UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Health Sciences

School of Health Care Sciences

Department of Radiography

RADIOGRAPHERS' PERCEPTIONS REGARDING ESTABLISHING A SELF-REGULATORY BODY FOR RADIATION CONTROL PURPOSES IN THE RADIOGRAPHY DEPARTMENTS IN SWAZILAND

A dissertation submitted in fulfilment of the requirements for the Degree

Master of Radiography (Diagnostics)

Author: Lungile N. Dlamini

Student number: 25083075

Supervisor: Dr. Mable Kekana

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DECLARATION

I, Lungile Nonhlanhla Dlamini, student number 25083075,

Declare that the research study titled;

“**Radiographers’ perceptions regarding establishing a self-regulatory body for radiation control purposes in the radiography departments in Swaziland”**

is my own original work and has not been submitted to any other institution of higher learning. All sources quoted in this research report have been acknowledged by means of a complete reference list.

L.N. Dlamini

4 November 2019

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ABSTRACT

Introduction

The use of x-rays for medical imaging has benefited the medical field tremendously. The International Atomic Energy Agency (IAEA) advises that all radiography departments have some sort of radiation protection programs available in their departments due to the possible long term and short term effects of x-ray use. The problem that led to this study is that Swaziland remains one of the countries in Southern Africa without a regulating authority for monitoring the safe use of x-rays in radiography departments.

Aim of the study

The aim of this study was to explore the perceptions of radiographers with regards to establishing a self-regulatory body for radiation control purposes in the radiography departments in Swaziland.

Methodology

A qualitative, exploratory and descriptive approach was undertaken. Radiographers were purposively selected and invited to be part of the study. This was because radiographers are trained in quality assurance procedures. They are therefore knowledgeable on how to ensure safety for themselves, the patients and the public. Individual interviews were conducted with those who agreed to participate in this study. Data collection continued until data saturation. The raw data was first transcribed verbatim and then analyzed using qualitative content analysis. Six themes emerged, namely a) awareness of the need for QC tests, b) radiation protection and safety in the radiography departments, c) radiographers' responsibility towards radiation protection, d) education and training in radiation safety for radiographers and other stakeholders, e) support from governmental and management structures and f) the need for the self-regulatory body in the radiography departments.

Conclusion

Three findings were made, namely; a) there is awareness that radiation safety practices are necessary in the radiography departments, b) education and training can help improve radiation safety in the radiography departments, and c) the self- regulatory body can be established with support from government and management structures. In conclusion, while radiographers seem aware of the importance of radiation safety practices, there is a need for continuous education and training, radiation safety awareness for other stakeholders and finally the need for the self-regulatory body in Swaziland.

Key words

Quality assurance, quality control, radiation safety, radiation protection, regulation, self-regulation.

TABLE OF CONTENTS

CHAPTER 1

OVERVIEW TO THE STUDY

CHAPTER TWO

LITERATURE REVIEW

CHAPTER THREE

RESEARCH DESIGN AND METHODOLOGY

CHAPTER FOUR

RESULTS, DISCUSSION AND INTEPRETATION

CHAPTER FIVE

FINDINGS, CONCLUSIONS, LIMITATIONS AND RECOMMENDATIONS

LIST OF ANNEXURES

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS AND ACRONYMS

ABBREVIATION	MEANING
AEC	Automatic Exposure Control
ALARA	As Low As Reasonably Achievable
ARPANSA	Australian Radiation Protection and Nuclear Safety Agency
CRCPD	Conference of Radiation Control Program Directors
CPD	Continuous Professional Development
CR	Computed Radiography

DRL	Diagnostic reference level
ESD	Entrance skin dose
HPCSA	Health Professions Council of South Africa
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiation Protection
ISRRT	International Society of Radiographers and Radiologic Technologists
kV	Kilo voltage
mAs	Milliampere-seconds
NCRP	National Commission on Radiation Protection
QA	Quality Assurance
QC	Quality Control
SABS	South African Bureau of Standards
SID	Source to Image Distance
UNSCEAR	United Nations Scientific Committee on the Effects of Atomic Radiation
WHO	World Health Organization

CHAPTER 1
OVERVIEW TO THE STUDY

1.1 INTRODUCTION

Diagnostic radiographers are professionals whose responsibility is to provide high quality diagnostic image information about anatomical detail or ongoing physiological processes within a patient's body using ionising radiation.[1] Diagnostic radiography as a profession provides one of the most essential services in the health professions with its many imaging modalities and applications which aids in diagnosis of disease. While this may be so, the use of x-rays in diagnostic radiography represents the most significant man-made source of ionizing radiation exposure to the human population in western and developing countries.[2] It has been reported that there is a growing trend in the use of medical exposures using ionizing radiation.[3] The World Health Organization (WHO) further concurred with this, where they reported that this increase in the use of x-rays in radiography, results in an increase in ionizing radiation exposure to the human population which is a serious concern due to the risks associated with this frequent use.[4]

