BASIC CHEST IMAGING IN ADULT TRAUMA PATIENTS: INTERPRETATION SKILLS OF RADIOGRAPHERS IN THE COPPERBELT PROVINCE OF ZAMBIA

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DECLARATION

I, Ethel Chilambe, hereby declare that BASIC CHEST IMAGING IN ADULT TRAUMA PATIENTS: INTERPRETATION SKILLS OF RADIOGRAPHERS IN THE COPPERBELT PROVINCE OF ZAMBIA is my independent work. I declare, furthermore, that this dissertation has not been submitted to any university to obtain a degree. All the sources that I used have been acknowledged using complete references.

08/06/2022

Ethel Chilambe   Date

DEDICATION

I dedicate this dissertation to my dear husband Dr Kennedy Jere, my daughter Temwani Jere, and my son Malumbo Jere.

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ABSTRACT

BACKGROUND: Zambia is currently faced with a shortage of radiologists, with nine qualified radiologists in public hospitals countrywide to serve a population of 18 million people. Therefore, trauma chest x-ray (CXR) images in public hospitals are assessed by trauma teams comprising medical officers (MOs) and clinical officers (COs). Trauma teams routinely lack adequate time for image interpretation. Ideally, image interpretation and subsequent reporting on the images should be performed by radiologists. However, due to the shortage of radiologists and a yearly increase in radiologists' workload, the United Kingdom has explored delegating plain image reporting to carefully selected radiographers. One of the areas of reporting for radiographers that has been explored is CXR interpretation and reporting. In Zambia, radiographers are currently not involved in interpreting CXR images, despite the critical shortage of radiologists. Hence, this study is deemed critical, because it investigated the skills of radiographers in basic adult trauma CXR image interpretation. The findings of this study can be helpful in discussions with stakeholders regarding revising radiographers' current scope of practice in Zambia.

PURPOSE: The study aimed to determine the basic adult trauma CXR image interpretation skills of radiographers in the Copperbelt Province of Zambia. The objectives were to (i) determine the basic adult trauma CXR image interpretation skills of radiographers in the Copperbelt Province of Zambia; (ii) to determine if there is a need to involve radiographers in basic trauma CXR image interpretation in the Copperbelt Province of Zambia and (iii) to recommend the development and implementation of a training programme to develop radiographers' skills in adult trauma CXR image interpretation, if indicated by this inquiry.

METHODOLOGY: An experimental pre- and post-intervention study and a descriptive, quantitative study design were used. A total of eight public hospitals in the Copperbelt

Province of Zambia were included, with a sample size of 27. A checklist was used to acquire the pre- and post-intervention results for a total of 28 CXR images that had been purposively selected (20 CXR images for the pre- and post-intervention phase and 8 CXR images for the post-intervention phase). The pre-intervention phase included a lecture on basic CXR image interpretation and eight weeks of online interactive adult trauma CXR image review and discussions. Additionally, questionnaires were distributed in hard copy to the 15 MOs and COs of the eight hospitals, to solicit their views on the need to involve radiographers in CXR image interpretation in the Copperbelt Province of Zambia.

RESULTS: The median overall score for pre-intervention results was 82.8% and the interquartile range (IQR) = (79.5%–87.2%). The median overall score for post-intervention results was 87.2% and the IQR = (85.6%–89.2%). This positive median score difference is associated with a statistically significant p-value of <0.0001 when the two scores are compared. Years of work experience (p = 0.16) and the type of qualifications (p = 0.59) of the radiographers were not associated with their performance. However, the level of the hospital where the radiographers were employed presented a statistically significant p-value of <0.0323 concerning their performance in CXR image interpretation. Of the MOs and COs, the majority (86.7%) stated that no written reports were issued for trauma CXR images by radiology departments. Furthermore, 60% of the MOs and COs experienced challenges interpreting adult trauma CXR images. The majority (93.3%) of the MOs and COs indicated a need at their hospitals to involve radiographers in adult trauma CXR image interpretation.

CONCLUSION: The study confirms that radiographers working in public hospitals in the Copperbelt Province of Zambia possess basic adult trauma CXR image interpretation skills. The study confirms that there is a need to involve radiographers in basic CXR image interpretation of adult trauma in the Copperbelt Province of Zambia. It is, however, important to note that the involvement of radiographers in CXR image interpretation

demands an extension of the scope of practice of radiographers in Zambia; hence postgraduate training is required.

Keywords: radiographic image interpretation, radiographer reporting, radiologist, Chest x-ray; protectional radiography

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ACRONYMS AND ABBREVIATIONS

AP	Antero-posterior
CO	Clinical officer
CR	Computed radiography
CTR	Cardio-thoracic ratio
CXR	Chest X-ray
DR	Digital radiography
ECUREI	Ernest Cook Ultrasound Research Institute
HPCZ	Health Professions Council of Zambia
HSREC	Health Sciences Research Ethics Committee
IQR	Interquartile range
KDH	Kalulushi District Hospital
KGH	Kalulushi General Hospital
KTH	Kitwe Teaching Hospital
kVp	Kilovoltage peak
LDH	Luanshya District Hospital
MO	Medical officer
mAs	Milliamperes
NNGH	Nchanga North General Hospital
NTH	Ndola Teaching Hospital
PA	Postero-anterior
PCE	Preliminary clinical evaluation

RADS	Radiographer Abnormality Detection Scheme
RGH	Roan General Hospital
RRGH	Ronald Ross General Hospital
RSZ	Radiological Society of Zambia
SAS	Statistical analysis system
SID	Source to image distance
TDRC	Tropical Diseases Research Centre
UK	United Kingdom
WHO	World Health Organization

LIST OF DEFINITIONS OF SELECTED TERMS

Chest x-ray examination

Image produced using x-rays to demonstrate the heart, lungs, blood vessels, airway, bones of the chest and spine (Mayo Clinic, 2022 online).

Clinical officer

Medical personnel (trained in clinical medical sciences) who provide basic essential medical care and management, mainly at primary health facilities (Kafue Institute of Health Sciences Education and Research, 2018 online).

Image interpretation

An opinion regarding anatomical and physiological appearances on a radiographic image, to assist in diagnosing and managing a particular clinical problem (Murphy, Ekpo, Steffens and Neep, 2019: 67).

Medical officer

Trained medical personnel who complete training in Bachelor of Medicine, Bachelor of Surgery/Chirurgery (MBChB) doctors (University of Zambia, 2019 online).

Radiographer

A health care professional who operates medical equipment, such as x-ray machines, to produce radiographic images for medical purposes (Brennan, 2021 online).

Physical Trauma

Serious injury to the body (National Institute of General Medical Science, 2020 online)

WhatsApp®

An online application that supports sending and receiving a variety of media, including texts, photos, videos, documents, and voice calls (WhatsApp® LLC, 2022 online).

Zoom

A cloud-based application that allows video/audio conferencing meetings, webinars, live chats and meeting recordings (Tillman, 2022 online).

CHAPTER 1
ORIENTATION TO THE STUDY

1.1 INTRODUCTION

In this chapter, a brief orientation to the study, including the literature background, problem statement, research questions, aim of the study, overall goal, a summary of the research methodology and arrangement of the dissertation, are presented.

Radiographic image interpretation is the ability to formulate an opinion regarding anatomical and physiological appearances on a radiographic image, to assist in diagnosing and managing a particular clinical problem (Murphy, Ekpo, Steffens and Neep, 2019: 67; Royal College of Radiologists, 2006 online). Radiologists perform image interpretation and subsequently report on it. However, due to the shortage of radiologists and the annual increase in radiologists' workload, the United Kingdom (UK) has explored delegating plain image reporting to appropriately and sufficiently trained radiographers (Brealey *et al*., 2005: 232). One of the areas of reporting by radiographers that has been explored is chest reporting. The involvement of radiographers in adult chest x-ray (CXR) image interpretation was first considered over 40 years ago (Piper *et al*., 2014: 94). Studies conducted in the UK suggest that radiographer accuracy in CXR image interpretation and reporting improves after they have received accredited postgraduate training (Piper *et al.,* 2014:14; Todd, Bird, Wong and Barker, 2014: 1). Studies conducted in Africa to assess the CXR image interpretation skills of radiographers who had not received formal training found that they could identify abnormalities on a CXR image. However, radiographers are limited in the ability to describe abnormal patterns on CXR images (Gqweta and Naidoo, 2014, Ekpo, Egbe and Akpan, 2015). A study conducted in Zambia following an educational interventional programme found that Zambian radiographers provided insight into what was visible on the CXR images (Munsanje, 2013: 180). However, a comparison before and after the training was not done.

In Zambia, radiographers are currently not involved in interpreting radiographic images, despite the critical shortage of radiologists, with only nine radiologists in public hospitals, serving a population of over 18 million people (Bwanga, Sichone, Sichone and Kazuma, 2021: 126). Due to the shortage of radiologists in Zambia, many radiographic images are sent to referring medical officers (MOs) and clinical officers (COs) without radiological reports. This includes trauma radiographic images taken of critical patients when accurate image interpretation is critical (Bhimji, 2020 online). However, MOs and COs in emergency departments do not routinely have adequate time to perform radiographic image interpretation on patients who have suffered physical trauma (Aukema, Beenen, Hietbrink and Leenen, 2012: 49). The lack of time for radiographic interpretation by MOs and COs and the lack of provisional of radiological reports by radiology departments negatively affect the management of trauma patients.

The Copperbelt Province in Zambia has seen a steady increase in trauma cases. In 2021, Zambia recorded 32 372 road traffic accidents, of which the Copperbelt Province had the second highest number (Zambia Police Service, 2021 online). Figure 1.1 shows the total number of patients in emergency departments in the Copperbelt Province in 2017, 2018 and 2019. CXR imaging is the main modality used to screen and diagnose thoracic injuries in trauma patients in Zambia. This is because CXR is part of the advanced trauma life support protocol and CXR is readily available in all hospitals in the country (Aukema *et al*., 2012: 49). However, radiographers in Zambia are currently not officially involved in interpreting radiographic images (Bwanga, Chanda, Kafwiimbi and Sichone, 2021; Munsanje 2013: 27).

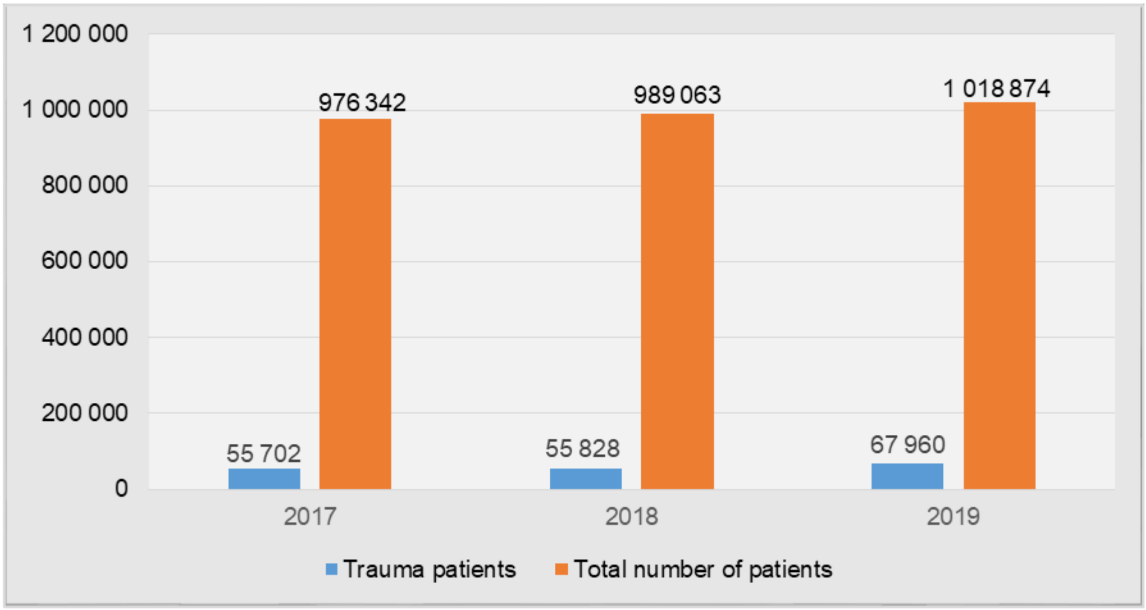

Figure 1.1: Trauma patients against the total number of patients in emergency departments in the Copperbelt Province

Source: Ministry of Health (2020)

The aim of this study was to determine the basic adult trauma CXR image interpretation skills of radiographers in the Copperbelt Province of Zambia. The researcher inquired whether there was a need to involve radiographers in basic adult trauma CXR image interpretation in the Copperbelt Province of Zambia. This information was used to make recommendations to the Zambian government.

1.2 LITERATURE BACKGROUND

The shortage of radiologists in Zambia leads to many radiographic images, including trauma radiographic images, being sent back to referring MOs and COs without radiological reports. There are currently only **nine** qualified radiologists in the public health sector in Zambia. Only **two** of the nine radiologists are employed in the Copperbelt Province (Bwanga, Sichone *et al.,* 2021: 126); they are stationed at third-level hospitals (Ministry of Health, 2019). Third-level hospitals in the Zambian context are the highest referral hospitals, and are staffed by specialised medical staff and equipped with highly technical equipment to serve a population of more than 800 000 people (Ministry of Health, 2013: 20). Second-level hospitals, also referred to as provincial or general hospitals, have a catchment of between 200 000 and 800 000 people (Ministry of Health, 2013: 20). First-level hospitals, also known as district hospitals, are primary hospitals with a catchment of 80 000 and 20 000 people (Ministry of Health, 2013: 20). There are currently eight third-level hospitals, 34 second-level hospitals and 99 first-level hospitals in Zambia (Ministry of Health 2021: 11). Therefore, most radiological examinations go unreported, and are being sent as such to referring MOs and COs. Since the Ministry of Health in Zambia recommends radiological reporting services at every public health institution, most radiology departments are functioning below the required standard (Munsanje, 2013: 17; Ministry of Health, 2005).

In Zambia, trauma CXR images are assessed by a trauma team comprising MOs and COs. However, the trauma team seldom has adequate time to do image interpretation. This is confirmed by Aukema et al. (2012: 49), who documented that a trauma team may have adequate trauma CXR image interpretation skills; however, they do not routinely have the luxury of enough time to interpret the images. Emphasising the need for this investigation further is that, despite the current shortage of radiologists in Zambia and the increasing number of trauma cases, the current scope of practice of radiographers in Zambia does not refer to the involvement of radiographers in image interpretation (Bwanga, Chanda *et al.*, 2021: 126).

1.3 PROBLEM STATEMENT

This study is based on the premise that the lack of involvement of radiographers in basic adult trauma CXR image interpretation negatively impacts the delivery of quality radiological services to the public, due to the shortage of radiologists in Zambia.

1.4 RESEARCH QUESTIONS

The main question posed and answered by this investigation is as follows:

What are the basic adult trauma CXR image interpretation skills of radiographers in the Copperbelt Province of Zambia?

Two subsidiary questions were formulated to inform the data collection of this study, namely

- Is there a need to involve radiographers in basic adult trauma CXR image interpretation in the Copperbelt Province of Zambia?
- Is there a need for training programmes in Zambia to develop the CXR image interpretation skills of radiographers, so that they can assist with basic CXR image interpretation of adult trauma patients, considering the dire shortage of radiologists and the increasing number of trauma cases?

1.5 AIM OF THE STUDY

The study aimed to determine the basic adult trauma CXR image interpretation skills of radiographers in the Copperbelt Province of Zambia.

1.6 OBJECTIVES OF THE STUDY

To achieve the aim of the study, the following objectives were formulated:

- To determine the basic adult trauma CXR image interpretation skills of radiographers in the Copperbelt Province of Zambia (to answer the main research question and to achieve the aim of the study).
- To determine if there is a need to involve radiographers in basic CXR image interpretation of adult trauma patients in the Copperbelt Province of Zambia (to answer subsidiary question – bullet 1).

- To recommend developing and implementing a training programme to develop radiographers' skills in adult trauma CXR image interpretation, if indicated by this inquiry.

1.7 OVERALL GOAL OF THE STUDY

The overall goal of the study was to make recommendations to policymakers in Zambia regarding the involvement of radiographers in assisting with basic adult trauma CXR image interpretation. This goal was articulated against the background of a critical shortage of radiologists, which has resulted in most radiology departments not providing reports for projectional radiography images, including trauma CXR images.

1.8 SUMMARY OF THE RESEARCH METHODOLOGY

An experimental pre- and post-test study design was used to gather data, using a checklist for qualified radiographers, while a descriptive quantitative research design was used to gather data, using a questionnaire, from MOs and COs. Data collection was performed through an experimental pre- and post-study design and a descriptive, quantitative study design. In this study, the sample size for MOs and COs was n = 15, and radiographers was n = 27. The study locations were eight hospitals in the Copperbelt Province.

To gather data from the radiographers, a checklist with 20 hard-copy trauma CXR images was used to determine their basic adult trauma CXR image interpretation skills. Assessment of radiographers' skills in adult trauma CXR image interpretation was performed in two phases. A pre-test assessed radiographers' basic adult trauma CXR image interpretation skills. The pre-test was followed by a lecture on basic CXR image interpretation and eight weeks of informal training in trauma CXR image interpretation. The post-test was conducted to assess if the lecture on basic CXR image interpretation and the eight weeks of training in trauma CXR images had affected radiographers' CXR image interpretation skills. The same checklist and 20 hard copy CXR images were used in the pre- and post-test. A questionnaire was used to collect data from the MOs and COs regarding the need to involve radiographers in basic trauma CXR image interpretation.

The researcher captured data from the checklist and questionnaire electronically in Microsoft Excel. Statistical analysis was conducted by a statistician using Statistical Analysis System (SAS) Version 9.2 (Appendix K). Descriptive statistics, namely frequencies and percentages, were calculated for categorical data, and medians and percentiles were calculated for numerical data. The majority of the pre- and post-test score distributions did not follow a normal distribution pattern; therefore, the median and IQR are reported. A normality test was performed using the Shapiro-Wilk test to establish if a significant difference was present between the pre- and post-test interventions for adult trauma CXR image interpretation skills of the participating radiographers. The Kruskal Wallis test was performed on the overall differences between the overall pre-test and post-test scores to establish if significant differences existed in the interpretation of CXR images between the different categories of radiographer experience at a significance level of 5%. Radiographers' experience referred to years of experience, level of hospital and radiography qualification.

1.9 ARRANGEMENT OF THE DISSERTATION

This dissertation comprises five chapters and is arranged as follows:

Chapter 1: Orientation to the study

This chapter provides the introduction, a summary of the literature background, and the problem statement. In this chapter, the research questions, overall goal, aim of the study, objectives, and summary of the research methodology are also described.

Chapter 2: Literature review

The concept of radiographer involvement in image interpretation, factors that contribute to optimal adult CXR image interpretation and guidelines for basic image interpretation of the chest are described. This chapter also provides the theoretical framework of the study.

Chapter 3: Materials and methods

In this chapter, the study location, research team, study design, research tools, study population, sample and sampling methods, and the inclusion and exclusion criteria are described. The data collection, data analysis, pilot study, ethics approval, information document and informed consent, validity and reliability are reported.

Chapter 4: Results

In this chapter, the data that were collected from radiographers and MOs and COs are presented. Radiographers' skills in basic adult trauma CXR image interpretation and the need to involve radiographers in adult trauma CXR image interpretation in the Copperbelt Province of Zambia are presented.

Chapter 5: Discussion, limitations, recommendations and conclusion

In this chapter, a discussion of the findings, a conclusion, recommendations, and limitations of the study are presented. The chapter also alludes to the possible contribution of the study.

CHAPTER 2
LITERATURE REVIEW

2.1 INTRODUCTION

In Chapter 1, orientation to the study was presented. In Chapter 2, more information is provided to inform the research study, such as radiographer involvement in image interpretation. Information reported by the literature regarding CXR image interpretation are discussed; factors contributing to optimal image interpretation, and basic CXR image interpretation guidelines are provided.

2.2 BACKGROUND OF RADIOGRAPHER IMAGE INTERPRETATION

Traditionally, medical image interpretation was performed by radiologists. However, due to a shortage of radiologists and a yearly increase in radiologists' workload, Brealey *et al.* (2005: 232) explored the possibility of delegating plain image reporting to carefully selected radiographers. In 1971, Swineburne, a radiologist based in the UK, first raised the possibility of trained radiographers expanding their role to include preliminary reporting (Swineburne, 1971: 590). However, radiologists remained sceptical until 1985, when the Radiographer Abnormality Detection Scheme (RADS) or Red Dot System was introduced (Berman *et al*., 1985: 422).

2.2.1 Radiographer Abnormality Detection Scheme and Preliminary Clinical Evaluation

The RADS involves the radiographer fixing a red sticker (the red dot) to an image or images, to indicate anything that appears not normal, to alert the referring physician to the possible presence of pathology (Brown and Leshchke, 2012: 510). In other words, the RADS allows radiographers to alert referring MOs and COs to the presence of a possible abnormality. This is particularly beneficial in departments where radiologists are not always available (Smith, 2006: 4). However, RADS has its limitations, because it is practiced voluntarily, unless otherwise indicated for a specific department (Van de Venter and ten Ham-Baloyi, 2019: 179). Therefore, the absence of a red dot does not necessarily exclude the presence of an abnormality (Woznitza, 2014:66). In addition, RADS is ambiguous and does not provide the referring physicians with any indication of the nature and location of the abnormality (Williams, 2009: 15). Therefore, RADS fails to guide physicians in making definite decisions regarding diagnosis, management and treatment of patients (van de Venter and ten Ham-Baloyi, 2019: 179).

Because of the limitations of RADS, preliminary clinical evaluation (PCE) was introduced, which builds on RADS, in the UK (Woznitza, 2014:66). PCE requires a concise written statement that localises and describes relevant findings regarding images (Society and College of Radiographers, 2013: 3). A survey of radiology departments conducted in the UK in 2007 found that a large majority of the departments use RADS, while some departments use PCE and other departments use both RADS and PCE (Snaith and Hardy, 2008: 281). Clinical reporting by radiographers was introduced as a role extension for radiographers in the UK to build on PCE. Radiographer has reporting become research-driven, with most publications focusing on radiographers' reporting abilities in relation to the musculoskeletal system (Williams, 2009: 15; Piper *et al*., 2005: 27; McConnel and Webster, 2000: 608).

