EXPERIENCES OF ANALOGUE-TRAINED RADIOGRAPHERS UTILISING DIGITAL IMAGING IN PROJECTION RADIOGRAPHY

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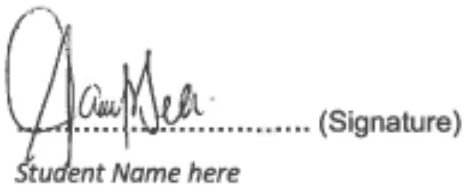

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DEDICATION

I would like to dedicate this study to my parents, **Mina and the late Johnny Campbell.**

Thank you for all the many sacrifices you have had to make to enable me to have a better life. I will forever be indebted to you.

I would also like to recognise my siblings: Rodney, Mollian and Franklin.
Allister, saggies rus jongman.

I would like to thank the Almighty God for granting me the grace to complete this project.

Opportunities to find deeper powers within ourselves come when life seems most challenging – Joseph Campbell

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ABSTRACT

The professional work of a radiographer encompasses both patient care and the use of technology. The technology employed could either be analogue or digital technology. Since 1973, the analogue imaging system has slowly been replaced by digital radiography imaging systems. Despite the many advantages of digital imaging it does present the radiographer with added responsibilities. Furthermore, analogue-trained radiographers have found adjusting to digital imaging especially challenging.

The aim of the study was to explore and describe the experiences of analogue-trained radiographers utilising digital imaging in projection radiography with the intention of developing guidelines to equip radiography managers to assist analogue-trained radiographers to better utilise digital imaging. The researcher used Schlossberg's Transition Theory as a lens to look at the experiences of analogue-trained radiographers using digital imaging to produce radiographs.

The research study used a qualitative design which was explorative, descriptive and contextual in nature. The target population included all diagnostic radiographers (public and private) in the local municipality who were registered with the Health Professions Council of South Africa. Purposive sampling was employed to select the radiographers that represented all radiographers in the Nelson Mandela Bay Health District. The sample included all radiographers who fulfilled the identified selection criteria. The selected participants were recruited to take part in in-depth, semi-structured individual interviews. The data was analysed using a computer-aided qualitative data analysis software package, ATLAS.ti.

The trustworthiness of this study was ensured by applying Guba's model of trustworthiness that includes credibility, transferability, dependability and confirmability. The ethical principles of respect for persons, beneficence and justice, as espoused by the Belmont Report, were adhered to in order to ensure that the study was conducted in an ethical manner.

Two themes emanated from the data, namely the evolution of the radiographer when faced with the advances in technology as well the role that the work environment played in the manner that the participants experienced the change. The experiences of the participants were described using direct quotations from the interviews and a literature control was used to verify the participants' experiences. Evidence was found of radiographer indifference towards exposure selection, dose optimisation and placement of anatomical side markers when utilising digital imaging. Finally, guidelines were developed to equip radiography managers to assist analogue-trained radiographers to better utilise digital imaging. In addition, the guidelines will assist all other radiographers to better utilise digital imaging.

KEY WORDS AND PHRASES

Analogue imaging

Digital imaging

Digital radiography

Guidelines

Projection (general) radiography

Radiographer

Technology advancement

Changing workplace

LIST OF ABBREVIATIONS AND ACRONYMS

AAPM	American Association of Physicists in Medicine
AEC	Automatic exposure control
ALARA	As low as reasonably achievable
BIR	British Institute of Radiology
BTech	Bachelor of Technology
CAQDAS	Computer-aided qualitative data analysis software
CR	Computed radiography
CT	Computed tomography
DICOM	Digital Imaging and Communications in Medicine
ECDOH	Eastern Cape Department of Health
EI	Exposure indicator
FHS	Faculty of Health Sciences
FPGSC	Faculty Postgraduate Studies Committee
HPCSA	Health Professions Council of South Africa
ICT	Information and communications technology
ICU	Intensive care unit
IR(ME)R	Ionising Radiation (Medical Exposure) Regulations
kV	Kilovoltage
mA	Milliampere
mAs	Milliampere-second
MRI	Magnetic resonance imaging
ND	National Diploma
NMBHD	Nelson Mandela Bay Health District
NMMU	Nelson Mandela Metropolitan University
PACS	Picture archiving and communication systems
PET	Port Elizabeth Technikon
RCR	The Royal College of Radiologists
RIS	Radiology Information System
RRP4200	Advances in Diagnostic Imaging – Module II

RSA3310	Radiation Science III
SCoR	Society and College of Radiographers
UK	United Kingdom
US	United States

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ADDENDA

CHAPTER 1 – OVERVIEW OF THE STUDY

1.1 INTRODUCTION AND BACKGROUND

The professional work of a radiographer encompasses both patient care and the use of technology (Lundvall, Dahlgren & Wirell, 2014). The technology employed could either be analogue or digital technology. In radiography, images are formed from the interaction of the x-ray beam with an image receptor. The x-ray beam passes through or is absorbed by the patient's body and the transmitted beam then interacts with the selected image receptor. This pattern of transmitted radiation and absorbed radiation is captured on an image receptor and produces an x-ray image. X-ray images can be formed by using one of two recording systems, namely an analogue system or a digital system.

The type and quality of images produced by analogue or digital technology differ but what remains the same is that the x-ray beam still passes through or is absorbed by the patient. The major differences between the two technologies are found in the type of image receptor used as well as the use of computer technology when recording the x-ray image. Since 1973, the analogue imaging system has slowly been replaced by digital radiography imaging systems (Carlton & Adler, 2013; Körner et al., 2007).

The first radiograph by Professor Wilhelm Roentgen, in 1895, was produced employing analogue imaging (Fauber, 2013). Analogue imaging is a complex process utilising x-ray technology which consists of a number of interrelated components. The analogue recording system uses a light-tight cassette that holds either one or two intensifying screens with an x-ray film sandwiched between the intensifying screens (Fauber, 2013). The incoming radiation interacts with this image receptor and it causes the intensifying screens to fluoresce (Carlton & Adler, 2013). The light given off by the intensifying screens is absorbed by the light sensitive x-ray film (Bushong, 2013). This absorption of the light by the film forms an invisible latent image on the emulsion layer of the film. The radiographer can then make this latent image visible by processing the x-ray film using an automatic processor (Fauber, 2013). The automatic processor

has various compartments filled with water-based chemicals to develop and fixate the permanent image (Ball & Price, 1995).

Analogue imaging has a number of advantages. A major advantage of analogue radiography is that it gives radiographers an explicit response on the correctness of the selected exposure factors (Ball & Price, 1995). Often images produced in digital radiography are of a uniform density and brightness despite the exposure factors selected (Fauber, 2013). This disconnect between the selected exposure factors and the density/brightness produced may give rise to unwanted and undetected overexposure of the patient (Ball & Price, 1995).

However, analogue imaging has a number of limitations. Analogue imaging necessitates the use of harmful chemicals for automatic processing (Bansal, 2006). Bansal (2006) also asserts that extra personnel are required to perform image processing, the archiving and retrieval of x-ray films. In addition, the x-ray image produced cannot be manipulated to improve the content of the information on the x-ray film (Bushong, 2013). The fact that an x-ray film can only be in one place at any given time presents a further limitation for the management of the patient (Schulze, Ackermann, Greyling, Viljoen & Andronikou, 2007). Another drawback of analogue imaging systems is its limited response to a range of radiation exposures or its limited dynamic range (Fauber, 2013). This limited dynamic range means that a small degree of over or underexposure may result in an image of unacceptable quality (Fauber, 2013). The radiographer would be required to repeat the examination adding to the radiation dose of the patient (Bansal, 2006). Analogue radiography has served the profession since the 19th century and continues to do so in many parts of the world, including South Africa, but is gradually being replaced by digital radiography.

The first recorded innovation in digital radiography was the development of a computed radiography image receptor, in 1973, that was patented by the Eastman Kodak Company in Rochester, New York (Luckey, 1975). According to Körner et al. (2007), the first use of digital technology in a clinical setting, was in 1980 when an image was produced using a computed radiography cassette containing an image plate to form a digital image. Digital radiography has been

practiced in the United States (US) since the early 1980s (Huang, 2011). Countries such as the Netherlands, Belgium, United Kingdom (UK), Austria, Italy and France introduced digital radiography during the latter part of the 1980s (Lemke, 2011). The Asian countries adopted picture archiving and communication systems (PACS) in two stages; the early stage from 1984 to 2002 and the mature stage from 2002 to 2010 (Inamura & Kim, 2011). However, there is a dearth of information with regard to the implementation of digital radiographic imaging systems in South Africa, but according to Daniell (n.d.), the first digital x-ray department was equipped at the Little Company of Mary Hospital in Pretoria, South Africa, in 1996.

Digital radiography imaging systems are split into two types commonly referred to as computed radiography and digital radiography (Carlton & Adler, 2013). Computed radiography recording systems consist of a cassette that contains an imaging plate unlike the analogue system (Bushong, 2013). The image receptor used in digital radiography is referred to as a flat panel detector (Fauber, 2013). These detectors can either be direct or indirect detectors hence the direct and indirect digital radiography appellation (Carlton & Adler, 2013). Digital radiography has affected the way work is normally done by radiographers. It has introduced “new activities, new ways of communicating and new responsibilities” for the radiographer (Larsson et al., 2007, p. 235).

Digital radiography has provided the radiographer with a number of advantages. Digital detectors respond in a linear fashion across a broad dynamic range (Bansal, 2006). The greater dynamic range results in improved image quality and a possible reduction in the patient radiation dose (Körner et al., 2007). The introduction of digital imaging has led to a decrease in the time a radiographer takes to perform a general radiographic examination (Reiner & Siegel, 2002). The consequence of this is that there has been an increase in productivity and a saving in human resource costs as well as an increase in the efficiency of the x-ray department (Reiner & Siegel, 2002). Digital radiography has also led to a reduced number of repeat radiographs (Pilling, 2003). Additionally, the radiographer is able to manipulate and process the image after acquisition (Bansal, 2006). The technology has allowed radiographers to distribute images

via a telecommunications network to other members of the healthcare team in remote areas (Pilling, 2003).

Despite the many advantages of digital radiography there are also certain disadvantages. Radiographers are required to examine more patients in a given time because of the workflow improvements (Dackiewicz, Bergsneider & Piraino, 2000; May, Deer & Dackiewicz, 2000). In addition there has been an increase in the number of requests for x-ray services by referring clinicians (Larsson, Lundberg & Hillergård, 2009; May, et al., 2000). The increase in x-ray requests and the higher throughput rate have, however, given rise to an increase in work related stress for radiographers (Fridell, Aspelin, Edgren, Lindsköld & Lundberg, 2009).

The change in technology has added another new skill for radiographers as they are now expected to apply informatics principles (Langer, Ramthun & Bender, 2012). This requires the radiographer to use the computer to produce x-ray images. The computer provides the opportunity to manipulate the x-ray image and to apply various measurements and post-processing tools (Van Heerden, Lockhat, Bam, Fletcher & Sommerville, 2011). Furthermore, digital technology has introduced new ways of communicating by the radiographer.

Digital imaging requires radiographers to create new routines and to find new ways of working with other colleagues such as the radiologist, the referring clinician or other healthcare professionals (Fridell et al., 2009). Digital technology has also had an effect on the way radiographers communicate with other healthcare professionals. Communication, in this way, can be sluggish when a large number of images have to be transmitted at the busiest times of the day (Van Heerden et al., 2011). Although this may be so, communication in the digital environment remains faster and more convenient than in the analogue setting.

Despite the many advantages of digital imaging it presents the radiographer with added responsibilities (Larsson et al., 2007). In the digital environment the role of the radiographer as ‘image producer’ has changed from being an individual who used to set exposure parameters to someone who now has to be an expert

in exposure parameters (Fridell et al., 2009). A reduction of up to 47% in patient radiation dose can be attained with certain x-ray examinations if improved exposure factors and modified work practices are employed (Livingstone, Peace, Sunny & Raj, 2007). Notwithstanding the contention of Livingstone et al. (2007), patient radiation dose can increase appreciably during the change from analogue to digital radiography (Vaño et al., 2007). The increase in patient radiation dose can be ascribed to the resistance of radiographers to use higher kilovoltage (kV) values and their insistence on using higher milliampere-second (mAs) values to combat quantum mottle (Carroll, 2014). Quantum mottle represents noise on a radiographic image and is therefore unwanted as it will undermine the quality of the image (Fauber, 2013). Hayre (2016) espouses that radiographers may select to use pre-set exposures and thereby unintentionally over or underexpose their patients. Radiographers, therefore, may shirk their responsibility for applying exposure factors that are as low as reasonably achievable (ALARA) in favour of an increase in image quality.

A further responsibility of the radiographer, in the digital environment, is to have a critical and reflective attitude when performing their job, because their work is largely composed of problem-solving activities. They are called upon to use sound judgement in their professional work. The radiographer can no longer just sign the images off, but they are required to carefully examine the digital x-ray images that they have produced (Larsson et al., 2009; Lundvall et al., 2014). Radiographers are called upon to assess the image quality in relation to patient safety and the imaging of the pathology present (Lundvall et al., 2014).

It is clear that digital imaging systems have had a positive effect on the work practice of the radiographer, but it has also increased the workload and the responsibility of this cadre of worker. A number of challenges have emerged as analogue-trained radiographers transitioned from using analogue to using digital technology. These challenges cause Hayre (in press) to question whether diagnostic radiographers are still the experts in acquiring images in general radiography using digital radiography.

1.2 PROBLEM STATEMENT

According to the Health Professions Council of South Africa (HPCSA) (HPCSA, 2016), approximately 55% of all diagnostic radiographers in the Eastern Cape Province, obtained their undergraduate qualification before November 2007. This is the cohort of radiographers that the researcher intends to include in his study. The researcher is aware that the local university introduced studies on digital technology in one of its modules in 2007. The researcher sought to determine the experiences of analogue-trained radiographers who are expected to produce radiographic images utilising digital techniques.

The researcher as a radiography lecturer at a South African university is in regular contact with radiographers at the accredited hospitals used for clinical placements of radiography students in the Nelson Mandela Bay Health District (NMBHD). Conversations with these radiographers revealed anecdotal evidence that the shift from analogue to digital radiography presented them with a number of difficulties namely under preparedness and feelings of inadequacy. In addition, the different response of the digital image receptors was mentioned as a problem.

Analogue-trained radiographers at the identified hospitals suggest that they were required to operate the digital equipment with very little preparation. For instance, at the time when digital technology was being introduced only a small selection of radiography personnel was exposed to a two or three day workshop offered by the retailers supplying the digital imaging equipment. Hence, the radiographers expressed feeling under prepared.

Staff at the same hospitals also intimated that they experienced feelings of ‘inadequacy’. Such feelings stemmed from the fact that although they were regarded as senior members of staff they were not able to handle the equipment proficiently. Often they had to solicit the assistance of junior members of staff who were more computer literate. The feelings of inadequacy had a negative influence on the morale of the affected radiographers.

The researcher also observed how experienced radiographers would attempt to

transfer their knowledge of analogue technology to the digital environment, but with limited success, leading to frustration. The radiographers had an expectation that the computed radiography and digital radiography image receptors would respond in a similar way to an analogue image receptor to selected exposure factors. The radiographers would select exposure factors that were deemed acceptable in analogue radiography and these exposure factors would then yield radiographic images with unacceptable image characteristics in the digital setting.

1.3 RESEARCH QUESTION

The challenges mentioned in the background and problem statement of the study led the researcher to ask the question:

- What are the experiences of analogue-trained radiographers of utilising digital imaging for projection radiography?

1.4 AIM OF THE STUDY

The aim of the study was to explore and describe the experiences of analogue-trained radiographers utilising digital imaging in projection radiography with the intention of developing guidelines to equip radiography managers to assist analogue-trained radiographers to better utilise digital imaging.

1.5 OBJECTIVES OF THE STUDY

The study encompasses two objectives:

- To conduct in-depth interviews with analogue-trained radiographers to explore and describe their experiences of utilising digital imaging for projection radiography.
- To develop guidelines in order to equip radiography managers to assist analogue-trained radiographers to better utilise digital imaging.

1.6 CONCEPT CLARIFICATION

Kumar (2014) posits that concepts are conceptual or perceptual descriptions and their understanding differ considerably from person to person. A conceptual definition will often be at variance with the dictionary meaning of a word because a conceptual definition is more wide-ranging (Burns & Grove, 2011). The concepts identified below will be operationalised in order to determine how to measure them (Kumar, 2014).

- **Analogue imaging**

  Analogue imaging is the production of x-ray images utilising a film-screen system and developing the image using an automatic processor. It is often referred to as conventional radiography (imaging) or film-screen radiography (Oborska-Kumaszynska & Wisniewska-Kubka, 2010). In this study analogue imaging refers to the production of x-ray images using a film-screen system and developing the image using an automatic processor.

- **Radiographer**

  A radiographer is a healthcare professional who is responsible for the production of x-ray images of the human body to assist the clinician with a particular diagnosis (Adler & Carlton, 2016). This individual would be required to produce x-ray images using analogue or digital imaging. In this study this professional is a diagnostic radiographer in the NMBHD who is registered with the HPCSA in terms of the Health Professions Act (56 of 1974) and who works in public and private hospitals.

- **Digital imaging**

  Digital imaging refers to the production of x-ray images that are composed of numeric data (Fauber, 2013) in order for the images to be transmitted or processed (Carlton & Adler, 2013). In this study digital imaging will allude to electronic x-ray images that are produced using photostimulable phosphor plates as well as direct and indirect conversion detectors. The images produced would be electronically processed and transmitted via a

telecommunications network.

- **Digital radiography**

  Digital radiography will denote the production of electronic images using direct and indirect conversion detectors (Carlton & Adler, 2013). This flat panel detector technology is increasingly being used in public and private hospitals in the NMBHD and it will apply to this study.

- **Projection (general) radiography**

  Projection or general radiography is the production of two-dimensional x-ray images. For the purposes of the envisaged study it will refer to the production of two-dimensional images that were obtained without the introduction of a contrast agent. This type of radiography will exclude specialised modalities such as computed tomography (CT), magnetic resonance imaging, (MRI) or fluoroscopic studies.

- **Experience**

  According to the Concise Oxford English Dictionary (Soanes & Stevenson, 2008), an experience is an applied interaction with and surveillance of facts and events. Experience, in this study, refers to the noticing or endurance of events, notably the introduction of digital imaging, by radiographers, as they happened over a period of time (Crozier, Grandison, McKeown, Summers & Weber, 2005).

1.7 RESEARCH PARADIGM

Neuman (2014) describes a paradigm as a scheme for theory and research that comprises fundamental assumptions, important issues, models of quality research and approaches in pursuit of answers. The selected paradigm can assist the researcher to link the aims and methodology of a study in order to achieve the aims of the study (Houghton, Hunter & Meskell, 2012). The researcher has chosen to use Schlossberg's Transition Theory as a lens to look at the experiences of analogue-trained radiographers using digital imaging to

produce radiographs. This adult development theory focuses on the transitions that adults experience during their lives and how these adults are able to cope and make adjustments (Evans, Forney & Guido-Dibrito, 1998).

According to Evans et al. (1998, p. 111), Schlossberg describes a transition as "any event or non-event that results in changed relationships, routines, assumptions, and roles". Three types of transitions are identified namely, an anticipated transition, an unanticipated transition and a non-event (Evans et al., 1998). An anticipated transition is described as any achievement and misfortune or major change of roles that takes place predictably in the life of an individual (Anderson, Goodman & Schlossberg, 2012). An unanticipated transition, on the other hand, is not predictable or planned (Evans et al., 1998) and it may include crises, uncontrollable situations and other unanticipated incidents (Anderson et al., 2012). Furthermore, non-event transitions are defined as transitions that are anticipated but that do not happen (Evans et al., 1998). In addition to the types of transitions, Schlossberg's theory also recognises four variables of a transition that influences how well adults will deal with the change (Evans et al., 1998).

These four variables – situation, self, support, strategies – are often referred to as the 4S's. According to Anderson et al. (2012) every person's situation differs according to the following aspects:

- Trigger – what initiates the transition?
- Timing – does the transition coincide with the individual's "social clock"?
- Control – which elements of the transition can the individual control?
- Role-change – does the transition bring about a role change?
- Previous experience with a similar transition – how did the person handle an analogous situation?
- Concurrent stress – are there added causes of stress present at the time of the transition?
- Assessment – does the person regard the situation to be positive, negative or benign?

There are two important factors related to the second variable, *self*:

- Firstly, personal and demographic features such as age, gender, ethnicity, stage of life, health status and socioeconomic status;
- Secondly, psychological resources that are the personality features that individuals rely on to be of assistance when facing threats (Pearlin & Schooler, 1978 as cited in Anderson et al., 2012).

In addition to self, Schlossberg's theory describes the variable of support as vital in dealing with stress (Anderson et al., 2012). The support can be in the form of intimate relationships, networks of friends, family units and/or the organisations or communities that individuals belong to (Evans et al., 1998). And finally, the strategies or coping responses that people undertake in order to avoid being injured by the struggles of life (Anderson et al., 2012). The strategies can either "modify the situation', control the meaning of the problem" or help in handling the repercussions of stress (Evans et al., 1998).

This adult development theory was employed as a basis to analyse the experiences of analogue-trained radiographers who are currently using digital imaging to produce radiographs for projection radiography. The main features of Schlossberg's Transition Theory were engaged in order to develop guidelines to equip radiography managers to assist analogue-trained radiographers to better utilise digital imaging.

1.8 RESEARCH DESIGN AND METHODS

The research design is a plan of how the researcher intends to conduct the research (Burns & Grove, 2011). This plan outlines the study design that was used, how the data were collected from participants, how the participants were selected, how the data analysis was conducted and how the findings were conveyed (Kumar, 2014). The research study was carried out making use of a qualitative, explorative, descriptive and contextual design. Research methods, on the other hand, refer to the gathering of data, data analysis and ensuring rigour in research (Botma, Greeff, Mulaudzi & Wright, 2010). The research study consisted of two phases to achieve the objectives of data collection and analysis,

and the development of guidelines. Data was gathered using semi-structured interviews and Tesch's steps of thematic coding was used to analyse the data (Creswell, 2014). The trustworthiness, of this qualitative study, was ensured by adhering to the four criteria suggested by Guba, i.e., credibility, transferability, dependability and confirmability (Shenton, 2004). The ethical principles that were followed will be explained in the next chapter.

1.9 CHAPTER LAYOUT

The layout for this qualitative study is as follows:

- Chapter 1 – Overview of the study
- Chapter 2 – Research design and methods
- Chapter 3 – Data analysis and discussion
- Chapter 4 – Development of guidelines
- Chapter 5 – Conclusions, recommendations and limitations

1.10 CONCLUSION

This initial chapter describes the background and rationale for the study as well as the problems related to this study. The research question, the aim and objectives of the study described the experiences of analogue-trained radiographers utilising digital imaging for projection. Also, the selected research paradigm that assisted the researcher to link the aims and methodology of the study was outlined in detail. Furthermore, the research design and methods were briefly introduced, but these will be comprehensively discussed in the next chapter.