Radiation has been known to have detrimental effects to the human body if not used appropriately. WHO explains that cell death is probable if persons are exposed to doses higher than that used in typical examinations in diagnostic radiography.[5] While cells may not die from the low exposures from diagnostic radiography, they may undergo transformations which may become malignant after a long latency period.[5] This was further supported by Linet, Slovis, Miller et al., where they stated that ionizing radiation is an established carcinogen.[6] It is for this reason that unnecessary radiation exposure is to be avoided as much as possible by firstly ensuring that the medical diagnostic procedure is justified and will benefit the patient.[7] Secondly there should be optimisation of radiation protection whilst achieving good image quality by using the as low as reasonably achievable (ALARA) principle which aims at using minimum radiation doses while not compromising the diagnostic quality of images.[7] This prompts the need to control the use of ionizing radiation in the radiography departments by putting in place established policies and procedures that ensure radiation exposures are justified and kept at a minimum. This is because the benefit of diagnostic radiography to patients far outweighs the detriments if appropriately prescribed and performed.[5] The background to the study is presented next.

1.2 BACKGROUND TO THE STUDY

Radiation protection is described as all activities directed towards minimizing radiation exposure of patients and personnel.[7] The International Atomic Energy Agency (IAEA) describes the primary aim of radiation protection as being to provide an appropriate standard of protection for humankind against the harmful effects of ionizing radiation without unduly limiting the beneficial practices of such exposures.[7] Radiation protection of patients, members of the public and staff in diagnostic radiography is important owing to the adverse effects exposure to ionizing radiation might cause if uncontrolled.

Africa faces challenges with regards to effectively implementing and adhering to radiation safety in the radiography departments as demonstrated by a number of studies.[8-10] Some of these challenges include the absence of regulatory bodies for radiation protection and therefore the absence of policies and procedures for radiation protection.[11] Regulatory bodies ensure the presence of radiation safety programs which encompass quality assurance (QA).[11] QA programs include equipment quality control (QC) tests which are done to ensure proper functioning of equipment. Radiation safety programs further encompass the principles of radiation protection which are; justification of medical exposure, optimization of radiation doses and implementation of diagnostic reference levels (DRLs).[7]

The IAEA states that QA programs in diagnostic radiography must include monitoring of patient and staff absorbed doses which are effectively affected by the performance of the diagnostic equipment.[7] Aghahadi, Zhang, Zareh, et al., further mentioned that the radiation dose absorbed by the patient can be greatly reduced by regular QC tests on equipment. These authors further go on to emphasize that lack of QC leads to unnecessary exposures to the patient which increases the risk to develop cancers.[12] The main goal of a radiation safety program which includes equipment QC is to ensure that optimal clinical diagnostic information is provided with the lowest exposure to radiation of the patient at the lowest cost possible.[1] It becomes very important then to regulate and control the safe use of ionizing radiation in diagnostic imaging. It is for that reason that many countries have a regulatory authority that monitors radiation safety practices and QC tests that are performed on the radiation emitting equipment and other associated accessories as a means of ensuring radiation protection for all concerned.

Swaziland is a small landlocked country in Southern Africa neighbouring Mozambique and South Africa. The Swaziland government is the main provider of health services in the country delivering services to the majority of the population. There are a few private hospitals. The health service system consists of three main levels namely; primary, secondary and tertiary.[13] Radiology services are provided mainly by the government at the regional and national referral hospitals as well as a few health centres at the secondary and tertiary level. Conventional general radiography is the main service that is provided in the public sector. To the lesser extent, specialised procedures like contrast media studies are being performed on fluoroscopy machines. Computerised tomography is slowly emerging with one machine servicing the public sector in the national referral hospital as well as a few in the private sector.

It is imperative that there is a radiation safety program which encompasses radiation protection policies and procedures. There is further a need for a QA program which includes QC tests. These programs need to be monitored by a defined regulatory body. This will ensure accreditation and safe installation of x-ray machines, monitoring their effective functioning as well as ensuring that corrective actions are taken where there is non-adherence to laid down procedures and processes. Periard and Chaloner state that a QA programme in the radiography department requires a special regulatory body for the programme to be effective.[14] This body becomes responsible for the implementation and enforcement of radiation safety and QA programmes which ensures controlled safety practices and optimal equipment use and function at all times.[15]

Swaziland presently has no formal regulatory authority for radiation control services which regulates radiation safety practices in the radiography departments. This is despite being a member state of the IAEA since 15 February 2013.[16] The IAEA recently visited the country and held workshops from which the country was strongly advised to improve its regulatory infrastructure by establishing and strengthening the regulatory control of radiation sources in accordance with the IAEA safety standards.[16] This then required that the Ministry of Health officials take up initiative in drafting national standards of radiation safety and in drafting the radiation control bill. There seems to be challenges when it comes to these initiatives as to date there are still no set radiation safety standards for radiography departments. The radiation control bill has not been released as well. In the meantime, the use of x-rays in the radiography departments remains uncontrolled without guiding radiation safety standards.