2.3 RADIOGRAPHER CXR IMAGE INTERPRETATION

The involvement of radiographers in plain adult CXR image interpretation was first considered over 40 years ago and, by 2012, there were over 30 radiographers involved in chest reporting in the UK (Piper *et al.,* 2014: 94). A study by Stevens, Skermer and Davies (2021:1006) found that a total of 121 radiographers report on CXR images in England. The study concludes that the increase in the number of radiographers reporting on CXR indicates a continuing reliance on radiographers to contribute to managing CXR reporting workload (Stevens *et al.*, 2021: 1006).

Studies show that radiographers' accuracy in CXR image interpretation and reporting improves after accredited postgraduate training. One such example is reported by a 2014 study in the UK to analyse the objective structured examination results of radiographers who had completed an accredited postgraduate programme in the clinical reporting of adult CXR images (Piper *et al.,* 2014: 94). A wide range of abnormal cases was included, showing cardiac, pulmonary, pleural, interstitial, inflammatory, neoplastic and traumatic appearances. Normal variants and incidental findings were also included. The results found radiographer reporting sensitivity and specificity of 95.4% and 95.9%, respectively. The study concluded that radiographers could correctly identify normal and abnormal appearances to a high standard (Piper *et al.,* 2014: 74). Another study, at a specialist cancer centre in the UK, found a 97% radiographer accuracy in adult CXR image interpretation and reporting after a postgraduate training programme (Todd *et al.*, 2014 online).

Studies conducted in Africa to assess radiographers' CXR image interpretation skills in the absence of formal training have found that radiographers can identify abnormalities on CXR images. However, they have limitations in describing abnormal patterns on CXR images (Gqweta and Naidoo, 2014, Ekpo *et al.,* 2015). In contrast, a study conducted in Zambia found that Zambian radiographers, after following an educational interventional training programme, accurately interpreted CXR images (Munsanje, 2013: 142).

2.4 ACCURACY OF RADIOGRAPHERS IN IMAGE INTERPRETATION

The accuracy of radiographers has always been a concern. A meta-analysis study was conducted in 2005 in the UK to determine the accuracy of radiographer plain image reporting in clinical practice (Brealey *et al.,* 2005: 232). The meta-analysis study demonstrated that radiographers compared well with the reference standard, reporting images with 92.6% and 97.7% sensitivity and specificity, respectively (Brealey *et al.,* 2005: 232). Radiologists' reports were the reference standard against which the accuracy of radiographers in image interpretation was measured (Brealey *et al.,* 2005: 239). A study conducted by Woznitza *et al.* (2014: 223) compared radiographers' performance in interpreting adult CXR images; three radiologists reported on the same images. The results found a very high concordance between the radiographers' interpretation with the radiologists (Woznitza *et al.*, 2014). In 2012, a study in Denmark compared the diagnostic accuracy and validity of reporting of radiographers and trainee radiologists on plain images of the appendicular skeleton. Reporting radiographers found sensitivity and specificity of 99% and 97%, respectively, while, for the radiologists, the sensitivity and specificity were 94% and 97%, respectively (Buskov *et al*., 2013:55). It was concluded that trained radiographers constitute a qualified resource that could help to alleviate the increasing workload of radiologists, and the demands of quality radiology standards (Buskov *et al*., 2013:55).

2.5 COMPETENCE OF RADIOGRAPHERS IN IMAGE INTERPRETATION

A study performed in the UK to analyse the objective structured results of radiographers who had completed an accredited postgraduate programme in clinical reporting of adult CXR images found that radiographers could report abnormal appearances to a high standard after undergoing structured training in image interpretation (Piper *et al.,* 2014: 96). Results of studies conducted in South Africa (Gqweta and Naidoo, 2014) and Nigeria (Ekpe, Egbe and Akpan, 2015: 88) to determine skills in CXR image interpretation of radiographers who had not undergone formal training were referenced to compare, corroborate and support findings of this study. The findings of both the South African and Nigerian studies show that radiographers could identify abnormalities in CXR images (Gqweta and Naidoo, 2014: 7; Ekpe *et al.,* 2015: 1). The only study conducted in Zambia on radiographers' image interpretation skills following training found that radiographers' CXR image interpretation skills were improved by training (Munsanje, 2013: 72).

2.6 EDUCATION AND TRAINING OF RADIOGRAPHERS INVOLVED IN IMAGE INTERPRETATION

The basics of image interpretation are introduced during radiography training at an undergraduate level (Hardy and Culpan, 2007: 65). However, it has been argued that basic knowledge does not satisfactorily prepare radiographers for either RADS or PCE (Neep, Steffens, Owen and McPhail, 2014: 70). Thus, a radiographer who wants to become involved in image interpretation must undergo further education and training.

This is supported by findings of several studies, which report that radiographer confidence and accuracy in RADS and PCE improved after they had completed a structured image interpretation course. One such example is a study conducted to evaluate the accuracy of radiographers in image interpretation of plain musculoskeletal images in Australia. Results of the study found that short-term intensive continuing education programmes could improve radiographers' skills in image interpretation (Smith, Traise and Cook, 2009: 8; Woznitza, 2014: 66; Buskov *et al*., 2013:55; Munsanje, 2013: 72; Piper *et al.,* 2014: 96). There are currently 16 universities offering image interpretation courses in the UK (Society and College of Radiographers, 2021 online). The Ernest Cook Ultrasound Research Institute (ECUREI) in Uganda and Nnamdi Azikiwe University in Nigeria (Bwanga, Sichone *et al.,* 2021: 133), both in Africa, also offer image interpretation courses. In Zambia, the University of Zambia is planning to establish image interpretation courses (Bwanga, Sichone *et al*., 2021: 132). The Radiological Society of Zambia (RSZ), in turn, is working with stakeholders to extend the scope of radiographers working in Zambia (Bwanga, Sichone *et al.,* 2021: 132).

2.7 STANDARDS OF PRACTICE FOR RADIOGRAPHERS INVOLVED IN IMAGE INTERPRETATION

Changes in existing boundaries and codes of professional practice for radiographers require collaboration and consultation by key stakeholders at local and national levels, to ensure that image interpretation is conducted within legal, ethical, moral, social and economic frameworks (Australian Institute of Radiography 2009:3). Therefore, radiographers who undertake the task of image interpretation must ensure that it is executed as safely and competently as possible (Royal College of Radiologists, 2018: 6). Regular audits and reviews of radiographers involved in image interpretation ensures that the work is executed according to explicit clinical governance standards (Society and College of Radiographers, 2010 online).

Therefore, the involvement of radiographers in image interpretation demands changes in the existing boundaries and code of professional practice (Williams, 2009: 15). In South

Africa, a study by Van de Venter and ten Ham-Baloyi (2019: 179) revealed that the Health Professions Council of South Africa (HPCSA) was reviewing the regulations defining radiographers' scope of practice; this review include formal image interpretation, and recommends that radiographers undergo postgraduate training. Zambian radiographers have shown their willingness to get involved in image interpretation (Munsanje, 2013: 180). However, radiographers' current scope of practice regarding x-ray examinations is limited to performing radiographic examinations (HPCZ, 2009). This means the RSZ has to engage the Ministry of Health, Zambian radiologists, Zambia Medical Association and Health Professions Council (HPCZ), who are the key stakeholders (Bwanga, Sichone *et al.,* 2021: 132).

2.8 SERVICE BENEFITS OF RADIOGRAPHERS DOING IMAGE INTERPRETATION

The involvement of radiographers in image interpretation can result in service improvements for patients, referring MOs and COs, and radiographers (Gqweta and Naidoo, 2014: 8; Society and College of Radiographers, 2010: 8). Studies have shown that the involvement of radiographers in image interpretation reduces patient waiting times (Henderson, Gray and Booth, 2013: 298). Reporting by radiographers helps to reduce radiologists' workload, which also results in reduced patient waiting time for radiological reports or specialised procedures (Culpan, Culpan, Docherty and Denton, 2019: 159). Using a decision tree, it was found that using radiographers to report on CXR images using a lung cancer pathway was more effective than using radiologists. Furthermore, radiographers' image interpretation has been shown to reduce incidences of missed pathology (Williams, 2009:15; Hardy, Hutton and Snaith, 2013: 24). Also, radiographers involved in image interpretation describe high levels of job satisfaction and feelings of contentment, pride, motivation, confidence and value within clinical teams (Kilburn, Iddles and Carrington, 2017: 4). This job satisfaction has a positive impact on the quality and performance of radiology departments (Thomas, Manning and Piper, 2004 online). Moreover, the involvement of radiographers in image interpretation is cost-effective and a safe alternative to managing radiological reporting backlogs (Stevens *et al*., 2021: 1006; Hardy *et al*., 2013: 23).

2.9 FACTORS CONTRIBUTING TO OPTIMAL ADULT CXR IMAGE INTERPRETATION

A good quality CXR image is key to accurate image interpretation. A good quality image refers to an image that displays optimal image quality and positioning of the anatomical part to be imaged. As stated by the Royal College of Radiologists (2022 online), identifying normal and abnormal structures on an image is only possible if the quality of the image allows for optimal visualisation of the structures.

2.9.1 Technical considerations

Adequate knowledge of the technical considerations to be used to ensure optimal chest imaging is essential for radiographers involved in image interpretation.

2.9.1.1 Positioning of the patient for an adult CXR examination

A postero-anterior (PA) position for adult CXR imaging is preferred. This is because this position places the heart closer to the image receptor; therefore, it limits magnification of the heart shadow (Sloane, Holmes, Anderson and Whitley, 2010). Besides, arranging the arms so that the scapulae are away from the lung fields is easy in the PA position (Porter and Kaplan, 2011). An erect, standing position is preferred to a supine position for imaging the chest, since it allows for lower standing of the diaphragm due to gravity (Whitley, Jefferson, Holmes, Hoadley, Sloane and Anderson, 2015). This position ensures better visualisation of the lung bases. Additionally, when performing the imaging with the patient in an erect position, possible air/fluid levels are visible, and a more accurate measurement of the heart shadow are possible (Lloyd-Jones, 2019 online).

2.9.1.2 Source-to-image distance

The longer the source-to-image distance (SID), the less the magnification of the heart shadow. SID is in the range of 150–180 cm for CXR, depending on the generator output and indication for the examination (Whitney *et al.,* 2015: 202). The greater the SID, the less the magnification of the image (England, 2015: 246). Radiology departments in public hospitals in the Copperbelt Province of Zambia routinely use 150 cm as source-to-image distance (Ministry of Health, 2012).

2.9.1.3 Sufficient inspiration

With sufficient inspiration, a CXR image should demonstrate at least six anterior ribs and ten posterior ribs above the diaphragm (Chand *et al*., 2013: 51). Inadequate inspiration causes the lung markings to appear crowded and the heart shadow is not adequately demonstrated (Hobbs, 2007: 502).

2.9.1.4 Collimation

An adult CXR image should demonstrate the whole rib cage, including the surrounding soft tissue (Whitney *et al.,* 2015: 205). CXR images should demonstrate the lung apices to the lung bases, both hemi-diaphragm and costo-phrenic sulci (Hobbs, 2007: 503).

2.9.1.5 Correct exposure

A CXR image should demonstrate vessels to at least one third of the upper part of the lungs, allowing visualisation of the para-spinous margins and the left hemidiaphragm behind the heart (Avinash, Sachin and Ravindra, 2015: 47). This is achieved by applying the correct exposure factors when the exposure is made. A high kVp technique, which is achieved when using a kilovoltage (kVp) of between 100 and 120 and low milliamperes per second (mAs) with a grid, is preferred for achieving proper penetration of the lungs and mediastinum (Sound Imaging, 2018 online). Correctly exposed PA CXR images demonstrate faint outlines of at least the mid and upper vertebrae and posterior structures through the heart and mediastinal structures (Bontrager and Lampignano, 2017). The high kVp technique is recommended for all hospitals in Zambia, including those in the Copperbelt Province (Ministry of Health, 2012).

2.9.2 CXR image anatomy

Equally important for radiographers involved in image interpretation is adequate knowledge and understanding of the anatomy of the specific region. This also applies to the interpretation of CXR images (Lloyd-Jones, 2020 online). Many structures in the CXR image are readily visible, while others are invisible or obscured, and others are only visible when abnormal. Structures readily visible in a CXR image include the trachea, hila, lungs, diaphragm, heart, aortic knuckle, ribs, scapulae, clavicles, breasts, and gastric air bubble (Lloyd-Jones, 2020 online). In turn, obscured structures include the sternum, oesophagus, spine, pleura, fissures and aorta (Hobbs, 2007: 495). Visible and invisible structures on a routine PA CXR image are discussed in the sections to follow.

2.9.2.1 Trachea

The trachea begins just under the larynx and stretches down to the sternum; it is about 10 cm long and less than 2.5 cm in diameter (Hoffman, 2021 online). On a normal CXR image, the trachea should be centrally placed, although it typically deviates slightly to the right of the midline due to the aortic knuckle (Patel, 2021 online). If the trachea deviates more than normal, one should scrutinise the image for anything that could be pulling or pushing the trachea, and inspect for para-tracheal masses/lymph nodes (Patel, 2021 online).

2.9.2.2 Carina and bronchi

The carina is a point at which the trachea bifurcates into the right and left main bronchi (Eldridge, 2022 online). The carina is visible in a good quality CXR image and is an important landmark for assessing nasogastric tube placement (Patel, 2021 online). The right main bronchus is generally wider, shorter and more vertical than the left main bronchus (Patel, 2021 online). The angle between the two bronchi is about 70 degrees in adults, 25 degrees to the right and 45 degrees to the left midline (Busti and Kellogg, 2015 online). Flattening this angle is a sign of alteration, which is often caused by an enlargement of the tracheobronchial group of lymph nodes near the bifurcation (Jacob, 2016 online).

2.9.2.3 Hila

The hila consist of the major bronchi, phrenic nerves, pulmonary veins, arteries and lymph nodes (Zimlich, 2021 online). The hila are not symmetrical on both sides, though they do contain the same basic structures. The hila may be at the same level, but commonly the left hilum is slightly higher than the right (±2 cm) (Sarkar, Jash, Maji and Patra, 2013: 33). There is a wide range of normal appearances, but the two hila should be similar in size and density (Patel, 2021 online). Differences in size and density are a good indication of an abnormality (Patel, 2018 online).

2.9.2.4 Lung lobes and zones

The lung zones are divided into an upper and lower lobe for the left lung, and an upper, middle and lower lobe for the right lung (Chaudhry and Bordoni, 2021 online). These lobes have their pleural covering and lie together to form an oblique fissure for the left lung and an oblique and horizontal fissure for the right lung (Van der Plas, 2014 online). The pleura is not usually visible in healthy individuals, unless there is an abnormality causing pleural thickening or fluid or air has gathered in the pleural spaces (Patel, 2021 online).

To interpret the lung fields, the lungs are divided into upper, middle and lower horizontal zones. The lower zones reach below the diaphragm, because the bases of the lungs pass beyond the dome of the diaphragm, into the posterior sulcus of each hemi-thorax (Chaudhry and Bordoni, 2021 online). Asymmetry of the lungs is normal and is caused by the presence of anatomical structures, such as the heart on the left side and the liver on the right side (Patel, 2021 online). However, lung pathology can cause changes in lung symmetry. Lung pathology will often present as areas of increased density or decreased density (Smithuis, 2014 online). Decreased density occurs with vessel loss, such as emphysema or pneumothorax, while increased density results from alveolar or interstitial fluid (Cadogan, 2020). Increased density manifests in the following patterns: consolidation, nodule or mass and atelectasis (Cadogan, 2020).

2.9.2.5 Cardiac size

The cardiac size is assessed with the total thoracic width, known as the cardio-thoracic ratio (CTR), and is expressed as a percentage (Mensah, Mensah, Asiamah, Gbdamosi, Idun, Brakohiapa and Oddoye, 2015: 159). A CTR is obtained by dividing the transverse cardiac diameter by the maximum internal thoracic diameter; 50% is considered to be the upper limit of the normal (Mensah *et al.,* 2015: 159).

2.9.2.6 Diaphragm

The diaphragm is an unpaired, dome-shaped skeletal muscle used in breathing, and separates the abdominal organs below the lungs and heart above (Gorman and McLaren, 2022 online). On a normal CXR image, each hemi-diaphragm should appear as a rounded, domed structure with a crisp white edge contrasted against the adjacent dark lung (Lloyd-Jones, 2019 online). The right hemi-diaphragm is usually higher than the left by 1–3 cm, to accommodate the liver (Patel, 2021 online). The stomach, below the left hemi-diaphragm, appears as a less dense bubble – the bubble is sometimes used as a window to view part of the left lung (Cadogan, 2020).

2.9.2.7 Costophrenic angles

Costophrenic angles are well-defined acute angles formed from the dome of each hemi-diaphragm and lateral chest wall (Patel, 2021 online). Normal costophrenic angles measure about 30 degrees or less (Kerkar, 2018 online). The loss of acute angles, also known as costophrenic blunting, suggests fluid, consolidation, and lung hyperinflation due to diaphragmatic flattening (Patel, 2021 online).

2.9.2.8 Mediastinum

The mediastinum is in the thoracic cavity between the lungs (Vaskovic, 2022 online). The boundaries of the mediastinum are the thoracic spine posteriorly, sternum and costal cartilages anteriorly, mediastinal pleural laterally, thoracic inlet superiorly and diaphragm inferiorly (Agarwal, 2018 online). The mediastinum is widened if the transthoracic distance at the aortic knuckle on a PA erect CXR image, with good patient inspiration, is more than 8 cm (Cadogan, 2020). A widened mediastinum is usually due to vascular abnormality or mediastinal mass (Agarwal, 2018 online).

2.9.2.9 Soft tissue

Soft tissue must always be inspected for obvious abnormalities, such as large haematoma and surgical emphysema, especially around the neck and the thoracic wall (Cadogan, 2020).

2.9.2.10 Bones

Bones that are visible on a CXR image include ribs, scapulae, spine, proximal humeri, clavicles, and the sternum (Lloyd-Jones, 2020 online). Bones in CXR images are useful image quality markers for assessing patient rotation, x-ray penetration, and inspiration adequacy. It is also important to scrutinise the bones for apparent abnormalities, for example, fracture lines or lytic process (decreased density) and sclerotic lesions (increased density) (Lloyd-Jones, 2019 online).

2.10 MEDICO-LEGAL AND TECHNICAL ADEQUACY OF CXR IMAGES

Radiographic evaluation criteria of a CXR image relate to assessing the quality of a CXR image to determine if the image meets the acceptable quality standards for the image to be of diagnostic value (Chand *et al.*, 2013:51). Patient details, date of examination, (Chand *et al.,* 2013: 51), right (-R) or left (-L) anatomical side markers and position should be included, to ensure an accurate diagnosis of the correct patient (Chung, Kumar, Oldfield, Phillips and Stratfold, 2020: e116).

Evaluation criteria for the PA CXR image include the following (Whitley *et al*., 2015; Bontrager and Lampignano, 2017):

- Full lung field with scapulae projected laterally away from the lung fields;
- The medial ends of the clavicles are symmetrical and sterno-clavicular joints equidistant from the spinous processes;
- The lungs are well inflated, showing either six anterior ribs or nine posterior ribs above the diaphragm;
- The costo-phrenic angles and diaphragm are outlined clearly;
- The mediastinum and heart are central and defined sharply; and
- The fine demarcation of the lung tissues is shown from the hilum to the periphery.

2.11 GUIDELINES FOR BASIC IMAGE INTERPRETATION OF THE CHEST

Basic image interpretation of the CXR image means interpreting and recording observations made from the image (Royal College of Radiologists 2021 online; Society and College of Radiographers, 2010 online). When assessing a CXR image, it is important to develop a systematic approach and to avoid overlooking valuable radiological signs (Rich, 2018 online). The order in which one looks at the radiograph is unimportant. However, what is cardinal is to follow the systematic approach each time; otherwise, significant abnormalities may be missed (Armstrong, Wastie and Rockall, 2009: 17).

The **ABCDEF systematic approach** was employed in the study to limit overlooking valuable radiological signs during image interpretation (Rich, 2018 online), where A refers to the airway, B refers to bones and soft tissue, C refers to circulation, D refers to the diaphragm, E refers to everything else and F refers to the lung fields. A brief discussion of this approach follows;

2.11.1 A for airway

When looking at the airway, the trachea, carina, right and left bronchi should be carefully assessed to identify any variations from the normal (Rich, 2018 online).

2.11.2 B for bones and soft tissue

When assessing the bones, one should carefully compare the clavicles, ribs, scapulae, vertebral bodies and humeri for any fractures, dislocations or lesions (Rich, 2018 online). Additionally, the soft tissue structures next to each bony component should be scrutinised for symmetry, swelling, loss of tissue planes, subcutaneous air, masses, shadows and calcifications (Brims, 2019 online).

2.11.3 C for circulation

Concerning the “C for circulation” part of this approach, one should carefully assess the heart shadow position, size, and shape, to see if there is any variation from the normal. Also categorised in this part of the approach is the mediastinum, including the aortic knuckle and aortic stripe (Brims, 2019 online). Also, assess the hila size and density, and level of the hila. Commonly, the left is ±2 cm higher than the right.

2.11.4 D for diaphragm

When assessing the diaphragm, one should assess the shape and height of both domes (Puddy and Hill, 2007: 73). Additionally, the costo-phrenic angles and pleura should be scrutinised for the presence of fluid or other overlying shadows. It is also important to note the position of the gastric bubble and assess for any free air under the diaphragm (Rich, 2018 online).

2.11.5 E for everything else

The E of this approach generally refers to other objects in the image, such as tubes and lines. The position of each line/tube should be carefully assessed to ensure the correct placement of its tip (Puddy and Hill, 2007: 73). For example, central lines should pass to the lower vena cava and should not enter the right atrium (Puddy and Hill, 2007: 73), pulmonary artery catheters should not be wedged into small branches, the tip of an endotracheal tube should be at least 3 cm above the carina, tubes should pass below the diaphragm into the stomach and the tip of a chest drain pipe should be in the appropriate position (Puddy and Hill, 2007: 73).

2.11.6 F for fields

The lungs are the areas that provoke the greatest interest when screening for abnormalities. Therefore, most literature sources suggest that the screening of the lungs should be performed last, to prevent distractions when scrutinising these structures (Rich, 2018 online). Both lungs should be assessed from the apex to below the diaphragm and be compared to one another for differences in density. Additionally, the vascularity and field outlines of each lung should be checked for abnormal opacity or lucency, atelectasis, collapse or consolidation (Brims, 2019 online). It is also important to evaluate the horizontal fissure in the right lung and the oblique fissure in the left lung (Brims, 2019 online).

2.12 CONCLUSION

In this chapter, a theoretical framework to support the study was presented. This chapter also outlined the benefits of radiographers' involvement in image interpretation. In Chapter 3, the methodology that was used in this study and the ethical considerations that were adopted, are relayed.