CHAPTER 2 – RESEARCH DESIGN AND METHODS

2.1 INTRODUCTION

Chapter 1 provided a background to the study as well as a brief description of the methodology. This chapter is a presentation of the research design used for this research study. A full description of the research design, the methodology used, the trustworthiness of the study, as well as the ethics applied to the study will be discussed.

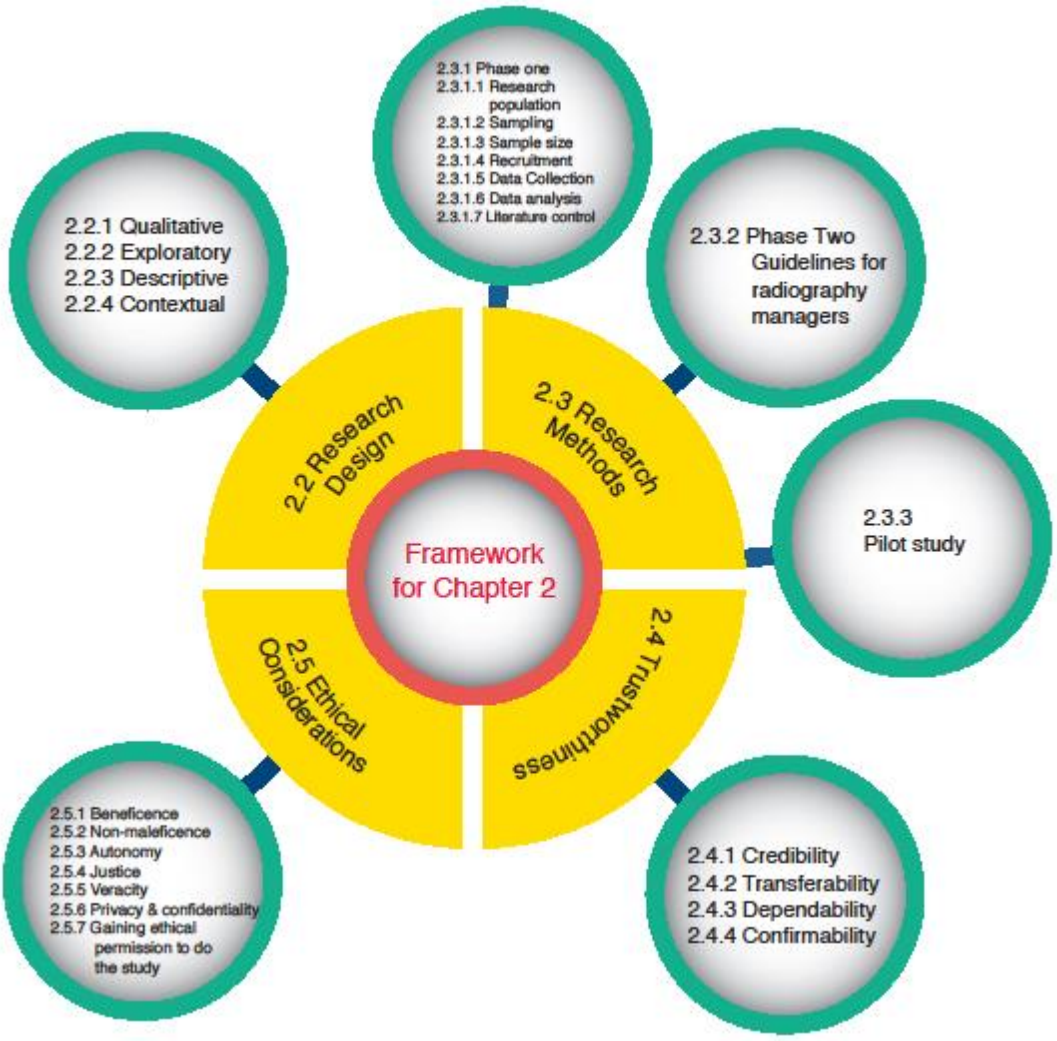

Figure 2.1: Framework for Chapter 2

2.2 RESEARCH DESIGN

A research design is a plan of how the researcher intends to conduct the research (Burns & Grove, 2011). This plan outlines the study design that was used, how the data was collected from participants, how participants were selected, how the data was analysed and how the findings were conveyed (Kumar, 2014). This research study was conducted making use of a qualitative design which was explorative, descriptive and contextual in nature.

2.2.1 Qualitative design

Creswell (2014) argues that qualitative research is an approach that is applied if the researcher wants to explore and understand the meaning that individuals attach to a social or human problem. Qualitative research also allows for the voice of individuals to be heard and therefore empowers the participants (Creswell, 2013). The central focus in a qualitative study is to appreciate, explore and elucidate situations, feelings, views, opinions, standards, principles and experiences of a particular community (Kumar, 2014).

There is limited research in South Africa about the experiences of analogue-trained radiographers who are required to utilise digital imaging for projection radiography. The dearth of research has made a qualitative design ideal for this study as it allowed the researcher to gain an understanding of the feelings, views and opinions of radiographers undergoing this change.

2.2.2 Exploratory design

The research uses an exploratory design. Blaikie postulates that exploratory research is undertaken to gain insight into a phenomenon, a situation, an individual or a community (as cited in Fouché & De Vos, 2011). This type of design allows the researcher to study a phenomenon where there is a lack of information about a particular situation (Fouché & De Vos, 2011).

The phenomenon of radiographers trained in the analogue environment employing digital imaging to produce radiographs has not been adequately studied in the South African setting. The present research aims to explore the

experiences of analogue-trained radiographers who have had to utilise digital imaging for projection radiography, as little is known about this phenomenon.

2.2.3 Descriptive design

The research is also descriptive in nature. Descriptive research is designed to gather more information about features within a particular field of study (Burns & Grove, 2011). This type of design is also employed when not much is known about the topic (Botma et al., 2010). The purpose of this research is to sketch a picture of a situation in its natural setting (Burns & Grove, 2011).

This type of design permitted the researcher to provide a comprehensive description of the phenomenon without altering any of the variables (Brink, van der Walt & van Rensburg, 2012). The experiences of radiographers, trained in analogue imaging, who are now utilising digital imaging for projection radiography, were described as they experienced it in their respective x-ray departments without manipulating any of the variables.

2.2.4 Contextual design

Contextual research deals with recognising what is present in the social world and the manner in which it shows itself (Ritchie, Lewis, Mc Naughton & Ormston, 2014). The social context is crucial because the significance of a social action is largely reliant on the context in which it occurs and gives meaning to a particular action or practice (Neuman, 2014).

Exploring and describing the experiences of analogue-trained radiographers utilising digital imaging is an important aspect of contextual research (Ritchie et al., 2014). The context in this study refers to all analogue-trained radiographers employed in public and private radiography departments in the NMBHD. These radiographers were using computed radiography and digital radiography imaging systems to produce radiographs.

2.3 RESEARCH METHODS

Research methods refer to the gathering of data, data analysis and ensuring rigour in research (Botma et al., 2010). The research methods that the researcher employed were determined by the research question, the conceptual framework, as well as the aims of this study (Nieuwenhuis, 2016). The research study comprised two phases and these are presented below.

2.3.1 Phase One

Phase One involved data collection, the pilot study, and the semi-structured interviews with the selected analogue-trained radiographers. It also involved the data analysis and literature control.

2.3.1.1 Research population

The target population is described as the whole set of elements or people that meet the sampling criteria (Burns & Grove, 2011). The target population for the present study included all diagnostic radiographers in the NMBHD who are registered with the HPCSA in terms of the Health Professions Act (56 of 1974). The study was conducted in both the private and public sector radiology (radiography) departments and the target population comprised an estimated 140 radiographers in the NMBHD.

2.3.1.2 Sampling

Qualitative research is employed principally to investigate diversity and therefore sample size, and sampling methods do not form such an important part of selecting a sample (Kumar, 2014). Sampling, though, will define the selected group of individuals that will represent a population of individuals (Burns & Grove, 2011). This study employed purposive sampling to select the group of radiographers that represented all radiographers in the NMBHD. Purposive sampling is a type of non-probability sampling that allows the researcher to make a judgement on the suitability of participants (Brink, et al., 2012). In the case of this study they comprised analogue-trained radiographers who are now utilising digital imaging for projection radiography.

2.3.1.3 Sample size

A total of ten participants (radiographers) were interviewed for this qualitative study. Two of the interviews conducted, formed part of the pilot study for this project. The researcher believes that data saturation was reached as no new data transpired after about the eighth interview.

2.3.1.4 Recruitment

The participants were selected using the following inclusion selection criteria.

The radiographers who were included in the study were those who:

- Have obtained at least an initial undergraduate qualification in diagnostic radiography, for example, a National Diploma (ND) in Radiography: Diagnostic.
- Have obtained their ND before 2007 or the Bachelor of Technology (BTech) qualification before 2005 at the Nelson Mandela Metropolitan University (NMMU) or the former Port Elizabeth Technikon (PET). The researcher inspected the examination papers for the ND programme and noticed that the first questions on digital imaging appeared in the Radiation Science III (RSA3310) November 2007 paper. The first questions on digital imaging appeared in a module Advances in Diagnostic Imaging – Module II (RRP4200) - a module in the BTech programme in 2005.
- Are from either the public or private sectors in the NMBHD.

Any radiographers who did not comply with the inclusion selection criteria were excluded from the study.

2.3.1.5 Data collection

The researcher sought and obtained ethical clearance from the Faculty Postgraduate Studies Committee (FPGSC) of the Faculty of Health Sciences (FHS) at the NMMU (cf. Addendum A). Following the FPGSC approval the researcher requested permission from the Eastern Cape Department of Health (ECDOH) by means of an electronic application to the National and Provincial Health and Ethics Committees of South Africa through the National Health Research Database website. Permission (cf. Addendum B) was granted to conduct the study in the various public hospitals pending the approval of the

identified hospitals. The endorsement of the selected public hospitals were sought (cf. Addenda C-E) and received (cf. Addenda G-J). A concurrent application was tendered to the private radiology practice (cf. Addendum F) to conduct the study with radiographers in their employment and approval was received (cf. Addendum K).

Subsequently, contact was made with the identified public and private sector radiography departments in the NMBHD. The researcher acquired a list of names of all the radiographers, working, in the various radiology (radiography) departments, from the radiographers-in-charge at the various hospitals. The solicited lists were used in conjunction with the 2016 Register of Radiographers published by the HPCSA (HPCSA, 2016) to select radiographers based on when they obtained their various diagnostic radiography qualifications. The researcher personally made contact with potential participants via face-to-face interaction, social media platforms and electronic mail. A letter to request permission to interview the participant (cf. Addendum L) was e-mailed to all potential participants. The letter informed the potential participants about the purpose and objectives of the study. Before any interviews were conducted the researcher solicited informed consent from each participant (cf. Addendum L).

According to Burns and Grove (2011), the most frequently used data collection method in qualitative studies is interviewing research participants. Interviews are often used in exploratory and descriptive research as it is the most direct way of procuring evidence from participants (Brink et al., 2012). In this study the interviewer employed semi-structured individual interviews. Semi-structured interviews were used because it allowed the researcher to explore the experiences of radiographers who were trained in the analogue imaging environment and are now utilising digital imaging, in a qualitative way (Botma et al., 2010). The researcher made use of an interview guide to ensure that all the important issues and points of discussion were discussed with all the participants and that the information obtained from participants were comparable (Kumar, 2014). The interview guide comprised a main question and a further six sub-questions.

The main question:

- How did you experience the move from analogue to digital imaging?

The sub-questions:

- What was your experience after the initial training by the application specialists?
- What kind of challenges are you now experiencing with the digital technology?
- How did you cope with the move from analogue to digital imaging?
- How has the introduction of the “new” technology affected staff relations in the x-ray department?
- How has the introduction of the “new” technology affected your experience of radiographic practice?
- How can management assist you with optimising your digital imaging skills?

The researcher confirmed the place and time of the interviews with the participants via electronic mail and the various messaging services. At the outset of the interview participants were made to feel comfortable and they were reassured that the interview was not a question and answer session but rather an opportunity for the researcher to record their experiences of the move from analogue to digital imaging. Although the letter of consent (cf. Addendum L) was emailed to the participants (cf. 2.3.1.5. para 2), it was again handed to participants to familiarise themselves with the content of the letter. At this point participants were again reminded that they should not feel coerced and that they may withdraw from the study at any time. It was also further emphasised that the information sourced from the participants would be managed confidentially. Once participants agreed to continue with the interview they were requested to complete the aforementioned informed consent form (cf. Addendum L). Participants were allowed to ask any clarifying questions before the commencement of the interview proper. The consent of participants was requested to allow for the use of voice recording devices. At the start of the interview the main question was posed to the participants. The sub-questions

were only used depending on the responses of the participants. Participants were probed further to ensure that the researcher clearly understood the responses that were tendered by the participants. Throughout the interview participants were offered emotional bids, as described by Dr Gottman (Lisitsa, 2012), to assure participants of the researcher's interest in their responses. Each participant's permission was requested to employ the use of a digital voice recorder and the researcher's smartphone's voice recorder. All participants agreed to the use of the voice recorder devices.

At the conclusion of each interview participants were acknowledged for their input and insights. The interviewer continued to engage participants even after the recordings were terminated. However, during one such interaction the recording devices were turned back on again and this allowed the interviewer to capture very useful information. Following the interviews I would make descriptive field notes of the participants and their non-verbal communication. Reflective notes of what I was learning were also recorded (De Poy & Gitlin, 2016). The interviews were transcribed verbatim, by the researcher, within a short period after it was recorded.

2.3.1.6 Data analysis

The data analysis commenced once the researcher transcribed all the interviews. Data analysis refers to the process of "making sense of text and image data" (Botma et al., 2010). Tesch's eight steps in the coding process were used to perform the data analysis process (Creswell, 2014):

- Once the interviews were transcribed the researcher read all the transcriptions carefully in order to gain an understanding of the entire data set. The researcher wrote down some ideas as he was reading the transcriptions.
- A single interview was selected to determine what the essence of the interview was and also to establish the core meaning of the interview. Short notes were then recorded.

- Following this, all interviews were uploaded on a computer-aided qualitative data analysis software (CAQDAS) package, ATLAS.ti, to assist in facilitating the analysis process (Babbie & Mouton, 2001).
- Each interview was coded by assigning key words to sections or fragments of texts.
- The researcher generated preliminary or deductive codes based on the research title, aims and objectives of the study. Further codes or inductive codes were advanced from the participants' information.
- Related codes were then grouped into code families, using the code manager on ATLAS.ti. The code manager enabled the researcher to establish counting frequencies of codes and assisted in the drawing up of conclusions.
- The code families allowed the researcher to identify themes. In addition to using ATLAS.ti the researcher analysed the interviews manually. According to Rubin and Rubin (2012, p. 195) words like "because" and "therefore," used by participants in their interviews, often signifies a theme. This method was used in conjunction with the code families to settle on the emerging themes.

The researcher submitted the data set of interviews to an independent coder to analyse the data set. The independent coder was requested to employ Tesch's eight steps of coding to analyse the data. Following the analysis the researcher convened a meeting with the independent coder to review and discuss the emerging themes. A matrix of emerging themes, sub-themes and categories was agreed upon by the researcher and independent coder. The independent coder issued the researcher with a coding verification letter.

Whilst the data analysis process is described in an undeviating and successive way it was really a repetitious and reflexive procedure as suggested by Fereday (2006). The themes, sub-themes and categories will be discussed in Chapter 3.

2.3.2 Phase Two: Guidelines for radiography managers

Phase two involved the development of guidelines. In terms of the Collins English Dictionary: Complete and Unabridged (2014), a guideline is defined as a rule that is advanced in order to set standards or ascertain a particular course of action. Clinical guidelines are designed to assist clinicians and patients to determine the suitable healthcare for a particular condition and or situation (Broughton & Rathbone, 2001). As clinicians, it is critical that radiographers are able to utilise digital imaging effectively as it can affect the quality of care to their patients. Broughton and Rathbone (2001) further state that good clinical guidelines should be valid, cost-effective, reproducible, clinically applicable, representative, clear, flexible, reviewable, and acquiescent to clinical audit. The study aimed to develop guidelines to assist radiography managers to better aid analogue-trained radiographers, and radiographers in general, to effectively utilise digital imaging.

2.3.3 Pilot study

A pilot study is a limited version of the future study to be conducted. The pilot study allows the researcher to determine whether the intended detailed study is feasible (Burns & Grove, 2011). Furthermore, the pilot study may uncover any defects in the methodology of the proposed study (Brink et al., 2012). Brink et al. (2012) assert that the pilot study could be used to test the data-collection instrument. The pilot study is generally conducted on a few participants that satisfy the inclusion selection criteria (Botma et al., 2010).

For the purposes of this study two radiographers that met the inclusion selection criteria were interviewed for the pilot study. The two radiographers were drawn from the public sector. The interviews were transcribed verbatim and presented to the supervisor and co-supervisor for scrutiny.

2.4 TRUSTWORTHINESS

Trustworthiness is of paramount importance in qualitative research as it will be the conclusive test of the researcher's data analysis, findings and conclusions (Nieuwenhuis, 2016). According to Shenton (2004), Guba suggested four criteria that qualitative researchers should adhere to in order to ensure trustworthiness

in their studies. These criteria are credibility, transferability, dependability and confirmability (Shenton, 2004). The researcher applied the aforementioned criteria to his study.

2.4.1 Credibility

Shenton (2004) indicates that credibility is one of the main aspects of ensuring trustworthiness. According to Nieuwenhuis (2016), credibility deals with whether the research findings correspond with reality as well as how the researcher will certify the credibility of the research findings. The following methods were applied to ensure credibility in this study:

- Triangulation: this is where the researcher takes diverse viewpoints on a phenomenon being studied in an attempt to answer the research question (Flick, 2009). Individual interviews were recorded using a digital voice recorder (cf. 2.3.1.5). An independent coder was enlisted to analyse and code the data. The independent coder and researcher then reviewed the themes for concordance (cf. 2.3.1.6). The researcher also used literature to strengthen the findings.
- Member checking: the transcribed interviews of participants were e-mailed to them and they were requested to read the transcripts. The researcher asked informants whether their words matched what they actually intended.
- Bracketing: the researcher, as a radiography lecturer, made a conscious effort to put aside his views and opinions about the phenomenon being studied in order to understand the experiences of the participants. The researcher as a former practitioner was educated in analogue imaging during the period 1978-2006.

2.4.2 Transferability

Transferability refers to the extent to which the outcome of the research can be related to different contexts and individuals (Botma et al., 2010). The researcher has given a clear description of the purposive sampling method employed (cf. 2.3.1.2), the inclusion selection criteria (cf. 2.3.1.4) and the contexts within which

the research was conducted (cf. 2.2.4). This clear description provides the necessary information in order to transfer this study to other digital x-ray departments where analogue-trained radiographers are utilising digital imaging for projection radiography.

2.4.3 Dependability

Guba posits that dependability and credibility are closely linked to each other (as cited in Shenton, 2004). An exposition of credibility goes a long way towards establishing dependability in a study (Nieuwenhuis, 2016). To ensure dependability the researcher has given a detailed report of the research design employed (cf. 2.2) in order to enable other researchers to repeat the study with the same participants in a similar context and produce similar findings.

2.4.4 Confirmability

Confirmability requires that the researcher be free from any bias during the research process and when reporting the findings of the study (Nieuwenhuis, 2016). The researcher's position as a radiography lecturer has been stated earlier. Also, a rich description of the research findings, are given, and examples of direct expressions of participants are used in Chapter 3.

2.5 ETHICAL CONSIDERATIONS

De Poy and Gitlin (2016) state that research ethics allows the researcher to conduct himself appropriately during the research process and to protect human subjects involved in the study. The Belmont Report (1979) identifies three ethical principles – respect for persons, beneficence and justice – that apply to research of human subjects. However, the principles of beneficence, non-maleficence, autonomy, justice, veracity, privacy, and confidentiality as applied to this study will be discussed here.

2.5.1 Beneficence

The principle of beneficence is rooted in the argument that an individual has the right to be secured against harm and distress (Botma et al., 2010). In terms of the Belmont Report (1979), the researcher should also make an effort to ensure

the well-being of participants. The researcher is also called upon, above all, to do good and not to harm participants (Botma et al., 2010).

The researcher believes that the research question was relevant to the present radiography setting. Although the study may not necessarily benefit the participants it may yield benefits for the radiography fraternity in the NMBHD. King (in Botma et al., 2010) describes this type of benefit as an aspirational benefit.

2.5.2 Non-maleficence

Non-maleficence refers to not doing harm to the participants (De Poy & Gitlin, 2016). The participants were not exposed to any pain or risk of damage to their person. The researcher structured the interview questions in such a way that it did not cause discomfort to the participants. Participants were informed that if they felt threatened or distressed that they were allowed to withdraw at any stage.

2.5.3 Autonomy

Autonomy suggests that that there should be respect for the right of the individual to choose (De Poy & Gitlin, 2016). Respect for persons includes two ethical philosophies, namely, that individuals should be considered as self-governing agents and secondly, that individuals with a reduced autonomy should be offered protection (Belmont Report, 1979). The principle of autonomy was ensured by eliciting informed consent (Addendum L) from participants.

The radiographers participating in this study were given the opportunity to decide whether or not to participate in the study, without any form of coercion. The identity of all participants was kept confidential. They were given the right to disengage from the study at any time without fear of reprisal. Furthermore, they were informed of their right to withhold information should they choose to do so. The participants were also offered the opportunity to ask clarification questions about the aim of the study. The participants of this study were not persons with a diminished autonomy.

2.5.4 Justice

The Belmont Report (1979, p. 5) states that “equals ought to be treated equally” and it regards this stance as justice. The principle of justice ensures that the benefit that is due to an individual does go to the said individual. Justice promotes fairness for all participants involved in the study (Brink et al., 2012).

In this study all radiographers, that took part in the study, were treated equally. The researcher personally conducted the interviews to ensure that all participants were treated equally and fairly. The researcher showed respect for diversity in the selection of participants. There was no discrimination against participants on the basis of their gender, age, race or sexual orientation.

2.5.5 Veracity

In healthcare, veracity refers to providing participants with precise and detailed information and taking cognisance of the participants’ understanding of the provided information (Holloway & Wheeler, 2010). The researcher was truthful and honest with all participants in order to show respect for their autonomy. All questions and queries participants may have had were answered openly and frankly.

2.5.6 Privacy and confidentiality

Burns and Grove (2011) regard privacy as the freedom that people have to decide on the time, the level, and the general conditions under which their information will or will not be divulged to others. Confidentiality, on the other hand, denotes that names may be ascribed to information, but they should be kept secret from the general public (Neuman, 2014).

The identity of all participants was not disclosed to any other person. The identity of the public or private hospitals from which the participants were recruited was also not declared publicly. The interview transcripts and raw data have been secured against public scrutiny. The researcher was personally responsible for typing the interview transcripts. The researcher has ensured the anonymity, privacy and confidentiality of all participants as far as is possible.