The radiographers and other radiation workers have dosimeters that are monitored by the South African Bureau of Standards (SABS) for readings every three months. There are however, no dose registers for radiation workers therefore making it difficult to regulate doses received. In undertaking a literature search, the researcher could not find any published studies conducted in Swaziland on radiation protection, QA and QC measures in the Swaziland radiography departments. This means it could not be determined if these measures are in place or if they are being practised effectively by radiographers in Swaziland. The next section presents an overview of the health care system in Swaziland.

1.2.1 The healthcare system in Swaziland

As mentioned earlier, the health service system in Swaziland consists of three main levels namely; primary, secondary and tertiary. At the primary level there are community based health care services, the secondary level comprises of health centers and the tertiary level comprises of the regional and national referral hospitals.[13] Primary health care and decentralization is the main form of health care delivery to the Swazi nation.[17] The Ministry of Health developed the essential health care package which is a document that acts as a reference in guiding the delivery of health care at all levels of service delivery and provides the standards to be followed by all health providers.[18] It is worth mentioning that this document does not contain standards that must be followed to ensure safety for staff, patients and the public in the radiography department from the harmful effects of x-rays.

The Ministry of Health performs administrative functions as well as provides strategic guidance on the delivery of the standards outlined by this document.[18] Swaziland is divided into four geographic regions namely; Hhohho, Lubombo, Manzini and Shiselweni. At the regional level it is the responsibility of regional health officers to implement regional health policies and plans.[13] The tertiary level comprises of four hospitals, one in each of the regions.[18] It is mainly in these referral hospitals where radiology services are provided to the general public. The country also has two specialized hospitals including the National TB hospital, both of which are in the Manzini region. There are two mission hospitals namely Good Shepherd hospital in Lubombo and Raleigh Fitkin Memorial Hospital in Manzini, both receiving subsidies from the Ministry of Health.[13] These are also main providers of radiology services.

The Ministry of Health acts as the main regulator for all the services being delivered in each health facility. However there are no policies defined by the Ministry of Health that will oversee the safe use of x-rays in the radiography departments. Regulating radiation safety in the radiography department requires specific expertise by appropriately trained individuals. The country also faces a challenge of human resources in the health sector according to the Human Resources for Health Sector Strategic Plan.[13] Radiographers are no exception to this problem. Inadequate supervision in the health cadres is another problem that challenges the health system and nurses have also reported this problem.[19] Presently, the radiography profession has no proper hierarchy structures and this poses a great health risk to the public in terms of quality service delivery and radiation protection. The next section provides an overview of the current legislations that govern health and safety in Swaziland.

1.2.2 Health and safety legislations in Swaziland

The absence of regulatory structures with regards to the safe use of ionizing radiation in Swaziland poses a great risk to public health and safety. The legislation governing the control of radioactive substances dates back to 1964 and this act applies to all premises where radioactive substances are stored or used other than for medical purposes.[20] This act was governed by the Ministry of Enterprise and Employment, a ministry that is now defunct resulting in the act also being defunct. This then leaves the use of ionizing radiation in the health sector with no legislation governing it and subsequently no set rules and regulations to ensure the safety of staff, patients and the public from the harmful effects of these x-rays. It is for this reason that the researcher found it necessary to explore the perceptions of radiographers regarding the establishment of the self-regulatory body for radiation protection and safety in Swaziland.

Occupational exposure to ionizing radiation is another concern. Staff cannot guarantee their safety from the harmful effects of x-rays in the work place since equipment QC tests are not standardised. There are also no standards for radiography room design and location. The occupational health and safety act of Swaziland was established in 2001 to provide for the safety and health of persons at the workplace as well as the protection of persons other than the persons at the workplace against hazards to safety and health arising from activities that are going on in the workplace.[21] This then emphasises the importance of ensuring safety for all concerned in the workplace.

As already mentioned in the introduction, radiographers have a duty to perform QC tests on the machines that they use, take corrective action where indicated and keep records of all results. Without a regulatory body for radiographic services, these QC tests may not be performed. This could mean that radiographers are compromising their own safety as well as those of the patients and the general public. The national health policy was drafted and published in 2007 with an aim to bring about improved quality, safe and cost effective service delivery.[17] This aim is not met in diagnostic radiography because there are no policies and procedures aimed at ensuring quality services in these departments in terms of health and safety from ionizing radiation. The rationale for conducting the study is elaborated on in the next section.