CHAPTER 3
MATERIALS AND METHODS

3.1 INTRODUCTION

In Chapter 2, information reported regarding CXR image interpretation was discussed. In this Chapter, Chapter 3, the data collection process for this study is explained. This will include the research design, study location, research team, research tools, sampling methods, data collection, analysis, and inclusion and exclusion criteria. The measures taken to ensure that the results are valid and reliable will also be outlined.

3.2 DESIGN OF THE RESEARCH

An experimental pre- and post-study design and a descriptive, quantitative study design were used for the study. Experimental designs, also known as interventional designs, involve the researcher intervening at some point during the study (Aggarwal and Ranganathan, 2019: 138). Experimental designs include randomised controlled trials, pre-post study design, non-randomised controlled trials and quasi-experiments (Stratton, 2019: 573). In this project, an experimental pre-post study design was used to assess radiographers' interpretation skills regarding adult trauma CXR interpretation skills before and after a training intervention had been implemented. An experimental pre-post-study design was ideal in this study since the study involved the assessment of radiographers' basic CXR image interpretation skills.

A descriptive study systematically describes a community's situation, problem, phenomenon, or condition (Van Wyk, 2018). There are three main types of descriptive methods: observational, case, and survey methods. For this study, the researcher used the survey method, because the survey method requires radiographers in a study to answer questions through questionnaires, after which the researcher analyses and reports on the responses given (Lau, 2017 online).

A quantitative study involves collecting and analysing numerical data to describe, explain, predict or control variables and phenomena of interest (Roni, Mega and Morris, 2020: 108). A quantitative study design was used in this study to assess radiographers' adult CXR image interpretation skills by comparing their test scores in the pre- and post-tests. The study also utilised a quantitative study design to determine the need to involve radiographers in CXR image interpretation by assessing data MOs and COs had provided in questionnaires.

3.3 STUDY LOCATION

This study was conducted in the Copperbelt Province of Zambia, in eight public hospitals. The hospitals were Kitwe Teaching Hospital (KTH), Ndola Teaching Hospital (NTH), Luanshya District Hospital (LDH), Roan General Hospital (RGH), Ronald Ross General Hospital (RRGH), Kalulushi District Hospital (KDH), Kalulushi General Hospital (KGH) and Nchanga North General Hospital (NNGH). The Copperbelt Province was selected for this study because it is the industrial core of Zambia, with a population of 2 605 116 people (City Population, 2019 online). However, the whole province only has two radiologists working in the public sector, despite the extensive industrial activities and large population – the second-highest of a province in the country (City Population, 2019 online; Ministry of Health, 2019). In addition, the researcher is based in the Copperbelt Province, which simplified logistical arrangements concerning collecting the data. In Table 3.1, a summary of the specifics of each of the sampled hospitals is provided. The facts are as follows.

- All hospitals have surgical wards to which trauma patients are admitted. However, not all hospitals have specific chest trauma admission wards.
- Radiology departments in Zambia are converting from film screen x-ray machines to Computed radiography (CR) /Digital radiography (DR) machines. DR machines were procured for level 3 hospitals; however, they are not yet operational.
- Data are not disaggregated to specific body regions, but according to pathology; therefore, data for chest trauma cases were not available.

- Copperbelt Provincial Health Office information was aggregated by districts, towns or cities, for example, Ndola city; therefore, the researcher was given data for the whole province and not data specific to hospitals.
- Radiographers working in the hospitals include those on vacation leave, maternity leave and study leave. Staff establishment in radiology departments relates to the level of the hospital.

Table 3.1: Summary of study locations

Hospital name	Hospital level	Trauma unit available	Admits chest trauma	X-ray machine(s) available film screen, CR, DR)	Full-time radiologist	Reporting structures: Tele-radiology	No. of radiographers working at the hospital
Ndola Teaching Hospital	3	Yes	Yes	Film screen (DR available but not fully installed)	Yes	N/A	15
Kitwe Teaching Hospital	3	Yes	Yes	Film screen (DR available but not fully installed)	Yes	N/A	13
Roan General Hospital	2	Yes	Yes	DR	No	None	6
Ronald Ross General Hospital	2	Yes	Yes	Film screen	No	None	6
Kalulushi General Hospital	2	Yes	Yes	Film screen	No	None	6
Nchanga North General Hospital	2	Yes	Yes	Film screen	No	None	6
Luanshya District Hospital	1	Yes	Yes	Film screen	No	None	4
Kalulushi District Hospital	1	Yes	Yes	Film screen	No	None	4

3.4 STUDY POPULATION

The target population of this study was radiographers, MOs and COs working at KTH, NTH, KGH, KDH, RRGH, RGH, NNGH and LDH in the Copperbelt Province, Zambia. The population of radiographers employed in the eight hospitals at the time of the study numbered 60, while the population of MOs and COs working in emergency departments for the eight hospitals was 45 and 30, respectively (Ministry of Health, 2019).

Only radiographers, MOs and COs registered with the Health Professions Council of Zambia (HPCZ) and working in one of the eight participating public hospitals in the Copperbelt Province of Zambia were eligible for inclusion in this study. Radiographers, MOs and COs who participated in the pilot study were excluded, because they had previewed questions in the checklist and questionnaire, respectively.

3.5 RESEARCH TOOLS

A checklist and one questionnaire were used to acquire data for this study.

3.5.1 Checklist for basic adult trauma CXR image interpretation by radiographers

The checklist presented participating qualified radiographers with statements related to trauma adult CXR image interpretation. A checklist was used in this study since it is a quick and easy way for the research radiographers to assess images. Checklist data are also easy to analyse, and it is easy to draw comparisons between sets of data (Hicks, 2009:25). However, a disadvantage of a checklist is that it offers restricted analysis due to response categories offered to radiographers (Hicks 2009:25). Nonetheless, the researcher was aware of this limitation and ensured that all necessary information was included to elicit the required information (Appendix I).

The checklist was developed for this study by the researcher and the study supervisors, based on a literature review specific to this study. The checklist consisted of two Sections. Section **A** covered CXR image quality aspects and Section **B** focused on the ability of the radiographers to distinguish between normal and abnormal appearance in the images. Sections **A** and **B** allowed the radiographers to select from the following options; **Yes** if they agreed with the statement supplied, **No** if they did not agree with the statement supplied, and **Not sure** for areas they were unfamiliar with or undecided about. In the checklist, a space for writing comments on the option selected was provided.

3.5.2 Questionnaire for medical and clinical officers

The opinions of MOs and COs were elicited to find out if there is a need to involve radiographers in basic adult trauma CXR image interpretation in the Copperbelt Province of Zambia. MOs are trained medical doctors, while COs are medical personnel who have completed three or four years of training in clinical medical sciences (Kafue Institute of Health Sciences Education and Research, 2018 online; University of Zambia, 2019 online). COs are trained to provide basic, essential medical care and management at the primary health care level (level 1), focusing on common health problems in Zambia. The graduates are registered with the HPCZ, together with paramedical professionals and MOs (Kafue Institute of Health Sciences Education and Research, 2018 online). COs are, however, also employed at secondary (level 2) and tertiary (level 3) institutions due to a shortage of MOs (Ministry of Health, 2020).

A questionnaire was used to collect data from MOs and COs (Appendix J). The questionnaire had two sections, Sections **A** and **B**. Section A acquired information about the demographics of the MOs and COs. Section B was used to determine the radiology services that were available and to enquire if there was a need to involve radiographers in basic adult trauma CXR image interpretation in their respective hospitals (Appendix J).

The MOs and COs were requested to indicate **Yes** if they agreed with the statement supplied, and **No** if they did not agree with the statement supplied. Some questions allowed them to comment to complement their answers, while others required them to select the best option.

3.6 SAMPLE AND SAMPLING METHOD

3.6.1 Sampling of radiographers

Sampling aims to enable the researcher to obtain data in the most reliable way without involving a whole population (Cherry, 2022 online). There are two basic sampling methods: probability and non-probability sampling. In probability sampling, the researcher uses probability theory, and every member of a population has an equal chance of being included in the research study (Choudhary, 2021 online). In contrast, in non-probability sampling, the researcher chooses specific participants who meet predetermined inclusion criteria (Omeihe, 2021 online). Non-probability sampling was used to select radiographers in this study, because the study was conducted during the COVID-19 pandemic and radiographers were working on rotational shift arrangements.

The total number of radiographers who were employed in the selected hospitals during this study was **60** (Ministry of Health, 2019). A total of 27 radiographers participated in the study. Proportional random sampling method was initially planned for this study, where the sample of radiographers would be proportional to the number of radiographers at each hospital, as indicated in Table 3.2. However, convenient sampling was implemented instead, because the study was conducted during the COVID-19 pandemic. Simple random sampling is an unbiased representation of a group; therefore, each individual is chosen entirely by chance and each member of a population has an equal chance of being selected (Crossman, 2020 online). On the other hand, convenience sampling is a non-probability collection of data from a population conveniently available to participate in the study (Etikan, Musa and Alkassim, 2016: 1).

During this study, radiographers in the hospitals worked according to rotational work schedules, to curb the spread of COVID-19. Therefore, there was a limited number of radiographers on each shift. Consequently, the researcher explained the study to all the radiographers present during a particular shift (Appendix D). The radiographers who were willing to participate in the study were asked to sign consent forms (Appendix F). The results of the study were not affected by the change from simple random sampling to convenience sampling, since the inclusion criteria remained the same (Section 3.7). The total number of radiographers who participated in this study was n = 27.

3.6.2 Sampling of CXR images

Purposive sampling was used to select the postero-anterior (PA) and antero-posterior (AP) CXR images of adult trauma that radiographers would interpret using the checklist. The goal of purposive sampling is to focus on particular characteristics of a population of interest that would best answer the research questions for the study (Crossman, 2020 online). A total of **20** adult trauma CXR images, each with patient history, were purposively selected from the archives at Ndola Teaching Hospital (NTH). The **20** CXR images were used in the experimental phase. The selection of the CXR images was done in consultation with a radiologist. The trauma pathologies on the selected CXR images were the most common in the archives at NTH. Normal CXR images with image-quality-related issues and CXR images with pathology related to trauma, such as haemothorax, pneumothorax, cardiomegaly, pneumothorax, pulmonary contusion, fractures and soft tissue injury, were selected (Figure 3.1). The CXR images with trauma-related pathology included subtle and outspoken pathology.

The **20** CXR images were used for the pre-testing and post-testing phases. Each image interpretation session was estimated to take two hours and was facilitated in two segments. The sample was benchmarked against a similar study and included a larger sample size. The benchmarked study had been conducted in South Africa to assess the skills of diagnostic radiographers in CXR image interpretation. The study supplied valuable data relevant to the development of the image interpretation skills of radiographers in South Africa (Gqweta and Naidoo, 2014: 17).

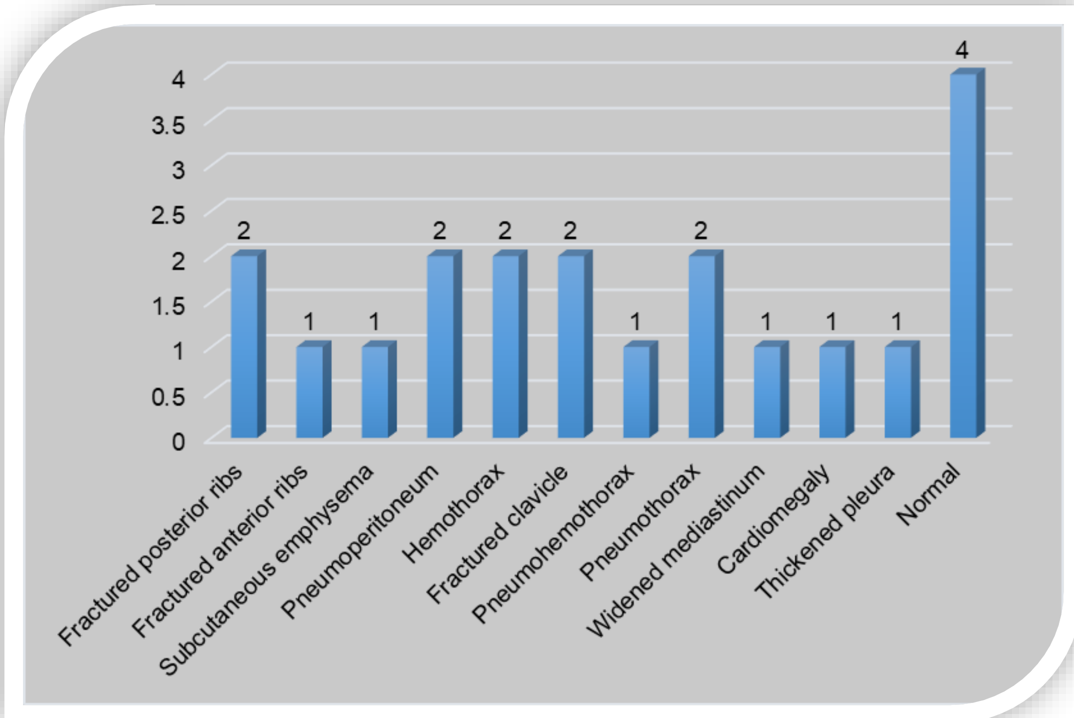

Figure 3.1: Case-mix of trauma CXR images

A total of **eight** CXR images were used in the interventional phase of the study. The intervention phase was eight weeks of training for radiographers in adult trauma CXR interpretation. The **eight** CXR images for the intervention phase were selected from the Radiology Masterclass website (//www.radiologymasterclass.co.uk). Radiology Masterclass is a webpage that provides online medical imaging educational resources for medical students, junior doctors and allied health care professionals. Permission was obtained from Radiology Masterclass to use study material (CXR images) (Appendix Q). Permission was granted on condition that all the CXR images that would be used would be referenced accordingly and would not be used for commercial gain or reproduced online (G. Lloyd-Jones 2020, personal communication, 29 May). An example of the content that the researcher used was sent for final approval. The terms and conditions of using Radiology Masterclass material were that all content used, images and text had to be acknowledged at every point of use (not only in the reference section). The website name, Radiology Masterclass, and the URL had to be clearly visible under each image.

3.6.3 Sampling of medical and clinical officers

MOs and COs who worked at the hospitals included in the study formed part of the population for the questionnaire survey. As for the selection of radiographers, proportional sampling was planned for data collection. However, convenience sampling was used instead, because MOs and COs in the study were working on rotational work schedules to curb the spread of COVID-19. The researcher explained the study to all the MOs and COs available on a shift in the emergency departments for the study hospitals (Appendix E). The MOs and COs who were willing to participate in the study signed the consent form (Appendix F). A total of eight MOs and seven COs participated in the study. Results of the study were not affected by the change from simple random sampling to convenience sampling, since the inclusion criteria remained the same (Section 3.7.2). Therefore, the sample size for MOs and COs combined is n = 15.

3.7 INCLUSION AND EXCLUSION CRITERIA

3.7.1 Inclusion and exclusion criteria for radiographers

Only qualified radiographers registered with the HPCZ and working at KTH, NTH, RADH, RGH, RRGH, KDH, KGH or NNGH were included in the study. Student radiographers were excluded, since they may not be as knowledgeable about all aspects of basic image interpretation of adult CXR images and the benefits of doing interpretation themselves.

Only PA and AP adult trauma CXR images were used in this study. Lateral CXR images were not included, since the lateral projection is considered to be an additional projection in public health institutions in Zambia, according to the standard operation procedure of the Ministry of Health (2012) and is not always included in a trauma setting. Therefore, not all requested CXR examinations include PA/AP and lateral projections. Only adult CXR images were used for image interpretation in this study, because diagnostic imaging of the paediatric chest differs vastly from that of adult patients and lung development shows visible differences at the different stages of development (Sood, Rissmiller and Hryhorczuk, 2018 online). Additionally, both common and rare pathologies may manifest differently in younger children than in adult patients (Sood *et al.*, 2018).

A total of **28 CXR images** were used in this study; **20** CXR images were used in the experimental phase and **eight CXR images** in the intervention phase. Each of the 28 CXR images had a radiological reference report from a radiologist and as documented by Radiology Masterclass.

3.7.2 Inclusion and exclusion criteria of medical and clinical officers

Only MOs and COs on the trauma team of each of the eight hospitals in the study were included in the study. Student MOs and student COs were not included in the study. This is because student MOs and COs may not be as knowledgeable of all aspects of CXR image interpretation yet.

3.8 DATA COLLECTION

3.8.1 Data collection using a checklist for radiographers

During data collection, the checklist (Appendix I) was used to determine the basic skills of the radiographers in interpreting adult trauma CXR images. Assessment of radiographers' skills was performed in two phases, namely a pre-test and a post-test. The checklist was in hard-copy format. The CXR images were also hard-copy film screen images for pre- and post-testing. This is because seven hospitals included in this study were using analogue film screen x-ray machines, and only one had a digital x-ray machine, which had been installed approximately eight months prior to data collection.

The researcher made prior arrangements with the selected hospitals to reserve a room, which was used for adult trauma CXR image interpretation sessions and a lecture on basic adult CXR image interpretation.

3.8.1.1 Pre-test

Radiographers’ interpretation skills in adult trauma CXR image interpretation were assessed using a checklist during the pre-test. The checklist contained CXR image interpretation questions which were categorised under image quality and signs indicative of pathology. A total of 20 CXR images were used. Radiographers were requested to complete one checklist for each of the 20 CXR images. Therefore, each radiographer filled out 20 checklists for the pre-test. Figure 3.2 shows one of the images that was used during the pre-test, it shows a normal CXR.

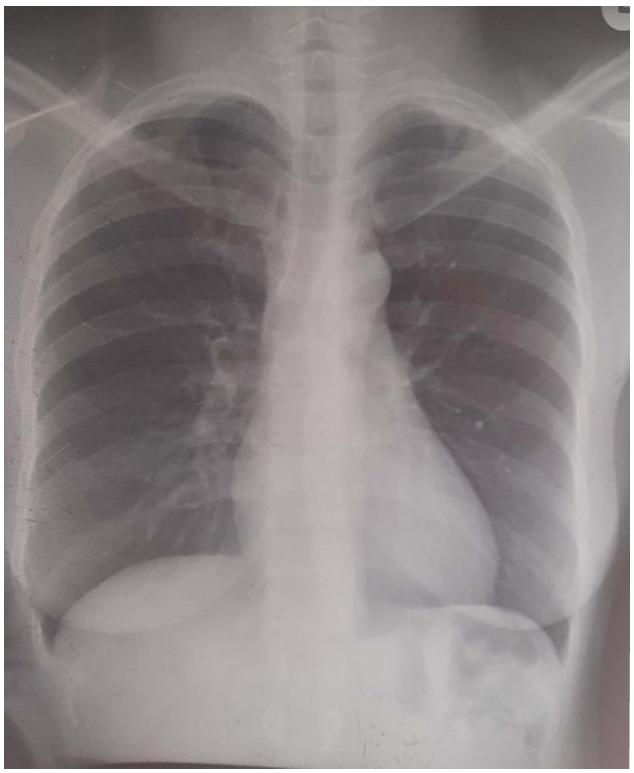

Figure 3.2: Normal CXR image (Ndola Teaching Hospital, 2020)

3.8.1.2 Pre- and post-test procedure

Ten stations were arranged in the room, each with one CXR image on a viewing box. The adult trauma CXR image interpretation sessions were divided into two segments. Each segment lasted approximately 60 minutes. Time for each session for CXR image interpretation and break was estimated to 60 minutes each after the pilot study for radiographers. In addition, the time was limited because the study was conducted during the COVID-19 pandemic, and, therefore, long meetings were not allowed, to avoid the spread of the virus. **Ten** CXR images were displayed on the viewing boxes at each of the ten stations. After the first segment of interpretation of the first **ten** CXR images, the radiographers took a break of five minutes, during which time the researcher displayed the remaining ten CXR images. The second segment also took approximately 60 minutes. Each CXR image was marked with a unique number and radiographers were requested to indicate the unique number on the checklist. The researcher placed a box at the entrance of the reporting room, in which the radiographers dropped their completed checklists, to maintain anonymity. Each participant had a unique identification number, which they were requested to indicate on the checklists for both pre- and post-testing, to link the results of the pre- and post-testing while, at the same time, maintaining their anonymity.

Viewing conditions, that is, viewing box luminance (brightness), viewing box luminance uniformity and viewing area ambient lighting are important factors that contribute to accurate image interpretation (Nyathi, Mwale, Segone, Mhlanga and Pule, 2008: 2). Table 3.2 displays the luminance, uniformity of viewing boxes and ambient lighting recommended by various institutions.

Table 3.2: Recommended luminance, uniformity of viewing boxes and ambient lighting

Organisation	Luminance of viewing box (cd m-2)	Uniformity of viewing box (cd m-2)	Ambient lighting (lux)
Directorate: Radiation Control (South Africa)	≥ 1500	≤ 20	≤ 100
NORDIC (Denmark, Finland, Iceland, Norway and Sweden)	1 500–3 000	≤ 15	≤ 100
European Commission	≥ 1 700	≤ 30	≤ 50

Source: Nyathi *et al*. (2008: 2)

The luminance level of x-ray viewing boxes and ambient lighting levels in the reporting rooms were not measured by this study, because a calibrated Nuclear Associates precision photometer was not available. Additionally, no recommendations by the Radiation Protection Authority of Zambia regarding luminance, lighting and uniformity of viewing boxes and ambient lighting could be found. However, the researcher worked with the heads of the radiology departments and biomedical engineers in the selected hospitals to ensure that the viewing boxes were cleaned and fluorescent lamps were checked for brightness and uniformity of light. Rooms used for adult trauma CXR image interpretation were prepared systematically to optimise viewing conditions.

3.8.1.3 Lecture in basic adult CXR image interpretation

After the pre-test session, a lecture was presented to the radiographers at each of the eight hospitals. The radiographers took a five-minute break after the pre-test session, during which the researcher prepared the room for the lecture. The researcher presented a PowerPoint lecture on the topic of basic adult trauma CXR image interpretation. The researcher received extensive training in pattern recognition as part of her postgraduate studies, and she has 15 years of experience of clinical practice.

Prerequisites of CXR image interpretation, including adequate knowledge of anatomy, physiology, and pathology, were emphasised. Technical aspects of obtaining optimum CXR image quality and the **ABCDEF** systematic approach to performing CXR image interpretation were presented. The ABCDEF systematic approach to CXR image interpretation was emphasised in the lecture and adopted for the intervention training. This is because the ABCDEF approach helps the person doing the interpreting to avoid overlooking valuable radiological signs. The lecture made reference to examples of adult trauma CXR images from the Radiology Masterclass website. The images were all referenced (Figure 3.3). The lecture took approximately 30 minutes, and was followed by 10 minutes for questions and discussions related to the lecture. Each radiographer participant received a hard copy of the lecture in basic CXR image interpretation that the researcher had presented. Figure 3.3 demonstrates one of the CXR images that was used as examples in the lecture.