2.5.7 Gaining ethical permission to do the study

Ethical clearance was obtained from the FPGSC of the FHS at the NMMU (cf. Addendum A). Permission to conduct the study in the various public hospitals (cf. Addenda G-J), was obtained from the ECDOH (cf. Addendum B) and a private radiology practice (cf. Addendum K) in NMBHD (cf. 2.3.1.5).

2.6 CONCLUSION

This chapter described the research design, research methods, the trustworthiness of the study and the ethical considerations that were employed for this study. The research methods comprised two phases: Phase One and Phase Two. Phase one emphasised the sampling, data collection and data analysis, whereas Phase Two delineates the development of guidelines for radiography managers to assist analogue-trained radiographers, and radiographers in general, to effectively utilise digital imaging for projection radiography. In Chapter 3 the identified themes and sub-themes, and the underpinning literature control will be presented.

CHAPTER THREE – DATA ANALYSIS AND DISCUSSION

"*Some time ago, I investigated the possibility that a computer might be able to reconstruct a picture from sets of very accurate X-ray measurements taken through the body at a multitude of different angles". – Godfrey Hounsfield (1919-2004)*

3.1 INTRODUCTION

The preceding chapters presented the research methodology and design applied in this study. This chapter will provide an elucidation of the analysed data and how the analysed data was placed in context with the current theory. A literature control was used to show how the analysed data was verified by existing knowledge or how the analysed data brought new understanding to the current professional domain (Nieuwenhuis, 2016).

3.2 CHARACTERISTICS OF THE POPULATION

The population for the present study comprised all diagnostic radiographers in the NMBHD who, at the time of data collection were registered with the HPCSA in terms of the Health Professions Act (56 of 1974). The population included approximately 140 radiographers who were employed in the public and private sector radiology (radiography) departments. The study utilised purposive sampling to select the radiographers to represent all radiographers in the NMBHD. The sample encompassed radiographers who satisfied the inclusion selection criteria as stipulated in this document (cf. 2.3.1.4). The researcher explained the study to the radiographers in order to establish their willingness to participate in the study. Appointments were scheduled with the radiographers who consented to take part. Semi-structured interviews were held with the participants who the researcher felt would best describe their experiences of the changeover from analogue to digital imaging.

The year participants gained their first qualification ranged from 1978 to the cut-off date of November 2006. The researcher selected at least one radiographer

from each of the decades from 1978 to 2006. Nine of the participants were female and one was male. This ratio between males and females reflects the demographics of the radiographers in the NMBHD where most radiographers are female (HPCSA, 2016). Of the ten participants, six were employed by the ECDOH and four were employed by private radiology practices. The 60-40 split between public and private sector, more or less, represents the distribution of radiographers in public and private radiology departments in the NMBHD. The level of radiographic work experience of the participants ranged from 11 to 36 years. Hence, participants had substantial experience and the expectation was that rich data were going to be obtained from them. All of the participants obtained their National Diploma (ND) in Radiography: Diagnostic or Bachelor of Technology (BTech) in Radiography (Diagnostic) from the NMMU or the pre-merger institution, the Port Elizabeth Technikon. Table 3.1 below gives a summary of the aforementioned criteria.

Table 3.1: Biographical information of radiographers working in the NMBHD

Participant	Gender	Years of experience	Qualifications obtained and year obtained	Institution where qualification was obtained	Public or private practice
Participant 1	Female	11	National Diploma in Radiography: Diagnostic (ND: Rad (D)) – 2005	NMMU	Public
Participant 2	Female	35	ND: Rad (D) - 1978 Bachelor of Technology (BTech) in Radiography (Diagnostic) (BTech: Rad (D)) – 1999	NMMU	Public
Participant 3	Female	35	ND: Rad (D) – 1980	NMMU	Private
Participant 4	Female	32	ND: Rad (D) – 1987 BTech: Rad (D) - 2002	NMMU	Public
Participant 5	Female	11	ND: Rad (D) – 2005	NMMU	Private
Participant 6	Female	23	ND: Rad (D) - 1992	NMMU	Public
Participant 7	Female	21	ND: Rad (D) - 1995	NMMU	Private
Participant 8	Male	36	ND: Rad (D) – 1982	NMMU	Public
Participant 9	Female	25	ND: Rad (D) - 1984	NMMU	Public
Participant 10	Female	20	ND: Rad (D) - 1995	NMMU	Private

All of the participants were initially trained in analogue image production. However, at the time of data collection they were using either computed radiography or digital radiography to produce radiographs for general radiography.

Prior to the study proper, a pilot study consisting of two interviews was conducted to ascertain whether the researcher's method of interviewing and interview schedule would generate the appropriate information. The data gained from the pilot study was included as part of the main study after determining the success of the interview and the value of the data, and also after consulting with the research supervisors. Digital audio recordings were transcribed within a short period of time following the interviews. The verbatim transcriptions and the field notes constituted the database. The data was analysed using a CAQDAS package, ATLAS.ti while conforming to Tesch's method of data analysis.

The database was submitted to an independent coder to increase the rigour of the study. The researcher and the independent coder both generated themes and sub-themes independently. Thereafter a consensus meeting was held where the researcher and independent coder discussed the themes and sub-themes in detail. The generated themes and sub-themes were presented to the research supervisors for scrutiny (cf. 2.3.1.6). Two themes and six sub-themes emerged from the data. Furthermore, a literature control was conducted to identify what was already known about the phenomenon under discussion and to establish whether the generated themes had been identified in other studies.

3.3 DISCUSSION OF THEMES AND SUB-THEMES

This section constitutes a discussion of the identified themes and sub-themes with supportive literature. Excerpts from the interview database have been added to demonstrate the link to the themes and sub-themes. Table 3.2 below presents a matrix of the emergent themes and sub-themes:

Table 3.2: A matrix of the emergent themes and sub-themes

Themes	Sub-themes
Theme 1 The evolution of the radiographer in the face of technological advancement	1.1 Radiographers' changing skill sets in relation to technological change
	1.2 Perceptions and attitudes of radiographers towards technological change
	1.3 Radiographers experience challenges with adapting to new technology
Theme 2 Role of radiographers' work environment on their experiences of technological change	2.1 Hospital and or radiography/radiology management have influenced the manner in which radiographers have experienced coping with the new technology
	2.2 Changing technology has impacted on radiographers' staff relations in the health care environment
	2.3 Changing technology has led to intergenerational differences (conflict) emerging among radiographers

3.3.1 Theme 1: The evolution of the radiographer in the face of technological advancement

Participants, in both public and private sector, expressed how their radiographic work has rapidly been changed by the introduction of digital technology. The conversion from analogue to digital imaging has caused radiographers to respond in diverse ways towards the technological change. Although some radiographers responded positively to the change they also experienced a number of challenges with adapting to the changeover. Figure 3.1 illustrates theme one and its relationship to the identified sub-themes. The sub-themes in Table 3.2 will be discussed below.

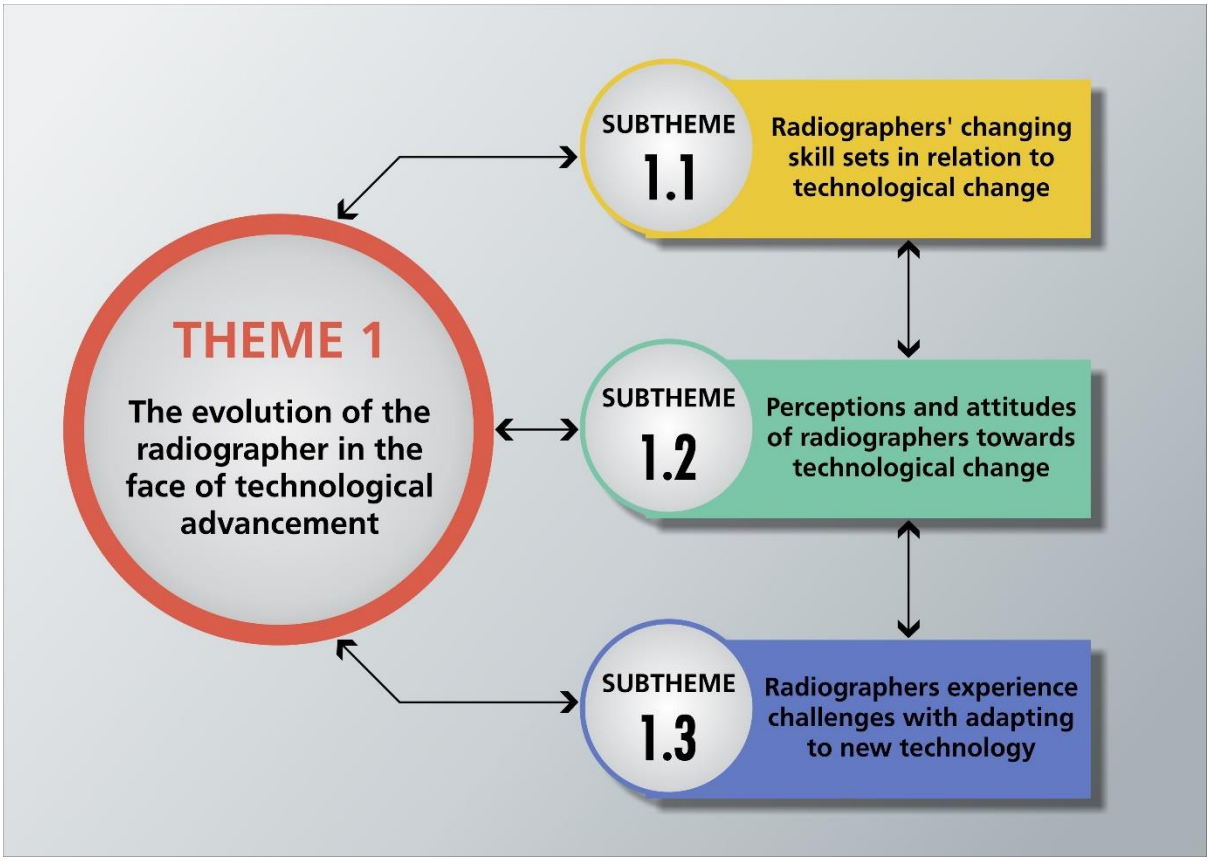

Figure 3.1: Theme one and its sub-themes

3.3.1.1 Sub-theme 1.1: Radiographers' changing skill sets in relation to technological change

The participants felt that, since the advent of digital technology, it was no longer necessary to think when making a selection of the exposure factors to be used for a particular examination. It was the opinion of one participant that the machine will do the thinking on behalf of the radiographer.

"So, you doing more in less time - without applying your brain. Your brain is not really needed - it still is to a certain degree, obviously. But, there is less needed, the machine does a lot more of the thinking for you……." (Participant 7, line 1723-1726)

"…….. it's good for pushing numbers and for making it easier for the radiographer - she doesn't have to think that much more than what she used to have to think in the old days. So it's maybe a bit sad because now we really are becoming button pushers……..." (Participant 7, line 1756-1759)

In order to make the radiographic image visible, radiographers have to apply optimal exposure factors. According to Herrmann et al. (2012), digital imaging best practice requires radiographers to utilise the highest optimal kV for the particular body part and the lowest acceptable amount of mAs required to provide sufficient exposure to the image receptor. However, digital image receptors are said to have a wider exposure latitude and post-processing algorithms that may disguise exposure errors (Ching, Robinson & McEntee, 2014). This concealment of exposure errors is in stark contrast with analogue imaging where the radiographer was given a direct response on the correctness of the selected exposure factors (Ball & Price, 1995). The fact that in digital imaging exposure errors are no longer obvious, could lead radiographers to believe that they were no longer required to think anymore when selecting exposure factors. Fridell et al. (2009) are in support of the participants as they state that in the analogue environment, if the radiographer used excessive radiation, a black image that is not diagnostically acceptable would have ensued. Digital imaging, however, produces a readable image despite the undue radiation dose as the digital image can be manipulated.

Such undue radiation dose was a concern to the participants. Participants felt that they no longer seemed to think about radiation dose and its effects on the patient when examining them. This is illustrated by the two excerpts below.

"They not worried about the dose they're giving the patient they worried about the EI they get on their plates." (Participant 4, line 886-887)

"So, if you give too much or you give too little you could still manipulate the image to get a better image. So, unfortunately that's one of the bad things about it. It's no longer, as I said, ALARA." (Participant 4, line 1063-1065)

"…… I mean the collimation and that concerns me because we talking about radiation dose and we not just talking about the quality of images here, its radiation dose. Uhm…, and definitely that is lacking." (Participant 2, line 379-381)

Radiographers are required to weigh up the likely benefits of exposing a patient to radiation against the impairment for the patient (British Institute of Radiology (BIR), Society and College of Radiographers (SCoR) & The Royal College of Radiologists (RCR), 2015). Unlike the sentiments expressed by Participant 4, the radiographer is called upon to ensure that the radiation dose received by the patient is in accordance with the "as low as reasonably achievable" (ALARA) principle (Bushong, 2013, p.312). Herrmann et al. (2012) concur with Participant 4 that digital images can be adjusted to make amends for exposure selection errors, however they discourage this practice as it is not regarded as best practice in the US. Hence, Herrmann et al. (2012) implore radiographers to follow the ALARA principle and therefore reduce patient exposure when adopting digital imaging.

Furthermore, Participant 2 bemoaned the lack of collimation as it may contribute to an increase in the radiation dose received by the patient. This notion is supported by a Belgian study conducted by Gijbels, Sanderink, Wyatt, Van Dam, Nowak and Jacobs (2003) that found that using collimation can reduce the effective dose received by the patient by 47%.

Another participant also felt that radiographers no longer seem to collimate adequately anymore.

"Now, you don't even bother to do that – you'll do a wrist on a big cassette. Because, you know it's just an image you can crop it down." (Participant 6, line 1529-1530)

Collimation is referred to as the limiting of the x-ray beam by using a lead apparatus around the edges of the beam (Carroll, 2014). Good collimation, as stated by Uffmann and Schaefer-Prokop (2009), is vital for improved image quality and radiation protection and this validates the concern expressed by Participant 2. Bomer, Wiersma-Deijl and Holscher (2013) refer to good collimation as the 'silver lining', indicating that all the anatomy of interest is included in the image and there is a small collimated border around the anatomy of interest. In digital radiography, however, the radiographer can electronically

collimate the image after processing (Bomer et al., 2013). The electronic collimation that is referred to by Participant 6, is proscribed by the American Society of Radiologic Technologists (Herrmann et al., 2012), as it implies that the radiation field should have been smaller and the patient may have been exposed to needless radiation (Bomer et al., 2013).

Radiographers, when performing analogue radiography affix a lead anatomical marker to the image receptor before the image is processed, whereas in digital radiography it is possible for the radiographer to append an electronic anatomical marker after image processing. There was also a feeling among participants that radiographers no longer seem to place anatomical side markers before processing the image. The two passages below are indicative of that sentiment.

"…… you know, in the old days it's compulsory your…, your letters must show – you know, it must show. And here…, I've put my letters on but, I've collimated too much and it's not showing so let's put on a…, you know, those ones that's pre-set on the machine." (Participant 5, line 1329-1332)

"…… we stopped, not stopped but anatomical markers weren't as important anymore [chuckle], uhm because you could put the anatomical [sic] on afterwards….." (Participant 1, line 45-46)

The appropriate use of anatomical side markers is deemed to be best practice in radiography (Titley & Cosson, 2014). Each radiograph produced should include a lead marker to indicate the left or right side of the patient's anatomy (McQuillen-Martensen, 2011) and this is in stark contrast to the statement of Participant 1 who did not appear to see the importance of utilising anatomical markers. The observations of both participants that anatomical markers can be put on later is in contrast to Herrmann et al.'s (2012) view that in digital radiography the anatomical side markers should be depicted on the original image during the x-ray exposure. Anatomical markers that are applied after the image has been processed should be seen as a safety net and should not be regarded as praxis (Johnson, 2014).

3.3.1.2 *Sub-theme 1.2: Perceptions and attitudes of radiographers towards technological change*

Radiographers utilising analogue radiography acquire the image and process it using water-based chemicals and the image is displayed on an x-ray film. All the radiographers in this study were originally trained to use this analogue technology. Hence, many of the participants articulated feeling resistant to the introduction of digital imaging as designated by the citations below.

"So…, but in a way, I think, like I said maybe I'm just resistant to change but I still miss that old way." (Participant 7, line 1820-1821)

"In the beginning it was very difficult. We were very resistant and it was quicker to do analogue radiography than it was digital." (Participant 4, line 765-766)

Technology, such as the digital technology used in radiography, is a force that drives change in an organisation (Booyens, 2014). Booyens (2014) further adds that one of the reasons why people are inclined to resist change is because it is easier to do a job in the conventional way than it is to learn a completely new way of doing the job. The view held by Booyens (2014) regarding why people resist change is also the sentiment expressed by the above Participant 4 who stated that it was quicker to do analogue radiography than digital radiography.

The participants also expressed frustration about being required to adjust to the new digital technology. They experienced a diverse range of emotions as a result of the new technology. The extracts below express the feelings of two of the participants regarding the adjustment to the new technology.

"…And there was lots of tears and tantrums and frustrations uhm…, of course, as it is you know everybody resists change." (Participant 2, line 428-429)

"The only thing that frustrated me is we were trained a certain way." (Participant 10, line 2987-2988)

More and more professions are requiring their staff to be computer literate. According to the US National Telecommunications and Information Administration, 73% of people in the US make use of a computer to perform their job (Lazar, Jones & Shneiderman, 2006). In digital imaging the radiographer is now required to utilise a computer in the image production process. This expanded use of technology requires employees, such as the quoted radiographers, to be more skilled in the use of computer technology (Zimmerman, Sambrook & Gore, 2014). Employees, newly exposed to computer technology, may have a negative computer experience, where the computer does not do what the user wants it to do, and this may lead to frustration (Bessière, Newhagen, Robinson & Shneiderman, 2006) as expressed by the participants quoted above.

The participants expressed further negative feelings towards digital imaging as opposed to analogue imaging. For instance, one participant lamented having to use a very rigid mounted flat panel detector used in digital radiography as opposed to the portable cassette used in analogue radiography as evidenced by the following excerpts.

"With DR, I would say, the extremities was [sic] the worse to adjust to because we used to doing, you know, these patients in plaster of Paris [POP] – you're used to maneuvering the cassette for them, now all of a sudden you have to try and force the patient into the middle of the table." (Participant 1, line 51-54)

"Ja, you don't have a cassette anymore so now you have to do an elbow over there and they're in POP and they can't extend their arm nicely so you must make them lie half onto the table to get the elbow in the middle of the table…, [participant demonstrating how patient will extend across the table] instead of when you using a cassette you can put it right here [participant pointing to the edge of the table]. So that still is uncomfortable for the patient." (Participant 1, line 58-63)

A study conducted among dentists in the State of Indiana in the US corroborated the experience of this participant (Brian & Williamson, 2007). The study by Brian

and Williamson (2007) found that rigid direct digital receptors made patients uncomfortable and it made digital images more difficult to produce.

A different participant bemoaned the slow rate of image retrieval in digital radiography and the negative effects thereof. The participant ascribes it to the restricted memory of the computers that they were using.

"The computer's memory is only…, the RAM is only so big. So, therefore if it's a big program running, the computer runs slower. So, if the doctor's got a huge file like, I'm going to use a CT scan, for example, or an MRI that is trying to….. So, it's going to take extremely long for him to be able to…, to download those images." (Participant 4, line 1096-1099)

The slow retrieval of radiographic images, identified by this participant, is in accordance with a South African study conducted by van Heerden et al. (2011) that specified the slow traffic as a disadvantage of a picture archiving and communication system (PACS). Carlton and Adler (2013) validate the claim of the participant regarding the slow movement of computed tomography (CT) images. The authors indicate that in order to retrieve CT images, a network with adequate bandwidth is required to handle large data files (Carlton & Adler, 2013). In contrast to the slowness of image transmission, participants found image production to be faster than was the case in analogue imaging.

Despite the negative sentiments articulated above, radiographers also voiced feeling positive towards digital imaging. They stated that digital imaging was quicker than analogue imaging.

"So, it took a while and then once we settled in, we realised it actually is far quicker than what we were used to." (Participant 9, line 2697-2699)

"And this digital is so quick. It's like on the beat you see the picture you can see to repeat. You know, there isn't that minutes and hours of waiting and waiting for the pictures to come through a processor. So, it's just so much better." (Participant 3, line 572-574)

"…… digital is much better. I do like digital - it's quicker." (Participant 10, line 2983-3193)

A study by Andriole (2002) comparing film-screen radiography with computed and digital radiography for chest examinations concluded that both computed and digital radiography deliver better productivity compared to analogue imaging. This view corresponds to the opinion expressed by the three participants above that digital imaging is quicker than analogue imaging. Andriole (2002, p.161) describes productivity as the "rate of throughput from normalized timing studies". The participants' perception of digital imaging being quicker is also supported by Reiner and Siegel (2002) who posit that using digital imaging appreciably decreases radiographic examination times when compared to conventional film-screen radiography.

Another positive feeling expressed by the participants regarding the use of digital technology in radiography related to the ability to manipulate digital images.

"Now with modern technology you can make adjustments, you can manipulate your image." (Participant 9, line 2872-2873)

The observation by Participant 9, that images can be manipulated is echoed by a number of sources. Images in digital imaging can be adjusted during display whereas the contrast of the final image in analogue imaging cannot be changed once the image is processed (Körner et al., 2007; Bansal, 2006). The advantage of manipulating the image is that the content of the information on the x-ray image can be improved (Bushong, 2013). Post-processing manipulation could, however, change the original raw data in the digital image and lead to loss of information and therefore affect the quality of the images retrieved by radiologists and medical doctors (Herrmann et al., 2012).

Another participant also articulated a further positive impression of digital imaging.

"Now, you don't repeat so often because if your technique is good you don't need to repeat." (Participant 3, line 690-691)

The participant was of the opinion that when using digital technology the repeat rate of x-ray examinations is decreased in comparison to the analogue environment. In a study comparing conventional film-screen radiography and computed radiography, Lau, Mak, Lam, Chau and Lau (2004) found that the overall rejection rate for computed radiography was 1.3% compared to 2.1% for conventional radiography. This finding reinforces the perception of Participant 3. The participant's perception is further supported by Peer, Peer, Giacomuzzi and Jaschke (2001), in a comparative retrospective study that found the rejection rate for conventional imaging to be 27.6% and that of digital imaging to be 2.3%. A third study estimates the image reject/retake rate of analogue imaging to be 10-15% and that of digital imaging at 3-5% (Waaler & Hofmann, 2010). Whichever rate is accepted it supports the perceptions of the participant.

3.3.1.3 *Sub-theme 1.3: Radiographers experience challenges with adapting to new technology*

Radiographers reported experiencing problems with information and communications technology (ICT). The major problems experienced related to images being lost and the intermittent interruption of the digital system.

"He [doctor] doesn't find the image. The image is on the computer but the patient was done he knows the patient was done but it's not on uhm……" (Participant 4, line 1033-1034)

The participant indicated that at times doctors were unable to find the image that they had ordered despite the fact that the patient has had an x-ray examination. In abutment of this participant's view Gale and Gale (2000) say that undependable data can negatively influence patient care when images are labelled and stored inaccurately. The inaccurate storage and labelling of the images render them inadequate, dissimilar, odd or simply missing (Gale & Gale, 2000). The storage and labelling errors may occur when patient information is manually entered and typographical errors may arise (Kuzmak & Dayhoff, 2001).