1.3 RATIONALE

The researcher is a diagnostic radiographer based in Swaziland. The researcher observed that in the absence of regulatory structures in Swaziland, radiation protection measures as well as QC tests may not be present in the radiography departments. The pursuit to conduct this study was as a result of further observations of the frequent breakdowns of machines and repeat radiographs which were often common in the radiography departments. In light of reported increased radiation doses to the patients, staff members and the general public in such cases as well as increased costs to the government due to wasted resources [9,10] the researcher then became curious as to what would be radiographers' views in Swaziland towards establishing a self-regulatory body that will monitor QC tests and radiation protection in the radiography departments.

QA programs as well as radiation protection principles are considered as self-monitoring and include conducting self-assessments to ensure that there is compliance to established standards.[22] Radiographers receive training in radiation safety as part of their undergraduate training.[23] They are therefore knowledgeable and well positioned to establish their own set of rules in order to ensure their own protection, patients and the public from the harmful effects of ionizing radiation. According to Van der Merwe, Kruger and Nel, the radiography curriculum includes the principles of radiation protection and QC tests that must be performed by the radiographer in the department.[23] This author further highlights the exit level outcomes pertaining to radiation safety for the qualification as a diagnostic radiographer and that learners should be guided in total quality management; this encompasses the application of radiation safety and conducting QC tests.

Further, it is highlighted that learners should be able to implement and adhere to the ALARA principle at the end of their training.[23] In South Africa, the Health Professions Act, No 56 of 1974 defines the scope of the radiography profession as imaging of internal organs. In addition to this, the act specifies that radiation protection is part of the scope of the profession and radiographers are expected to apply measures and techniques to minimise exposure to patients, staff, self and the public.[24] This requirement is further endorsed in the regulations that have been defined by the Directorate of Radiation Control of the Department of Health in South Africa.[25]

It is thus possible to rectify the situation by means of establishing informal self-regulatory mechanisms. Regulatory bodies are responsible for setting up rules and regulations for radiation protection and also recommend dose limits for radiation workers, patients and the public.[15] The International Commission on Radiological Protection (ICRP) was formed in 1928. It acts as an advisory body which offers recommendations to regulatory and advisory agencies worldwide, mainly by providing guidance on the fundamental principles on which appropriate radiation protection can be based.[26] The main objective of the Commission's recommendations is to provide an appropriate standard of protection for humanity without compromising health service delivery.[27]

Regulatory bodies outside the ICRP develop their set of rules and regulations regarding radiation protection based on the commission's recommendations and are expected to have their aims consistent with the objective of the commission. The IAEA emphasises that activities such as the medical uses of ionizing radiation needs to be subjected to standards of safety and regulating safety is a national responsibility.[7]

In the absence of regulatory structures in Swaziland, the basic training that radiographers receive in radiation safety and QC might not be put to use. It is based on this basic training and the responsibility that radiographers have as per the recommendations made by international organisations for radiation protection that the researcher decided to explore the perceptions of radiographers regarding the possibility of establishing a self-regulatory body in Swaziland. The researcher envisaged a situation where radiographers would outline a set of rules and guidelines for radiation protection as part of patient care. This would also be a means to reduce the effects of occupational exposure to ionizing radiation to staff as well as unnecessary overexposure to the public. Self-regulation relies on factors such as the existence of a specialised body of knowledge and the recognition that good or bad practice is difficult to evaluate by those who do not have that body of knowledge.[28]

The problem that led to this study is presented below.

1.4 PROBLEM STATEMENT

According to Creswell, a research problem is an educational issue or concern that an investigator presents and justifies in a research study. The research problem establishes the importance of the topic and focuses the reader on how the study will be conducted.[29] To ensure quality of healthcare delivery, the equipment as well as the staff in the radiography departments requires that performance evaluation be consistently conducted. These performance evaluations include assessing staff for proper adherence to radiation protection practices and assessing proper functioning of radiography equipment. It is necessary to establish and implement policies and procedures that will monitor these practices.

The problem that led to this study is that there is no regulatory body monitoring radiation protection practices and QC tests that are performed in the radiography departments in Swaziland. The researcher observed that equipment QC tests are not being performed consistently due to the fact that there are no set policies and procedures. The extent to which radiographers employ QC measures and apply radiation protection practices in the work place is unknown. It is of concern that the radiographers, patients and members of the public might be subjected to unnecessary radiation exposures due to malfunctioning equipment and lack of standardised procedures and processes for radiation protection. It is therefore important that a self-regulatory body for monitoring the safe use of ionizing radiation in the radiography department be established. The research questions that the study attempted to answer are presented below.