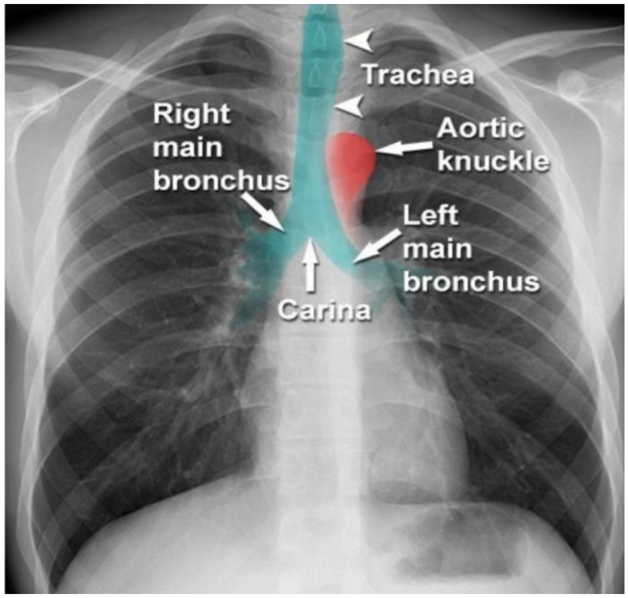

Table 3.3: CXR image with normal airway anatomy

Source: Radiology Masterclass (www.radiologymasterclass.co.uk); Lloyd-Jones (2020 online)

3.8.1.4 Trauma CXR image training using a WhatsApp® group

Training of radiographers in basic adult trauma CXR image interpretation was conducted after the pre-test and the lecture. The researcher used the medium of WhatsApp® for the training. WhatsApp® is an online application that supports sending and receiving media, including texts, photos, videos, documents, and voice calls (WhatsApp® LLC, 2022 online). The researcher created a WhatsApp® group for all the participating radiographers, the aim of which was solely discussions and training in trauma CXR image interpretation.

To curb the spread of COVID-19, WhatsApp® was used for the training of the radiographers, since the study was conducted during the COVID-19 pandemic (World Health Organization, 2020 online). The period of the training was eight weeks. If the researcher had met with the radiographers physically during the training, it would have caused the radiographers to be off duty at least one day every week for eight consecutive weeks. Furthermore, because radiographers worked in eight hospitals in different cities and towns throughout the Copperbelt Province of Zambia, the researcher would have travelled almost every day for eight consecutive weeks to conduct the training at the eight different hospitals. Thus, the study would have been extremely costly in terms of time and travel expenses. Hence, the WhatsApp® group allowed radiographers to undergo the training during the week. The WhatsApp® group made it possible for radiographers to have interactive discussions about each CXR image.

Since the WhatsApp® platform required radiographers to be online, each radiographer received two monthly data allowances to cover data costs during the eight-week training period. The WhatsApp® group had ground rules, which were posted immediately after the group had been created, to ensure the aim of the group was achieved. The rules were as follows:

- "Keep to the purpose of the group. Please do not share any other information except the above-mentioned.
- The CXR images are solely for research purposes and may not be copied or shared with a third party.
- Keep to the discussion of the CXR image for that specific week. We encourage active participation and welcome constructive feedback if you should differ from a colleague.
- Try to limit discussions to office hours. You are welcome to mute the notifications for the group after hours.
- To stay abreast of the discussions, check colleagues' comments regularly.
- For any queries, kindly contact the administrator privately for any concerns to be addressed" (see Appendix G).

Prior to the training, the researcher posted on the WhatsApp® group, a soft copy of the lecture that the researcher had presented after the pre-test session, to remind the radiographers about basic adult trauma CXR image interpretation. During the eight weeks of training, the researcher posted **one** selected adult trauma CXR image at the beginning of each week, for eight consecutive weeks (Monday by 10:00). Trauma pathologies that were discussed from week one to week eight during the training were tension pneumothorax, pneumoperitoneum, rib fractures with haemothorax, drain/surgical emphysema, diaphragmatic rupture, multiple acute rib fractures, hiatus hernia, and misplaced endotracheal with lung collapse. All the CXR images had reference reports from the radiologist. Reports by the radiologist were reflected as provided and nothing was changed (Appendix H). Figure 3.4 displays one of the images that was used during the training; it shows a tension pneumothorax on the left side.

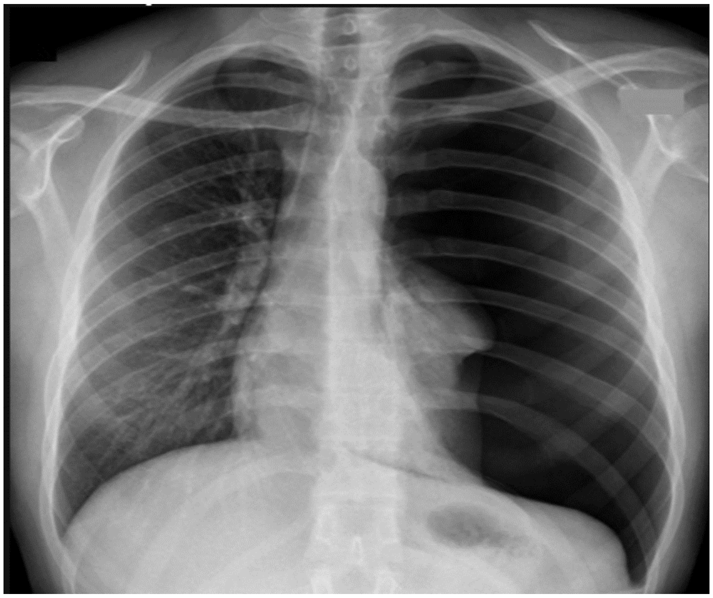

Figure 3.4: CXR image with tension pneumothorax

Source: Radiology Masterclass (www.radiologymasterclass.co.uk), Lloyd-Jones (2020 online)

All the radiographers discussed the posted CXR using the WhatsApp® group at their convenience during office hours within the week using the **ABCDEF** systematic approach. Discussions of each CXR during a specific week were either typed, or radiographers recorded short comments via a voice note on the WhatsApp® group. A radiological report for each CXR image was posted at the end of each week (Friday at 15:00). The radiographers were encouraged to send their questions and concerns to the administrator (the researcher). The researcher compiled all the questions and concerns that were raised. Concerns that were specific to radiographers were addressed immediately, and the conversations about the concerns were not included in the compilation.

3.8.1.5 Post-test

The post-test was conducted after the eight-week training in adult trauma CXR interpretation. Post-testing was conducted to assess if the lecture in basic adult trauma CXR image interpretation and the training had improved the radiographers' CXR image interpretation skills. The same checklist and CXR images that were used in the pre-test were used in the post-test. Therefore, radiographers completed a total of 20 checklists in the post-test. However, the order of display of the CXR images in the post-test differed from that in the pre-test to avoid recall bias (Nikolopoulou, 2022 online). The same procedure for data collection that had been used during the pre-test was repeated for the post-test (Section 3.8.1.2). Figure 3.5 shows one of the images that was used during the post-test – right-sided pneumoperitoneum.

Table 3.5: CXR image with right-sided pneumoperitoneum

Source: Ndola Teaching Hospital (2020)

3.8.1.6 Zoom meeting and certification of radiographers

After the post-test had been conducted for all study locations, a Zoom meeting was held the following week. The meeting was held to address the questions and comments that had been raised during the training. The meeting lasted about 1 hour and 30 minutes. Zoom is a cloud-based application that allows video/audio conferencing meetings, webinars, live chats and meeting recording (Tillman, 2022 online). The radiographers, the radiologist who had assisted with the selection of the CXR images for this study, and the study supervisor and co-supervisor attended the meeting; the researcher was the host of the meeting.

The radiologist who had assisted in selecting the images for this study answered the questions raised concerning the CXR images that were used during the training. The radiologist also answered all other questions and comments regarding image interpretation that had been raised. The study supervisor, co-supervisor and researcher addressed other concerns that were not directly related to image interpretation. The main request that the radiographers raised was for the WhatsApp® group to continue to exist after the training and post-test. Appreciation was expressed for the radiographers' enthusiasm for image interpretation, and they were encouraged to continue discussions through initiatives such as WhatsApp® groups. However, the WhatsApp® group that the researcher had created was mainly for the training intervention in this study.

The radiographers, the radiologist and the researcher were awarded certificates by the Central University of Technology in Bloemfontein, the Free State, South Africa, through its Faculty of Health and Environmental Sciences. Radiographers were awarded certificates of **participation**, the radiologist was awarded a certificate of **appreciation** and the researcher was awarded a certificate of **leadership** (Appendix R). Each certificate found the name of the bearer with their HPCZ licence number. Furthermore, the HPCZ awarded the radiographers and the researcher 30 continuous education units (CEU) for 2021 –100 continuous education units are required per annum. The participants were awarded 30 CEUs, because HPCZ has a policy of awarding CEUs to members, depending on the type of training or workshop attended, when proof of participation is provided (HPCZ 2018:4). The researcher consulted HPCZ telephonically concerning the radiographers who participated in the study, to enquire about CEUs. The HPCZ awarded the 30 CEUs, since the participants were trained in basic trauma CXR image interpretation, and were certified.

3.8.2 Data collection for medical and clinical officers

The researcher made prior arrangements with the MOs and COs regarding a time and venue for the session. The researcher distributed questionnaires (Appendix J) in hard-copy form to individual MOs and COs. Data collection required the MOs and COs to complete the questionnaires anonymously. The MOs and COs answered the questionnaires individually at the agreed time, with the researcher present. Therefore, the MOs and COs filled out the questionnaires separately, each in their office. The completed questionnaires were dropped in a box that had prepared for completed questionnaires, and the box was collected by the researcher. Each questionnaire had a unique number. The session with MOs and COs was estimated to take **30 minutes**. The total number of questionnaires collected was 15 out of 16 participants who had signed consent forms.

3.9 DATA VERIFICATION AND ANALYSIS

The researcher verified all the data for radiographers, MOs and COs to ensure that the data met the inclusion criteria. The researcher entered the results into Microsoft Excel spreadsheets. Data were grouped into two categories, one for radiographers and one for MOs/COs (Sections 4.2 and 4.3).

The radiographer category involved data for demographics, pre-test intervention results and post-test intervention results. A normality test was performed using analytical statistics, namely the Shapiro-Wilk test, to establish if there was a significant difference (p-value < 0.05) between pre- and post-test results for adult trauma CXR image interpretation skills of the participating radiographers.

The majority of the pre- and post-test score distributions did not follow a normal distribution. Therefore, the median and interquartile ranges (IQR) were reported for all the variables, and the Wilcoxon sign-ranked test was used to compare and evaluate the differences between the pre- and post-test scores. The results for the pre-and post-test were arranged according to the images: image A to image T. If $p < 0.05$, then there was a significant median difference between the pre- and post-intervention scores. If $p \geq 0.05$, then there was no significant median difference between pre- and post-intervention scores.

Results for radiographers were presented and illustrated in tables and figures (section 4.2 and 4.3).

The category for MOs and COs was for demographic data and radiology services available at their hospitals. Descriptive statistics for the MOs and COs were used to analyse results for MOs and COs.

3.10 PILOT STUDY

3.10.1 Pilot study for the checklist for radiographers

A pilot study is a preliminary run of the main study (Hicks, 2009: 395). A pilot study aims to get an idea of the practical situation in which the study was conducted (Vogel & Draper-Rodi, 2017:3). Two radiographers were conveniently selected to comment on the length, structure and phrasing of the questions in the checklist. No major changes were made to the checklist after the pilot study, except for correcting one or two typing errors. The corrections were made to the checklist before it was used in the study. Radiographers in the pilot study were not included in the main study, since they had already been exposed to the questions in the checklist.

3.10.2 Pilot study for the questionnaire for medical and clinical officers

To pilot the questionnaire that was used for data collection in this phase of the study, one MO and one CO were included. The MO and CO were requested to comment on the length, structure and phrasing of the questions in the questionnaire. The necessary adjustments were made to the questionnaire before it was administered. Similar to the pilot study for radiographers described in 3.10.1, the MO and CO who participated in the pilot study were not included in the main study, since they had already been exposed to the questions in the questionnaire.

3.11 ETHICS APPROVAL

Ethics approval for the research study was obtained from the Health Sciences Research Ethics Committee (HSREC) (**UFS-HSD2020/0670/28709**) at the University of the Free State (Appendix N). Since the research study was conducted in Zambia, ethical approval was also requested from the Tropical Diseases Research Centre (TDRC) (**FWA: 00003729**) (Appendix O). Permission to conduct the study was also requested from the Copperbelt Provincial Health Office, as well as from the management of each of the hospitals included in the study (Appendix P). This study was conducted according to the principles and guidelines of the Belmont Report (US Department of Health and Human Services, 2018 online). Therefore, information regarding this study was provided to the population, and participants volunteered to be included in the study and signed the consent form. Information relating to the participants was used solely for the purposes of this study.

3.11.1 Informed consent

Participation in this study was voluntary. The researcher explained the aim, objectives and overall goal of the study and gave hard-copy information documents about the study to each participant. The researcher also sensitised the participants on their right to refuse to participate in the study, or to cease participation at any time, should they wish to do so. The researcher, furthermore, discussed the contents of the consent form before participants who were willing to be included in the study signed it (Appendix F).

All information in the study was treated confidentially. The researcher distributed and collected the questionnaires, and the data collected was used only for research purposes. Patient details on the CXR images were removed and, instead, the images were marked with identification (unique) numbers. Measures were taken to safeguard the identity and anonymity of participants. Therefore, only broad, generic categorisations of radiographers, such as ‘radiographer’, ‘medical officer’ and ‘clinical officer’ are reflected in the study report. Each radiographer was given a unique number for easy comparison of their pre- and post-results for skills in basic adult trauma CXR image interpretation. Identities for radiographers were not revealed in the study and names were save as participand 1 and 2 etc, due to the workings of WhatsApp®.

3.12 VALIDITY

Validity determines the truthfulness of the research results (Heale and Twycross, 2015: 66). The validity of this research was ensured by carefully planning the checklist and questionnaire with reference to information covered in the literature section of this study. The checklist and questionnaire were tested through a pilot study before the study commenced. The researcher worked with a radiologist to select the CXR images that were used in the study; all the CXR images had been reported by the same radiologist. To ensure the validity of the acquired data further, options selected and answers provided by radiographers in the checklist were compared to reports by the radiologist (Appendix H). The radiologist who helped to select the CXR images reference reports for CXR images in this study has a Master’s degree in radiology and had been working as a radiologist for seven years.

The radiographers involved in the study attended a lecture presented by the researcher. The researcher and the study supervisors prepared the lecture on adult trauma CXR interpretation using current literature provided in this study (Sections 2.9 and 2.10), with examples from the Radiology Masterclass website (www.radiologymasterclass.co.uk). The researcher is a qualified radiographer with a diploma and a B-Tech degree in radiography, and she has worked as a radiographer for 15 years.

3.13 RELIABILITY

Reliability relates to the consistency of a measure (Heale & Twycross, 2015: 67) or the possibility of repeating the research and achieving the same results (Leung, 2015: 326).

A pilot study was conducted to assess the feasibility of the study. All the participants in this research were professionals representing radiographers, MOs or COs, who were capable of independently forming and expressing their opinions. The radiologist who assisted with the selection of CXR images and reference radiological reports was a professional who had specialised in image interpretation. All the data in this research study were accounted for by directly transferring data for closed-ended questions from the checklists and questionnaires using Excel spreadsheets. The checklists and questionnaires were assigned identification numbers to anonymise the data. The responses of all the participants were kept confidential.

3.14 CONCLUSION

This chapter outlined the procedure that was followed to obtain data for radiographers on basic adult trauma CXR image interpretation in the Copperbelt Province, which indicated the possibility of involving radiographers in trauma CXR image interpretation in the Copperbelt Province of Zambia. Ethical considerations taken by the researcher and the validity and reliability of the study were also discussed. In Chapter 4, the results of the study are presented and illustrated using tables and figures.

CHAPTER 4
RESULTS

4.1 INTRODUCTION

In Chapter 3, the methodology for this study was presented. Chapter 4 presents the results of data collected from 27 radiographers and 15 MOs and COs who participated in the study fully. The data represents eight public hospitals in the Copperbelt Province of Zambia.

4.2 RESULTS FOR RADIOGRAPHERS

A total of 30 radiographers initially met the inclusion criteria and consented to participate in the study. However, three radiographers did not participate in the post-test after the intervention. Therefore, the results for only 27 of the radiographers are presented. A checklist was used to determine the image interpretation skills of the radiographers in interpreting adult trauma CXR images before and after training in basic CXR image interpretation. A total of 20 hard-copy adult trauma CXR images were used for a pre-and post-test, and eight soft-copy adult trauma CXR images were used for the intervention. The results in relation to the demographic attributes of the radiographers and their basic adult trauma CXR image interpretation skills are presented in Sections 4.2.1–4.2.3.

4.2.1 Demographic characteristics of radiographers

4.2.1.1 Work experience

Table 4.1 shows that the median of work experience of radiographers was 4 years, while the IQR was between 3 and 13 years.

Table 4.1: Work experience of radiographers (n = 27)

	Interquartile range				
Work experience in years	Median	Lower quartile	Upper quartile	Minimum	Maximum
	4	3	13	1	16

4.2.1.2 Professional qualifications of radiographers

Figure 4.1 shows that, of the 27 radiographers who participated in the study, the majority (78%) had a diploma in diagnostic radiography as their highest qualification.

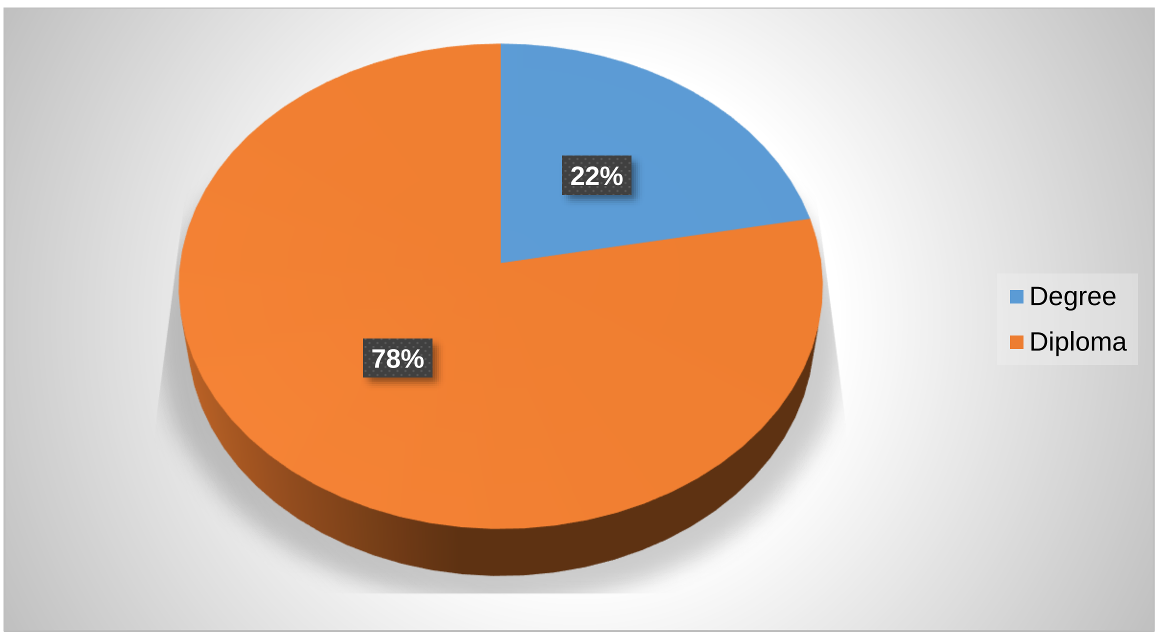

Figure 4.1: Professional qualifications of radiographers (n = 27)

4.2.1.3 Level of hospital

Figure 4.2 shows that most of the radiographers (52%) were working at level 3 (teaching referral hospital) health institutions, followed by level 2 and, lastly, level 1 health institutions.

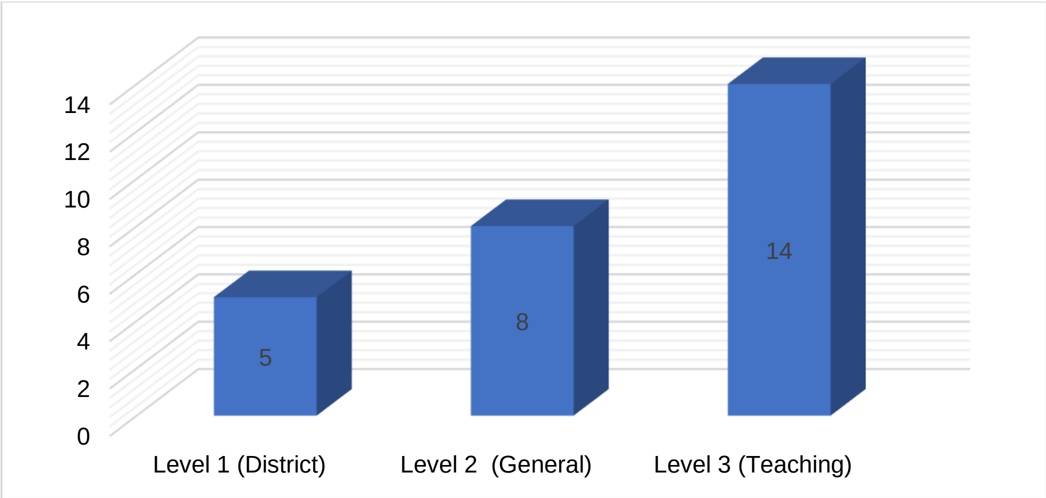

Figure 4.2: Level of the hospitals where the radiographers were employed (n = 27)

4.2.2 Basic skills of radiographers in adult trauma CXR image interpretation before and after the intervention

This section will present the results relating to the basic skills of the participating radiographers in adult trauma CXR image interpretation pre and post intervention. The CXR images were labelled A, B, C, D, E, F, G, H, I, J, K, L, M, N, O, P, Q, R, S and T. Results were grouped in different categories, namely images with positive median test scores with a significant difference, images with positive median test scores with no significant difference, and images with negative median test scores with no significant difference. Furthermore, overall scores were related to radiographers' experience, qualifications and hospital level.