The other difficulty experienced involved intermittent stoppages of the PACS system. One of the participants described the problem as follows:

"So our system would intermittently switch off and the doctors would complain that your system is down - because it could not take this load."
(Participant 8, line 2391-2393)

The participant complained about the intermittent downtime of the digital system. According to McBiles and Chacko (2000) when a PACS system fails rapid image accessibility and prompt image reporting availability are made redundant. It explains why the doctors would complain because they would not be able to retrieve any images or reports for the patients that they care for. The participant also indicated that this problem is intermittent and McBiles and Chacko (2000) recognise PACS downtime as a challenge, even though PACS downtime is uncommon.

In addition to the problems with ICT, the participants also faced challenges with the new equipment associated with the digital technology. Participant 8, uniquely, expressed the problems as follows:

"Because the CR's that was sent to us they were…, they were heat…., thermal ones. They were not the laser CR's…, laser printers…, the laser ones. Now, as a result for quite some time…, for a period of about a year or two we were struggling with exposures."(Participant 8, line 2259-2262)

The participant is opposed to the use of thermal printers and feels that these printers are a cause of the radiographers' struggles with adequate exposure selection. It appears as if the radiographer prefers the laser printers over the thermal ones. According to Sony Medical Systems (n.d.), a direct thermal printer delivers notably superior quality diagnostic images whereas they recommend laser printers for office purposes and for referring physicians and not necessarily for diagnostic printing. This recommendation seems to refute the participant's preference for a laser printer. The participant is also disproved by a Belgian study

that found that the finest image quality was acquired with direct thermal prints (Gijbels, Sanderink, Pauwels & Jacobs, 2004).

A further challenge, apart from the printers, was the Digital Imaging and Communications in Medicine (DICOM) compatibility of the machines (equipment) used by radiographers. This is verbalised by Participant 8 in the following manner:

"My machine's DICOM compatible, but he means…, what he means is that his machine can be connected to another machine, neh. But…, that machine can only send to the other machine, it cannot receive. Now, once you talk about DICOM you must be specific and say it must be DICOM retrieve and receive, uyabona." (Participant 8, line 2669-2673)

DICOM is a universal yardstick used to transmit, store and display medical imaging data (Kahn, Langlotz, Channin & Rubin, 2011). According to Honeyman-Buck (2003), it is essential that the machine executes at least a DICOM modality worklist, DICOM send and DICOM print functions. Honeyman-Buck (2003) concurs with this participant when she indicates that all modalities should spell out precisely what they mean by DICOM. Moreover, the author suggests that the PACS merchant should confirm that their equipment is able to co-function or interface with the existing modality (2003). The successful interfacing with other modalities is a notion held by Participant 8. Another important feature is for DICOM imagers to effectively communicate with both upstream and downstream collaborators as stated by the participant when he speaks of DICOM retrieve and receive. Sreenivas (2013) posits that end users should adequately evaluate their workflow requirements and insist on the interoperability capacity of medical (x-ray) systems before procuring them for their hospitals in order to overcome the complications highlighted by the participant.

Apart from the difficulties experienced with the new equipment, participants also experienced challenges with the quality of the images transmitted to doctors via PACS. This is how participants pronounced on this challenge:

"You get a nice image - by the time…, the image the doctor views in trauma is really not the same quality image. And they are…, the doctors will often turn around and say poor quality image or they can't see what they want." (Participant 9, line 2773-2775)

"……. but we also have a problem, for example, that the images from our fluoroscopy unit for example on the fluoroscopy unit it's beautiful but you send it through to the PACS - it's awful." (Participant 4, line 1075-1077)

In digital radiography several factors, along the digital imaging chain, can have an impact on the quality of the digital radiographs. The digital imaging chain is comprised of various steps such as image acquisition, archiving, processing, display, transmission, interpretation and reporting (Reiner, 2013). Often when the quality of a digital image is suboptimal it is difficult to ascertain the exact cause of the degradation. In the final analysis the quality of a digital radiograph is reliant on the management of the electronic information throughout the digital imaging chain (Butt, Mahoney & Savage, 2012). Two of the more common factors, i.e. image compression and image display degradation may explain the loss in image quality experienced by the participants.

Digital images can be compressed in order to enable the image processing, communication and storage of digital images (Canadian Association of Radiologists, 2011). This compression can take one of two forms, that is, lossy (irreversible) or lossless (reversible) compression (Huang, 2010). According to the Canadian Association of Radiologists (2011), radiographic digital images should ideally be reduced using lossless (reversible) compression as there is no loss of imaging data when the image is reconstructed. Lossy (irreversible) compression, conversely, minimises the size of the initial image and it may lead to the impairment of the substance of the image data (Seeram & Seeram, 2008). The possible use of lossy compression in the participants' hospital may explain the loss of quality of the images when sent to doctors via the PACS.

The digital images received by the medical doctors are viewed and interpreted on display monitors. If a suboptimal or an inappropriate display monitor is used it

will compromise the quality of the transmitted digital image (Butt et al., 2012). Badano (2004) posits that display monitors will always diminish the electronic information contained in the image. Furthermore, the functioning of the display will always decline over time therefore decreasing the quality of the displayed image (Samei et al., 2005). This could possibly explain the decreased image quality experienced by the referring doctors and confirm the statements of the participants.

The challenges participants were experiencing with adapting to the new technology, as seen through the lens of Schlossberg's Transition Theory (Schlossberg, 2011), underlines the notion of moving in, through and out of a transition. In this case the participants explained the challenges as they were moving through the transition. According to Schlossberg (2011) transitions take time and during this time individual's reactions may change – for better or for worse – as they move through the change. Departing from a series of routines and assumptions and implementing new ones take time (Anderson et al., 2012). During this time many people, or in this case radiographers, may be left vacillating while searching for the correct niche and this may even take years (Schlossberg, 2011).

The participants described the developments that they experienced as a result of the introduction of the new technology. They expressed having experienced changes in their radiographic skill set with regard to the selection of appropriate exposure factors, the radiation dose delivered to the patient, the application of proper collimation and the placement of anatomical markers. Furthermore, they expressed their positive and negative perceptions and attitudes towards the ushering in of digital imaging. Ultimately, the participants identified the challenges they experienced in their attempt to adapt to the digital technology. The evolution of the radiographers during this period of technological change was impacted on by their work environment. The role of the work environment on how the participants experienced the technological change will be dealt with in the next section.

3.3.2 Theme 2: Role of radiographers' work environment on their experiences of technological change

The participants reported that hospital and or radiography/radiology management have influenced the way in which they have experienced coping with the digital imaging technology. Further to this, the participants also observed that the changes in technology have influenced the way in which they related to certain members of the health care team. Finally, the shift in technology has led to intergenerational differences emerging among radiographers working with the digital imaging technology. Figure 3.2 demonstrates the correlation of theme two and the associated sub-themes. Below follows a deliberation of the sub-themes related to theme two.

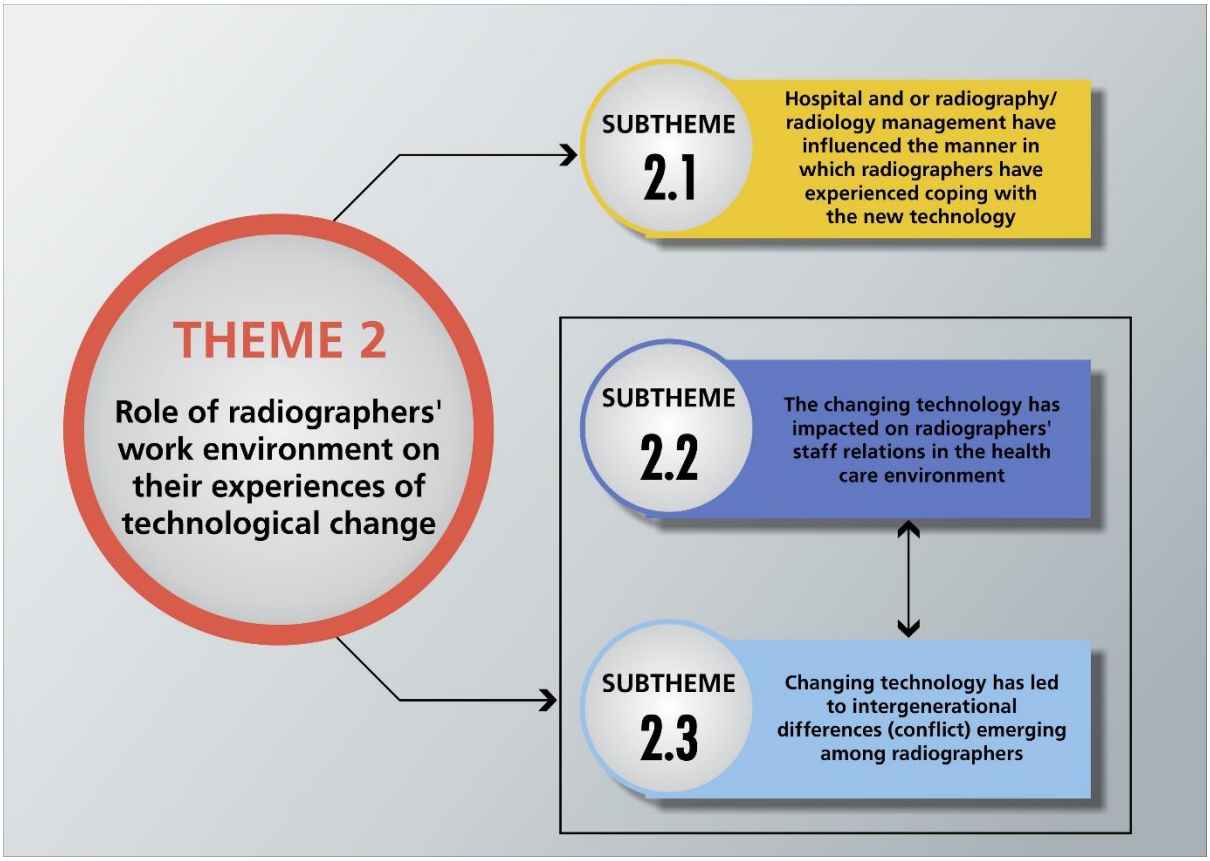

Figure 3.2: Theme two and its sub-themes

3.3.2.1 *Sub-theme 2.1: Hospital and or radiography/radiology management have influenced the manner in which radiographers have experienced coping with the new technology*

The participants suggested that hospital and or radiography/radiology management did not adequately plan for the introduction of the new technology. This is how the first participant expressed this sentiment:

"But, definitely I think, at the first introduction there should have been more understanding with radiographers of the switch over to the digital era." (Participant 4, line 932-935)

It appears that this participant felt that radiographers were not consulted about the changes that were to take place. The feelings of this participant resonate with a Finnish study by Maass and Eriksson (2006) that discovered that personnel, in general, had to cope with inadequate information and direction while management were suitably informed about the ideals of the digital endeavour. Eid and Al Shardan (2005) argue that in order to successfully instigate change programmes, departmental leaders should engage and actively involve the staff most affected by the change. The view by Eid and Al Shardan (2005) echoes the call, by the participant, for "understanding" and involvement of radiographers, by management, during the switch to the digital era.

Another participant verbalised the lack of planning by management in the following manner:

"I, uhm…, I was still working at [hospital V] then, yes and these people with the stands and monitors were suddenly wheeled into the department. We have been told that now the time has come to convert. The darkroom was officially closing down." (Participant 2, line 408-410)

It is clear from this participant's statement that the change was a sudden and abrupt one. This sudden change is in opposition to the recommendation by Bramson and Bramson (2005) who propose that the individuals who will be

utilising the new scheme should be participating in formulating the changes in the organisation. The reference to the darkroom in this participant's statement is what Campbell (2008) describes as the old identity. Campbell (2008) asserts that this old identity is not easy to relinquish as it means a discarding of the world as the individual knows it. Campbell (2008, p.34) describes this world as coming with its "security, self-identity and self-efficacy". The allusion to the darkroom is also addressed by Bramson and Bramson (2005) when they say that change upsets the way things are done and this prompts two opposing responses. The applicable response is to keep things as they are and to rehash the good old days, because the past brought eminence, acclaim and deference (Bramson & Bramson, 2005). The other response is to disregard what happened in the past and to race into the future (Bramson & Bramson, 2005).

Schlossberg postulates in Anderson et al. (2012) that older people tend to question their identity when they experience a transition. Often when reviewing their lives they would evaluate the present by viewing the past (Anderson et al., 2012).

Finally, another participant had this to say about the perceived lack of planning on the part of management:

"So, we were all confused and we've heard about it and we're bit unsure about the technology, 'cause you know you were trained in one thing and now to…, to suddenly change". (Participant 5, line 1131-1134)

Bezuidenhout (2014) theorises that a lack of information about upcoming events leads to confusion and this provokes an apprehension about the unfamiliar. Bezuidenhout (2014) further postulates that individuals do not know how the change will influence them and they may be concerned that they will not be in a position to fulfill the demands of the new technology. The assertions by Bezuidenhout (2014), reverberate with the confusion, the uncertainty about the technology and the concern about having been trained in the analogue environment and now the expectation to suddenly change as expressed by the participant.

Schlossberg (2011) refers to such unplanned, unpredictable and unexpected events – as described by the above participants – as an unanticipated transition and says that this type of transition is often very disruptive. Unanticipated transitions are much more stressful than a predictable, anticipated transition, however, the possibility for personal growth and learning are more likely than during an anticipated transition (Merriam, 2005).

Along with the perceived lack of planning for the switch from analogue to digital technology, participants also were of the opinion that their managers were insensitive to their needs as communicated by the participant below.

"So, you know, that's also part of the problem…, when you don't have the proper backup or the proper hierarchical tree that can do the things you have a problem. If there's a doctor around you've got more…, more oomph. But, if you don't have a doctor you…, you know just…, fart in the wind. Unfortunately, radiographers are……., very low on the scale of……., medical……uhm….., importance. You are nothing in comparison to Doctor So and So. Doctor So and So is God! And, unfortunately, the radiographers know that, so ja." (Participant 4, line 1109-1115)

In the excerpt above reference to the 'doctor' in actual fact refers to the radiologist in the x-ray department. The sole radiologist, referred to, was also the head of the radiology/radiography department. The participant is therefore describing her perception of how management viewed radiologists as important and radiographers as insignificant. Hence, it can be deduced from the quotation above that the participant felt that radiographers were not accorded the same respect and authority as medical doctors or radiologists. This belief, expressed by the participant, is described in the literature as medical dominance where doctors are looked upon as the predominant health care professional (Cooper, et al., 2011). In a study performed in Sydney, Australia it was found that about 73% of health care professionals felt, like the participant, not looked at as the professional equivalent of the medical doctor (Kenny & Adamson, 1992). Another study also conducted in Australia among radiographers, radiologists and medical doctors ascertained that radiographers in that country are also debilitated by

problems of medical dominance (Lewis, Heard, Robinson, White & Poulos, 2008). All the preceding studies affirm the feelings of the participant.

Apart from the felt lack of planning and the insensitivities of management, radiographers also held the view that management failed to implement acceptable change management strategies. Participant 8 expressed it in the following way:

"Training when you moving from one system to another system to orientate people. You know, people resist change and also they need to be orientated. Change management need to be implemented, uyabona……" (Participant 8, line 2583-2585)

The understanding deduced from this participant's use of the word orientation, is that managers should have provided radiographers with training and information regarding the new situation. Bramson and Bramson (2005) advise that any venture in new technology, like PACS, necessitates concomitant investments in training and continuing support. The authors state that often managers rely on perfunctory, one-off training stints presented by vendors when the new equipment is installed (Bramson & Bramson, 2005). The perspective of the said authors seem to corroborate the viewpoint of the participant. Similarly, Littlejohns, Wyatt and Garvican (2003), in a South African study on the failed implementation of a computerised hospital information system in the Limpopo Province, warn that inadequate education of hospital staff before implementing the change may lead to the failure of the new technology. This stance clearly supports the outlook of Participant 8. The participant also makes the link between the lack of training and information and resistance. In like manner, this link is also chronicled by Bezuidenhout (2014) when she outlines that the lack of information on forthcoming experiences causes people to resist the impending change. Honeyman-Buck (2003) comments that the finest and highest priced software and hardware will be ineffectual if the personnel operating the system resists it or undermines its working.

Earlier reference was made to Schlossberg's four variables (cf. 1.7 & 3.3.1.2) that have an influence on how well people deal with change. It is Schlossberg's (2011) contention that support on hand at the time of a transition is vital to the employee's sense of contentment. There seems to be a lack of contentment in the statement by the participant in accordance with Schlossberg's Transition Theory.

Additionally, the participant felt that management did not commit sufficient funding for the change process.

"They did not have a separate budget for this project. So, there's a lot that management can do. When you do project…, a project…, this change you need to have a budget. There's no change that you can implement…, no project that you can do without having a separate budget." (Participant 8, line 2601-2604)

According to Bezuidenhout (2014), managers often do not ruminate on the cost of change as they tend to focus on the advantages that stem from the change. In support of the participant, Maass and Eriksson (2006) recount how a PACS project at the Turku University Central Hospital (TUCH) in Finland suffered as a result of insufficient funding. Maass and Eriksson (2006) indicate that funding is required for, *inter alia*, personal computers, human resources, training, maintenance costs, hardware and software outlay as well as unexpected and indirect costs. All of the mentioned costs point to the idea that funding, or a budget as the participant phrased it, is much needed. At the TUCH, they spent less than 1% of the hospital budget on the PACS change process and that proved wholly inadequate as they lacked funding for training and for employing the appropriate staff (Maass & Eriksson, 2006).

The limitation of funding with regard to training and people could potentially have a detrimental effect on the change process. Honeyman-Buck (2003) has identified insufficient training as a reason for the failure of a PACS system. Jreisat in Schraeder, Tears and Jordan (2005) says that training projects are important in assisting the workforce to accept the new standards and configurations. The

views of the two aforementioned sources underline the importance of procuring funding for training activities. This strengthens the reasoning of Participant 8.

As a final point, for this particular sub-theme, radiographers also felt that senior management reportedly did not cooperate with management in the radiography/radiology department during the changeover from analogue to digital imaging. This is evidenced by the statement below:

"…… in actual fact, wena [ZZ], you need cooperation of the senior management in order for, uyabona. Senior management can assist a lot by cooperating……" (Participant 8, line 2626-2628)

Leadership is vital during the change management process. It is essential to gain adequate management commitment for the change, both at senior management level and below (Newton, 2011). Newton, therefore, is in agreement with the participant who advocates for cooperation from senior management. Luecke (2003) in his Seven Steps also proposes that an institution has a strong, visible leader who will own and lead the change programme. This leader will be in charge of aggregating the necessary resources required and will take responsibility for the accomplishment or failure of the project (Luecke, 2003). Luecke (2003) further underlines the importance of good management when he says that if an organisation has mediocre managers then the change management programme is doomed to failure. Management can ensure that there is productive cooperation, communication and synchronization between and among the respective team members in order to attain the aspirations of the change initiative (Vrazel, 2013). The ideas by Luecke and Vrazel further support the plea for the cooperation of senior management during the change management process.

Participant 8 was, of course, requesting for the cooperation of senior management from a position as middle manager. These middle managers are conventionally seen as the link between top management and those individuals required to deliver the necessary outputs and they therefore provide a complicated change intercessor role during the change pursuit (Balogun, 2003).

Hence, it is very important for senior managers to understand that they may influence change outcomes but middle managers have a lot more control over those outcomes and senior management should consequently view middle managers as partners in the change enterprise (Balogun, 2003). This is an important observation as senior management often regards middle management as a blockage to change, as reluctant implementers of change or merely as good foot soldiers (Balogun, 2003). The cooperation, as proffered by the participant, among all levels of management is fundamental because employees characteristically will observe the behaviour of their line manager (Newton, 2011).

Schlossberg (Anderson et al., 2012) identified the strategies adopted during a transition as one of the variables that will affect the success of the change undertaking. Schlossberg (2011) identified coping strategies as those that seek to change the situation, that attempt to re-evaluate the situation and those strategies that assist to lessen stress. Participant 8 alluded to the fact that management did not seem to have strategies to deal with the changeover from analogue to digital imaging.

3.3.2.2 *Sub-theme 2.2: Changing technology has impacted on radiographers' staff relations in the health care environment*

The changes required to effect new work methods do not only influence an employee's daily work routines and procedures, but also their relationships with other people within the organisation (Bramson & Bramson, 2005). Participants in this study were of the opinion that the working relationship between radiographers and medical doctors were influenced by the change in technology from analogue to digital imaging.

"The anaesthetist, the doctor in theatre, they also think this is pretty much an arbitrary job. I mean how hard can it be to push the machine in and screen. But, they don't realise what we do here. So, sometimes it is…, you do feel like you are just a second rate citizen." (Participant 7, line 2211-2214)

The participant describes a scenario where she goes to theatre to provide a radiographic service to the operating team. This scenario where one

radiographer delivers a service to a team in the operating theatre may lead to professional isolation and this isolation creates difficulties with professional identity (Strudwick & Day, 2014). According to Rose (2011), a lack of professional identity leads to feeling insecure. This insecurity can clearly be detected in the first part of the participant's statement. Rose (2011) does remark that in such an interprofessional team, collaboration demands a certain level of professional sacrifice. The professional isolation experienced by the radiographer may also give rise to in-group and out-group behaviour (Hean, Clark, Adams, Humphris & Lathlean, 2006). Where members of the operating team may view themselves as 'us' and the radiographer as 'them'. The 'other' is often subjected to stereotyping and prejudice (Strudwick & Day, 2014). Although the scenario described above is not unique to the digital environment it is certainly exacerbated by the introduction of the technology with its new terminology and language. Strudwick and Day (2014) identify the terminology and language that other professionals use as a possible obstacle to interprofessional team work. Barring feelings of professional insecurity the participant also felt that the medical doctors did not really understand what a radiographer does.

In the second half of the participant's statement she alludes to the idea that doctors do not understand the work of a radiographer. Strudwick and Day (2014) theorise that a number of professionals do not really have a grasp of the tasks of other professionals and this may give rise to prejudice and misunderstanding. Eggertson (2012) reports about a seasoned intensive care unit (ICU) doctor working side-by-side with nurses for 20 years not knowing what they did and what their daily professional activities and responsibilities entailed. The author proffers that all professionals of the interprofessional team should know the roles and responsibilities of the other team members and act towards one another with respect (Eggertson, 2012).

A further example of the effect of the changing technology on the radiographer-doctor relationship is encapsulated by another participant.