1.5 RESEARCH QUESTIONS

Research questions are those questions that the researcher would like to address in the study.[29] From the current situation in Swaziland regarding the non-regulation of radiation protection practices and QC tests in the radiography departments, the following research questions were phrased;

- What are the views of radiographers with regards to the performance of QC tests and radiation protection practices in the radiography departments in Swaziland?

- What are the perceptions of radiographers regarding establishing a self-regulatory body that will monitor radiation protection practices and QC test performances in the radiography departments in Swaziland?

1.6. AIM AND OBJECTIVES

The aim of this study was to explore radiographers' perceptions regarding establishing a self-regulatory body for radiation control purposes in the radiography departments in Swaziland. The following research objectives were formulated;

- To describe radiographers' views towards the performance of QC tests in the radiography departments in Swaziland.

- To establish whether radiographers apply radiation protection measures in the radiography departments in Swaziland.

- To describe radiographers' views regarding establishing a self-regulatory body that will monitor radiation protection and QC test performances in the radiography departments in Swaziland.

1.7. IMPORTANCE AND BENEFITS OF THE PROPOSED STUDY

It was envisaged that the results obtained from this study will provide the Ministry of Health in Swaziland with an understanding of radiographers' views and perceptions regarding the need to have a self- regulatory body for radiography departments in the absence of official regulatory structures. Recommendations from this study will be presented to policy makers in the Swaziland Ministry of Health to consider taking action and start monitoring radiation protection practices and QC tests that are performed in the radiography departments.

1.8 DELINEATION OF THE STUDY

This study was aimed at exploring the perceptions of radiographers regarding the establishment of a self-regulatory body for radiation control purposes in radiography departments in Swaziland. The focus of the study was on radiographers that were practicing in Swaziland at the time of data collection. The study was not focused on determining if the different radiography departments comply with standards set by Radiation Control Directorate in South Africa or even the international agencies. The study was therefore delineated to include only radiographers who were practicing in Swaziland.

1.9. PHILOSOPHICAL ASSUMPTIONS

All research is based on some underlying philosophical assumptions about what constitutes valid research and what methods are appropriate to conduct and evaluate the study. Polit and Beck describes assumptions as principles that are assumed to be true without scientific proof or verification.[30] According to Creswell philosophical assumptions are described as interpretive frameworks used by qualitative researchers to guide their study.[31] The three major philosophical assumptions known as ontology, epistemology and methodology are explained below;

1.9.1 Ontological assumptions

Mouton and Marais define ontology as being the study of being or reality.[32] This is the reality of what is being investigated. Ontology assumes that reality can be explored, and constructed through human interactions and meaningful actions. It also assumes that it is possible to discover how people make sense of their social worlds in the natural setting by means of daily routines, conversations and writings while interacting with others around them.[33] In this study, the reality is that radiography services with regards to radiation protection and safety are not regulated. It is also a reality that setting up a regulatory body according to government policies is a process that may take long. Furthermore it is a reality that as previously explained, radiographers receive training in radiation protection and quality management during their undergraduate studies. This then makes it possible that radiographers can regulate these services and hence this study.

1.9.2 Epistemological assumptions

According to Saldana epistemology refers to the theory of knowledge construction based on the researcher's world view.[34] Epistemology assumes that those active in the research process socially construct knowledge by experiencing the real life or natural settings around them.[30] In this study the researcher described her practical experiences and observations around the radiation protection and quality control practices in the radiography departments in Swaziland. The researcher further explored the perceptions of radiographers in Swaziland regarding the establishment of a self -regulatory body for radiation control purposes. Information gathered from this study, provided guidance on what the radiographers' perceptions were, regarding the non-availability of the regulatory body in Swaziland. The information further provided some guidance on whether the self-regulatory body can be established in Swaziland or not.

1.9.3 Methodological assumptions

According to Brink, van der Walt and van Rensburg, methodological assumptions are ways of obtaining knowledge about the described reality.[35] This assumption is about how best the evidence can be obtained from the participants. This study employed a qualitative, exploratory and descriptive design. One-on-one interviews were the best way of collecting data from the research participants in their natural settings. The choice of interviews was influenced by how the radiographers are distributed in the different public and private radiography departments in Swaziland as well as the need to gather in-depth information. The interviews had open ended questions so as to enable the gathering of in-depth information. An inductive process of reasoning was followed during the analysis process because in qualitative research, the researcher values the voices of the participants.[36]

1.10 OVERVIEW OF RESEARCH DESIGN AND METHODOLOGY

Mayring states that it is of essence that an appropriate research methodology is chosen so that the research question is successfully addressed.[37] A qualitative research approach was undertaken in this study. This approach was deemed appropriate to address the research questions and aim as outlined in the previous sections. The purpose was to gain in depth understanding into the perceptions of radiographers towards establishing a self-regulatory body that will monitor radiation protection practices and QC tests in the radiography departments in Swaziland. According to Polit and Beck, qualitative research is concerned with gaining an in depth understanding of phenomena in a holistic manner through the collection of rich narrative information.[38] It is because of these views by these authors that qualitative research was thought to be appropriate in this study so as to obtain in depth information. The next section provides an overview of the research design undertaken.