4.2.3 Comparison of pre- and post-test image interpretation skills

A normality test was performed using analytical statistics, namely the Shapiro-Wilk test, to establish if a significant difference between the pre- and post-test interventions for adult trauma CXR image interpretation skills among the participating radiographers was present. The majority of the pre- and post-test score distributions did not follow a normal distribution pattern; therefore, median and IQR are reported (Table 4.2).

Table 4.2: Pre- and post-test summary statistics

Image	Image name	Pre-test			Post-test			Difference	p-value
		Median	Min	Max	Median	Min	Max	Median	
A	Normal	92.9	82.1	100.0	92.9	67.9	100.0	3.6	0.0896
B	Over-exposed film	75.0	35.7	96.4	71.4	57.1	89.3	0.0	0.3810
C	Normal	92.9	39.3	100.0	92.9	60.7	100.0	0.0	0.7571
D	Fractured rib with soft tissue injury	82.8	51.7	93.1	93.1	51.7	96.6	6.9	0.0004
E	Right pneumoperitoneum	86.2	58.6	100.0	93.1	69.0	100.0	6.9	< 0.0001
F	Normal with poor inspiration	82.1	46.4	92.9	85.7	57.1	89.3	3.6	0.5110
G	Normal rotated image	89.3	32.1	92.9	89.3	60.7	92.9	0.0	0.4253
H	Scoliosis	71.4	25.0	92.9	89.3	53.6	96.4	14.3	<0 .0001
I	Underexposed widened mediastinum	82.8	48.3	96.6	93.1	62.1	100.0	6.9	0.0005
J	Right clavicle fracture with shifted trachea	82.8	20.7	96.6	96.6	65.5	96.6	0.0	0.0026
K	Cardiomegaly	92.9	32.1	100.0	96.4	39.3	100.0	3.6	0.0498
L	Normal	92.9	67.9	100.0	96.4	75.0	100.0	0.0	0.7344

Image	Image name	Pre-test			Post-test			Difference	p-value
		Median	Min	Max	Median	Min	Max	Median	
M	Right pneumoperitoneum	86.2	37.9	100.0	86.2	51.7	100.00	3.4	0.0116
N	Left pneumohemothorax and shifted trachea	72.4	27.6	82.8	82.8	51.7	93.1	6.9	<0 .0001
O	Fractured ribs	100.0	62.1	100.0	96.6	75.9	100.0	-3.4	0.7297
P	Thickened pleura	86.2	51.7	89.7	86.2	69.0	93.1	3.4	0.0007
Q	Pneumothorax with wrongly placed endotracheal tube	62.1	24.1	79.2	79.3	34.5	93.1	13.8	<0 .0001
R	Normal	92.9	25.0	100.0	96.4	85.7	100.0	0.0	0.0247
S	Fractured ribs with pneumothorax	89.7	27.6	100.0	93.1	44.8	96.6	0.0	0.7751
T	Endotracheal tube with a fractured clavicle	73.3	23.3	96.7	86.7	33.3	96.7	3.3	0.0286
	Overall assessment	82.8	46.1	89.3	87.2	71.0	91.6	4.5	<0.0001

4.3 OVERALL RESULTS

The overall results in the tables below show that the post-test scores have a slightly higher median, of 87.2%, with IQR = (85.6%–89.2%). By comparison, pre-test scores have a smaller median, 82.8%, with IQR = (79.5%–87.2%). This positive median test score difference was associated with a statistically significant p-value of < 0.0001 and < 0.0004.

4.3.1 Results of pre- and post-test with a positive significant median difference

4.3.1.1 Images with significant positive median difference for bones and soft tissue

Table 4.3 indicates that images D, H and T have slightly higher medians, 93.1%, 89.3% and 86.7%, respectively, for the post-test scores. By comparison, the pre-test scores of these images have smaller medians, of 82.8%, 71.4% and 73.3%, respectively. The positive median test scores difference is associated with a statistically significant p-value of < 0.0001 and 0.0286, respectively.

Table 4.3: Images with a significant positive median difference for bones and soft tissue (n = 27)

Image	Pre-test score median (IQR)	Post-test score median (IQR)	Difference between pre- and post-test scores median (IQR)	p-value (difference between pre- and post-intervention scores)
D	82.8% (69.0%–89.7%)	93.1% (79.3%–96.6%)	6.9% (3.4%–10.3%)	<0.0004
H	71.4% (60.7%–82.1%)	89.3% (82.1%–92.9%)	14.3% (10.7%–28.6%)	<0.0001
T	73.3% (63.3%–93.3%)	86.7% (66.7%–93.3%)	3.3% (0.0%–10.0%)	0.0286

4.3.1.2 Images with significant positive median difference for circulation and diaphragm

Table 4.4 indicates that images I, E, K and M have slightly higher median of 93.1%, 93.1%, 96.4% and 86.2% respectively for post-test scores, compared to a median of 82.8%, 86.2%, 92.9% and 86.2% respectively for pre-test score. Image E had slightly higher medians, of 93.1% for the post-test scores, compared to smaller medians of 86.8% for pre-test scores. The positive median test scores difference is associated with statistically significant p-values of <.0001 and 0.0498, as shown in Table 4.4.

Table 4.4: Images with a significant positive median difference under circulation and diaphragm (n = 27)

Image	Pre-test scores median (IQR)	Post-test scores median (IQR)	Difference between pre- and post-test scores median (IQR)	p-value (difference between pre- and post-test scores)
I	82.8% (75.9%–89.7%)	93.1% (86.2% - 96.6%)	6.9% (3.4%–17.2%)	<0.0005
E	86.2% (79.3%–89.7%)	93.1% (89.7% - 96.6%)	6.9% (0%–17.2%)	<0.0001
K	92.9% (78.6%–100%)	96.4% (85.7% - 100%)	3.6% (0.0%–7.1%)	0.0498
M	86.2% [65.5%–96.6%]	86.2% [75.9%–96.6%]	3.4% [0.0%–13.8%]	0.0116

4.3.1.3 Images with significant positive median differences for lung fields

Table 4.5 shows that images N and P have slightly higher medians, of 82.8% and 86.2% respectively, for post-test scores, compared to smaller medians, of 72.4% and 86.2% respectively, for the pre-test scores. Images T and Q also have slightly higher medians, of 86.7% and 79.3% respectively, compared to smaller medians, of 73.3% and 62.1% respectively, for pre-intervention test scores. The positive median test scores difference is associated with statistically significant p-values of < 0.0001 and 0.0007.

Table 4.5: Images with a significant positive median difference for lung fields (n = 27)

Image	Pre-test score median (IQR)	Post-test score median (IQR)	Difference between pre-and post-test scores median (IQR)	p-value (difference between pre- and post-test scores)
N	72.4% (65.5%–75.9%)	82.8% (75.9%–86.2%)	6.9% (3.4%–17.2%)	<0.0001
P	86.2% (86.2%–86.2%)	86.2% (86.2%–89.7%)	3.4% (0.0%–6.9%)	<0.0007
Q	62.1% (51.7%–75.9%)	79.3% (75.9%–82.8%)	13.8% (10.3%–24.1%)	<0.0001

4.3.2 Images with positive median test scores with insignificant differences

Table 4.6 shows that images A and F had slightly higher medians, of 92.9% and 85.7% respectively, for the post-test scores, compared to smaller medians, of 92.9% and 82.1 respectively, for the pre-test scores. The positive median test scores differences are associated with p-values of 0.0896 and 0.5110.

Table 4.6: Images with positive median test scores with insignificant difference (n = 27)

Image	Pre-test score median (IQR)	Post-test score median (IQR)	Difference between pre-and post-test scores median (IQR)	p-value (difference between pre- and post-test scores)
A	92.9% [85.7%–96.4%]	92.9% [92.9%–96.4%]	3.6% [-3.6%–7.1%]	0.0896
F	82.1% [75.0%–92.9%]	85.7% [82.1%–89.3%]	3.6% [-7.1%–7.1%]	0.5110

4.3.3 Image with a negative median test score with insignificant difference

Image O has a slightly higher median of 100% and an IQR = (100%–96.6%) for the pre-test score, compared to a smaller median of 96.6% and an IQR = (96.6%–96.6%) post-test score. However, this negative median test score difference remains statistically insignificant, with a p-value of 0.7297.

4.3.4 Images with no difference between the pre-and post-intervention test scores

Table 4.7 shows that images B, C, G, R, S, L and T had 0% median difference between the post-test and pre-test scores. However, the median scores for post-test and pre-test are above 85%, except for image B, which has median scores of 71% for the post-test and 75% for the pre-test.

Table 4.7: Images with no difference between pre- and post-intervention scores (n = 27)

Image	Pre-test score median (IQR)	Post-test score median (IQR)	Difference between pre- and post-test scores median (IQR)	p-value (difference between pre- and post-test scores)
B	75.0% (67.9%–82.1%)	71.4% (67.9%–78.6%)	0.0% (-3.6%–0.0%)	0.3810
C	92.9% (82.1%–85.7%)	92.9% (100.0%-100%)	0.0% (-10.7%–10.7%)	0.7571
G	89.3% (85.7%–89.3%)	89.3% (85.7%–89.3%)	0.0% (-3.6%–0.0%)	0.4253
R	92.9% (89.3%–100%)	96.4% (92.9%–100%)	0.0% (0.0%–7.1%)	0.0247
S	89.7% (72.4%–96.6%)	93.1% (79.3%–96.6%)	0.0% (-6.9%–3.4%)	0.7751
L	92.9% (92.9%–100%)	96.4% (92.9%–100%)	0.0% (-3.6%–3.6%)	0.7344

4.3.5 Overall scores in relation to radiographers' experience, qualifications and hospital level

4.3.5.1 Work experience

Table 4.8 shows that radiographers with 1–5 years of experience had the lowest scores in the pre-tests, and they found the greatest improvement in the post-test: medians of 82.5% and 87.2% for the pre- and post-test scores respectively. They were followed by radiographers with more than ten years' experience, with medians of 80.8% and 86.5%

for the pre- and post-test scores respectively. The highest scores were achieved radiographers with 6–10 years of experience, with medians of 87.6% and 89.2% for pre- and post-test scores respectively. However, the difference in the overall pass rate by experience is statistically insignificant, with a p-value of 0.1616.

Table 4.8: Overall score compared to work experience (n = 27)

Years of experience	Variable	N	Median	Lower Quartile	Upper Quartile	p-value
1–5 years	Pre-test overall pass rate	15	82.5	76.1	86.2	0.1616
	Post-test overall pass rate	15	86.5	84.7	89.3	
	Difference	15	5.2	1.7	10.4	
6–10 years	Pre-test overall pass rate	5	87.6	87.2	87.6	
	Post-test overall pass rate	5	89.2	89.1	89.9	
	Difference	5	2.3	1.2	3.5	
More than 10 years	Pre-test overall pass rate	7	80.8	80.0	82.8	
	Post-test overall pass rate	7	86.5	85.4	87.2	
	Difference	7	4.7	3.2	8.8	

4.3.5.2 Qualifications

Table 4.9 shows that radiographers with degree qualifications had a lower score for the pre-test, and a lower improvement in the post-test, with medians of 82.4% and 86.5% for the pre- and post-test scores respectively, compared to radiographers with diploma qualifications, who have medians of 83.5% and 87.3% for the pre-and post-intervention test scores respectively. However, the difference in the overall pass rate by qualification is statistically insignificant, with a p-value of 0.5997.

Table 4.9: Overall score compared with qualification (n = 27)

Qualification	Variable	N	Median	Lower Quartile	Upper Quartile	p-value
Degree	Pre-test overall pass rate	6	82.4	80.8	83.7	0.5997
	Post-test overall pass rate	6	86.5	86.0	88.4	
	Difference	6	3.9	2.8	4.7	
Diploma	Pre-test overall pass rate	21	83.5	76.5	87.3	
	Post-test overall pass rate	21	87.3	85.6	89.3	
	Difference	21	4.8	2.3	10.1	

4.3.5.3 Level of hospital

Table 4.10 shows that radiographers from level 3 hospitals had the lowest score in the pre-intervention test and found the greatest improvement in the post-test, with medians of 79.8% and 86.1% for the pre- and post-test scores respectively. They are followed by radiographers from level 1 hospitals, with medians of 87.2% and 88.4% for the pre- and post-test scores respectively. Radiographers from level 2 hospitals had the highest score with the least improvement, with medians of 82.5% and 87.2% for the pre- and post-intervention test scores respectively. The difference in the overall pass rate by level of the hospital is statistically significant, with a p-value of 0.0323.

Table 4.10: Overall score compared with the level of hospital (n = 27)

Level of hospital	Variable	N	Median	Lower Quartile	Upper Quartile	p-value
Level 1	Pre-test overall pass rate	5	87.2	82.8	87.6	0.0323
	Post-test overall pass rate	5	88.4	86.0	89.9	
	Difference	5	3.2	2.3	3.5	
Level 2	Pre-test overall pass rate	8	86.7	83.7	88.7	
	Post-test overall pass rate	8	89.1	88.1	89.3	
	Difference	8	2.7	1.4	4.1	
Level 3	Pre-test overall pass rate	14	79.8	75.7	83.5	
	Post-test overall pass rate	14	86.1	84.7	87.3	

4.3.6 Results for the medical and clinical officers

The demographic attributes of MOs and COs and radiology services available in the hospitals where they work are presented in this section. The questionnaires were distributed in hard-copy format to each participant by the researcher and collected in the same way as for the radiographers. A total of 15 questionnaires were completed. A total of 16 MOs/COs had initially signed the consent form to be included in the study; however, one participant did not complete a questionnaire despite agreeing to be included in the study. The questionnaires were completed anonymously, and each participant received a unique number, which was indicated on the questionnaire.

4.3.6.1 Demographics of the medical and clinical officers

Table 4.11 indicates that 53.3% of the participants were MOs and 46.7% were COs (n = 15). Of all the participants, 46.7% had diploma qualifications, while 33.3% had degree qualifications; only 20% had Master's degrees. The majority (60%) had work experience of between 1 and 5 years, followed by 20% and 13.3% who had work experience of between 6 and 10 years and 11 and 15 years respectively, while only one (6.7%) participant had more than 15 years' work experience. The majority (60%) of MOs and COs were employed at level 2 hospitals, and the rest of the radiographers were employed at level 1 (20%) and level 3 (20%) hospitals.

Table 4.11: Demographic attributes of medical and clinical officers (n = 15)

Attributes	**Frequency**	**Percent (%)**
	Employment Status	
Clinical officer	7	46.7
Medical officer	8	53.3
Totals	**15**	**100**
	Professional qualifications	
Diploma	5	33.3
B degree	7	46.7
Master's	3	20
Totals	**15**	**100**
	Work experience (in years)	
1–5	9	60
6–10	3	20
11–15	2	13.3
> 15	1	6.7
Totals	**15**	**100**

Level of Institution where employed		
Level 1 (District hospital)	3	20
Level 2 (General hospital)	9	60
Level 3 (Referral hospital)	3	20
Totals	**15**	**100**

4.3.6.2 Availability of radiology services

This section will report on the availability of radiology services at hospitals, and whether there was a need to involve radiographers in basic adult trauma CXR image interpretation at the hospitals where the study was conducted.

Table 4.12 shows that 13 MOs and COs of the (n=15) stated that no written reports were issued for trauma CXR images. Furthermore, 60% of the 13 MOs and COs experienced challenges interpreting adult trauma CXR images (Table 4.12). The challenges experienced by the MOs and COs are presented in Section 4.3.6.3.

Table 4.12: Availability of radiology services (n = 15)

Characteristics	**Frequency**	**Percent (%)**
A written report issued from the radiology department for trauma chest x-ray examination		
No	13	86.7
Yes	1	6.7
Sometimes	1	6.7
Totals	**15**	**100**
If no report is issued, do you experience challenges interpreting adult trauma CXR images?		
No	1	6.7
Yes	9	60
Sometimes	3	20
Total	**13**	**86.7**

4.3.6.3 Challenges experienced with the interpretation of adult trauma CXR images

The researcher asked the MOs and COs, through an open-ended question, to indicate the challenges they experienced in adult trauma CXR image interpretation. The challenges indicated included poor quality images or analogue images, as confirmed by the following direct quotes from the respondents' responses.

> *'Most radiographic images are of poor quality'* *Particip. 1*

> *'Poor CXR images quality'* *Particip. 4*

> *'Quality of radiographic images at times is not good'* *Particip. 6*

However, subtle injuries were also indicated as posing challenges. Some of the responses of the MOs and COs are as follows:

'Identification of rib fractures' *Particip. 6*

'Picking up subtle injuries when images are not clear' *Particip. 7*

'Subtle fractures' *Particip. 5*

4.3.6.4 Medical and clinical officers' views on radiographers' involvement in adult trauma CXR image interpretation

This section will report on the current involvement of radiographers in basic adult trauma CXR image interpretation, and whether, according to MOs and COs, there is a need to involve radiographers in interpretation at their respective hospitals.

The researcher inquired if radiographers were involved in trauma CXR image interpretation, and n = 13 MOs and COs responded. The large proportion of 9 (69%) found that radiographers were not involved in adult trauma chest imaging interpretation, while the rest (n = 4; 31%) found that radiographers were involved, as displayed in Figure 4.3.

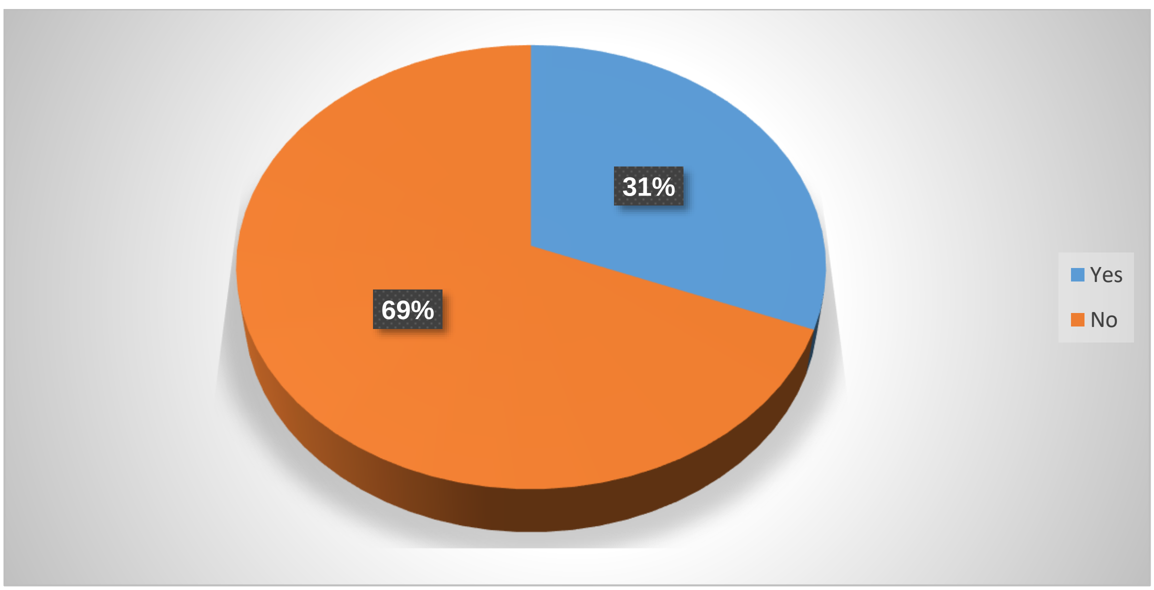

Figure 4.3: Radiographers' involvement in adult trauma CXR image interpretation

4.3.7 Waiting time for radiology reports

According to Table 4.12, four MOs and COs (n = 4) indicated that radiology reports are provided for trauma CXR images, of whom 3 (75%) indicated that the waiting time for a radiology report was 30 minutes to one hour, and 1 (25%) stated that the waiting time was less than 30 minutes.

4.3.8 System in place to assist interpretation of CXR images

Out the four MOs and COs who indicated that radiographers are involved in CXR image interpretation at their health care facility, 50% (two MOs and COs in total) indicated that radiographers use PCE and reporting (Table 4.13) as methods for CXR image interpretation, respectively.

Of the nine MOs and COs (n = 9) who stated that they experienced challenges in adult trauma CXR image interpretation, 4 (43.5%) indicated that there was a system in place to assist with challenges related to CXR image interpretation, while 3 (33.3%) were not sure if there was a system in place, and 2 (22.2%) indicated that no system was in place (Table 4.13).

The MOs and COs who indicated that a system was in place to assist CXR image interpretation, were then requested to comment on what system was in place at the hospital they were working at; they indicated the following:

> *'CXRs are discussed with radiographers' (Particip. 1)*
>
> *'Consult surgeons or consultants' Particip. 3*
>
> *'Go to the radiology department and discuss with radiographers' (Particip. 4)*
>
> *'Physically going to radiology for radiographers' input' (Particip. 2)*

Table 4.13: Waiting times for reports and system in place to assist interpretation of CXR image

Characteristics	**Frequency**	**Percent (%)**
Image interpretation method for radiographers		
Preliminary clinical evaluation	2	50
Reporting	2	50
Totals	**4**	**100**
Waiting time for a written report on chest imaging examination		
30 minutes to one hour	3	75
Less than 30 minutes	1	25
Totals	**4**	**100**
System in place to assist with interpretation of CXR images challenges		
No	2	22.2
Yes	4	43.5
Not sure	3	33.3
Totals	**9**	**100**

4.3.9 Need to involve radiographers in basic adult trauma CXR image interpretation

This section will report the need to involve radiographers in basic adult trauma CXR image interpretation.

All the MOs and COs responded (n = 15). The majority (n = 14; 93.3%) of the MOs and COs (Figure 4.4) indicated a need to involve radiographers in basic adult trauma CXR image interpretation. In contrast, only 1 (6.7%) indicated no need for radiographers to interpret adult trauma CXR images.