"He picks up the phone and craps on everybody because the patient is not on the…, on the computer. So, those are part of the problems that we do have." (Participant 4, line 1039-1041)

From the excerpt above it is evident that there may be challenges with regard to the radiographer-doctor communication pathway and their negotiation skills for conflict resolution. Professionals have diverse skills and expertise and in order to function successfully, communication is imperative in achieving an efficiently operating team (Shaw, de Lusignan & Rowlands, 2009). Communication according to Strudwick and Day (2014) is essential, between professional groups, in order to satisfy the requirements of the patient. The aforementioned sources are wholly applicable to the statement by the participant because effective communication would have led to the doctor and radiographer resolving what had happened to the patient's digital radiographs. The resolution may have spared the patient an unnecessary repeat x-ray examination.

The citation of the participant also highlights the conflict between the two professionals. Conflict is inexorable in interprofessional teams according to Brown, Lewis, Ellis, Stewart, Freeman and Kasperski (2010). Brown et al. (2010) recommend that professionals communicate openly and directly whilst showing the other professional respect, in pursuance of conflict resolution.

The changing technology has also impacted the relationship between the radiographer and the radiologist. The quote below highlights the unequal relationship between the professionals in the x-ray department.

"……. we'll be having fights, big fights with the radiologist and the radiographers would say, no there it is, you can see it. What more do you want, there it is, it is straight. Radiologists are saying no, no, no you're aren't supposed to……." (Participant 8, line 2529-2532)

The issue of medical dominance, which was discussed in an earlier passage (cf. 3.3.2.1) is very much applicable to the radiographer-radiologist professional relationship. The notion of where medical doctors are seen as the apex health

care professionals is evident in this relationship (Cooper et al., 2011). The fact that radiographers work very closely with radiologists causes the phenomenon to manifest in a different way to the radiographer-doctor relationship. In this excerpt the radiologist is seen to be overriding the opinion of the radiographer. The radiographer's opinion appears to be subordinate to that of the medical specialist (radiologist). This view is supported by Sim and Radloff (2009) who say that in radiography, medical dominance has meant that radiographers continue to be subordinate to radiologists. The subordination is entrenched because to a large extent radiologists would regulate the content of the radiographer's work and directly supervise the work performed by the radiographer (Lewis et al., 2008). This diminished autonomy disempowers the radiographer as professional power is associated with professional autonomy (Sim & Radloff, 2009). In this case the autonomy of the radiographer is flagrantly overruled by the radiologist (Lewis et al., 2008). The subordination, however, breeds contempt for authority and manifests itself in dissent as can be seen in this excerpt (Lewis et al., 2008).

Another participant expressed herself regarding the relationship between the radiographer and radiologist in a private practice setting. The relationship, in this setting, differs from the public sector interface purely because the radiologist would also be the employer of the radiographer.

"And I think those radiologists especially the one had a very different approach to…, his staff. And how things were done it was not a matter of you had a say. Or you…, you know, he was just different. He was in charge and that was it……" (Participant 7, line 2049-2052)

Australian radiographers in private practice described their workplace as a "pressure cooker" and they related radiologists and senior management as the culprits of this culture (Lewis et al., 2008, p. 94). According to the private practice radiographers, much of the pressure came from the notion of "getting the patient and money through the door" (Lewis et al., 2008, p. 94).

In this particular interaction above, highlighted by the participant, all the facets of medical dominance mentioned in an earlier reference apply. However, there is

also an added gender dimension or a male/female interplay. A largely female group of radiographers who have no say when interacting with a male radiologist brings Anne Witz's (1992) idea of patriarchy into play. Witz (1992, p. 11) identifies patriarchy as a "societal-wide system of gender relations of male dominance and female subordination". This definition outlines the situation as mentioned by the participant in the private practice milieu. Based on the discussion in the last two paragraphs, the radiographer-radiologist relationship is characterised by medical dominance manifested as subordination and patriarchy.

The discussion in the last few paragraphs has focused on the changed relationship between the participants and the medical professionals – both medical doctors and radiologists – brought about by the change in technology. Experiencing a transition modifies the professional roles of employees, but more applicably Schlossberg (2011) argues that it will change relationships in the workplace thereby confirming the feelings of the participants.

Finally, the changing technology has also impacted the relationship between the radiographer and patient. The focus of the radiographer can often be aimed at the technology and this may lead to the radiographer neglecting or disregarding the patient and patient care (Munn & Jordan, 2011). The first radiographer expressed the radiographer-patient relationship in terms of patient waiting time in the following manner:

"Particularly, [ZZ], neh, there is this thing of patient waiting time, neh. Because our patients, neh, although according to the Core Standards, neh, we…, our patients are not supposed to be waiting for more than an hour, neh. But, uhm…, but…, uhm…, our patients [ZZ], neh, like I've said to you. They don't even wait five minutes and then they are gone from x-ray. Five minutes is very long for a patient to be waiting for an x-ray - it is VERY long. Patient comes into x-ray he goes back to the doctor - he's back there by the doctor." (Participant 8, line 2571-2577)

The participant opined that the patient waiting time, in the digital dispensation, has been reduced. Another participant embraced a similar outlook:

"You know every day like the way we work, the speed that we can work at, the patients that we can get through and it's wonderful that we can do them and they can go." (Participant 7, line 2028-2030)

Sicotte, Paré, Bini, Moreault and Laverdure (2010) report that digital imaging has had a direct, positive influence on the quality of patient care because of the shorter waiting times for patients. The view of Sicotte et al. (2010) is consistent with the participants' suggestion and it is further substantiated by a US study performed at the University of Pennsylvania Medical Center (Redfern et al., 2002). The Redfern et al. (2002) study reported a two minute reduction per patient in an environment where there was a lack of an interface between the equipment and the Radiology Information System (RIS). However, Murphy (2006) questions the focus on 'input and output' because the author is concerned whether the patient's humanity is not impaired in the process. A similar view is espoused by Hayre, Blackman and Eyden (2016) who assert that using digital imaging has introduced an 'in and out' culture which means that patient throughput rate is increased but patient care may be compromised.

Another participant intimated that digital imaging allowed the radiographer to manipulate the digital image and therefore reduce the number of retakes.

"…… in a way, is good you don't have to re-expose the patient to radiation because you can manipulate the image." (Participant 6, line 1606-1607)

The dynamic nature of digital radiographic images allows for them to be manipulated (Bushong, 2013). The ability to manipulate the image was discussed in an earlier part of this chapter (cf. 3.3.1.2). An added advantage of this image enhancement is that the image does not have to be repeated and this spares the patient an additional exposure to radiation (Fauber, 2013) and it corroborates the statement of the participant. However, Körner et al. (2007) warn that altering processing attributes on digital images may suppress other attributes and this may unintentionally obscure the diagnostic attributes of the image thereby influencing the management of the patient.

A similar idea was expressed by another participant who felt that in the analogue environment radiographers repeated examinations more than in the digital environment, thus increasing the radiation dose to the patient.

"And you could do it five times, I mean…, you didn't worry about over exposing a patient - in a sense. Because, I mean, you had to produce a picture so what could you do you have to repeat that. Now, you don't repeat so often because if your technique is good you don't need to repeat." (Participant 3, line 687-691)

The matter of the reduced repeat/retake rate was visited in section 3.3.1.2 and the patient radiation dose was discussed in section 3.3.1.1. There is however, another matter where the participant reduces the patient to a 'picture' and the focus is on getting the picture right, so that the patient and patient care are ignored. The reductionist language, used by the participant, objectifies the patient and it places the image at the heart of the radiographic examination (Reeves & Decker, 2012). This technical priority or the necessity to create a diagnostic image distances the radiographer from the patient and negatively impacts on patient care (Booth, in press). Murphy (2006, p. 170) also believes that the "glorification of technology" is an obstacle to patient care.

Ultimately, another participant described the radiographer-patient relationship in the following terms:

"You know, it just becomes a slap the patient there and do the x-rays." (Participant 5, line 1207)

From the quote above it is clear that the patient is not at the centre of the radiographic endeavour. Murphy (2006) postulates that during high technology procedures patients are often dehumanized and objectified. This view is reinforced by Adler (1990), who says that the evolution in technology has created distance between the patient and radiographer as the radiographer is now hiding behind the controls of the high technology.

3.3.2.3 *Sub-theme 2.3: Changing technology has led to intergenerational differences (conflict) emerging among radiographers*

Radiographers are of the opinion that the change of technology has led to intergenerational differences developing among them. The work experience of the participants ranged from 11 to 36 years. The diversity of some of the x-ray departments in this study was complicated by the presence of student radiographers in those x-ray departments. The presence of the different generations is succinctly captured by Participant 4.

"…… you know we have got different generations and uhm…, we have different outlooks in life. You've got…, I'm going to use myself in that category…, you've got your 45 to 60 year olds which have been in this job for many, many years and then you have the child that is newly qualified that thinks she knows everything and…, uhm…, they will tell you're just as a radiographer like I am." (Participant 4, line 950-954)

The seminal input on the theory of generations was made by Mannheim in 1923 who identified a generation as a cohort of a society who have undergone comparable events in their youth; this cohort is placed within a particular period of time (Pilcher, 1994). As Participant 4 indicated, the workplace consists of people of different ages and these people therefore find themselves in different generations. And as these generations interface they develop opinions about one another (Urick, Hollensbe, Masterson & Lyons, 2016). Participant 4 is clearly expressing an opinion about the younger radiographer "that [sic] thinks that she knows everything." Fasbender and Deller (2016) posit that age-diversity has become more prevalent in the workplace and this diversity may contribute to negative outcomes between the different age groups. The negative outcomes could include conflict, miscommunication, misunderstanding, lowered productivity and poor working relationships (Becton, Walker & Jones-Farmer, 2014). From the excerpt above it is apparent that some of the negative organisational outcomes, described by Becton et al. (2014), such as conflict and miscommunication are present.

Older radiographers in this study also felt that younger radiographers were not performing to the desired standards, that they were careless and had a gap in their knowledge. According to them younger radiographers produce work of lower standard, younger radiographers are careless and there is a gap in the information (knowledge) of younger radiographers. Participant 2 explained the perceived lower standards of work in this way:

"…… his comment was that the era of the younger radiographers that are being produced, and working not just in State because he's worked in State as well but now what you experience in private is that the standard of work is just not what it used to be. It's not as high as it used to be so I'm not quite sure what the reason for that is. Uh.., is it because digital has spoilt us to such an extent that we are now letting a machine do what we used to do." (Participant 2, line 332-337)

While, on the other hand, Participant 4 articulated the observed careless attitude of younger radiographers towards their work in the following way:

"And also carelessness is another problem. Uhm…, I don't want to say the younger radiographers – us [sic] older radiographers are more mature. We are aware of all the problems that can occur so you make double sure that you…, and the young girls will just get through the work as quick as possible. Uhm…, not that the older ones don't want to get the through the work as well, but it's just a case of they become more careless." (Participant 4, line 1023-1028)

Finally, Participant 10 discussed the noted gap of information or knowledge in the following terms:

"…… there is a gap in information because the new staff or the newly qualifieds I find…, that they……. Uhm…, the thing is uhm…, we were taught, I think, in much more detail in certain respects." (Participant 10, line 3046-3048)

The perceptions held by older radiographers, of lowered work standards, carelessness of younger radiographers and the perceived gap of information will be classified as work values as per the definition used by Wils, Saba, Waxin and

Labelle (2011). Wils et al. (2011) define work values as (i) suitable workplace actions or behaviours, (ii) reflections of the importance of work, (iii) the meaning of work, and (iv) the foundation for business or professional ethics. Saba (2013) in reference to Wils et al.'s (2011) study indicates that employees in all generations have relatively similar work values. This stance, by Saba (2013), is in opposition to the statements made by the three participants quoted above. Despite Saba's (2013) stance, Hillman (2014) is of the opinion that work value conflict may arise due to technology-use differences, miscommunication and work balance issues. The position taken by Hillman (2014) affirms the participants' views.

Older radiographers in this study felt that student radiographers were not performing optimally because of a perceived lack of training and education. Older radiographers or radiographers trained in analogue imaging were particularly concerned that students have lost the art of radiography.

"Now, I can see it with the students it doesn't matter anymore. Which in that way…, radiographic practice is lost, that old school practice is definitely lost. …….we used to do scaphoids and wrists and things, small images all on one film because now you saving film. And I think there was a bit of an art to it. It's gone now." (Participant 6, line 1536-1539)

"Not anymore how you produced your work and even with the students there's no…, I don't know if they think that but there's no pride in what they doing it - because it can all look the same. You can split your image in to four, five, six different things and put it all in there - and it goes off to the doctor and it looks nice. Whereas if you wanted it to look nice, in my time, you had to make it nice - for your film to come out nice." (Participant 6, line 1554-1559)

The participant indicated how she experienced radiography as an art form. The art, according to her, lies in the fact that the radiographer was previously able to produce multiple, well collimated images on a single film. The idea of radiography being an art form is supported by Carlton and Adler (2013, p. 227) who say "radiographers can become technically artistic". Ricketts (2016) is of the opinion

that analogue imaging requires more finesse than digital imaging with regards to collimation and exposure selection, but he feels that digital imaging has not completely eradicated the artistry of radiographic imaging. Ricketts' (2016) belief does, in part, support the view of Participant 6.

In addition to the participants lamenting the demise of the art in radiography, they also expressed themselves on exposure selection by student radiographers in the digital era. Participants bemoaned the students' purported inability to select appropriate exposure factors that comply with the ALARA principle.

And exposures, I mean, now even as students they have no idea about…, forming your own exposure. I don't know if they are trained that but, it's all by the wayside now." (Participant 6, line 1540-1542)

"So, now for the students for example…, they are apparently, I hear they put the radiation…, or they set a [sic] exposure and they give all the patient's the same exposure. Because at the end of the day they look at the EI. They not worried about the dose they're giving the patient they worried about the EI they get on their plates." (Participant 4, line 883-887)

Typically, in an organisation where there is age-diversity, there are often differences in how various cohorts perceive what is right or wrong (Hillman, 2014). Older radiographers believe that they select their exposure in the correct way and student radiographers not. Ricketts (2016) advocates for the retention of film-screen radiography in bachelor's degree programmes because it is his contention that radiographers who were trained on film-screen radiography have a better understanding of the effects of the technical (exposure) factors (kV and mAs). According to Ricketts (2016), radiographers who have a good grasp of the technical factors are more accurate when selecting exposure factors and furthermore, he asserts that the exposure factors are fundamental to the reduction of patient radiation dose. Rickets (2016) is therefore in agreement with the participants who believe that older radiographers, or radiographers trained in the analogue environment are better at selecting exposure factors. Conversely, Ricketts (2016) and the participants' opinions are controverted by Hayre (2016)

who, in a UK study, found that radiographers do not understand or utilise digital radiography appropriately. This failure to understand digital radiography undermines the attempts of radiographers to apply the ALARA principle thus possibly leading to 'dose creep' as radiographers increase exposure factors in order to produce images of diagnostic quality (Hayre, 2016).

In addition to the perception that younger radiographers were not performing to the desired standards and students who were perceived not to be performing optimally, older radiographers also felt that it was scary working with interface devices. The older radiographers felt that they were not proficient enough to work with the computer and this made them fearful and nervous. With the migration from analogue to digital imaging, radiographers were required to produce radiographic images using the computer as a tool. Participants expressed themselves about their ability and feelings about the computer in the image production process in the following manner:

"Also I would say with the older radiographers, who were also not computer literate, they also struggled." (Participant 1, line 26-27)

"So, I'm very nervous of a computer - I only do what people show me to do. I'm not the…, kids…, you…, the youngsters grow up with the computer. So, they…, they can press buttons and they're not scared. I'm still the era where you scared you wipe out the program and you clear it and……" (Participant 3, line 579-582)

In analogue imaging the radiographic image was captured on a plastic radiographic film whereas in digital imaging the image is acquired, processed and displayed via electronic means by using a computer (Butt et al., 2012). In the x-ray department the staff complement is composed of radiographers who come from four different generations. According to The Center for Generational Kinetics (2016), these generations include the Baby Boomers who were born between 1946 and 1964, the Generation X's (1965-1976), the Millennials or Generation Y (1977-1995) and the iGeneration, Generation Z or Centennials (1996 and later). The participants in this research study were drawn from three of the four groups

identified. The only group that was not represented was the so-called iGeneration, Generation Z or Centennials. In a UK study to determine the confidence of diagnostic radiographers in the use of information management and technology, it was found that diagnostic radiographers largely displayed an elevated level of confidence when using PACS and RIS – which are both information management and technology systems (Rogers, Pratt, Brown & Gambling, 2010). Rogers et al. (2010) did not find a strong suggestion that confidence was influenced by age. This finding by Rogers et al. (2010) contradicts the statements by Participants 1 and 3.

Prensky in Helsper and Eynon (2010), on the other hand, seek to divide individuals into two broad categories, the so-called digital natives and the digital immigrants. The natives, he argues, were born in the last 25 to 30 years while the digital immigrants were born before the middle 1980s (Helsper & Eynon, 2010). The majority of participants in this study would have been drawn from the digital immigrant group. In a survey conducted by Helsper and Eynon (2010) it was found that younger people would use the Internet and they come from households where many more information technology media are used. This UK study, however, did not find any generational difference between the digital natives and immigrants in as far as ICT use is concerned (Helsper & Eynon, 2010). Yet again this study repudiates the sentiment expressed by the participants.

Contrary to the two quoted studies, Levine and Donitsa-Schmidt (1998), in a study with Israeli school children found that if students have prior computer experience it leads to lower levels of anxiety when working with a computer. This study confirms the experience of fear and anxiety suffered by the participants. It can, therefore, be deduced that the participants had very limited prior computer experience, hence the negative feelings experienced.

Ultimately, older radiographers felt that they would prefer to do the positioning and leave the computer work to the younger radiographers or students. Older radiographers were comfortable with producing analogue images without using

a computer. However, when the computer became part of the image production process, they retreated to the part of the process with which they were familiar.

"Especially the older girls even felt at the time very threatened because they didn't know the computers. And they would…, they would prefer to do the patients and have the younger girls actually process the patients and do the quality assurance of the examinations because it was easier that way than for them to actually struggle with the digital things. Even today there is some of the senior girls that are not as proficient with the digital field. They are some that will pass on…, and some are even too scared to work." (Participant 4, line 775-781)

According to Urick et al. (2016), generational differences linked to the behaviour towards technology leads to disputes when multigenerational groups have to work together. Behaviour-based conflict emerges when an individual ascribes another individual's behaviour to their affiliation to another generational cohort (Urick et al., 2016). In this study radiographers from diverse generational groups are working together and this creates conflict because in Participant 4's quotation one can identify a reference to more than one generational cohort. The different generational cohorts identified are placed in categories based on their use and non-use of technology.

In another study by Fridell, Edgren, Lindsköld, Aspelin and Lundberg (2007) on how PACS influenced the work practice of radiologists, the authors found generational differences developing between junior and senior radiologists. Senior radiologists feared the technology while the junior radiologists readily adopted the new technology (Fridell et al., 2007). The junior radiologists became the tutors of their seniors when working with the new technology (Fridell et al., 2007) and this reinforces the view expressed by Participant 4. The views expressed by Participant 4 are also held by Schlossberg (Evans, 1998) when she describes a transition as an event that gives rise to changing relationships and routines (cf. 1.7 & 3.3.2.2).

The participants felt that management could have handled the change management process better. In addition, they were of the opinion that their

relationship with medical doctors and radiologists were typified by medical dominance, subordination and patriarchy. Finally, the introduction of digital imaging has seen the emergence of intergenerational conflict between older, younger and student radiographers.

3.4 CONCLUSION

In this chapter, the researcher explored and described the experiences of analogue-trained radiographers utilising digital imaging in projection radiography, both in public and private practice. The two themes and the respective sub-themes identified were bolstered with the aid of a literature control. To a large extent, international studies were employed to corroborate and verify the research findings since there is very limited South African literature on the topic of digital imaging. In Chapter Four, the researcher will discuss broad guidelines for radiography managers to assist analogue-trained radiographers, and radiographers in general, to better utilise digital imaging.

CHAPTER 4 – DEVELOPMENT OF GUIDELINES

4.1 INTRODUCTION

Chapter 3 provided a description of the data collected during the semi-structured interviews with the participants. The data were analysed using themes to describe the experiences of analogue-trained radiographers utilising digital imaging in projection radiography. In Chapter 4, the researcher presents guidelines that were developed to equip radiography managers to assist analogue-trained radiographers to better utilise digital imaging. In addition, the guidelines would also assist all radiographers, including digitally-trained radiographers, to better utilise digital imaging.

4.2 SUMMARY OF THE FINDINGS

This study aimed to explore and describe the experiences of analogue-trained radiographers utilising digital imaging. Following data collection, a CAQDAS package was utilised to analyse the data in Chapter 3. The analysed data yielded two themes and six sub-themes. Theme one related to the evolution of the radiographer in the face of technological advancement whereas theme two related to the role of the work environment on the participants' experiences of the change in technology. The identified themes and sub-themes were used in the development of guidelines for radiography managers.

In theme one the participants articulated how their radiographic work was influenced by the change in technology. The participants reported on both the positive and negative influences as well as the challenges experienced with the new technology. Theme two, on the other hand, described the influences of hospital and radiography/radiology management on the manner in which participants experienced the change from analogue to digital imaging. Furthermore, theme two outlined the impact that the change in technology has had on the interprofessional relationships of the participants. The two themes were used to guide the researcher in the development of the guidelines.

The guidelines developed in Phase Two of this study will be “systematically developed statements” to assist radiographer decision-making regarding the applicable health care for particular clinical situations (Gerrish & Lathlean, 2015, p. 557). The objective of Phase Two was to develop guidelines to equip radiography managers to assist analogue-trained radiographers to better utilise digital imaging. However, these guidelines would assist all radiographers to better utilise digital imaging. Hence, the title of the guidelines is: *Guidelines for the better utilisation of digital imaging.* And these guidelines are now presented below.

4.3 GUIDELINES FOR THE BETTER UTILISATION OF DIGITAL IMAGING

The guidelines were developed to equip radiography managers to assist analogue-trained radiographers to better utilise digital imaging. This set of methodically established statements will serve to guide decisions about applicable radiographic practice and health care.

4.3.1 Purpose of the guidelines

The findings of this research study suggest that radiographers are not utilising digital imaging optimally. These guidelines are meant for radiography managers to provide direction to analogue-trained radiographers to better utilise digital imaging. The guidelines will therefore provide radiography managers with a framework to assist analogue-trained radiographers to utilise digital imaging in an ethical, cost-effective and safe manner in order to render a quality radiographic service to referring clinicians and the patients under their care. Radiography managers would therefore be expected to oversee the implementation of the guidelines by the analogue-trained radiographers who report to them.

4.3.2 Development of the guidelines

Using the themes identified in Chapter 3 (cf. Table 3.2), the researcher made suppositions about the predominant topics for the guidelines to be used by radiography managers. The guidelines should enable radiography managers to

assist analogue-trained radiographers to better utilise digital imaging. Six primary guidelines were developed from a process as used by Nyangeni (2015):

- The primary guideline was specified.
- The fundamental purpose and rationale of each primary guideline were specified.
- Sub-guidelines (secondary guidelines) were specified in order to further elucidate and operationalise the primary guideline.
- A purpose, rationale and action steps were developed in order to operationalise the sub-guidelines identified.