1.10.1 Research design

Creswell states that qualitative research is a way of exploring and understanding people's conduct, perceptions and views of the world in which they live.[31] This study followed an exploratory and descriptive research design. Grove and Gray state that exploratory and descriptive research designs attempt to explore and describe the experiences of individuals regarding a particular area of interest.[39] Polit and Beck further mentioned that exploratory research allows for the investigation of the full nature of a phenomenon including the manner in which it manifests in order to gain a better understanding.[38] Furthermore, these uthors explain the objective of descriptive research as a means to accurately portray the characteristics of situations.[38] In this study, this research design allowed for the researcher to explore participants' perceptions regarding the idea of self-regulation in the radiography departments. Participants were able to describe these perceptions in detail. The next section presents an overview of the research setting.

1.10.2 Setting

Holloway and Wheeler define the research setting as the physical location where the study is conducted.[40] This study was conducted in seven radiography departments located in public and private hospitals in Swaziland. The hospitals included in the study were located in the Manzini, Lubombo, and Hhohho regions of Swaziland. These are three of the four geographic regions of the country. Four hospitals were from the Manzini region, two from the Hhohho region and one from the Lubombo region. The fourth region was excluded after the researcher reached data saturation. The next section provides a description of the research participants.

1.10.3 Research Participants

The participants in the study were radiographers registered and practising in public and private hospitals in Swaziland. These participants were identified because they were what other researchers call as 'key informants' in the study.[41] Radiographers are described as health care professionals who use radiation emitting equipment to produce images of internal structures for diagnostic purposes.[42] Papp mentions that radiographers are required to apply radiation protection for patients, themselves and the public in practice by using the ALARA techniques as well as application of the time, distance, principle.[43] Further, radiographers are required to perform the routine QC tests on the equipment so as to ensure their proper functioning and ensuring that they deliver radiation doses safely.[44] In light of these duties, the researcher assumed that radiographers were aware and knowledgeable of these practices. This, therefore made the radiographers the appropriate participants for the study and were able to provide the required information to answer the research questions.

1.10.4 Sampling strategies

Babbie defines a sample as a subset of individuals in the population who meet specific inclusion criteria. [45] Sampling, according to Brink, van der Walt and van Rensburg, is the process of selecting the sample from a population in order to obtain information regarding the phenomenon in a way that represents the population of interest.[35] In this study non-probability purposive sampling was used to select the sample. According to Grove and Gray purposive sampling involves selection of individuals who portray certain characteristics pertaining to the research problem.[39] These authors further recommend the use of purposive sampling in qualitative research because it enables selecting participants with rich information that can provide the researcher with vast knowledge that are of interest to the research questions.[39] The researcher purposively sent out invitations to all the radiographers registered with the Swaziland Medical and Dental Council. Invitations were hand delivered to the radiographers in each department after receiving permission from the heads of departments. Those that agreed to participate were then included in the sample.

1.10.5 Data collection methods

Data was collected by means of individual face-to-face interviews. The researcher together with the supervisor developed the interview guide. The interview guide was semi-structured and consisted of open ended questions. The participants that agreed to be part of the study were given the opportunity to freely express themselves during the interviews. Audiotapes were used to capture participants' narratives. The researcher took field notes during the interview process. The interviews were conducted in private rooms within the radiography departments that were arranged by the head of departments. Interviews continued with willing participants until data saturation was reached. Polit and Beck define data saturation in qualitative research as the point whereby the researcher has explored the area of inquiry adequately and is satisfied with the data abtained.[38] Further, Mason explains saturation as the point during data collection where no new information emerges.[46] The researcher attempted to obtain as much information as possible as she continued with interviews until data saturation was reached at the 18th interview. The next section presents an overview of the analysis process.

1.10.6 Overview of data analysis process

Following data collection, data was transcribed verbatim. The researcher used qualitative content analysis to extract meaning from participants narratives. Hsieh and Shannon state that this analysis process involves interpretation of the content of textual data through the systematic classification process of coding, categorising and identifying themes or patterns.[47] The researcher used Zhang an Wildermouth steps to qualitative content analysis.[48] Firstly, data was prepared by transforming the audio recorded interviews into written text. The unit of analysis was then defined which the researcher decided was going to be the whole interview transcripts. The descriptive coding scheme was then developed. Data was then coded. Inductive reasoning was then applied in order to generate categories from the codes. The researcher then searched for patterns across the categories in order to draw conclusions and extract themes. Themes were then interpreted to report findings. The section presents how the researcher ensured the study was trustworthy.