The MOs and COs were asked to comment on why radiographers should be involved in adult trauma CXR image interpretation. Most MOs and COs indicated that radiographers' involvement would improve the quality of images, accurate diagnosis, and timely reports. The quotes below affirm this:

> *'Radiographers will bridge the gap of image interpretation'* Particip. 2
>
> *'So that they understand the challenges clinicians face with poor radiographic images'* Particip. 3
>
> *'Radiographers can attach a report on the x-rays if there are signs of pathology'* Particip. 1
>
> *'For better quality images'* Particip. 4
>
> *'Quick results for patients, doctors too busy to handle film reporting'* Particip. 8
>
> *'It will greatly improve correct diagnosis and better management of patients'* Particip. 6

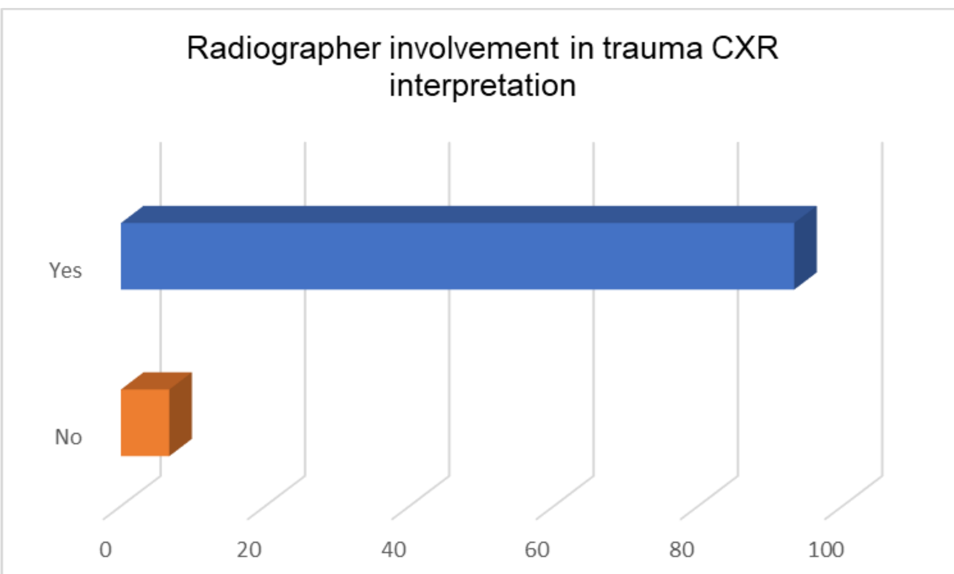

Figure 4.4: Need for involvement of radiographers in CXR image interpretation

4.3.10 Level of the effect of radiographer CXR image interpretation

The researcher sought to investigate the level of effect radiographers being involved in basic CXR image interpretation of adult trauma may have. Table 4.14 confirms that the MOs and COs were of the opinion that involving trained radiographers in basic adult trauma CXR image interpretation would significantly reduce missed fractures/pathology incidences. The majority (n = 10; 66.7%) of the MOs and COs indicated that training radiographers involved in basic adult trauma CXR image interpretation would decrease the MOs and COs' workload in the emergency department. The rest of the MOs and COs (n = 5; 33.3%) indicated that radiographers would only somewhat reduce MOs and COs' workload in the emergency department.

The results also indicate that the majority (80%) of the MOs and COs believe that involving trained radiographers in basic adult trauma CXR image interpretation would shorten waiting times for patients, followed by 20% who indicated that the involvement of radiographers in basic adult trauma CXR image interpretation would shorten waiting time only somewhat (Table 4.14).

Table 4.14: Level of the effect of radiographers involved in basic CXR image interpretation

Characteristics	**Frequency**	**Percentage (%)**
Trained radiographers involved in basic adult trauma CXR image interpretation will reduce incidences of missed fractures/pathology		
Great extent	15	100
Trained radiographers involved in basic adult trauma CXR image interpretation will decrease the MOs and COs' workload in the emergency department		
Great extent	10	66.7
Somewhat	5	33.3
Totals	**15**	**100**

Trained radiographers involved in basic adult trauma CXR image interpretation will shorten the waiting time for patients		
Great extent	12	80
Somewhat	3	20
Totals	**15**	**100**

4.3.11 Conclusion

In Chapter 4, the results relating to adult trauma CXR image interpretation skills of radiographers in the Copperbelt Province and the results relating to whether there is a need to involve radiographers in adult trauma CXR image interpretation are presented. A total of 27 radiographers – eight MOs and seven COs – participated in the study. Radiographers showed significant improvement in adult trauma CXR image interpretation after the intervention. The results from the questionnaire completed by MOs and COs revealed that 86.7% of the participating hospitals did not provide radiological reports. A total of 60% of the MOs and COs who participated in the study indicated that they faced challenges with adult trauma CXR image interpretation. The majority (93.3%) of the MOs and COs indicated that there was a need to involve radiographers in trauma CXR interpretation at their respective hospitals. The next chapter will present a discussion of the major findings from the data analysis of this study and their clinical implications.

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CHAPTER 5
DISCUSSION, LIMITATIONS, RECOMMENDATIONS AND CONCLUSION

5.1 INTRODUCTION

In Chapter 4, the results in relation to radiographers' adult trauma CXR image interpretation skills are presented. In this chapter, the results relating to whether there is a need to involve radiographers in adult trauma CXR image interpretation are presented. In this chapter, a brief overview of the study and how the objectives of the study were addressed are presented. Subsequently, the major findings from the data analysis of this study and clinical implications are discussed. In this chapter, the limitations and present recommendations of the study will also be discussed. The chapter will end with the contribution of the research and a conclusion.

5.2 OVERVIEW OF THE STUDY

This study was performed to determine the basic adult trauma CXR image interpretation skills of radiographers in the Copperbelt Province of Zambia. Radiographers and MOs and COs who met the inclusion criteria participated in this study. Radiographers participated in pre- and post-tests in CXR image interpretation to determine their skills in adult trauma CXR image interpretation. The intervention involved eight weeks of training of radiographers in adult trauma CXR image interpretation. MOs and COs completed a questionnaire to determine if they believed there was a need to involve radiographers in adult trauma CXR image interpretation. The researcher entered the results into Microsoft Excel spreadsheets. Data were grouped into categories for radiographers and MOs and COs. Statistical analysis was performed by a statistician using Statistical Analysis Software (SAS 9.2). A normality test was performed using analytical statistics, namely the Shapiro-Wilk test, to establish if there were significant differences between pre- and post-test results for adult trauma CXR image interpretation skills of the participating radiographers. The majority of the pre- and post-test score distributions did not follow a normal distribution. Therefore, the median and IQR were reported for all the variables, and the Wilcoxon sign-ranked test was used to compare and evaluate the differences between the pre- and post-test scores.

5.3 RESEARCH QUESTIONS AND OBJECTIVES OF THE RESEARCH STUDY

The main research question addressed in the study was: What are the basic adult trauma CXR image interpretation skills of radiographers in the Copperbelt Province of Zambia? Two subsidiary questions were formulated to inform the data collection for this study, namely;

- Is there a need to involve radiographers in basic adult trauma CXR image interpretation in the Copperbelt Province of Zambia?
- Is there a need for training programmes in Zambia to develop the CXR image interpretation skills of radiographers, so that they can assist with basic CXR image interpretation of adult trauma patients, considering the dire shortage of radiologists and the increasing number of trauma cases?

The objectives of the study addressed the research questions using a checklist for radiographers and a questionnaire for MOs and COs.

5.3.1 Objective 1: To determine the basic adult trauma CXR image interpretation skills of radiographers in the Copperbelt Province of Zambia

The objective was to determine the basic adult trauma CXR image interpretation skills of radiographers in the Copperbelt Province of Zambia. The results show that radiographers in the Copperbelt Province **possessed** basic adult trauma CXR image interpretation skills. The skills improved further after eight weeks of training in trauma CXR image interpretation. The findings are illustrated in Section 3.8.1 and Section 4.2. Section 3.8.1 explained the process, while Section 4.2 explained the results and displayed them in Tables; 4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 4.8 and 4.9. Objective 2: To determine if there is a need to involve radiographers in basic CXR image interpretation of adult trauma in the Copperbelt Province of Zambia.

5.3.2 Objective 2: to determine if there is a need to involve radiographers in basic adult trauma CXR image interpretation of adult trauma in the Copperbelt Province of Zambia.

The objective was to determine if there is a need to involve radiographers in basic adult trauma CXR image interpretation of adult trauma in the Copperbelt Province of Zambia. The results reveal that there is a need to involve radiographers in basic adult trauma CXR image interpretation in the Copperbelt Province. Section 4.3.9 and Section 3.8.2 explained the process that was used to determine if there was a need to involve radiographers in basic adult trauma CXR image interpretation. Results were explained in Section 4.3, and displayed in Tables 4.11, 4.12, 4.13 and 4.14 and Figures; 4.3 and 4.4.

5.3.3 Objective 3: To recommend developing and implementing a training programme to develop radiographers' skills in adult trauma CXR image interpretation, if indicated by this inquiry

The objective to recommend developing and implementing a training programme to develop radiographers' skills in adult trauma CXR image interpretation, if indicated by this inquiry, was achieved through the discussion of the results in Sections 5.3, 5.5 and 5.7.

5.4 DISCUSSION

The results of this study provide valuable data on CXR image interpretation by radiographers. The data is vital, and can be used in radiography professional development strategies in Zambia. This is especially needed if one considers the critical shortage of radiologists and the increasing demand for imaging services due to an increase in the Zambian population. This study profiles basic adult trauma CXR image interpretation skills for radiographers working in public hospitals in the Copperbelt Province of Zambia. The study also outlines the need to involve radiographers in CXR image interpretation.

5.4.1 Radiographers' skills in adult trauma CXR image interpretation

5.4.1.1 Radiographer demographics

Results show that the median years of work experience of the 27 radiographers was four, while the IQR range from 3 and 13. This shows that radiography staff at public hospitals in the Copperbelt Province of Zambia are relatively youthful, with the potential to progress professionally. The results also reveal that most radiographers (78%) had attained professional diplomas in diagnostic radiography, while 22% had attained professional degrees in diagnostic radiography. However, none of the radiographers had undergone postgraduate training in image interpretation.

The lack postgraduate of training for radiographers in image interpretation may be due to the training institutions in Zambia not offering postgraduate image interpretation courses (Bwanga, Sichone *et al*., 2021: 132). In countries such as Nigeria, Uganda and the UK, where postgraduate image interpretation courses are offered, radiographers have embraced the training (Bwanga, Sichone *et al*., 2021: 132; Society and College of Radiographers, 2021 online). Therefore, if postgraduate image interpretation training is introduced in Zambia, it may result in radiographers developing the required image interpretation skills. This relates to the background that radiographers in Zambia have expressed an eagerness to pursue advanced radiographic education and training, which will help them to adapt to current clinical needs (Munsanje, 2013: 180).

5.4.1.2 Radiographer skills before and after the intervention

The findings of the study are that radiographers working in public hospitals in the Copperbelt Province of Zambia possess the basic skills needed to interpret adult trauma CXR images to a comparable extent. This finding is indicated by the pre-test scores that indicate that adult trauma CXR interpretation has a median of 82.8%. The skills found significant improvement after eight weeks of training, resulting in a median score of 87.2% in the post-test (Section 4.2.4).

The results are comparable to similar studies conducted in South Africa and Nigeria to assess radiographers' CXR image interpretation performance. The study conducted in South Africa found radiographer sensitivity of 83% for their ability to identify abnormalities on CXR images (Gqweta & Naidoo, 2014: 11), while the study conducted in Nigeria found radiographer sensitivity to identifying abnormalities on CXR images of 84.1% and 93.6% for public and private hospitals respectively (Ekpe *et al.,* 2015: 5). In turn, a meta-analysis study conducted in 2005 in the UK found sensitivity of 92.9% for plain image reporting by trained radiographers in image interpretation, and 96.0% for untrained radiographers (Brealey *et al.,* 2005: 234).

The findings reveal, furthermore, that radiographers had basic adult trauma CXR image interpretation skills. The highest skills relating to trauma pathologies for circulation were for pneumoperitoneum, widened mediastinum and cardiomegaly. The median score for the pre-test in the circulation category is 82.2%, and this improved to 96.4% in the post-test. This was followed by trauma pathologies related to bones and soft tissue, including fractured ribs, fractured clavicle and a deviated trachea. The median score for the pre-test for the bone and soft tissue category was 71.4%, which improved to 96.6% in the post-test. The lowest sensitivity was for trauma pathologies related to the lungs, namely pneumothorax and haemothorax. The highest score in the lung fields' category for the pre-intervention test was 62.1%, and this improved to 82.8% in the post-intervention test. Radiographers found median scores of 75% pre-test and 96.4% post-test for interpreting normal CXR images. Radiographers demonstrated a negative improvement for one of the 20 CXR images that were used in the study. The median pre-test score is 100%, while the post-test score was 96.6%. The CXR image found rib fractures. This decrease in score from the pre- to the post-test may have been due to discolouration of the CXR image, since analogue film screen combination images were used in the study. However, the negative improvement was insignificant, and both pre- and post-test scores were above the gold standard score of 95% (Brealey, 2005: 234).

Comparing work experience and qualifications, the overall scores reveal that all the radiographers improved equally, with no significant differences, irrespective of their work experience or qualifications. Radiographers working at level 3 hospitals found the lowest median scores in the pre-test and the greatest improvement, compared to radiographers at level 2 and level 1 hospitals. Hence, the results confirm the importance of continuous education to improve image interpretation skills. These findings agreed with those of a study conducted to evaluate the accuracy of radiographers in plain musculoskeletal image interpretation (Smith *et al*., 2009 online). The study found that short-term, intensive continuing education programmes could improve radiographers' skills in image interpretation. Therefore, organisers of continuous professional development workshops for radiographers in Zambia need to include more image interpretation topics to improve and maintain their image interpretation skills (Gqweta & Naidoo, 2014: 16).

5.4.1.3 Postgraduate training and scope of practice for radiographers in Zambia

Postgraduate training is an important aspect of the involvement of radiographers in image interpretation. Radiography training involves introducing the basics of image interpretation (Hardy and Culpan, 2007: 65). However, basic knowledge does not satisfactorily prepare radiographers for either RADS or PCE (Neep et al*.,* 2014: 70). Thus, it is recommended that a radiographer who wants to become involved in image interpretation undergoes further education and training. Hence, the need for postgraduate image interpretation courses.

Currently, only two African universities offer image interpretation courses, namely the Cook Ultrasound Research Institute (ECUREI) in Uganda and Nnamdi Azikiwe University in Nigeria (Bwanga, Sichone *et al.,* 2021: 133). In contrast, the UK has 16 universities offering image interpretation courses (Society and College of Radiographers, 2021 online). This shows that successfully involving radiographers in image interpretation requires that they are trained. A survey conducted in 2021 reveals that radiographers in Zambia are ready and willing to be trained and be involved in image interpretation of general radiographic images to supplement the shortage of radiologists (Bwanga, Chanda *et al.*, 2021: 219). There are plans by the University of Zambia to establish postgraduate image interpretation courses (Bwanga, Chanda *et al.,* 2021: 219). The RSZ is working with stakeholders to extend the scope of radiographers working in Zambia (Bwanga, Chanda *et al.,* 2021: 219).

The involvement of radiographers in image interpretation will require changes to existing boundaries and the code of professional practice for radiographers. This is because radiographers' current scope of practice in Zambia is limited to performing radiographic examinations (HPCZ, 2009). There is a need for collaboration and consultation with key stakeholders at local and national levels to ensure that image interpretation is performed in accordance with legal, ethical, moral, social and economic frameworks (Australian Institute of Radiography, 2009:3). In the Zambian context, these frameworks refer to the RSZ engaging the Ministry of Health), Zambian radiologists, Zambia Medical Association and the HPCZ, who are the key stakeholders (Bwanga, Chanda *et al.,* 2021: 219).

5.4.2 The need to involve radiographers in image interpretation

5.4.2.1 Demographics for medical and clinical officers

A total of 15 MOs and COs participated in the study; 46.7% had diplomas as their highest qualification, 33.3% had degrees as their highest qualification, and 20% had a Master's as their highest qualification. The majority (60%) of the MOs and COs had work experience of 1–5 years. The results, therefore, reveal that the MOs and COs at the emergency departments at the selected hospitals were relatively inexperienced and needed support in adult trauma CXR image interpretation. The findings are similar to that of a study conducted in South Africa to explore methods used by general practitioners to interpret CXR radiographs in the city of Tswane (Sethole, Rudman and Hazell, 2020: 272). The study revealed that the general practitioners were not systematic utilising a systematic approach during image interpretation and demographics showed that the general practitioners in emergency departments were younger than 39 years and newly qualified in the three district hospitals involved in the study (Sethole *et al.*, 2020: 277). As stated by Safari *et al* (2014: 1), diagnostic accuracy depends on the MOs and COs' experience, and may be among the reasons why 60% of the MOs and COs in this study indicated that they experienced challenges in adult trauma CXR image interpretation (Section 4.3.6.3).

5.4.2.2 Radiology services available, challenges and the way forward

The MOs and COs indicated that they experienced challenges due to poor image quality, and to identify subtle injuries. At the time of the research study, only one hospital had a digital x-ray machine; seven of the selected hospitals had analogue film screen x-ray machines. Analogue screen film radiographic images are only provided in hard-copy format, with no provision for image manipulation. In addition, the images discolour over time if they are not adequately processed. Therefore, image quality challenges may be attributed to analogue screen film x-ray machines, among other reasons. A study by Sethole *et al.* (2020: 277) revealed that poor image quality can result in diagnostic errors. There is a need for public hospitals in the Copperbelt Province of Zambia to migrate from analogue screen film to digital x-ray machines. This would greatly improve the x-ray image quality and reduce x-ray image interpretation challenges (Safari *et al.*, 2014: 1).

Subtle injuries emerged as challenging in image interpretation faced by the MOs and COs. Twenty-two percent (22.2%) of the MOs and COs indicated that their hospitals did not have a system to address image interpretation challenges, while 33.3% were unsure if any system existed. Hospitals need to have clear guidelines for the interpretation of adult trauma chest imaging and associated challenges. This is because trauma CXR images are taken at critical times during emergencies and accurate image interpretation is essential (Bhimji, 2020 online). Similar to radiographers, MOs and COs need further image interpretation training, which builds on the basic image interpretation training they acquired during their undergraduate training (Hardy and Culpan, 2007: 65).

A total of 44.4% of MOs and COs indicated that their hospitals had systems in place to address trauma CXR image interpretation challenges. These systems involved discussing challenging CXR images with radiographers – this presented as the most common way of addressing image interpretation challenges. This is similar to the finding by van de Venter, du Rand and Grober (2017: 128), namely that the services of radiographers are used to assist with the reporting of trauma-related CXR images in after-hours trauma units. Only one participant indicated discussing the image with the consultant. Although the current scope of practice for radiographers is limited to performing radiographic examinations (HPCZ, 2009), radiographers are already involved in image interpretation through verbal discussions with MOs and COs.

The study also found that the vast majority (93.3%) of the MOs and COs indicated a need in their hospitals to involve radiographers in basic image interpretation. The reasons mentioned by the MOs and COs include bridging the gap in image interpretation, providing better quality images, providing more timely results for patients and better patient management. This was in keeping with the already established service benefits of the involvement of radiographers in image interpretation (Milner & Barlow, 2021: 82; Royal College of Radiologists, 2012: 15; Society and College of Radiographers, 2010:8; Williams, 2009:15; Thomas *et al*., 2004 online).

The benefits of involving Zambian radiographers in image interpretation cannot be overemphasised. Zambia is in need of more trained image interpreting radiographers than other countries, like the UK and Nigeria, where the involvement of radiographers in image interpretation is advanced and established. The situation in these countries, in terms of their economies, health care systems and number of radiologists, is more favourable than that of Zambia. Zambia is a middle-income country with high economic inequality, such that 58% of the population lives below the poverty line (World Population Review, 2021 online). Consequently, most Zambians are dependent on public sector health services, which currently faces a critical shortage of radiologists. There is also an increase in demand for imaging services, due to an increase in population and a steady increase in trauma cases (Bwanga, Chanda *et al*., 2021: 217; Ministry of Health, 2019; Zambia Police Service, 2021 online). Therefore, Zambia could benefit disproportionately from having image interpreting radiographers, compared to other countries where image interpretation by radiographers is well established.

5.5 LIMITATIONS OF THE STUDY

The luminance level of x-ray viewing boxes and ambient lighting levels in the reporting rooms could not be measured, because a calibrated Nuclear Associates precision photometer was not available. Additionally, no recommendations by the Radiation

Protection Authority of Zambia regarding luminance, lighting and uniformity of viewing boxes and ambient lighting could be found. Therefore, glare from the viewing boxes may influence image interpretation, given its configuration. However, the researcher worked with the heads of radiology departments and biomedical engineers at the hospitals selected for the study and ensured that the viewing boxes had been cleaned and fluorescent lamps checked for brightness and uniformity of light. Rooms that were used for trauma adult image interpretation were systematically prepared to optimise viewing conditions.

Not all radiographers were on duty during the research study, therefore, convenient sampling was used in this study.

The sample size for radiographers was 27 and 15 for COs and MOs because the study was conducted during the COVID-19 pandemic period. Therefore, members of staff of public hospitals were working according to rotational work arrangements to curb the spread of COVID-19. Therefore, the basic skills in adult trauma CXR image interpretation and the opinions regarding the need to involve radiographers in image interpretation provided by the radiographers may not represent the skills and opinions of all radiographers and MOs and COs at public hospitals of the Copperbelt Province of Zambia.

The time available for CXR interpretation sessions for pre- and post-test was 6 minutes for each CXR image. There was a break of only 5 minutes during the session, which could have caused fatigue and cognitive overload, since time was limited. However, the time was benchmarked by a similar study that was conducted in South Africa, which had a similar time for CXR interpretation session (Gqweta and Naidoo, 2014: 7). The lecture in CXR image interpretation lasted only 30 minutes due to time limitations on meetings during the COVID-19 pandemic. However, the researcher presented the lecture within 10 minutes and reserved the last 20 minutes for questions and discussion, in order to ensure that the radiographers understood the lecture.

The CXR images sent on WhatsApp® during the training could have been a limitation, due to the small display size of images on the participants' phones. However, a recent study conducted in South Africa reveals that the distribution of radiographic images via WhatsApp® was a reliable method that can be used with a high degree of confidence to aid clinical decision-making in emergencies (Ntja, Janse van Rensburg and Joubert, 2022). The study was conducted in the Copperbelt Province of Zambia and, therefore, findings only reflect the study radiographers' opinions in the specific region. In addition, data collection was done only at public hospitals; therefore, basic CXR image skills for radiographers and the opinions of MOs and COs regarding the involvement of radiographers in CXR image interpretation at private hospitals were not determined. However, radiology practices at the selected public hospitals were similar to other hospitals of the same level throughout the country.

5.6 RECOMMENDATIONS

- Radiographers should be empowered and supported to extend their roles by revising their current scope of practice.
- Radiographers who are interested in image interpretation and reporting should embrace postgraduate training in image interpretation and reporting, to standardise their education and practice.
- Radiography training institutions in Zambia should introduce postgraduate image interpretation courses to ensure successful implementation of radiographers' involvement in image implementation.
- Similar studies in the future should include a larger population consisting of radiographers from public and private hospitals.
- Future studies are recommended to explore radiographers' skills in musculoskeletal projectional radiography interpretation.