The researcher sourced information from publications of international organisations, such as the Society and College of Radiographers, the Royal College of Radiologists (both in the UK), the British Institute of Radiology, the International Atomic Energy Agency, the World Health Organisation and the American Society of Radiologic Technologists to compile the guidelines in this study. Where no sources are quoted the data come from the findings of the study. As far as the researcher could establish there are no South African guidelines on how to utilise digital imaging.

The guidelines for the better utilisation of digital imaging are mapped in Table 4.1 below. A detailed discussion of each primary guideline and sub-guideline follows Table 4.1.

Table 4.1 Guidelines for the better utilisation of digital imaging

Primary guideline	Sub-guideline
1. Selection of exposure factors	1.1 Radiographers have to apply optimal exposures 1.2 Radiographers must be aware that digital receptors have a wider exposure latitude and dynamic range 1.3 Radiographers must become acquainted with the particular

Primary guideline	Sub-guideline
	exposure indicator standards for their equipment 1.4 Radiographers must understand their responsibility when using an automatic exposure control (AEC) device
2. Patient radiation dose	2.1 Radiographers must weigh up the likely benefits of exposing a patient to radiation against the impairment for the patient 2.2 Radiographers must ensure that the radiation dose to the patient is in accordance with the ALARA principle
3. Apply optimal collimation	3.1 Radiographers should be cognisant of the advantages of proper collimation and should understand that the use of electronic collimation is not recommended
4. The placement of anatomical side markers	4.1 Radiographers should be mindful of placing anatomical side lead markers in the primary beam
5. Quality assurance	5.1 Radiographers must be aware that in digital radiography a comprehensive quality control and improvement programme must be implemented that includes: • A repeat analysis • Display monitors • A patient radiation dose management programme

Primary guideline	Sub-guideline
6. Implementation of digital imaging in an x-ray department	6.1 Radiography and hospital managers should be cognisant of the importance of the following during the implementation of digital imaging: • Training and support • Allocation of funding • Leadership • Teamwork • Planning

4.3.3 Primary guideline 1: Selection of exposure factors

The Ionising Radiation (Medical Exposure) Regulations 2000 (IR(ME)R), which is a piece of UK legislation, implores practitioners (radiographers) to intellectually consider the potential benefits of a radiographic exposure against the likely harm for the patient – which it describes as justification (BIR, SCoR, RCR, 2015). From this study it appeared as if participants did not apply their minds when selecting exposure factors for digital imaging. The radiographer's responsibility of intelligently selecting exposure factors has been supplanted by the introduction of digital receptors with a wider latitude and dynamic range. In addition to the wider latitude and dynamic range of digital systems there is also the use of AEC devices that give radiographers the impression that they do not have to think when applying exposure factors.

Main purpose

The main purpose of the guideline is to raise awareness among radiographers regarding the importance of selecting appropriate exposure factors. Also, the guidelines urge radiographers to justify the selection of particular exposure factors. Radiography managers should regularly encourage radiographers to select appropriate exposure factors.

Rationale

The selection of appropriate exposure factors is directly related to the production of a diagnostically acceptable radiographic image. Moreover, the selection of exposure factors also has a direct relationship with the radiation exposure received by the patient (Fauber, 2013). It is therefore important for the radiographer to select optimal exposure factors in order to ensure optimal image quality and a relatively low patient dose.

4.3.3.1 Sub-guideline 1.1: Radiographers have to apply optimal exposures

According to Fauber (2013), radiographers have the obligation to select a combination of exposure factors that will produce an image that will provide the information required to make a differential diagnosis. However, the participants in this study indicated that radiographers neglect to think about selecting exposure factors.

Purpose

This sub-guideline is designed to provide radiographers with a basic understanding of how their selection of kV and mAs influences the image quality and patient radiation dose.

Rationale

When selecting exposure factors the radiographer selects kV, milliampere (mA) and exposure time, in seconds (s), on the control panel. For the purposes of this discussion, mA and exposure time will be discussed as a single entity, namely mAs.

Kilovoltage will determine the penetrating ability of the x-ray beam (Fauber, 2013). Radiographers are reminded that an increase in kV will increase the likelihood of scattering and therefore decrease the quality of the radiographic image as digital receptors are more sensitive to scattered radiation (Carlton & Adler, 2013; Fauber, 2013). On the other hand, an increase in kV will lead to a decrease in patient dose. Therefore, an increase in kV with a concomitant decrease in mAs will decrease the radiation dose received by the patient (Carlton

& Adler, 2013). Furthermore, kV is used to control the contrast of the image in the analogue environment (Ball & Price, 1995).

Milliampere per second, however, determines the amount of x-ray photons in the x-ray beam and therefore determines the quantity of radiation reaching the image receptor and the patient (Fauber, 2013). In analogue imaging, mAs controls the density of the image (Ball & Price, 1995). In the digital environment the radiographer is able to adjust the brightness of the image even though the mAs applied is too low or too high. However, if the mAs selected is too low it will lead to image noise referred to as quantum mottle. Conversely, if the mAs selected is too high it will unnecessarily increase the radiation dose to the patient (Carlton & Adler, 2013). The radiographer therefore has to ensure that an optimal mAs is selected.

While selecting optimal exposure factors is a trade-off between image quality and patient radiation dose, the radiographer should adopt a bias in favour of reducing the dose received by the patient as required by the ALARA principle. Radiographers are also reminded that in the digital setting, unlike in analogue imaging, there is a disconnect between the mAs selected and the density or brightness produced. This disconnect also exists in the relationship between kV and the contrast of the image produced. Radiographers are therefore requested to consider using as low an mAs as possible and to increase the kV accordingly to retain the required exposure at the image receptor.

Action steps

The following action steps should be taken by radiography managers to achieve this sub-guideline:

- Encourage radiographers to select lower mAs values and correspondingly increase kV to ensure that the exposure at the image receptor is adequate.
- Inform radiographers about how changing mAs or kV influences the radiation reaching the digital receptor and the x-ray image.
- Familiarise analogue-trained radiographers with the dissonance between mAs selection and density or brightness in digital imaging.

- Familiarise analogue-trained radiographers with the dissonance between kV selection and contrast in digital imaging
- Remind radiographers about the link between mAs selection and patient radiation dose.
- Remind radiographers about the link between kV selection and patient radiation dose.
- Inform radiographers about how changing mAs or kV influences the quantity of radiation reaching the digital receptor and the x-ray image.
- Promote continuing professional development (CPD) activities related to exposure selection in digital imaging.
- Enjoin radiographers to attend short learning programmes (SLPs) regarding exposure selection in digital imaging.
- Encourage analogue-trained radiographers to enrol for postgraduate studies in diagnostic radiography.
- Initiate an in-service training programme that will deal with exposure selection in digital imaging.

4.3.3.2 *Sub-guideline 1.2: Radiographers must be aware that digital receptors have a wider exposure latitude and dynamic range*

Radiographers, trained in the analogue setting, need to understand that digital image receptors have a much greater exposure latitude and a wider dynamic range. It is therefore important for these radiographers to understand the effect this change in response of the receptors will have on the selection of exposure factors. Participants in this study did not appear to understand how different a digital image receptor responds to a selected exposure in comparison to the response of an analogue image receptor.

Purpose

The sub-guideline is intended to develop radiographers' understanding of the effect of the wider latitude and dynamic range of digital image receptors on their exposure selection.

Rationale

Radiographers need to be aware that digital receptors with their greater exposure latitude will allow the radiographer a greater margin of error, when setting exposure factors, yet still produce a diagnostically acceptable radiographic image (Carroll, 2014). The greater exposure latitude of digital receptors therefore allows the radiographer room to over or underexpose the image without having to repeat the radiograph. Overexposure, as previously mentioned, will have ramifications for patient dose while underexposure will affect image quality (cf. 4.3.2.2).

In addition to the greater exposure latitude, digital receptors also provide for a wider dynamic range. The wider dynamic range allows for more pixel values to be made available, by the hardware and software, during image formation (Carroll, 2014). This means that the digital receptors are able to precisely capture the various intensities that exit the patient's body (Fauber, 2013). However, the ability to capture the broad range of intensities does not necessarily signify that a quality radiographic image has been acquired (Fauber, 2013). It is the duty of the radiographer to ensure that the appropriate exposure factors are applied to produce a digital image of superior quality that complies with the ALARA principle.

Action steps

The following action steps should be implemented by radiography managers to achieve this sub-guideline:

- Encourage radiographers to apply optimal mAs and kV values as the digital receptors will allow them flexibility in the selection of exposure factors.
- Inform radiographers of the sensitometric response of digital receptors as compared to film-screen radiography.
- Inform radiographers of the potential for patient dose reduction because of the wider dynamic range of digital image receptors.
- Advise radiographers that digital receptors will invariably produce low contrast raw data images.

- Reinforce the notion of the dissonance between kV selection and image contrast (as mentioned in the previous statement that all digital images produced are low contrast raw data images).
- Inform radiographers about the function of lookup tables in altering the low contrast raw data images.
- Emphasise the link between mAs and kV and the patient radiation dose.
- Promote continuing professional development activities related to the principles of operation of digital image receptors.
- Urge radiographers to attend SLPs regarding the principles of operation of digital image receptors.
- Encourage analogue-trained radiographers to enrol for postgraduate studies in diagnostic radiography.
- Initiate an in-service training programme that will deal with the principles of operation of digital image receptors.

4.3.3.3 *Sub-guideline 1.3: Radiographers must become acquainted with the particular exposure indicator (EI) standards for their equipment*

Radiographers need to be aware that in digital imaging, exposure indicators (EIs) give the radiographer valuable information about the exposure to the image receptor (Fauber, 2013). In the analogue dispensation, radiographers would have inspected the x-ray film to gain an understanding of the appropriateness of the exposure factors selected. Participants appeared to be confused about the relevance of the EI value to the image production process.

Purpose

The purpose of this sub-guideline is to familiarise radiographers with the particular EIs applicable to the x-ray equipment utilised in their radiography department.

Rationale

Radiographers need to understand that the EI is a numeric value that indicates the amount of radiation reaching the image receptor (Fauber, 2013). Radiographers must be reminded that optimal ranges of EI are specific to a

particular vendor and the EI values fluctuate from procedure to procedure, so that the EI value for a chest image will differ from the EI value of an abdominal image, for example. The recommended EI range would have an upper limit and a lower limit. In the centre of this range is found the ideal or optimal amount of exposure to the digital image receptor referred to as the target exposure indicator (Carroll, 2014). It is also important for radiographers to note that there are three different methods adopted when forging a scale for an EI; these are logarithmic scales, proportional scales and inversely proportional scales (Carroll, 2014). Radiographers need to be aware that the upper and lower limits of the EI range will give an indication of over or underexposure depending on the EI scale used in their x-ray department. If the logarithmic scale is used, an EI value higher than the upper limit of the recommended range will denote overexposure of the patient (Carroll, 2014). Conversely, values lower than the lower limit will signify underexposure, which are associated with quantum mottle problems. Radiographers therefore have to select exposure factors that will yield an EI value that lies within the recommended range.

Action steps

The following action steps should be taken by radiography managers to achieve this sub-guideline:

- Understand that the final digital image is always adjusted by the computer.
- Be aware that the final digital image is the result of computer algorithms plus the technique applied by the radiographer.
- Be cognisant of the fact that the brightness or contrast achieved on the final image cannot be attributed entirely to the radiographer's technique.
- Ensure that radiographers are aware of the different types of EI methods that are employed by the different vendors.
- Be conscious of the type of EI method used in their x-ray department.
- Remind radiographers that there is no direct relationship between EIs and the brightness of the final image.
- Remind radiographers that inadequate exposure factors will lead to a low EI and this may lead to quantum mottle.
- Be mindful that a very high EI reveals an intolerable level of exposure to

the patient.

- Encourage radiographers to strive for the target exposure indicator.
- Encourage radiographers to select relatively high kV values and relatively low mAs values.
- Be aware of the limitations for EIs – such as the presence of big prostheses and anything that can bring about histogram analysis errors.

4.3.3.4 *Sub-guideline 1.4: Radiographers must understand their responsibility when using an AEC*

AEC devices are tools used to aid radiographers to determine the length of the exposure time (Carlton & Adler, 2013). Because AEC devices only control the length of the exposure, radiographers are still required to think when selecting the appropriate kV, mA and image receptor. Participants referred to the machine doing the thinking for them, implying that they were using equipment with an AEC device.

Purpose

This sub-guideline aims to provide radiographers with a fundamental understanding of their responsibility when employing an AEC device.

Rationale

This sub-guideline has been written to assist radiographers to better utilise AEC systems. Automatic exposure control devices are effective at keeping the exposure levels consistent, however radiographers have to be cognisant of the limitations of an AEC system (Fauber, 2013).

Action steps

Radiography managers should pursue the following steps to realise the sub-guideline:

- Ensure that the AEC system is properly calibrated for computed and digital radiography.
- Remind radiographers that relatively high kV values should be used to counteract the presence of quantum mottle.

- Remind radiographers to select the appropriate AEC detectors.
- Ensure that the patient is positioned properly over the selected detector/s.
- Refresh the memory of radiographers regarding the limitations of AEC systems, such as the minimum response time required for the AEC to react to the radiation and the generator to discontinue the exposure.
- Ensure that the AEC device has a backup time set to ensure that the exposure does not continue indefinitely. The backup time will safeguard the patient and the equipment.

4.3.4 Primary guideline 2: Radiographers must be conscious of the radiation dose administered to the patient

Participants in this study were of the opinion that one does not have to think about the exposure selected as the image can be manipulated afterwards to make it diagnostically acceptable. Contrary to this contention, radiographers are called upon to ensure that, firstly, an x-ray examination is justified and, secondly, that the exposure that is applied complies with the ALARA principle in order to minimise the patient radiation dose (BIR, SCoR & RCR, 2015).

Main purpose

The intention of this guideline is to ensure that radiographers understand their ethical and legal obligations and responsibilities regarding the radiation dose administered to the patient. The Hazardous Substance Act (94 of 1973) and the Regulations relating to Group IV Hazardous Substances (14596 of 1993) contained within the Act provides the regulatory framework to ensure the safety of the public. The ethical conduct of radiographers is regulated by the HPCSA.

Rationale

Radiographers need guidance to ensure that x-ray examinations that are requested are necessary and that the exposures applied are compliant with the ALARA principle in order to ensure that the patient dose is kept as low as reasonably possible.

4.3.4.1 *Sub-guideline 2.1: Radiographers must weigh up the likely benefits of exposing a patient to radiation against the impairment for the patient.*

Radiographers are required to consider the detrimental effects of exposing their patients to ionising radiation against the benefits of the x-ray examination (BIR, SCoR, RCR, 2015). Radiographers should, therefore, not perform x-ray examinations haphazardly without considering the safety of the patient.

Purpose

This sub-guideline seeks to inform radiographers of the importance of ensuring that a requested x-ray examination is indeed justified.

Rationale

Radiographers should understand that it is their ethical and legal responsibility to ensure that all x-ray requests received from authorised referring practitioners are definitely required. The request should be evaluated against the clinical history supplied by the referring clinician (BIR, SCoR, RCR, 2015), in order to ensure that patients are not unnecessarily subjected to ionising radiation.

Action steps

This sub-guideline can be accomplished if the following measures, proposed by BIR, SCoR and RCR (2015), are applied:

- Ensure that radiographers assess the examination requested to avert possible duplication and to establish the appropriateness of the current examination.
- Encourage radiographers to consult with the radiologist or referring clinician if there is a likelihood that the x-ray examination may be inappropriate.
- Inspect previous x-ray images to ascertain their relevance to the present problem.
- Ensure that radiographers are aware of the stochastic and deterministic effects of ionising radiation on their patients.
- Be cognisant of the vulnerability of certain organs to ionising radiation.

- Give specific consideration to children, young adults and females who may or may not be pregnant as their risk of cancer is increased because of their biologically more sensitive tissues.

4.3.4.2 *Sub-guideline 2.2: Radiographers must ensure that the radiation dose to the patient is in accordance with the ALARA principle*

Participants in this study exhibited an indifferent attitude towards exposing patients to ionising radiation, because, among other reasons, they could manipulate the digital image afterwards to obtain the desired image characteristics. It did not matter to them whether the exposure factors applied were too high or too low as they could still manipulate the image. According to the BIR, SCoR and RCR (2015), all medical exposures necessitate optimisation, which is a process where patient doses are held as low as reasonably practicable. In moving from analogue to digital imaging, radiographers often did not explore the possibility for dose optimisation because they used the new technology in the same way that they used the old equipment, that is they continued to use the same exposure factors and imaging methods (Rehani, 2011).

Purpose

The purpose of this sub-guideline is to provide information to radiographers in order for them to better understand digital technology and in particular the facets of the technology that influences patient dose.

Rationale

Radiographers should understand that the correct use of exposure factors is an integral part of any radiographic examination as the exposure factors will affect the quality of the image produced and, more importantly, the radiation dose to the patient (Seeram, 2011). Radiographers should, therefore, not have the indifferent approach, displayed by participants in this study, to the selection of exposure factors because it influences the radiation safety of the patient. While digital imaging has the capacity to reduce patient doses it also has the capacity to drastically increase patient doses (Rehani, 2011). This could be because radiographers know that underexposed images will have to be repeated because

of quantum mottle and therefore they use higher exposures to avoid repeats, resulting in dose creep (Seeram, 2011).

Radiographers should therefore be cognisant of selecting optimal exposure factors (cf. 4.3.3.1) and have an understanding of how the digital receptors respond to the selected exposures (cf. 4.3.3.2). Furthermore, radiographers must also be apprised of the EI standards in operation in their x-ray department (cf. 4.3.3.3). Finally, radiographers should have a good grasp of their responsibilities when using AEC systems (cf. 4.3.3.4).

Action steps

The following action steps should be implemented by radiography managers to achieve this sub-guideline:

- Remind radiographers about the link between kV selection and patient radiation dose.
- Remind radiographers about the link between mAs selection and patient radiation dose.
- Encourage radiographers to select relatively high kV values and relatively low mAs values.
- Ensure that the AEC device has a backup time set to ensure that the exposure does not continue indefinitely. The backup time will safeguard the patient and the equipment.
- Determine by using a phantom to what extent patient dose can be reduced before image quality is negatively influenced.
- Remind radiographers that diagnostically acceptable images can be achieved with a lower dose and images that exhibit some quantum noise.
- Inform radiographers of the potential for patient dose reduction because of the wider dynamic range of digital image receptors.
- Remember that a very high EI reveals an intolerable level of exposure to the patient.
- Recap the importance of good collimation.
- Initiate regular reject/repeat analysis programmes.

4.3.5 Primary guideline 3: Radiographers should apply optimal collimation

During the interviews, participants displayed a certain nonchalance towards collimating the x-ray beam, as they believed that it was possible to apply collimation after image acquisition. Radiographers should only collimate to include the anatomy of interest (Seeram, 2011) as this will improve contrast and avoid inappropriate EI values (Rehani, 2011).

Main purpose

This guideline was created to encourage radiographers to meticulously apply collimation, to include the anatomy of interest, when conducting digital x-ray examinations.

Rationale

Collimation is the curtailment of the x-ray beam by using lead shutters (Carter & Veale, 2014). By restricting the x-ray beam, a smaller area of the patient is exposed and this reduces patient dose and scatter production is minimised thereby improving image quality (Herrmann et al., 2012).

4.3.5.1 *Sub-guideline 3.1: Radiographers should be cognisant of the advantages of proper collimation*

It is important that radiographers apply proper collimation to all digital radiographs that they produce. Proper collimation allows the radiographer to optimise the radiographic technique (Bomer et al., 2013). Electronic collimation refers to the application of digital shutters after image acquisition (Bomer et al., 2013). This type of collimation is not recommended as the original field size and the digital image boundaries may not coincide. Participants in this study seemed to rely on collimation after image acquisition and this practice should be discouraged. Radiographers often apply electronic collimation because they believe that radiologists are distracted by the white or clear areas around the area of interest (Carter & Veale, 2014).

Purpose

This sub-guideline has the intention of conscientising radiographers to the advantages of applying proper collimation. In addition, this sub-guideline is to

discourage radiographers from relying on electronic collimation and to rather restrict the primary x-ray beam to the area of interest.

Rationale

Applying proper collimation prohibits excessive radiation exposure of the anatomy beyond the area of interest. This has the advantage of reducing scatter and thus improving image quality and also reducing the exposure to the patient. Electronic collimation suggests that the initial field size was bigger than the area of interest. All radiographs produced should reflect a white margin of one millimetre, known as the silver lining, around the anatomy of interest (Bomer et al., 2013). This silver lining can serve as a quality assurance tool to indicate what the original size of the x-ray beam was.

Action steps

The action steps below should be implemented by radiography managers to achieve this sub-guideline. Recommendations by Bomer et al. (2013) were used to compile the action steps for electronic collimation.

- Limit the x-ray beam to the anatomy of interest.
- Remind radiographers of the correlation between proper collimation and patient dose (cf. 4.3.4.2).
- Refresh radiographers' memories regarding the positive association between proper collimation and image quality.
- Inform radiographers of the effect of the lack of collimation that may lead to histogram analysis errors which may result in EI determination errors and rescaling errors.
- Remind radiographers of exposure field recognition failure which may lead to histogram analysis errors.
- Ensure that radiographers are conscious that multiple exposures on a single image receptor is contingent on the type of image receptor being used.
- Ensure that radiographers are awake to the fact that if multiple exposures are made on a single image receptor, the different exposure fields should

be aligned, there should be no overlapping of fields and lead shielding should be used.

- Discourage radiographers from collimating after image acquisition.
- Remind radiographers that electronic collimation holds the risk of overexposure.
- Inform radiographers that electronic collimation bears the risk of losing vital information.
- Notify radiographers that the silver lining may act as a quality control tool for proper collimation.

4.3.6 Primary guideline 4: The placement of anatomical side markers

The interviews revealed that participants were very eager to place anatomical markers at the post-processing stage or alternatively not to place an anatomical side marker at all. This is a very risky practice as it may expose the radiographer to legal action due to possible incorrect marking of the digital images (Herrmann et al., 2012; Bontrager & Lampignano, 2014).

Main purpose

The objective of this guideline is to highlight the importance of placing anatomical side markers on all digital radiographs.

Rationale

The placement of anatomical side markers is of the utmost importance and hence markers should be placed on every radiographic image during the exposure and not electronically after processing (Khosa, Thomas & Ramesh, 2015). Radiographers should be encouraged to conform to this practice, failing which, there could be possible legal consequences and possible negative outcomes for the patient.

4.3.6.1 *Sub-guideline 4.1: Radiographers should be mindful of placing anatomical side markers in the primary beam*

A left or right lead anatomical side marker should appear on every digital radiograph, prior to processing the image, denoting the left or right side of the

patient's body (Bontrager & Lampignano, 2014). Radiographers should therefore be discouraged from placing markers at the post-processing stage. The practice of not placing an anatomical marker at all, should not be tolerated by radiography managers.

Purpose

The intention of this sub-guideline is to promote the importance of attaching anatomical side markers to all images in the primary beam.

