attached.

Full names of candidate: *Khetlwa Margaret Setole*

Student number: *04352718*

Date: *24th October 2018*

Declaration

I understand what plagiarism is and am aware of the University's policy in this regard.

SIGNATURE OF CANDIDATE: *K. Setole*

SIGNATURE OF SUPERVISOR: *[Signature]*

SIGNATURE OF CO-SUPERVISOR:

This document must be signed and submitted to the Head: Student Administration within two months of registering for the research component of the programme.

UNIVERSITY OF PRETORIA
PLAGIARISM POLICY AGREEMENT

The University of Pretoria places great emphasis upon integrity and ethical conduct in the preparation of all written work submitted for academic evaluation.

While academic staff teaches you about referencing techniques and how to avoid plagiarism, you too have a responsibility in this regard. If you are at any stage uncertain as to what is required, you should speak to your lecturer before any written work is submitted.

You are guilty of plagiarism if you copy something from another author's work (e.g. a book, an article or a website) without acknowledging the source and pass it off as your own. In effect you are stealing something that belongs to someone else. This is not only the case when you copy work word-for-word (verbatim), but also when you submit someone else's work in a slightly altered form (paraphrase) or use a line of argument without acknowledging it. You are not allowed to use work previously produced by another student. You are also not allowed to let anybody copy your work with the intention of passing it off as his / her work.

Students who commit plagiarism will not be given any credit for plagiarised work. The matter may also be referred to the Disciplinary Committee (Students) for a ruling. Plagiarism is regarded as a serious contravention of the University's rules and can lead to expulsion from the University.

The declaration which follows must accompany all written work submitted while you are a student of the University of Pretoria. No written work will be accepted unless the declaration has been completed and attached.

Full names of candidate: *Khethiwe Margaret Setheole*
Student number: *04352781*
Date: *24th October 2018*

Declaration

I understand what plagiarism is and am aware of the University's policy in this regard.

SIGNATURE OF CANDIDATE: *Khethiwe Setheole*

SIGNATURE OF SUPERVISOR:

SIGNATURE OF CO-SUPERVISOR: *Aaron*

This document must be signed and submitted to the Head, Student Administration within two months of registering for the research component of the programme.



UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Health Sciences

SUBMISSION FORM / RESUBMISSION FORM: MINI-DISSERTATION, DISSERTATION, THESIS
(This form must be submitted together with the copies of the mini-dissertation, dissertation or thesis to the Student Administration office of the faculty)

STUDENT NUMBER: 04352718

Mrs KM Sethole
26 Mosalo Street
Atteridgeville
0008

(Please print)

Tel: 012 356 3239	Mobile tel: 083 226 2100
Work address: Faculty of Health, HWSnyman Building, Room 4-37	
Postal code: 0001	Tel: 012 356 3239

Details of mini-dissertation/dissertation/thesis:

Programme: MRad	Plan: Diagnostics
Department:	Radiography
Supervisor:	Empu Rudman
Co-supervisor(s):	L. Hazell

Title of the mini-dissertation/dissertation/thesis:

(Exactly as approved by the postgraduate committee including upper case, lower case and punctuation)
Interpretation of chest x-rays by radiographers and general practitioners at district hospitals in the city of Tswana

Statement by candidate:

- I am aware that, should the mini-dissertation, dissertation or thesis be accepted, I must submit the additional copies as well as a copy of the draft article (Doctoral students: proof that it has been accepted for publication or published by an accredited journal) before 15 February for the Autumn graduation or before 15 July for the Spring Graduation as required by the relevant regulations and that the degree will not be conferred if this requirement has not been fulfilled.
- I declare that the mini-dissertation, dissertation or thesis, which I hereby submit for the degree programme at the University of Pretoria, is my own work and has not previously been submitted by me for a degree at another university. Where secondary material is used, it has been carefully acknowledged and referenced in accordance with University requirements, I am aware of the University's policy and implications regarding plagiarism.

Signature: <i>KM Sethole</i>	Date: 1/11/2018
------------------------------	-----------------

Statement by the Supervisor:

I hereby declare that I approve that Mrs KM Sethole may submit his/her mini-dissertation/dissertation/thesis for examination. The co-supervisor has agreed to the submission.

Signature (Supervisor): <i>Chabon</i>	Date: 1/11/2018
---------------------------------------	-----------------

Signature (Co-supervisor(s)): <i>[Signature]</i>	Date: 1-11-2018
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Received by:	FOR OFFICE USE	Date:
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