5.7 CONTRIBUTION OF THE STUDY

At the time of the study, there were no published research studies on radiographers' trauma CXR image interpretation skills in Zambia. This study reveals the basic skills of Zambian radiographers in adult trauma CXR image interpretation. The findings of this study can be helpful in discussions with stakeholders regarding revising radiographers' current scope of practice in Zambia. The results can also be useful for curriculum development of postgraduate courses in CXR image interpretation. Revision of radiographers' current scope of practice, their postgraduate training, and their involvement in image interpretation will improve radiological services. This will, in turn, improve health service delivery in Zambia.

5.8 CONCLUSION

This study demonstrates that radiographers working in public hospitals in the Copperbelt Province of Zambia have basic adult trauma CXR image interpretation skills. The study also confirms a need to involve radiographers in basic CXR image interpretation of adult trauma in the Copperbelt Province of Zambia. The involvement of radiographers in image interpretation demands an extension of the scope of practice of radiographers in Zambia, and postgraduate training courses.

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APPENDIX A

APPLICATION FOR A CLEARANCE CERTIFICATE FROM THE HEALTH SCIENCES RESEARCH ETHICS COMMITTEE OF THE FACULTY OF HEALTH SCIENCES, UNIVERSITY OF THE FREE STATE

Central University of Technology, Free State

Arthur Davison Children's Hospital,
P.O. Box 240227,
Ndola,
Zambia.
30th April 2020

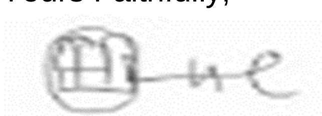
The Chair: Health Sciences Research Ethics Committee,
Dr LS Le Grange
For attention: Mrs. M. Marais
Block D, room 104,
Francois Retief Building,
P.O. Box 339 (G40),
Nelson Mandela Drive,
Faculty of Health Sciences,
University of Free State
Bloemfontein
9300

Best Dr L.S. Le Grange

PROJECT TITLE: **BASIC CHEST IMAGING IN ADULT TRAUMA PATIENTS: INTERPRETATION SKILLS OF RADIOGRAPHERS IN THE COPPERBELT PROVINCE OF ZAMBIA**

Enclosed please find the above research protocol for your evaluation and approval. Please note that the most recent literature available has been utilised on this specific topic. The proposal has been verified through SafeAssign submission (available on request).

Yours Faithfully,



Ms. Ethel Chilambe
Email address: mwenyajere@gmail.com
Cell phone nr: +260 950 941 993

APPENDIX B

APPLICATION FOR CLEARANCE CERTIFICATE FROM THE TROPICAL DISEASES RESEARCH CENTER

Arthur Davison Children's Hospital
P.O. BOX 240227
Ndola
30th April 2020

The Executive Director,
Tropical Diseases Research Centre
Private bag
Ndola.

Dear Sir,

PROJECT TITLE: **BASIC CHEST IMAGING IN ADULT TRAUMA PATIENTS: INTERPRETATION SKILLS OF RADIOGRAPHERS IN THE COPPERBELT PROVINCE OF ZAMBIA**

I am a student at the Central University of Technology, South Africa and currently working at Arthur Davison Children's Hospital as a senior radiographer.

I wish to conduct research in the Copperbelt Province of Zambia. The research is a project for complying with the requirements for a master's in Radiography.

Enclosed, please find the above research protocol for your evaluation and approval. Also enclosed are; an ethical approval letter from the Health Sciences Research Ethics Committee (HSREC), University of Free State and an introduction from the Head of Department Faculty of Health and Environmental Sciences, Central University of Technology.

Yours Faithfully,

Ethel Chilambe
Email address mwenyajere@gmail.com
Cell Phone nr +260 950 941 993

APPENDIX C

APPLICATION TO CONDUCT RESEARCH FROM THE COPPERBELT HEALTH PROVINCIAL OFFICE

Arthur Davison Children's Hospital
P.O. BOX 240227
Ndola
9th June 2020

The Provincial Health Director,
Copperbelt Provincial Health Office,
P.O Box 70032
Ndola
Zambia

Dear Sir,

RE: REQUEST TO CONDUCT RESEARCH IN THE COPPERBELT PROVINCE

The captioned matter refers. I am a student at the Central University of Technology, South Africa, working at Arthur Davison Children's Hospital as a senior radiographer.

I wish to conduct a research study, which is a project for complying with the requirements for a master's in Radiography. The title of the study is "**Basic chest imaging in adult trauma patients: interpretation skills of radiographers in the Copperbelt Province of Zambia".** The study aims to determine the basic adult trauma CXR image interpretation skills of radiographers in the Copperbelt Province of Zambia. The selected hospitals for the study include; Ndola Teaching Hospital, Kitwe Teaching Hospital, Roan General Hospital, Luanshya District Hospital, Ronald Ross General Hospital, Kalulushi General Hospital, Kalulushi District Hospital and Nchanga North General Hospital.

Please find attached an introductory letter from my school and ethics approval from the Tropical Diseases Research Centre (TDRC).

Yours Faithfully,

Ethel Chilambe
Email address mwenyajere@gmail.com
Cell Phone nr +260 950 941 993

APPENDIX D

INFORMATION DOCUMENT FOR PARTICIPATING RADIOGRAPHERS

Dear Sir/Madam,

I, Ethel Chilambe, am currently a Master's student in Radiography at the Central University of Technology, Bloemfontein, South Africa. I am investigating the **"basic chest imaging in adult trauma patients: interpretation skills of radiographers in the Copperbelt Province of Zambia."** The study aims to determine the basic adult trauma CXR image interpretation skills of radiographers in the Copperbelt Province of Zambia**.** To achieve the aim of the study, the following objectives were formulated:

- To determine the basic adult trauma CXR image interpretation skills of radiographers in the Copperbelt Province of Zambia (to answer the main research question and to achieve the aim of the study).
- To determine if there are need to involve radiographers in basic CXR image interpretation of adult trauma in the Copperbelt Province of Zambia (to answer subsidiary question-bullet 1).
- To recommend the development and implementation of a training programme to develop radiographers' skills in CXR image interpretation of adult trauma if indicated by this enquiry.

Invitation to participate: We are inviting you to participate in this research study to assist us in determining the basic CXR image interpretation skills of radiographers in adult trauma in the Copperbelt Province of Zambia.

The results of the study will reveal the basic adult trauma CXR image interpretation skills of radiographers in the Copperbelt Province of Zambia at a graduate level and during work experience after graduating. The found skills may be helpful in the curriculum development of the postgraduate training programme for adult CXR image interpretation in Zambia. The study will also show if there is a need to involve radiographers in basic adult trauma CXR image interpretation. This may help to map the way forward for radiographer role development in Zambia.

Risks and foreseeable discomfort for the patient/subject *(if applicable):*

There are no risks or discomfort for anyone participating in this study.

You may withdraw from the study at any time.

Kindly note that **participation is voluntary** and that you may withdraw from the study at any time.

No costs are payable by you to participate in the study; neither will you be **remunerated** for your participation.

The **expected time** you will require to participate in this study are approximately two hours for the pre-test, 30 minutes for the lecture in basic CXR image interpretation, two hours for the post-test and 45 minutes for each of the - 8 weeks for the intervention. During the eight weeks intervention phase, one CXR image with trauma-related pathology are posted each week for review and discussion by all the radiographers in the WhatsApp® group. Therefore, the total number of CXR images that are used for this training is eight. Review and discussion of each image are estimated to take about 45 minutes and data to download each image is estimated to cost not more than K 1 (equivalent to R 1).

All efforts are made to keep personal information **confidentia**l to ensure **anonymity**;

1. Due to the nature of the study, the researcher and consenting radiographers are required to communicate via WhatsApp®.
2. The researcher will add the names of the consenting radiographers as Participant 1, Participant 2 etc. but cannot guarantee the anonymity of each participant among radiographers due to the mechanical working of the WhatsApp® application.
3. The results of the WhatsApp® discussions will however be reported anonymously.

The **results** from the study may be **presented** at seminars/conferences related to the research and/or **published** in an applicable journal.

If you have any questions or queries, you are welcome to contact the researcher Ms Ethel Chilambe at:

Cell : +260 950 941993

WhatsApp® : +260 950 941993

Email : mwenyajere@gmail.com

Alternatively, you may contact the secretariat of the Health Sciences Research Ethics Committee at the University of the Free State. **Secretariat and Chair: Ethics Committee of the Faculty of Health Sciences, University of the Free State –** for reporting of complaints/problems: Telephone number 051 4017795.

13th April, 2020

Signature Date

APPENDIX E

INFORMATION DOCUMENT FOR MEDICAL AND CLINICAL OFFICERS

Dear Sir/Madam,

I, Ethel Chilambe, am currently a Master's student in Radiography at the Central University of Technology, Bloemfontein, South Africa. I am conducting an investigation titled, "basic chest imaging in adult trauma patients: interpretation skills of radiographers in the Copperbelt Province of Zambia." The study aims to determine the basic adult trauma CXR image interpretation skills of radiographers in the Copperbelt Province of Zambia. To achieve the aim of the study, the following objectives were formulated:

To determine the basic CXR image interpretation skills in adult trauma of radiographers in the Copperbelt Province of Zambia (to answer the main research question and to achieve the aim of the study).

To determine if there are need to involve radiographers in basic adult trauma CXR image interpretation in the Copperbelt Province of Zambia (to answer the subsidiary question).

To recommend the development and implementation of a training programme to develop radiographers' skills in CXR image interpretation of adult trauma if indicated by this enquiry.

Invitation to participate: We are inviting you to participate in this research study to assist us in determining the basic determine the basic CXR image interpretation skills of radiographers in adult trauma in the Copperbelt Province of Zambia.

The results of the study will help determine whether radiographers have the skills to get involved in basic CXR image interpretation of adult trauma. In addition, the study will also inquire if there is a need to involve radiographers in adult CXR image interpretation of adult trauma in the context of the Zambian situation.

Risks and foreseeable discomfort for the patient/subject (if applicable):

There are no risks or discomfort for anyone participating in this study.

You may withdraw from the study at any time.

Kindly note that participation is voluntary and that you may withdraw from the study at any time.

No costs are payable by you to participate in the study; neither will you be remunerated for your participation.

The expected time you will require to participate in this study are 60 minutes.

All efforts are made to keep personal information confidential to ensure anonymity;

The results from the study may be presented at seminars/conferences related to the research and/or published in an applicable journal.

If you have any questions or queries, you are welcome to contact the researcher Ms Ethel Chilambe at:

Cell : +260 950 941993

WhatsApp® : +260 950 941993

Email : mwenyajere@gmail.com

Alternatively, you may contact the secretariat of the Health Sciences Research Ethics Committee at the University of the Free State. Secretariat and Chair: Ethics Committee of the Faculty of Health Sciences, University of the Free State – for reporting of complaints/problems: Telephone number 051 4017795.

13th April, 2020

Signature Date

APPENDIX F

CONSENT TO PARTICIPATE IN RESEARCH

PROJECT TITLE: BASIC CHEST IMAGING IN ADULT TRAUMA PATIENTS: INTERPRETATION SKILLS OF RADIOGRAPHERS IN THE COPPERBELT PROVINCE OF ZAMBIA

You have been asked to participate in a research study and you have studied the information letter about this study.

Kindly note that your participation in this research is voluntary, and you will not be penalised or lose benefits if you refuse to participate or decide to terminate participation.

If you agree to participate, you are given a signed copy of this document as well as the information letter, which is a written summary of the research.

If you have any questions or queries, you are welcome to contact the researcher MS Ethel Chilambe at:

Cell : +260 950 941 993

WhatsApp® : +260 950 941 993

Email : mwenyajere@gmail.com

Alternatively, you may contact the secretariat of the Health Sciences Research Ethics Committee at the University of the Free State. Secretariat and Chair: Ethics Committee of the Faculty of Health Sciences, University of the Free State – for reporting of complaints/problems: Telephone number 051 4017795.

The research study, including the above information, has been verbally described to me. I understand what my involvement in the study means and I voluntarily agree to participate.

__ _ _______________ 13th April, 2020

Signature of researcher Date

Participant’s Demographics and signature

Highest qualification (Diploma, Degree, Masters, PHD etc.)

____

Work experience (Years or months)

____

Level of hospital currently working from (Primary, Secondary or referral)

____

__________________ ....

Signature of participant Date

APPENDIX G

GROUND RULES FOR THE WHATSAPP® GROUP

Dear Radiography Colleagues,

Thank you for your willingness to participate in the study: “Basic chest imaging in adult trauma patients: interpretation skills of radiographers in the Copperbelt Province of Zambia”.

The aim of this WhatsApp® group is solely y for discussions of trauma chest x-ray (CXR) images. We will post one selected adult trauma CXR image at the beginning (Monday by 10 o’clock) of each week for 8 weeks. All radiographers will discuss the posted CXR at their convenience within the week using ABCDEF systematic approach. Discussions can either be typed, or a short comment can be recorded via voice note. A radiological report for each of the CXR images are posted at the end of each week (Friday at 15 o’clock).

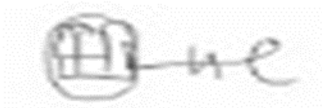
All members of this group are radiographers for the study. The supervisor and co-supervisor will act as observers in the group and not participate in the discussions.

GROUND RULES FOR THE WHATSAPP® GROUP

- Every member of this group must kindly adhere to the following:
- Keep to the purpose of the group. Please do not share any other information except the above mentioned.
- The CXR images are solely for research purposes and may not be copied or shared with a third party.
- Keep to the discussion of the CXR image for that specific week. We encourage active participation and welcome constructive feedback in the case you should differ from a colleague.
- Try to limit discussions to office hours. You are welcome to mute the notifications for the group after hours.
- To stay abreast of the discussions, check colleagues’ comments regularly.
- For any queries, kindly contact the administrator privately, for any concerns to be addressed.

All the best as we take up the journey of trauma CXR image interpretation.

With appreciation



Ethel Chilambe

Researcher

Contact details:

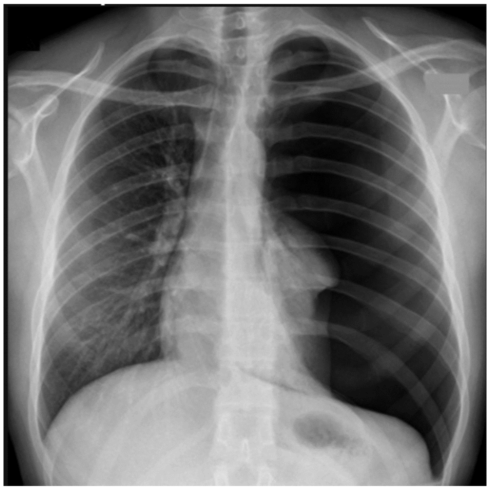
Cell: +260950 941 993

Email: mwenyajere@gmail.com

APPENDIX H

TRAUMA CXR IMAGES WITH RADIOLOGICAL REPORTS

Week one



Reference report

Left lung is completely compressed.

Reduced right lung volume.

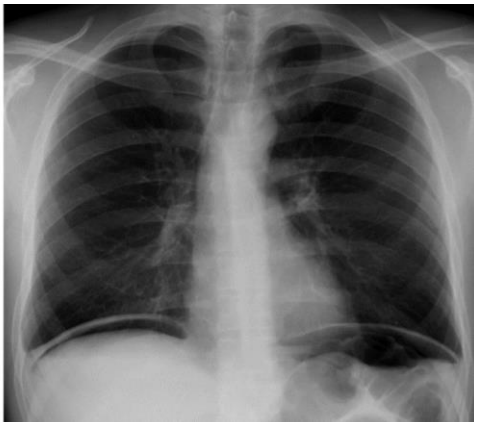
Mediastinal and trachea shift to the contralateral side.

Heart is shifted to the contralateral side.

Image 1: CXR image showing tension pneumothorax

Radiology Masterclass www.radiologymasterclass.co.uk(Lloyd-Jones: 2020online)

Week two



Reference report

Lungs are normal

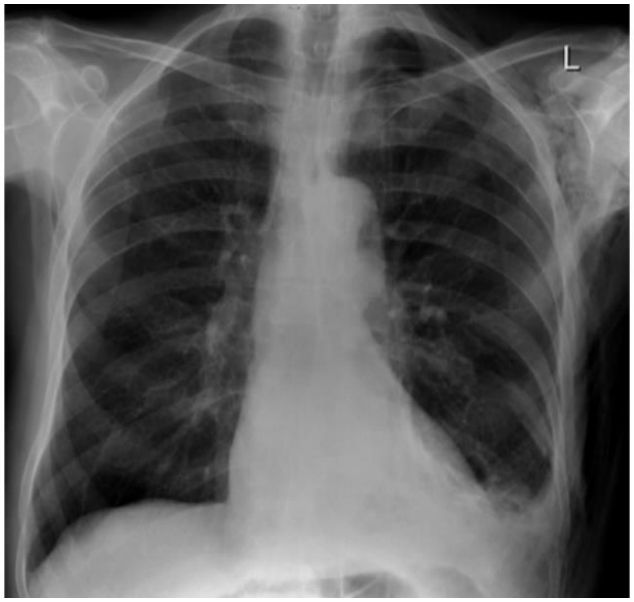
Diaphragm is crisply defined on both sides

Black air seen on both sides of the bowel wall (double wall or Rigler's sign)

Image 2: CXR image showing pneumoperitoneum

Radiology Masterclass www.radiologymasterclass.co.uk(Lloyd-Jones: 2020online

Week three

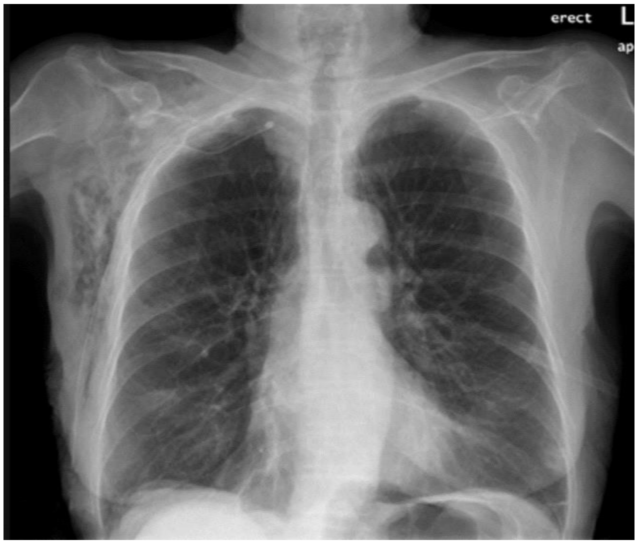


Reference report
Pneumothorax in the upper left lung.
Surgical emphysema in soft tissue-left side.
Fractured left 8th posterior rib.
Heamothorax in the left lung.

Image 3: CXR image showing rib fractures with haemothorax

Radiology Masterclass www.radiologymasterclass.co.uk (Lloyd-Jones: 2020 online)

Week four



Surgical emphysema right thorax.

Heamothorax- upper right lung.

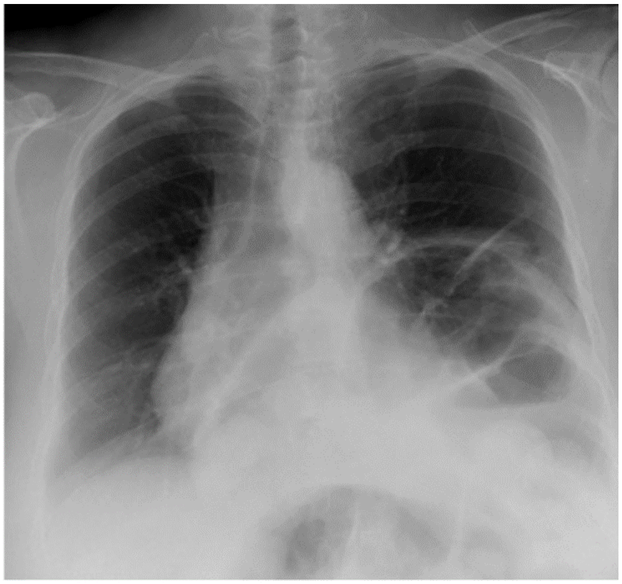
Chest drain in upper right lung.

Oxygen tubing running from the neck on the right lung.

Image 4: CXR image showing drain/surgical emphysema

Radiology Masterclass www.radiologymasterclass.co.uk (Lloyd-Jones: 2020online)

Week five

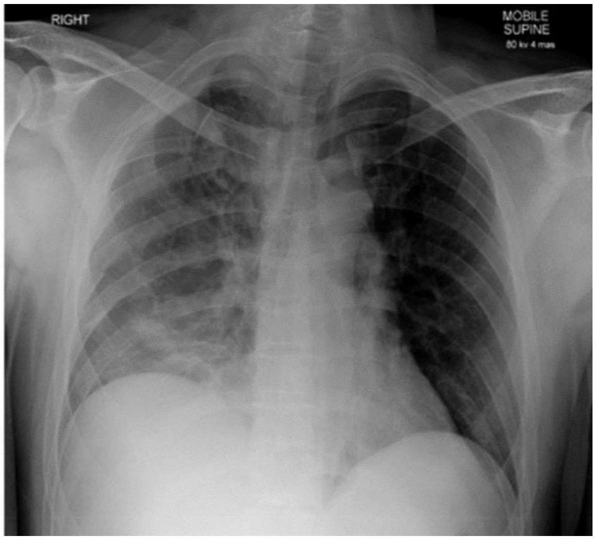


Reference report
Bowel with gas, in the lower half of the left hemidiaphragm.
Mediastinum displaced to the right.
Left hemidiaphragm not visible.

Image 5: CXR image showing diaphragmatic rupture

Radiology Masterclass www.radiologymasterclass.co.uk (Lloyd-Jones: 2020online)

Week six



Reference report

Image rotation.

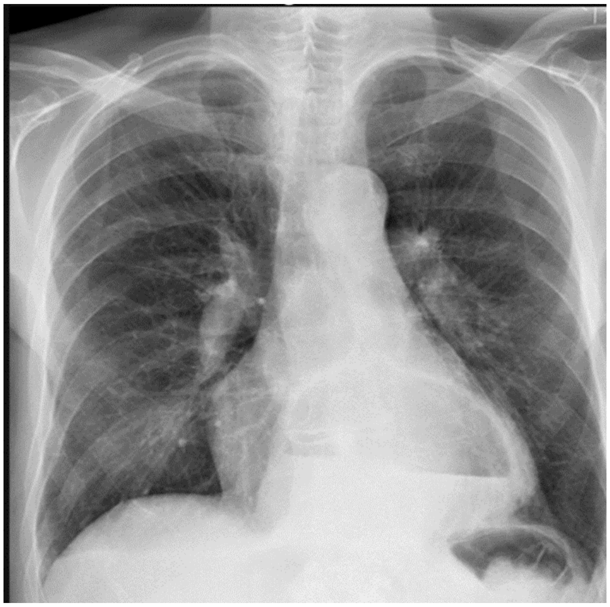
Lung contusion noted.