Rationale

The placement of anatomical side markers is crucial for projection radiography in order to identify the correct anatomical side of the patient. The correct lead marker also precludes radiological and clinical confusion and subsequent medico-legal issues (Khosa et al., 2015). Consequently, radiographers should be encouraged to place lead markers on all the images that they produce.

Action steps

This sub-guideline can be accomplished if the following measures are applied:

- Remind radiographers of placing a left or right lead anatomical side marker in the primary beam.
- Ensure that radiographic images do not show confusing anatomical side markers.
- Ensure that anatomical side markers do not obscure any of the anatomy of interest.
- Discourage radiographers from placing electronic/digital anatomical side markers as it carries the risk of error.
- Ensure that post-processing annotations are typed and placed suitably in order to avoid obscuring the anatomy of interest.
- Inform radiographers that if no anatomical marker was placed and there is uncertainty or any anatomical doubt, the image should be repeated.
- Provide radiographers with the necessary tools – lead anatomical markers - to achieve this sub-guideline.

- Carry out regular audits of the appropriate placement of anatomical markers practice.

4.3.7 Primary guideline 5: Radiography managers should initiate a quality assurance programme

Quality assurance refers to all the events that provide the radiography/radiology manager with confidence that the radiology service provided will regularly produce high quality images and services (Carlton & Adler, 2013). Participants in this study felt that the reject/repeat rate in digital imaging is lower than with the analogue technology. In addition, participants experienced a decrease in the image quality of transmitted images when compared to the original image. Lastly, participants also expressed a concern for the radiation dose delivered to their patients.

These guidelines will only focus on three such events, that is, a reject/repeat analysis, quality control of the display systems used and the monitoring of patient radiation safety. A reject or repeat analysis is an entrenched mechanism of quality control in radiography and is but one way of determining the levels of quality in the radiography department (Waaler & Hofmann, 2010). Another important factor that influences the image quality is linked to the functional features of display devices that are employed to examine digital images (Butt et al., 2013). It is therefore important that the radiography manager, in concert with radiography staff, audits the performance of display devices. Ultimately, radiographers are required to observe quality control procedures that will ensure that patient dose is kept reasonably low to ensure patient safety (Bushong, 2013).

Main purpose

This guideline has been developed to effect a consciousness among radiographers about selected quality assurance activities.

Rationale

According to Papp (2011), quality assurance is a comprehensive management programme that ensures excellence in the radiography department by systematically collecting and evaluating data. It is important for radiography

managers to establish the causes of rejects/repeats and to attempt to decrease or eradicate the rejects/repeats (Waaler & Hofmann, 2010). Radiographers and radiography managers should also realise that rejects/repeats, for whatever reason, will lead to an additional radiation exposure to the patient and this will compromise the management of patient radiation dose. Finally, all digital images are displayed on a monitor and it is therefore important to ensure that the display monitors perform consistently and within the appropriate limits (Butt et al., 2012).

4.3.7.1 *Sub-guideline 5.1: Radiographers must be aware that in digital radiography a comprehensive quality assurance programme must be implemented that includes a repeat analysis, a patient radiation safety programme and quality control of display monitors.*

Participants reported that the reject/repeat rate has decreased with the introduction of digital imaging. Radiography managers need to understand that it is very difficult to measure the actual reject/repeat rate in digital imaging even with specifically developed software (Waaler & Hofmann, 2010). It is also worth noting that rejects/repeats have not been eliminated with the advent of digital imaging, however, the causes of rejection have changed drastically (Waaler & Hofmann, 2010). Positioning errors, as opposed to exposure errors, have become the most common cause of repeated x-ray examinations (Seeram, 2011). These repeat examinations become a source of unnecessary patient dose and complicate the management of patient dose. In addition, to repeat examinations other sources of unnecessary exposures are unjustified x-ray examinations, improper radiographic technique, improper patient positioning, the non-use of shielding devices and inappropriate collimation (Bushong, 2013). Radiographers should be aware of these sources and seek to control them as far as is possible. Participants were concerned about the amount of radiation patients were exposed to. Finally, because every image in the digital environment is viewed on a display monitor, the performance of display monitors should be closely monitored. Participants stated that the quality of the original digital images were sometimes negatively affected when electronically transmitted to the referring clinician.

Purpose

This sub-guideline is designed to ensure that the reject/repeat rate is monitored regularly and kept as low as is reasonably possible. Secondly, it aims to assist radiographers to reduce or eliminate the sources of unnecessary patient dose. Thirdly, it was designed to ensure that the operation of display monitors are inspected on a regular basis.

Rationale

Rejects/repeats as well as unnecessary examinations contribute to patient dose and should therefore be closely monitored. Furthermore, the quality of all images displayed should be reasonably good to ensure proper patient management. Radiographers need to understand the display monitor is generally the most vulnerable link in the digital imaging chain (Carter & Veale, 2014).

Action steps

The following action steps should be implemented to ensure consistent quality images in the x-ray department:

A repeat analysis

The following steps proposed by Waaler and Hofmann (2010) should be implemented:

- Identify the specific criteria of how to count image rejects/repeats.
- Investigate the attitude and perceptions of radiographers towards clinical and technical image quality principles.
- Develop educational and training plans to improve the competence of radiographers with regard to digital image quality.
- Develop suitable software methods to record rejects/repeats using intuitive operating systems.

Patient radiation dose management

Papp (2011) proposes the following steps:

- Use high kV and low mAs exposure factors.
- Use high speed image receptors so a lower mAs value can be applied.
- Use the appropriate filtration as this can reduce the entrance skin dose of the patient by 90%.

- Employ the smallest filed size possible as it reduces the volume of the patient's body exposed to radiation.
- Utilise the optimum processing conditions in order to achieve uniform image quality.
- Avoid repeat examinations.
- Use the appropriate shielding, such as gonad shielding, which can decrease the dose received by the reproductive system by about 90%.

Display monitors

According to Butt et al. (2012) and Papp (2011), the following criteria, by the American Association of Physicists in Medicine (AAPM) in Task Group 18, should be examined:

- Check the general image quality and appearance of the monitor test pattern.
- Ensure that the display monitor shows no geometric distortion, that is, that there is no modification of the digital image by the display monitor.
- Ensure that there is no display reflection, therefore the radiography manager should select a display monitor that demonstrates a matt finish.
- Ensure that the luminance response of the display is within acceptable limits, that is, that it will display greyscale values with superior accurateness.
- Confirm that the luminance is uniform across the face of the display monitor.
- Ensure that the display resolution, or the ability of the monitor to show detail in an image as separate entities, is adequate.
- Ensure that the display noise is minimal, that is, that the display monitor does not have unwanted signals that may interfere with the image detail.
- Ensure that the graphics card that is used is optimal and complies with DICOM Part 14 Gray Scale Display Function and AAPM TG18 standards (Butt et al., 2012).

4.3.8 Primary guideline 6: Implementation of digital imaging in an x-ray department

Participants were of the opinion that management did not plan adequately for the

introduction of the new technology and they also felt that the training and support provided were not adequate. Moreover, participants felt that the funds allocated to initiate the programme were not sufficient. Participants also perceived the leadership, during the change process, to be lacking. Hospital and radiology/radiography management have to understand that implementing a digital project is a complicated task and it necessitates a management strategy with a substantial contribution from all stakeholders in order to produce a workable product (McLean, van der Putten & Delis, 2015). Furthermore, the migration from analogue to digital imaging affected radiographers and the radiology/radiography department as well as most members of the health care team. Participants reported that the new technology influenced their relationship with other health care professionals in the health care team. The researcher is aware that there are still hospitals in South Africa that use analogue imaging to perform radiographic examinations.

Main purpose

This guideline has been developed to assist managers to effectively deal with the change process when transitioning from analogue to digital imaging.

Rationale

It is essential that managers undertake effective planning as this will assist the organisation adjust faster to the impending change (Booyens, Jooste & Sibiya, 2015). Managers, while looking to the future, should also be mindful of providing radiographers and all other stakeholders with the necessary training and support to proficiently handle the new technology. Managers should also be aware that financial resources are required to ensure the delivery of a digital radiology service. And finally, unless there is strong leadership to influence the behaviour of the relevant employees and stakeholders it will be difficult to achieve the goals and objectives of the change process.

4.3.8.1 *Sub-guideline 6.1: Radiography and hospital managers should be cognisant of the importance of planning, training and support, the allocation of funding, provision of leadership and fostering teamwork during the implementation of digital imaging*.

Managers should provide leadership in the transition from analogue to digital imaging by planning the transition properly, providing training and support for the staff and allocating sufficient funding to bring about the change. The researcher is aware that certain sections of this sub-guideline may not be applicable to the hospitals where the participants were drawn from, because they may have already made the shift from analogue to digital imaging. However, the entire sub-guideline may be relevant to those radiography/radiology departments that are still contemplating making the move to digital imaging.

Purpose

This sub-guideline seeks to assist management to provide leadership by effectively planning, providing training and support, allocating funding and fostering teamwork during the change project.

Rationale

Any change project requires a strong, visible leader who will own and lead the project (Luecke, 2003). These leaders need to understand that a successful transition is contingent on meticulous planning and open communication (McLean et al., 2015) to ensure that the change is readily accepted by the staff and stakeholders (Booyens et al., 2015). Managers also need to be aware that the change process cannot be effected in the absence of adequate funding. A lack of funding may curtail the training and support of staff and stakeholders, among other things, and this may negatively influence the success of the digital project. Finally, any change project requires interprofessional collaboration in order to ensure its success. According to Fridell et al. (2009), the introduction of digital imaging required radiographers to find new ways of working with radiologists and referring clinicians.

Action steps

The action steps to achieve this sub-guideline will be discussed per subheading

that is, training and support, allocation of funding, leadership, teamwork and planning.

Training and support

This subsection of the sub-guideline can be achieved by following the guidelines by McLean et al. (2015) and Herrmann et al. (2012).

- Avoid overrating the computer knowledge of staff members. Elementary computer training may have to be offered to staff involved in digital imaging.
- Ensure that radiographers performing digital imaging are trained properly to manoeuvre the digital systems.
- Train radiographers in image acquisition, image processing, image review, proper selection protocols for particular examinations, exposure indicator protocols and radiation safety.
- Craft an all-inclusive training plan, assimilating training components for all categories of staff.
- Negotiate with equipment retailers to add training components as part of the purchasing deal.
- Apply a superuser model, where a small number of crucial staff receive supplementary on-site training. This cohort then becomes site specialists and will play an important role in future training endeavours. These site specialists will be responsible for the day to day training of staff.
- Concentrate on reusability of training programmes and materials.

Allocation of funding

This subsection of the sub-guideline can be achieved by keeping the following in mind as recommended by McLean et al. (2015):

- Plan adequate financial resources as part of a customised implementation plan.
- Allocate funds for the necessary hardware and software.
- Allocate funds to recruit vital staff, such as information technology staff and a medical physicist.
- Apportion funds to ensure that the communications infrastructure, such as a local area network, Internet and external connectivity is in place.
- Allocate funds for warranties and even extended warranties.

- Purchase a service contract at the time of installation. Distinguish between what is deemed to be spare parts and what are consumables in the service contract. Also differentiate between updates and upgrades in the service contract.
- Assign funding for training and further update training.
- Allocate funding for planning and managing the project.
- Designate funding for operating costs such as service costs, consumables and utility costs like Internet connections.
- Understand that all projects experience problems during implementation and therefore an additional 15% of the total costs should be allocated to support any contingencies.
- Be aware of installation costs, although this is almost always part of the purchase price.

Leadership

This subsection of the sub-guideline can be achieved by adhering to The RCR and SCoR (2012) document. The hospital or radiology/radiography leader should:

- Determine the direction
- Display the personal values and beliefs pertinent to the team.
- Lead the continuous improvement of the radiology service.
- Work mutually with all stakeholders to ensure the accomplishment of the agreed upon objectives of the project.

Teamwork

The following action steps, recommended by The RCR and SCoR (2012), could be implemented by managers to achieve the subsection of the sub-guideline:

- Identify clearly defined common goals and objectives in order to give the team an identity and to show that the identified goals and objectives are above the individual or personal goals. The common goals and objectives will also have a synergistic effect on the output of the team.
- Agree on what individual and mutual accountability entail among the various professionals.
- Value each other's skills in the various professions and work together to optimise the said skills.

- Identify agreed upon norms of conduct such as mutual respect, communication styles and expectations of excellence.

4.4 CONCLUSION

This chapter focussed on the development of guidelines that are intended to aid radiography managers to assist analogue-trained radiographers to better utilise digital imaging. Six primary guidelines were developed by means of the literature, the views of radiographers in this study and the experience of the researcher. Putting these guidelines into practice will ensure that all radiographers utilise digital imaging systems optimally thereby ensuring the best possible care for their patients.

CHAPTER 5 – CONCLUSIONS, RECOMMENDATIONS AND LIMITATIONS

5.1 INTRODUCTION

Chapter 1 related an outline of the research study as well as the description of the problem statement, goals and research objectives. Chapter 2 presented a detailed discussion of the research design and method applied. Whereas Chapter 3 provided a thick description of the data collected from participants during in-depth, semi-structured individual interviews. In addition, the chapter also presented an analysis of the collected data. In Chapter 4 the researcher presented guidelines for the better utilisation of digital imaging. This chapter will provide a summary of the findings, the limitations of the study, recommendations with regard to the data analysed in Chapter 3 and concluding remarks on the study.

5.2 SUMMARY OF THE FINDINGS

This research study stemmed from the researcher's interaction with radiographers in the NMBHD who revealed that the shift from analogue to digital imaging presented them with various problems. The aim of this study was to explore and describe the experiences of analogue-trained radiographers utilising digital imaging in projection radiography with the intention of developing guidelines to equip radiography managers to assist analogue-trained radiographers to better utilise digital imaging. Phase One of this study was to conduct in-depth interviews with analogue-trained radiographers to explore and describe their experiences of utilising digital imaging for projection radiography. The individual, semi-structured, in-depth interviews yielded information-rich data. The following two themes emanated from the interviews with the participants:

Theme 1: The evolution of the radiographer in the face of technological advancement

Participants revealed how their radiographic work had been changed by the introduction of digital technology. The participants indicated how radiographers no longer seemed to think about exposure selection, the radiation dose

administered to the patient, the collimation applied and the placement of anatomical markers before processing the image. In addition, participants also signalled that the introduced digital technology had caused them to act in various ways towards the new technology. Participants reported having both negative and positive feelings about the technology. Furthermore, the participants expressed experiencing various challenges with adapting to the new technology.

Theme 2: Role of radiographers' work environment on their experiences of technological change

The radiographers who participated in the study reported that the role of management has had an effect on how they have experienced coping with the introduction of digital imaging in the radiography department. Participants voiced that management did not adequately plan for the switch from analogue to digital imaging and further expressed that management were not sensitive to the needs of radiographers during the changeover. Participants were also of the opinion that acceptable change management strategies and cooperation were not followed. Moreover, during the changeover from analogue to digital imaging the staff relations between radiographers and other members of the healthcare team were impacted upon. The relationship between radiographers and medical doctors, inclusive of radiologists, were characterised by power imbalances and patriarchy. In addition, the relationship between younger and older radiographers saw intergenerational differences manifesting itself.

5.3 COMPLETION OF THE STUDY

The objectives of this study were:

- To conduct in-depth interviews with analogue-trained radiographers to explore and describe their experiences of utilising digital imaging for projection radiography.
- To develop guidelines in order to equip radiography managers to assist analogue-trained radiographers to better utilise digital imaging.

Objective one was realised in Phase One of this study by exploring and describing the experiences of analogue-trained radiographers utilising digital imaging for projection radiography. This objective was realised by employing a qualitative, exploratory, descriptive and contextual design. Objective two, furthermore, was accomplished in Phase Two by generating guidelines to equip radiography managers to assist analogue-trained radiographers, and radiographers in general, to better utilise digital imaging. The guidelines were generated by making suppositions from the interviews conducted with the participants and both the stated objectives were accomplished, therefore the research study is deemed to have been successful.

5.4 LIMITATIONS OF THE STUDY

The researcher identified the following limitations for this study:

- The study only probed radiographers in the NMBHD.
- Only radiographers who obtained their undergraduate qualification before 2007 and their BTech in Radiography before 2005 at the NMMU, were eligible for participation. The experiences of all other radiographers and student radiographers were not considered.
- The researcher only relied on the narrative of participants and did not observe them working with the digital technology in the clinical setting. Therefore, the suppositions made, were only based on the data received from the participants.
- There is a dearth of research on the utilisation of digital imaging in the South African context. The researcher was therefore compelled to consult international publications to validate the claims made by participants.

5.5 RECOMMENDATIONS

The researcher suggests the following recommendations in view of the findings and limitations of the study:

5.5.1 Recommendations for radiography practice

The recommendations for radiography practice are:

- The findings and guidelines of this study should be disseminated to all radiography managers in the public and private sector in order to create departmental policies on the appropriate use of digital imaging.
- The findings and guidelines should also be disseminated to the Professional Board of Radiography and Clinical Technology of the HPCSA in order to create national guidelines for digital image use in South Africa.
- Furthermore, the findings and guidelines should be disseminated to professional associations, such as the Society of Radiographers of South Africa, in order to develop relevant continuing professional development opportunities for their members.
- The findings and guidelines should also be circulated to the Directorate of Radiation Control in the South African Department of Health in order to monitor dose optimisation among radiographers utilising digital imaging.
- Radiographers should only be allowed to practice digital imaging once they have undergone a structured formal or non-formal training or education programme. This recommendation is made because radiographers are called upon to explore the possibilities for dose optimisation. Radiographers will not be in a position to pursue dose optimisation unless they have a firm understanding of the operation of digital imaging. In addition, the scope of practice of the profession requires that practitioners only perform those acts for which they have received training.

5.5.2 Recommendations for radiography education

The recommendations for radiography education are:

- The guidelines should be disseminated to all radiography educational institutions in South Africa to create learning opportunities in digital imaging for analogue-trained radiographers.
- Radiography educational institutions should develop formal and non-formal educational opportunities for analogue-trained radiographers in digital imaging.

- Radiology equipment vendors should be encouraged to desist from providing perfunctory, once-off training, but rather to offer training in conjunction with educational institutions.

5.5.3 Recommendations for radiography research

The recommendations for radiography research are:

- Research needs to be conducted to determine the knowledge, skills and attitudes of radiographers utilising digital imaging in the South African context.
- Further research needs to be conducted to determine dose optimisation among radiographers utilising digital imaging in South Africa.
- Also, more research needs to be performed with regard to the implementation of quality assurance programmes in digital imaging in the South African context.
- Furthermore, research needs to be conducted to determine the effectiveness of the guidelines proposed by this study.
- Finally, research on intergenerational conflict among radiographers, including younger radiographers, should be conducted.

5.6 CONCLUSION OF THE STUDY

This chapter provided a summary of the findings, limitations of the study identified by the researcher as well as recommendations for radiographic practice, radiography education and radiography research. Evidence was found of radiographer indifference towards exposure selection, dose optimisation and placement of anatomical side markers in the primary beam when using digital imaging. Further evidence emerged of interprofessional and intergenerational conflict as a result of the introduction of the new technology. This study proffered guidelines to equip radiography managers to assist analogue-trained radiographers, and radiographers in general, to better utilise digital imaging. The guidelines generated can be used to create local departmental policies. In addition, these guidelines can be used as the basis to develop national guidelines for best practice in digital imaging in South Africa.

"……the beginning is where the end gets born." – Catherynne M. Valente

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Addendum A

Nelson Mandela Metropolitan University
for tomorrow

Copies to:
Supervisor: Dr D Morton
Co-supervisor: Ms AD Grobler

Summerstrand South
Faculty of Health Sciences
Tel. +27 (0)41 504 2956
Fax. +27 (0)41 504 9324
Marilyn.Afrikaner@nmmu.ac.za

Student number: 205055371

Contact person: Ms M Afrikaner

3 June 2016

MR S CAMPBELL
7 BARTON ROAD
COTSWOLD
PORT ELIZABETH
6045

RE: OUTCOME OF PROPOSAL SUBMISSION

QUALIFICATION: MTech Radiography

FINAL RESEARCH/PROJECT PROPOSAL:
EXPERIENCES OF ANALOGUE-TRAINED RADIOGRAPHERS UTILISING DIGITAL IMAGING IN PROJECTION RADIOGRAPHY

Please be advised that your final research project was approved by the Faculty Postgraduate Studies Committee (FPGSC) subject to the following amendments/recommendations being made to the satisfaction of your Supervisors:

COMMENTS/RECOMMENDATIONS:

1. The proposal was well-structured and the problem statement well-defined.
2. The researcher and the supervisors must be commended on a well-presented and structured proposal.
3. Is the experience age related?
4. The aim seems to have some elements of bias, and it might be necessary to avoid this at the onset.
5. Budget needs revision, publication fees and the like seem vital for a Masters work.
6. The researcher should indicate having acquired or having plans to acquire skills with the research method to be used in the field such as coding. This is vital since an independent coder may not be available with the researcher in the field.

Please be informed that this is a summary of deliberations that you must discuss with your Supervisors.

FPGSC grants ethics approval. The ethics clearance number is **H16-HEA-RAD-001** and is valid for three years.

We wish you well with the project.

Kind regards,

Marilyn Afrikaner
FPGSC Secretariat
Faculty of Health Sciences

Addendum B: ECDOH approval

Eastern Cape Department of Health

Enquiries: Madoda Xokwe
Tel No: 040 608 0830
Date: 15 June 2016
Fax No: 043642 1409
e-mail address: madoda.xokwe@echealth.gov.za

Dear Mr. S. Campbell

Re: Experiences of Analogue-trained Radiographers Utilizing Digital Imaging in Projection Radiography (EC_2016RP51_805)

The Department of Health would like to inform you that your application for conducting a research on the abovementioned topic has been approved based on the following conditions:

1. During your study, you will follow the submitted protocol with ethical approval and can only deviate from it after having a written approval from the Department of Health in writing.
2. You are advised to ensure, observe and respect the rights and culture of your research participants and maintain confidentiality of their identities and shall remove or not collect any information which can be used to link the participants.
3. The Department of Health expects you to provide a progress on your study every 3 months (from date you received this letter) in writing.
4. At the end of your study, you will be expected to send a full written report with your findings and implementable recommendations to the Epidemiological Research & Surveillance Management. You may be invited to the department to come and present your research findings with your implementable recommendations.
5. Your results on the Eastern Cape will not be presented anywhere unless you have shared them with the Department of Health as indicated above.

Your compliance in this regard will be highly appreciated.

SECRETARIAT: EASTERN CAPE HEALTH RESEARCH COMMITTEE

PGDP EASTERN CAPE 2004 - 2014

Ikamva eliqaqambileyo!