1.11 ENSURING TRUSTWORTHINESS

Liamputtong defines rigour as a way of evaluating the quality of qualitative research.[49] Polit and Beck define trustworthiness as the amount of confidence that a researcher has on the results of the study.[38] Rigour and trustworthiness are elements in qualitative research that demonstrate what is termed reliability and validity in quantitative studies.[31,50] Reliability refers to whether a finding is reproducible at other times by other researchers. Johnson and Waterfield state that qualitative research is descriptive and unique to specific contexts therefore cannot be rigidly replicated to justify reliability.[51]

Validity refers to whether a method investigates what it purported to investigate. Validity in quantitative studies is measured upon strict rules and standards of the methodology that was employed.[49] Liamputtong states that qualitative data cannot be tested for validity using these rules and standards since it is based on social constructions by an individual and therefore cannot be measured but can be interpreted.[49] Lincoln and Guba proposed some criteria that qualitative researchers can use to ensure rigour and trustworthiness of their studies.[50] These authors further state that the purpose of trustworthiness is to support the argument presented by the findings of the study and show that these findings are worth noting.[50] These authors further recommend the strategies which must be followed in establishing trustworthiness, namely; credibility, transferability, conformability and dependability.[50] Each of these are described in detail in the next section.

1.11.1 Credibility

According to Polit and Beck, credibility refers to the confidence in the truth value of data and interpretation.[38] Credibility is comparable to internal validity in quantitative research.[52] It describes whether the research findings can be trusted. It establishes whether the findings represent the correct interpretations of the participant's original views. Saldana states that the amount of time spent in the field, the number of participants, the analytic methods used must persuade the reader that the research undertaken is credible.[34] In this study, credibility was maintained through gathering in depth information from participants. The data analysis was done using qualitative content analysis. Consensus meetings were held with the supervisor and where the researcher sought clarity regarding these steps further meetings were arranged with the supervisor. The following strategies were undertaken to ensure credibility of the study findings;

1.11.1.1 Prolonged engagement

Anney states that spending extended time in the field increases the trust of participants and provides a greater understanding of the participants' culture and contexts.[53] The researcher made sure to spend some time with the participants in their different fields of work before the actual interview began. Some level of trust was established. Prolonged engagement was also achieved by allowing participants to support their statements and the researcher asking follow up questions thus increasing the time spent in answering questions. This enabled more rich data to be elicited. The researcher further persisted with interviews until data saturation was reached.

1.11.1.2 Triangulation

Triangulation involves the use different methods to obtain corroborating evidence.[53] Carter, Bryant-Lukosius, DiCenso, Blythe and Neville mentioned that there are several ways a researcher can use triangulation to ensure credibility of a study.[54] These ways according to these authors include triangulation of data sets, data collection methods, investigators and environments.[54] To ensure credibility in this study, triangulation was done. The researcher used different data sets during data analysis. The interview transcripts were cross checked with the data from the audio recordings and the data in the field notes.

Further, after the researcher finished data collection and transcription of audio tapes, the transcripts were sent to the supervisor who co -coded the data. The researcher and the supervisor then met several times to come to a conclusion regarding the emerging themes and findings. Triangulation was also achieved by collecting data from different participants who are geographically dispersed from each other with different radiography departments. Some departments were generally small with limited services some were in big hospitals. These allowed for obtaining views from different perspectives. In doing all these, the researcher ensured credibility of the findings.

1.11.1.3 Member checking

Anney states that member checks mean the continuous checking of data as it is derived from the participant.[53] The researcher asked participants to verify what they were saying from reading through the field notes at the end of each interview. Anney further states that the purpose of member checks is to eliminate researcher bias when analysing and interpreting data.[53]

1.11.2 Transferability

Polit and Beck define transferability as the extent to which qualitative findings can be transferred to other contexts or settings.[38] Transferability can be likened to external validity in quantitative research. The intention here is to find out to what degree the study findings can be generalised or applied to other settings. This is achieved through thick descriptions and purposeful sampling.[55,56]

1.11.2.1 Thick descriptions

Thick descriptions are provided through detailed accounts of all the research processes from the data collection through to the presentation of the final results. This allows other researchers to see if they can be able to apply the same study in other contexts.[53] In this study, rich thick descriptions of what transpired during the whole study, from data collection to presenting results were provided. The researcher made sure to collect data until data saturation was reached with the aim of eliciting more information from participants so as to provide thick descriptions.