Fractured 3rd, 4th, 5th and 6th right posterior ribs.

Image 6: CXR image showing multiple acute rib fractures

Radiology Masterclass www.radiologymasterclass.co.uk (Lloyd-Jones: 2020online)

Week seven



Reference report

Air fluid level superimposed on the cardiac shadow.

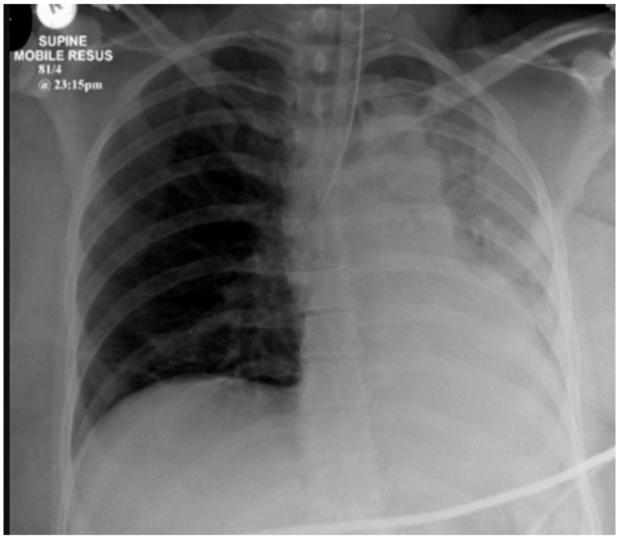
Loop of bowel herniation.

Normal diaphragm-left and right hemidiaphragms.

Image 7: CXR image showing hiatus hernia- large

Radiology Masterclass www.radiologymasterclass.co.uk (Lloyd-Jones: 2020online)

Week eight



Reference report

Endotracheal tube placed in the right main bronchus.

Left lung collapse

Air bronchogram in the left lung due to under-ventilation

Mediastinal shift to the left side

Image 8: CXR image showing misplaced endotracheal tube

Radiology Masterclass www.radiologymasterclass.co.uk (Lloyd-Jones: 2020online)

APPENDIX I

CHECKLIST FOR RADIOGRAPHERS IN BASIC ADULT TRAUMA CXR IMAGE INTERPRETATION SKILLS

CHECKLIST FOR RADIOGRAPHERS IN BASIC ADULT TRAUMA CXR IMAGE INTERPRETATION SKILLS.				
Kindly complete by selecting the correct option, with 'X', for the statement when assessing the postero-anterior (PA) chest radiograph.				**Questionnaire unique number:**
IMAGE UNIQUE NUMBER:				
	Example: The Earth is round	Yes **(X)**	No	Not sure
Section A: Image quality				
1	Is there a correct Lead marker (L or R) present?	Yes	No	Not sure
2	Does the image display all the important anatomical structures of an adult chest?	Yes	No	Not sure
3	What was the position of the patient?	Erect		
		Supine		
		Decubitus		
4	Is there any rotation of the image?	Yes	No	Not sure

5	Kindly state the reason for your answer to **question 4**.			
6	Is the exposure for assessing all-important structures adequate?	Yes	No	Not sure
7	Kindly state the reason for your answer to **question 6.**			
8	Is the degree of inspiration sufficient?	Yes	No	Not sure
9	Kindly state the reason for your answer to **question 8.**			
Section B: Signs indicative of pathology				
10	**A-Airway**			
a	Does the trachea appear centrally without any displacement?	Yes	No	Not sure
b	If '**No'**, briefly indicate the observed abnormality/ies.			
11	**B-Bony structures**			

a	Do the bony structures of the thorax show fractures or abnormalities?	Yes	No	Not sure
b	If '**<u>Yes</u>**' briefly indicate the observed abnormality/ies.			
12	**B-Soft tissue**			
a	Does the soft tissue of the thorax appear normal?	Yes	No	Not sure
b	If '**<u>No</u>**', please indicate the observed abnormality/ies			
13	**C-Cardiac**			
a	Does the cardiac (heart) appear normal?			

Cardiac	**Yes**	**No**	**Not sure**
Position			
Size			
Shape			

b	If '**<u>No</u>**' briefly indicate the observed abnormality/ies
14	**C- Hila**
a	Do both hila appear normal?

Hila	**Yes**	**No**	**Not sure**
Right hilum			
Left hilum			

b	If '**No**' briefly indicate the observed abnormality/ies			
15	**C-Mediastinum**			
a	Does the mediastinum appear normal?	Yes	No	Not sure
b	If '**No**' briefly indicate the observed abnormality/ies			
16	**D-Diaphragms**			

a	Do the right- and left diaphragms and the area below the diaphragm appears normal?				
	Diaphragm	**Yes**	**No**	**Not sure**	
	Right hemidiaphragm				
	Left hemidiaphragm				
b	If '**<u>No</u>**' briefly indicate the observed abnormality/ies.				
c	Is the gastric bubble shown?	Yes	No	Not sure	
d	If '**<u>Yes</u>**', kindly indicate the side for the gastric bubble.				
17	**E-Everything else**				
a	Are there other objects in the image such as pulmonary tubes/catheters?				
		Yes	No	Not sure	
b	If '**Yes**', are they correctly placed.				
		Yes	No	Not sure	

c	If your answer to 17 b is '**Yes**', kindly give a brief description of the correct placement of pulmonary tubes/catheters.
d	If your answer to 17 b is '**No**', kindly give a brief description incorrect placement of pulmonary tubes/catheters
18	**F- Lung fields**
a	Do the lung fields appear normal?
b	If '**No**', kindly indicate the affected zones.

Lungs	**Yes**	**No**	**Not sure**
Right lung			
Left lung			

Right Lung	**Left Lung**
Upper zone	Upper zone
Middle zone	Middle zone
Lower zone	Lower zone

<table>
<tr><td>19</td><td>F- Costo-phrenic angles</td></tr>
<tr><td>a</td><td>Do the Costo-phrenic angles appear normal?
<table>
<tr><th>Costo-phrenic angles</th><th>Yes</th><th>No</th><th>Not sure</th></tr>
<tr><td>Right Costo-phrenic angle</td><td></td><td></td><td></td></tr>
<tr><td>Left Costo-phrenic angle</td><td></td><td></td><td></td></tr>
</table></td></tr>
<tr><td>b</td><td>If ‘<u>No</u>’, briefly describe the observed abnormality/ies.</td></tr>
<tr><td>20a</td><td>Kindly state whether the image was normal or abnormal.
<table>
<tr><td></td><td>Normal</td></tr>
<tr><td></td><td>Abnormal</td></tr>
</table></td></tr>
<tr><td>b</td><td>In summary, briefly indicate the location of the abnormality/ies if your answer to question 20a is ‘<u>abnormal</u>’.</td></tr>
</table>

c	**Kindly give your impression of the observed abnormality**.
Thank you for your time to complete this questionnaire. Your participation is highly appreciated.	

APPENDIX J

QUESTIONNAIRE TO THE MEDICAL- AND CLINICAL OFFICERS

QUESTIONNAIRE TO MEDICAL –AND CLINICAL OFFICERS		
***Kindly complete the questionnaire by marking your answer with ' X' or by elaborating on your answer in the space provided*.**		
SECTION A: Demographics of the radiographers		
1	**Please indicate your employment status at your current institution**	
	Clinical officer	
	Medical officer	
2	**Please indicate your highest qualifications**	
	Diploma	
	Degree	
	Master's	
	PHD	
	Others (kindly specify)	
3	**How long have you been working as a medical doctor or clinical officer?**	

	__years______	
4	**Please indicate the level of the institution where you are employed:**	
	Level 1	
	Level 2	
	Level 3	
SECTION B: Available Radiology Services		
5	**Is there a radiologist at the radiology department of the institution where you are working as a medical officer or clinical officer?**	
	Yes	
	No	
6	**Are reports issued for adult trauma chest x-ray examinations?**	
	Yes	
	No	
	Sometimes	
7	**If 'Yes' to question 6, who reports adult trauma CXR images by selecting one of the options below? (you may select more than one)**	
	Radiologists	

	Medical officers	
	Clinical officers	
	Others (Please specify)	
8	**If 'No' to question 6, do you experience challenges with the interpretation of adult trauma CXR images at your institution?**	
	Yes	
	No	
	Sometimes	
9	**If you have selected 'Yes' or 'Sometimes' in question 8, kindly indicate the challenges you experience with the interpretation of adult trauma CXR images:**	
10	**Are radiographers involved in trauma adult CXR image interpretation?**	
	Yes	
	No	
11	**If 'yes' to question 10, please indicate the method of CXR image interpretation radiographers is involved in.**	

	Red dot system	
	Preliminary clinical evaluation	
	Reporting	
	Others (please specify)	
12	**How long do patients have to wait to receive a report on chest imaging examination?**	
	Less than 30 minutes	
	Between 30 min and an hour	
	Between 1 and 2 hours	
	1 day	
	1 week	
	Others (kindly specify)	
13	**If your answer to 'Yes' to question 8, is there a system or systems in place to assist you in cases where you face challenges with the interpretation of CXR images?**	

	Yes	
	No	
14	**If you have selected 'Yes' in question 13, kindly indicate what system/s is in place to assist you.**	
15	**Is there a need to involve radiographers in adult trauma CXR image interpretation at the hospital where you are currently working?**	
	Yes	
	No	
16	**Kindly comment on your selection in question 15**	

17 Please indicate the level of effect you think trained radiographers involved in basic CXR image interpretation of adult trauma patients may have.	**To a great extent**	**Some-what**	**Very Little**	**Not at all**
17.1 Trained radiographers involved in basic adult trauma CXR image interpretation **will reduce incidences of missed fractures/pathology**				

17.2 Trained radiographers involved in basic adult trauma CXR image interpretation will **decrease work on the MOs and COs' workload in the emergency department.**				
17.3 Trained radiographers involved in basic adult trauma CXR image interpretation will **shorten the waiting time for the patients**.				
Others (Kindly specify)				

APPENDIX K

APPROVAL LETTER FROM THE STATISTICIAN

Central University of Technology, Free State

Maryn Viljoen
Statistics Consulting Services

maryn.viljoen@vodamail.co.za
082 823 5731

Protocol and research methodology consultation • Ethical consultation • Database construction and capturing of data
Analyzing data using statistical software packages (SAS Version 9.1.3) • Statistics consultation services to analyze and interpret data
Conveys results with statistical tables and figures where needed

The Chairperson: Health Sciences Research Ethics Committee (HSREC)
For Attention: Mrs. M.G.E. Marais
Block D, Room 104
Francois Retief Building
Faculty of Health Sciences
University of the Free State

11 November 2019

Title: "**BASIC CHEST IMAGING IN ADULT TRAUMA PATIENTS: INTERPRETATION SKILLS OF RADIOGRAPHERS IN THE COPPERBELT PROVINCE OF ZAMBIA**."

Researcher:
Ethel Chilambe (Student number: 212002503)
M Rad (Diagnostic)
Department of Clinical Sciences
Faculty of Health and Environmental Sciences
Central University of Technology, Free State

I have seen and read through this protocol. I gave input and recommendations and are the biostatistician responsible for the analysis of the data.

Maryn Viljoen
M.Sc. Risk Analysis (UFS) maryn.viljoen1@gmail.com
082 82 35 731

APPENDIX L

LETTER FROM DR STRUWIG CONFIRMING LANGUAGE EDITING OF STUDY TITLE

Confirmation of Language Editing

To whom it may concern

I hereby declare that I have performed the language editing of the following:

Student: Ethel Chilambe

Student number: 212002503

Master of Radiography title: Basic chest imaging interpretation skills of radiographers in the Copperbelt Province of Zambia

____

Dr. Daleen Struwig

BSc, BSc (Hons), MMedSc, PhD

Member of the European Medical Writers Association (EMWA)

Member ID: 19039

Date: 15 January 2020

16 Harrismith Street, Dan Pienaar, Bloemfontein

Telephone: +27 82 562 8461

Email address: daleenstruwig@gmail.com

APPENDIX M

LETTER CONFIRMING LANGUAGE EDITING OF DISSERTATION

Declaration

2 June 2022

PO Box 4
Otjiwarongo
Namibia
+264 813359120
hettie.human@gmail.com

Dissertation: Basic chest imaging in adult trauma patients: Interpretation skills of radiographers in the Copperbelt Province of Zambia

Student: Ethel Chilambe

I confirm that I edited the dissertation, checked the reference list, and recommended changes to the text.

H Human

MA Language Practice

Hettie Human
WRITER | EDITOR | TRANSLATOR | INTERPRETER
+264 813 359 120 | hettie.human@gmail.com

Central University of Technology, Free State

APPENDIX N

CLEARANCE CERTIFICATE FROM THE HEALTH SCIENCES RESEARCH ETHICS COMMITTEE FACULTY OF HEALTH SCIENCES

Central University of Technology, Free State

UNIVERSITY OF THE FREE STATE
UNIVERSITEIT VAN DIE VRYSTAAT
YUNIVESITHI YA FREISTATA

UFS·UV
HEALTH SCIENCES
GESONDHEIDSWETENSKAPPE

Health Sciences Research Ethics Committee

06-Jul-2020

Dear **Miss Ethel Chilambe**

Ethics Clearance: **BASIC CHEST IMAGING IN ADULT TRAUMA PATIENTS: INTERPRETATION SKILLS OF RADIOGRAPHERS IN THE COPPERBELT PROVINCE OF ZAMBIA**

Principal Investigator: **Miss Ethel Chilambe**

Department: **CUT - Central University of Technology**

APPLICATION APPROVED

Please ensure that you read the whole document

With reference to your application for ethical clearance with the Faculty of Health Sciences, I am pleased to inform you on behalf of the Health Sciences Research Ethics Committee that you have been granted ethical clearance for your project.

Your ethical clearance number, to be used in all correspondence is:**UFS-HSD2020/0670/2807**

The ethical clearance number is valid for research conducted for one year from issuance. Should you require more time to complete this research, please apply for an extension.

We request that any changes that may take place during the course of your research project be submitted to the HSREC for approval to ensure we are kept up to date with your progress and any ethical implications that may arise. This includes any serious adverse events and/or termination of the study.

A progress report should be submitted within one year of approval, and annually for long term studies. A final report should be submitted at the completion of the study.

The HSREC functions in compliance with, but not limited to, the following documents and guidelines: The SA National Health Act. No. 61 of 2003; Ethics in Health Research: Principles, Structures and Processes (2015); SA GCP(2006); Declaration of Helsinki; The Belmont Report; The US Office of Human Research Protections 45 CFR 461 (for non-exempt research with human participants conducted or supported by the US Department of Health and Human Services- (HHS), 21 CFR 50, 21 CFR 56; CIOMS; ICH-GCP-E6 Sections 1-4; The International Conference on Harmonization and Technical Requirements for Registration of Pharmaceuticals for Human Use (ICH Tripartite), Guidelines of the SA Medicines Control Council as well as Laws and Regulations with regard to the Control of Medicines, Constitution of the HSREC of the Faculty of Health Sciences.

For any questions or concerns, please feel free to contact HSREC Administration: 051-4017794/5 or email EthicsFHS@ufs.ac.za.

Thank you for submitting this proposal for ethical clearance and we wish you every success with your research.

Yours Sincerely

Dr. SM Le Grange
Chair : Health Sciences Research Ethics Committee

Health Sciences Research Ethics Committee
Office of the Dean: Health Sciences
T: +27 (0)51 401 7795/7794 | E: ethicsfhs@ufs.ac.za
IRB 00011992; REC 230408-011; IORG 0010096; FWA 00027947
Block D, Dean's Division, Room D104 | P.O. Box/Posbus 339 (Internal Post Box G40) | Bloemfontein 9300 | South Africa

www.ufs.ac.za

APPENDIX O

APPROVAL LETTER FROM TROPICAL DISEASES RESEARCH CENTER

TROPICAL DISEASES RESEARCH CENTRE
Tel/Fax +260212 615444
P O Box 71769
tdrc-ethics@gmail.comzm
NDOLA, ZAMBIA

TDRC ETHICS REVIEW COMMITTEE
IRB REGISTRATION NUMBER : 00002911
FWA NUMBER : 00003729

TRC/C4/06/2020

8th June, 2020

Ethel Chilambe
SIN 212002503
CBU – School of Medicine
NDOLA

Dear Ethel,

RE: ETHICAL APPROVAL OF STUDY PROTOCOL

Reference is made to your request for approval the protocol entitled **"Basic Chest Imaging in Adult Trauma Patients: Interpretation Skills of Radiographers in the Copperbelt Province.**

On behalf of the Chairperson of the TDRC Ethics Review Committee (ERC), I wish to inform you that the Committee reviewed your protocol and noted that it adhered to key aspects of research ethics. Therefore, I wish to inform you that ethical approval has been granted based on the following conditions.

Under ethical consideration and in the Information Sheet, ensure that you state if there will be any benefits, risks, and compensation for taking part in the study. Further, explain how will confidentiality will be ensured and how the Informed consent be administered.

You are now required to submit your protocol to the National Health Research Authority for final approval following the link: **https://www.nhra.org.zm**. A final report must be submitted to the Ethics Review Committee at the end of the study.

This approval is valid for the period **8th June, 2020** to **8th June, 2021**

The Committee wishes you success in the execution of the study.

Yours faithfully
TROPICAL DISEASES RESEARCH CENTRE

Edna Mwale.- Simbayi (Mrs)
SECRETARY – TDRC Ethics Review Committee

TROPICAL DISEASES RESEARCH CENTRE
ETHICS REVIEW COMMITTEE
08 JUN 2020
P.O. BOX 71769
NDOLA, ZAMBIA

APPENDIX P

PERMISSION LETTER TO CONDUCT RESEARCH FROM THE COPPERBELT HEALTH PROVINCIAL OFFICE

PHO/CB/53/2/6

All Correspondences should be addressed to the
Provincial Health Director
Telephone/ Mobile No. +260861274/ +260 978529175
Email: copperbeltpho@gmail.com

REPUBLIC OF ZAMBIA
MINISTRY OF HEALTH
COPPERBELT PROVINCIAL HEALTH OFFICE

PWD Yard, Kabompo Road
P.O. Box 70032,
Kansenshi
NDOLA

10th June 2020

Ms Ethel Chilambe
Arthur Davison Children's Hospital
P.O. Box 240027
NDOLA

Dear Ethel

RE: REQUEST FOR PERMISSION TO CONDUCT RESEARCH

Reference is made to your letter dated 9th June 2020 regarding the above subject.

I am pleased to inform you that permission has been granted for you to conduct a study entitled ***"Basic chest imaging in adult trauma patients: interpretation skills of radiographers in the Copperbelt Province of Zambia"***

Kindly adhere to the guidelines as provided for by the TDRC Ethics Committee and National Health Research Authority.

Please share the finding of your study with this office

Yours faithfully
COPPERBELT PROVINCIAL HEALTH OFFICE

REPUBLIC OF ZAMBIA
MINISTRY OF HEALTH
COPPERBELT PROVINCIAL HEALTH OFFICE
09 JUN 2020
PROVINCIAL HEALTH DIRECTOR
P.O. BOX 70032,
NDOLA

Dr. Robert Zulu
PROVINCIAL HEALTH DIRECTOR
MNC/gm

APPENDIX Q

PERMISSION FOR THE USE OF CXR IMAGES FROM RADIOLOGY MASTERCLASS

Muller Henra

From: Radiology Masterclass <webeditor@radiologymasterclass.co.uk>
Sent: Friday, May 29, 2020 7:54 PM
To: Muller Henra
Subject: Re: Affiliates Form - Submission

Dear Henra

Thanks for getting in contact.

We would be very pleased for you to use images or text content from the Radiology Masterclass website for educational purposes, so long as you can confirm that this is in accordance with our terms and conditions (see the copyright section), particularly that there is no commercial gain and that images are not reproduced online. All content used, image or text, must be acknowledged at the point of every use (not just in a reference section) with reference to 'Radiology Masterclass' and the web address - www.radiologymasterclass.co.uk - clearly visible under each image. Before use of content from the site, please could you submit an example of your presentation/publication/tutorial materials so that we can ensure correct use and acknowledgement. Thank you.

We also require for all individuals who use content from the site to be registered as members of the Radiology Masterclass affiliate scheme, which is our way of ensuring that you agree to our terms and conditions. No cost is involved. I will gladly add you to the membership. If you haven't already, please could you sign up to our email newsletter which is the main way we keep in contact with affiliates and visitors of the site. You can sign up here - https://www.radiologymasterclass.co.uk/subscribe - (you can unsubscribe any time).

We look forward to seeing the work you have prepared using content from the site, and we hope you continue to find Radiology Masterclass a useful resource.

Best wishes
Graham

Dr Graham Lloyd-Jones
BA MBBS PCME MRCP FRCR
Web Editor - Radiology Masterclass

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--

On Wed, 20 May 2020 at 16:33, <webeditor@radiologymasterclass.co.uk> wrote:

Website enquiry

1

- **Title:** Mrs
- **Name:** Henra Muller
- **Institutional email address :** henramuller@cut.ac.za
- **Institution:** Central University of the Free State, Bloemfontein, South Africa
- **Position:** Lecturer Radiography
- **Institution website address:** www.cut.ac.za
- **Message:** Good day. Thank you for this wonderful site and learning opportunities. CUT is a University of Technology based in Central South Africa. We train Bachelor of Radiography (Diagnostic) students from 1st to 4th-year level and also have postgraduate radiography students. I would like to enquire about the possibility of CUT to become an affiliate scheme member. We would wish to use some of the images by Radiology masterclass during the teaching of undergraduate and postgraduate radiography students as part of education and non-commercial use whilst giving correct acknowledgement to Radiology Masterclass. Are there any costs payable to become a member of the affiliate scheme? Thank you in advance Kind regards Henra Muller Lecturer Radiography

APPENDIX R

EXAMPLE OF A CERTIFICATE AWARDED TO THE PARTICIPANTS

Central University of Technology, Free State

APPENDIX S

SIMILARITY INDEX

Ethel Chilambe

ORIGINALITY REPORT

3%	3%	1%	0%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	etheses.whiterose.ac.uk Internet Source	1%
2	orca.cf.ac.uk Internet Source	1%
3	hdl.handle.net Internet Source	1%
4	www.ncbi.nlm.nih.gov Internet Source	1%