Addendum C

• PO Box 77000 • Nelson Mandela Metropolitan University
• Port Elizabeth • 6031 • South Africa • www.nmmu.ac.za

Nelson Mandela Metropolitan University

for tomorrow

SS Campbell
7 Barton Road
Cotswold
Port Elizabeth
6045
0745044741
scampbell@nmmu.ac.za

15 June 2016

XXXXXXXXXXXX (removed to protect the identity of the individual)
Dora Nginza Hospital
Port Elizabeth

Dear XXXXXXXXXX

RE: REQUEST FOR PERMISSION TO CONDUCT RESEARCH AT DORA NGINZA HOSPITAL

My name is Sydney Campbell and I am a Masters student at the Nelson Mandela Metropolitan University (NMMU) in Port Elizabeth. The research I wish to conduct for my Master's dissertation is entitled: E*xperiences of analogue-trained radiographers utilising digital imaging in projection radiography*. The project is being conducted under the supervision of Dr D. Morton at the Department of Nursing Science and Mrs A.D. Grobler at the Department of Radiography at the NMMU.

Goal/Aim of the study

The aim of the study is to explore and describe the experiences of analogue-trained radiographers utilising digital imaging in projection radiography in order to provide guidelines on how analogue-trained radiographers can be better prepared to better utilise digital imaging.

I wish to interview radiographers at your institution. The data will be collected by conducting an unstructured interview with each participant. Each interview will last approximately 45-60 minutes. The question that they will be asked is:

- How did you experience the move from analogue to digital imaging?

Ethical considerations

Participants will not be coerced and they may withdraw from participating in the study at any time. The information gathered will be managed confidentially. Quotes from interviews may be used in the research report or in an academic article. However, the actual names of the participants will be replaced with

pseudonyms. There are no direct benefits for the participants, but the guidelines developed from the stud will be of benefit to their future patients.

Seeking consent

I am hereby seeking your consent to do research at your hospital. The Department of Health (DoH) has give me permission to conduct research at the following hospitals in the Eastern Cape: Uitenhage Provincia Livingstone, PE Provincial and Dora Nginza. The DoH permission letter is attached. I have attached a copy o my proposal and I have included a copy of the consent form to be used in the research process, as well as copy of the approval letter which I received from the NMMU Research Ethics Committee (Human).

Upon completion of the study, I undertake to provide your institution with a bound copy of the full researcl report. If you require any further information, please do not hesitate to contact me:

Cell:	0745044741	**Tel.:**	041-5043583
Fax:	041-5041643	**Email:**	scampbell@nmmu.ac.za

Thank you for your time and consideration in this matter.

Yours sincerely,

SS Campbell

Experiences of analogue-trained radiographers utilising digital imaging in projection radiography

I give consent for you to approach radiographers in my institution and that they may participate in the above mentioned project.

I have read the accompanying letter explaining the purpose of the research project and understand that:

- The role of the institution is voluntary
- I may decide to withdraw the hospital's participation at any time without penalty.
- Only radiographers who have signed will participate in the project
- All information obtained will be treated in strictest confidence
- The participants' names will not be identifiable and used in any written reports
- Participants may withdraw from the study at any time without penalty
- A report of the findings will be made available to the institution
- I may seek further information on the project from **SS Campbell** on:

Cell: 0745044741 **Tel.:** 041-5043583

Fax: 041-5041643 **Email:** scampbell@nmmu.ac.za

Name: _____ Signature: _____

Date: _____

Addendum D

• PO Box 77000 • Nelson Mandela Metropolitan University
• Port Elizabeth • 6031 • South Africa • www.nmmu.ac.za

Nelson Mandela Metropolitan University
for tomorrow

SS Campbell
7 Barton Road
Cotswold
Port Elizabeth
6045
0745044741
scampbell@nmmu.ac.za

15 June 2016

XXXXXXXXXXXXXXXXX (name removed to protect the identity of the individual)
The Clinical Governance Manager
Livingstone & PE Provincial Hospital
Port Elizabeth

Dear XXXXXXXXXX

RE: REQUEST FOR PERMISSION TO CONDUCT RESEARCH AT LIVINGSTONE & PE PROVINCIAL HOSPITAL

My name is Sydney Campbell and I am a Masters student at the Nelson Mandela Metropolitan University (NMMU) in Port Elizabeth. The research I wish to conduct for my Master's dissertation is entitled: E*xperiences of analogue-trained radiographers utilising digital imaging in projection radiography*. The project is being conducted under the supervision of Dr D. Morton at the Department of Nursing Science and Mrs A.D. Grobler at the Department of Radiography at the NMMU.

Goal/Aim of the study

The aim of the study is to explore and describe the experiences of analogue-trained radiographers utilising digital imaging in projection radiography in order to provide guidelines on how analogue-trained radiographers can be better prepared to better utilise digital imaging.

I wish to interview radiographers at your institution. The data will be collected by conducting an unstructured interview with each participant. Each interview will last approximately 45-60 minutes. The question that they will be asked is:

- How did you experience the move from analogue to digital imaging?

Ethical considerations

Participants will not be coerced and they may withdraw from participating in the study at any time. The information gathered will be managed confidentially. Quotes from interviews may be used in the research report or in an academic article. However, the actual names of the participants will be replaced with

pseudonyms. There are no direct benefits for the participants, but the guidelines developed from the study will be of benefit to their future patients.

Seeking consent

I am hereby seeking your consent to do research at your hospital. The Department of Health (DoH) has given me permission to conduct research at the following hospitals in the Eastern Cape: Uitenhage Provincial, Livingstone, PE Provincial and Dora Nginza. The DoH permission letter is attached. I have attached a copy of my proposal and I have included a copy of the consent form to be used in the research process, as well as a copy of the approval letter which I received from the NMMU Research Ethics Committee (Human).

Upon completion of the study, I undertake to provide your institution with a bound copy of the full research report. If you require any further information, please do not hesitate to contact me:

Cell: 0745044741 **Tel.:** 041-5043583

Fax: 041-5041643 **Email:** scampbell@nmmu.ac.za

Thank you for your time and consideration in this matter.

Yours sincerely,

SS Campbell

Experiences of analogue-trained radiographers utilising digital imaging in projection radiography

I give consent for you to approach radiographers in my institution and that they may participate in the above mentioned project.

I have read the accompanying letter explaining the purpose of the research project and understand that:

- The role of the institution is voluntary
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- Participants may withdraw from the study at any time without penalty
- A report of the findings will be made available to the institution
- I may seek further information on the project from **SS Campbell** on:

Cell: 0745044741 **Tel.:** 041-5043583

Fax: 041-5041643 **Email:** scampbell@nmmu.ac.za

Name: _____ Signature: _____

Date: _____

Addendum E

Nelson Mandela Metropolitan University

for tomorrow

• PO Box 77000 • Nelson Mandela Metropolitan University
• Port Elizabeth • 6031 • South Africa • www.nmmu.ac.za

SS Campbell
7 Barton Road
Cotswold
Port Elizabeth
6045
0745044741
scampbell@nmmu.ac.za

15 June 2016

XXXXXXXXXXXXXXXX (removed to protect the identity of the individual)
CEO: Uitenhage Provincial Hospital
Uitenhage

Dear XXXXXXXXXXX

RE: REQUEST FOR PERMISSION TO CONDUCT RESEARCH IN HOSPITAL

My name is Sydney Campbell and I am a Masters student at the Nelson Mandela Metropolitan University (NMMU) in Port Elizabeth. The research I wish to conduct for my Master's dissertation is entitled: E*xperiences of analogue-trained radiographers utilising digital imaging in projection radiography*. The project is being conducted under the supervision of Dr D. Morton at the Department of Nursing Science and Mrs A.D. Grobler at the Department of Radiography at the NMMU.

Goal/Aim of the study

The aim of the study is to explore and describe the experiences of analogue-trained radiographers utilising digital imaging in projection radiography in order to provide guidelines on how analogue-trained radiographers can be better prepared to better utilise digital imaging.

I wish to interview radiographers at your institution. The data will be collected by conducting an unstructured interview with each participant. Each interview will last approximately 45-60 minutes. The question that they will be asked is:

- How did you experience the move from analogue to digital imaging?

Ethical considerations

Participants will not be coerced and they may withdraw from participating in the study at any time. The information gathered will be managed confidentially. Quotes from interviews may be used in the research report or in an academic article. However, the actual names of the participants will be replaced with

pseudonyms. There are no direct benefits for the participants, but the guidelines developed from the study will be of benefit to their future patients.

Seeking consent

I am hereby seeking your consent to do research at your hospital. The Department of Health (DoH) has given me permission to conduct research at the following hospitals in the Eastern Cape: Uitenhage Provincial, Livingstone, PE Provincial and Dora Nginza. The DoH permission letter is attached. I have attached a copy of my proposal and I have included a copy of the consent form to be used in the research process, as well as a copy of the approval letter which I received from the NMMU Research Ethics Committee (Human).

Upon completion of the study, I undertake to provide your institution with a bound copy of the full research report. If you require any further information, please do not hesitate to contact me:

Cell:	0745044741	**Tel.:**	041-5043583
Fax:	041-5041643	**Email:**	scampbell@nmmu.ac.za

Thank you for your time and consideration in this matter.

Yours sincerely,

SS Campbell

E*xperiences of analogue-trained radiographers utilising digital imaging in projection radiography*

I give consent for you to approach radiographers in my institution and that they may participate in the above mentioned project.

I have read the accompanying letter explaining the purpose of the research project and understand that:

- The role of the institution is voluntary
- I may decide to withdraw the hospital's participation at any time without penalty.
- Only radiographers who have signed will participate in the project
- All information obtained will be treated in strictest confidence
- The participants' names will not be identifiable and used in any written reports
- Participants may withdraw from the study at any time without penalty
- A report of the findings will be made available to the institution
- I may seek further information on the project from **SS Campbell** on:

Cell: 0745044741 **Tel.:** 041-5043583

Fax: 041-5041643 **Email:** scampbell@nmmu.ac.za

Name: _____ Signature: _____

Date: _____

Addendum F

Nelson Mandela Metropolitan University
for tomorrow

• PO Box 77000 • Nelson Mandela Metropolitan University
• Port Elizabeth • 6031 • South Africa • www.nmmu.ac.za

10 June 2016

XXXXXXXXXXXXX (removed to protect the identity of the individual and practice)
Human Resources Manager
XXXXXXXXXXXXX

Attention: Managing partners of the Practice

Dear Sir/Madam

RE: REQUEST FOR PERMISSION TO CONDUCT RESEARCH IN YOUR PRACTICE

My name is Sydney Campbell and I am a Masters student at the Nelson Mandela Metropolitan University (NMMU) in Port Elizabeth. The research I wish to conduct for my Master's dissertation is entitled: E*xperiences of analogue-trained radiographers utilising digital imaging in projection radiography*. The project is being conducted under the supervision of Dr D. Morton at the Department of Nursing Science and Mrs A.D. Grobler at the Department of Radiography at the NMMU.

Goal/Aim of the study

The aim of the study is to explore and describe the experiences of analogue-trained radiographers utilising digital imaging in projection radiography in order to provide guidelines on how analogue-trained radiographers can be better prepared to better utilise digital imaging.

I wish to interview radiographers at your institution. The data will be collected by conducting an unstructured interview with each participant. Each interview will last approximately 45-60 minutes. The question that they will be asked is:

- How did you experience the move from analogue to digital imaging?

Ethical considerations

Participants will not be coerced and they may withdraw from participating in the study at any time. The information gathered will be managed confidentially. Quotes from interviews may be used in the research report or in an academic article. However, the actual names of the participants will be replaced with pseudonyms. There are no direct benefits for the participants, but the guidelines developed from the study will be of benefit to their future patients.

Seeking consent

I am hereby seeking your consent to do research at your practices in Port Elizabeth and Uitenhage. I have attached a copy of my proposal and I have included a copy of the consent form to be used in the research process, as well as a copy of the approval letter which I received from the NMMU Research Ethics Committee (Human).

Upon completion of the study, I undertake to provide your institution with a bound copy of the full research report. If you require any further information, please do not hesitate to contact me:

Cell:	0745044741	**Tel.:**	041-5043583
Fax:	041-5041643	**Email:**	scampbell@nmmu.ac.za

Thank you for your time and consideration in this matter.

Yours sincerely,

SS Campbell

E*xperiences of analogue-trained radiographers utilising digital imaging in projection radiography*

I give consent for you to approach radiographers in my institution and that they may participate in the above mentioned project.

I have read the accompanying letter explaining the purpose of the research project and understand that:

- The role of XXXXXXXXXXX is voluntary
- I may decide to withdraw the practice's participation at any time without penalty.
- Only radiographers who have signed will participate in the project
- All information obtained will be treated in strictest confidence
- The participants' names will not be identifiable and used in any written reports
- Participants may withdraw from the study at any time without penalty
- A report of the findings will be made available to the institution
- I may seek further information on the project from **SS Campbell** on:

Cell: 0745044741 **Tel.:** 041-5043583

Fax: 041-5041643 **Email:** scampbell@nmmu.ac.za

Name: _____ Signature: _____

Date: _____

Addendum G

Province of the
EASTERN CAPE
HEALTH

Room DG15 •1st Floor • Dora Nginza Hospital • Spondo Street • Zwide • Port Elizabeth• Eastern Cape
Private Bag X11951 • Algoa Park • Port Elizabeth • 6005 • REPUBLIC OF SOUTH AFRICA
Tel.: +27 (0)41 406 4428 • Fax: +27 (0)41 406 4206 • cathleen.davids@echealth.gov.za

TO:	Mr S. Campbell
CC:	
FROM:	Ms B.C. Ndlovu
SUBJECT:	***Experiences of analogue-trained radiographers utilising digital imaging in projection radiography***
DATE:	1 July 2016

Dear Mr S. Campbell

Permission is hereby granted for you for the ***Experiences of analogue-trained radiographers utilising digital imaging in projection radiography research*** at Dora Nginza Hospital and to perform such procedures as required in accordance with the university guidelines for students.

The duration that the above mentioned Research will be present in the hospital is as per arrangement. During such time you agree to abide by all hospital rules and regulations regarding conduct, patient privacy and confidentiality and access to sensitive information.

Further it is agreed and assurance is given that no information will be given to the media or used in any way to negatively impact on this hospital.

The participant fully indemnifies the hospital from any responsibility should any untoward event or accident befall him/her while on the premises of Dora Nginza Hospital.

Yours in health

MS B.C. NDLOVU
ACTING CEO (DNH)

CEO'S OFFICE
DORA NGINZA HOSPITAL / HOSPITAAL
PRIVATE BAG 11951
PRIVAATSAK
ALGOA PARK, 6005
DATE: 01/07/2016

Addendum H

Province of the EASTERN CAPE HEALTH

Office of the Senior Manager: Medical Services • 1st Floor • Nurses' Home
• Livingstone Hospital
• Stanford Road • Korsten • Port Elizabeth
PO Korsten • Port Elizabeth • 6014 • REPUBLIC OF SOUTH AFRICA
Tel: +27 (0)41 405 2100/2010/102 • Fax: +27 (0)41 405 2103

06 July 2016

Mr SS Campbell
7 Barton Road
Cotswold
Port Elizabeth
6045

Via e-mail: scampbell@nmmu.ac.za

Dear Mr Campbell

Re: REQUEST FOR PERMISSION TO CONDUCT RESEARCH AT LIVINGSTONE AND PE PROVINCIAL HOSPITAL – *"Experiences of analogue-trained radiographers utilising digital imaging in projection radiography"*

Your request to do research at Livingstone and PE Provincial hospitals refers.

Authorisation is herewith granted to do your research at the above named hospitals.

Kindly contact XXXXXXXXXX at Livingstone and XXXXXXXXXX at PE Provincial to make the necessary logistical arrangements.

You are to ensure that your study does not disrupt services and you must maintain strict confidentiality at all times.

On conclusion of your study, a research report detailing your findings and recommendations is to be made available to the hospital.

May I take this opportunity to wish you success with your studies.

XXXXX XXXXXX
ACTING SENIOR MANAGER MEDICAL SERVICES

NAMES REMOVED TO PROTECT THE IDENTITY OF THE INDIVIDUALS

Province of the
EASTERN CAPE
HEALTH

Addendum J

Room 110 • 1st Floor • Provincial Hospital • Charmer Street • Uitenhage • Eastern Cape
Private Bag X38 • Uitenhage • 6230 • REPUBLIC OF SOUTH AFRICA
Tel.: +27 (0)41 995 1103 • Fax: +27 (0)41 995 2604 • Website: www.ecdoh.gov.za

Attention: Mr. S. Campbell

Re: Requesting permission to conduct research on 'Experiencing of analogue-trained Radiographers utilizing digital imaging in projection radiography. Ethical clearance number: H16-HEA-RAD-001.

1. With reference to your letter dated 15 June 2016 regarding abovementioned matter, I would hereby grant officially permission for the study to be performed in our hospital.
2. We also acknowledge the letter from NMMU where you are currently busy with your studies confirming this.
3. It is also noted that permission was granted by the ECDOH.
4. Your request have been forwarded to the Deputy Director Clinical Support, XXXXXXXXXXX and the Assistant Director Radiography department, XXXXXXXXXX.
5. It will be expected from you to make prior arrangements with either of them on the days that you will visit the institution.
6. You must contact the Nursing manager on call if you are planning a visit after hours. Contact number and details of the person on call can be obtained at the security at the information desk.
7. We wish you well with the studies and would appreciate it if you will give us feedback of the findings of the study.
8. I do apologise for the delay in responding officially to your correspondence.

XXXXXXXXXXXXXXX

XXXXXXXXXXXX (removed to protect the identity of the individual)
CEO - Uitenhage Provincial Hospital

Addendum K

4 July 2016

To Whom it may concern

Research: Mr S Campbell -

Experiences of analogue-trained radiographers utilising digital imaging in projection radiography

I give consent for you to approach radiographers in my institution and that they may participate in the above mentioned project.

I have read the accompanying letter explaining the purpose of the research project and understand that:

- The role of is voluntary
- I may decide to withdraw the practice's participation at any time without penalty.
- Only radiographers who have signed will participate in the project
- All information obtained will be treated in strictest confidence
- The participants' names will not be identifiable and used in any written reports, and they will be informed of and consent to the use of voice recorders, where applicable.
- Participants may withdraw from the study at any time without penalty
- A report of the findings will be made available to the institution
- I may seek further information on the project from **SS Campbell** on:

Cell: 0745044741 **Tel.:** 041-5043583
Fax: 041-5041643 **Email:** scampbell@nmmu.ac.za

Yours Sincerely,

Name: H.R. Manager: Signature: _____

Date: 4 July 2016

Addendum L – Letter to request permission to interview participant and consent form

Nelson Mandela Metropolitan University
for tomorrow

• PO Box 77000 • Nelson Mandela Metropolitan University
• Port Elizabeth • 6031 • South Africa • www.nmmu.ac.za

SS Campbell
7 Barton Road
Cotswold
Port Elizabeth
6045
0745044741
scampbell@nmmu.ac.za

13 July 2016

Dear Participant

RE: REQUEST FOR PERMISSION TO INTERVIEW PARTICIPANT

My name is Sydney Campbell and I am a Masters student at the Nelson Mandela Metropolitan University (NMMU) in Port Elizabeth. The research I wish to conduct for my Master's dissertation is entitled: *Experiences of analogue-trained radiographers utilising digital imaging in projection radiography*. The project is being conducted under the supervision of Dr D. Morton at the Department of Nursing Science and Mrs A.D. Grobler at the Department of Radiography at the NMMU.

Goal/Aim of the study

The aim of the study is to explore and describe the experiences of analogue-trained radiographers utilising digital imaging in projection radiography in order to provide guidelines on how analogue-trained radiographers can be better prepared to better utilise digital imaging.

Seeking consent

I am hereby seeking your consent to interview you for the purposes of this study. I will be interviewing radiographers at your institution. Each interview will last approximately 45-60 minutes.

The question that you will be asked are:

- How did you experience the move from analogue to digital imaging?

Ethical considerations

You should not feel coerced. You may withdraw at any time and information will be managed confidentially. Quotes from the interviews may be used in the research report or in an academic article. However, the actual names of the participants will be replaced with pseudonyms. There are no direct benefits for you, but the

guidelines developed from the study will be of benefit to your colleagues and the institutions where they are employed.

Upon completion of the study, I undertake to provide your institution with a bound copy of the full research report. If you require any further information, please do not hesitate to contact me:

Cell:	0745044741	**Tel.:** 041-5043583	
Fax:	041-5041643	**Email:**	scampbell@nmmu.ac.za

Thank you for your time and consideration in this matter.

Yours sincerely,

SS Campbell

Experiences of analogue-trained radiographers utilising digital imaging in projection radiography

I give consent for you to interview me and I am willing to participate in the above-mentioned project. I have read the accompanying letter explaining the purpose of the research project and understand that:

- My participation is voluntary
- I may decide to withdraw at any time without penalty
- All information obtained will be treated in strictest confidence
- My name will not be identifiable and used in any written reports
- A report of the findings will be made available to me via my institution
- I may seek further information on the project from **SS Campbell** on:

Cell: 0745044741 **Tel.:** 041-5043583

Fax: 041-5041643 **Email:** scampbell@nmmu.ac.za

_____ _____

Participant Signature

_____

Date

Addendum M: Participant demographic sheet

Nelson Mandela Metropolitan University

for tomorrow

• PO Box 77000 • Nelson Mandela Metropolitan University
• Port Elizabeth • 6031 • South Africa • www.nmmu.ac.za

Participant demographic sheet

First name			**Surname**	
Gender	*Male*	*Female*	**Years of experience**	
Qualifications obtained			**Where and when obtained**	
Number of interview			**Date of interview**	
Identification number (researcher use only)			**Contact details**	**Work:** **Cell:**
Field notes:				

(Adapted from R van de Venter, 2016)

Addendum N

24 Justin Road

Broadwood

Port Elizabeth 6070

TO WHOM IT MAY CONCERN

I, Aileen Gail Klopper, declare that I have analysed the interviews for and developed the themes and sub-themes for the research conducted by SYDNEY CAMPBELL, (Student Number: 205055371) for the dissertation entitled:
EXPERIENCES OF ANALOGUE-TRAINED RADIOGRAPHERS UTILISING DIGITAL IMAGING IN PROJECTION RADIOGRAPHY.

The themes form the data analysis for the above dissertation for the degree of Master of Technology (Research) in the Faculty of Health Sciences at the Nelson Mandela Metropolitan University.

Any queries related to this analysis can be directed to me at 074 3209463.

Signed at Port Elizabeth on 26 January 2017.

Ms AG Klopper (MA HWM)
Associate: Professional Editors Guild

Addendum O

24 Justin Road

Broadwood

Port Elizabeth 6070

TO WHOM IT MAY CONCERN

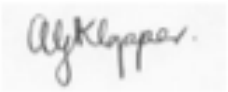
I, Aileen Gail Klopper, declare that I have assessed and edited the dissertation of SYDNEY CAMPBELL, (Student Number: 205055371) with the title of:

EXPERIENCES OF ANALOGUE-TRAINED RADIOGRAPHERS UTILISING DIGITAL IMAGING IN PROJECTION RADIOGRAPHY

submitted in complete fulfilment of the degree of Master of Technology (Research) in the Faculty of Health Sciences at the Nelson Mandela Metropolitan University.

Any queries related to the editing of this thesis can be directed to me at 074 3209463.

Signed at Port Elizabeth on 26 January 2017.



Ms AG Klopper (MA HWM)
Associate: Professional Editors Guild