1.11.2.2 Purposeful sampling

Purposeful sampling allows the researcher to select participants who are particularly knowledgeable about the issue being investigated. This allows for greater in depth findings compared to other probability sampling methods.[57] In this study all participants were qualified radiographers, this made them the perfect candidates for the study since they are more knowledgeable about QC and radiation protection in the radiography departments. They would be able to provide clear and meaningful accounts of their perceptions with regards to establishing a self-regulatory body that will monitor these practices in these departments. This then implies a similar study in similar settings can be done with similar participants.

1.11.3 Confirmability

Confirmability refers to the degree to which the results of a study could be confirmed or corroborated by other researchers.[54] Polit and Beck refer to confirmability as a criterion for integrity in the qualitative inquiry.[38] It is concerned with establishing that the findings are derived from the data and not from the imaginations of the researcher.[58] In this study, confirmability was achieved by the availability of an audit trail of the data collection and analysis process.

Bowen states that an audit trail provides visible evidence that the researcher did not just make up her own findings.[59] Audio recordings, interview transcripts and field notes were made available. In chapter three, the researcher provides a detailed description of the data collection methods and data analysis process that was used in the study. Further in the appendices section, copies of interview transcripts, field notes (Annexure A) and consensus notes (Annexure B) between the supervisor and the researcher are provided.

1.11.4 Dependability

Bitsch refers to dependability as the stability of findings over time.[56] Dependability involves the researcher evaluating the findings and the interpretation and recommendations of the study to make sure that they are all supported by the data received from participants.[57,58] Polit and Beck further state that the findings of a study will be dependable if an independent researcher replicates the study with the same participants in a similar context.[38] Dependability in this study was achieved by availing the audit trail, using a code-recode strategy and triangulation. The availability of the audit trail where the researcher clearly outlines the data analysis process ensures the study is dependable. The use of triangulation methods as previously explained further ensured the study was dependable. The researcher coded the data a number of times and consistently checked these with the supervisor to find out if the same results are obtained. This enhanced the dependability of the study.

The next section presents the ethical considerations.

1.12 ETHICAL CONSIDERATIONS

The possible adverse effects of research involving human participants need to be considered at all times and researchers are obliged to consider the rights of these participants. Guidelines emanating from ethical values, certain standards and principles need to be followed for the research to be considered scientifically, ethically and legally sound. All health research protocols require approval by an accredited health research ethics committee before research commences.[60] To ensure that the researcher complied with the ethical requirements where human participants are involved the researcher followed the following steps;

1.12.1 Permission

Permission to conduct the study in the radiography departments of the hospitals was obtained from the Ministry of Health Directorate office in Swaziland (Annexure C) which was taken to the Chief Executive Officers (CEOs) of individual hospitals as soon as ethical approval was obtained. Permission from the CEOs of these individual hospitals was sought and those that agreed to participate in the study granted permission before data collection began. The proposal was then sent to the Faculty of Health Sciences research ethics committee of the University of Pretoria, Medical Campus, Tswelopele Building, Level 4-59, contact number 012-356 3085, for ethical consideration. Ethical approval was granted on protocol number 465/2018 (Annexure D). Ethical consideration was also received from the National Health Research Review Board of Swaziland. (Annexure D)

1.12.2 Non-maleficence and beneficence

The principle of non-maleficence states that risks or harm to participants must be minimised. [60] Beneficence is guided by the fact that the benefits of health research must outweigh the risks to the participants.[60] The researcher ensured that the interview questions caused no emotional distress or social disadvantage to participants during the study. No participant reported any of these during the course of the study which meant adherence to the principle of non-maleficence. The purpose of the research as well as its relevance and possible benefits were clearly explained to participants. This was in accordance with the ethical principle beneficence where the benefits of the research outweighed any kind of risks that would have befallen the participants.[60]

1.12.3 Autonomy

The researcher ensured that the principle of respect for persons was maintained. An information leaflet was given to participants. The leaflet explained the purpose and benefits of the study. (Annexure E). This leaflet also explained that participation was voluntary and participants reserved the right to withdraw from participation in the study at any given point. This allowed participants to make informed decisions regarding their participation in the study. Participants were further asked to provide written consent to participate in the study. Written consent was in the form of signatures which the participants provided on the informed consent form (Annexure E). This was in accordance with the basic ethical principle of autonomy, which states that participants must be afforded the opportunity to make informed decisions with regard to their participation in research.[60]

The researcher explained to participants that they will be audio taped. Participants were then asked for consent to be audiotaped. As soon as permission was obtained it was explained that audiotapes and transcriptions will be stored at the Department of Radiography of the University of Pretoria HW Snyman Building level 4 Room 4.48. Participants were therefore assured of anonymity and confidentiality. Annexure F indicates the declaration of storage. Confidentiality was also maintained by assigning codes to participants in the interviews and keeping their names confidential. The names of the hospitals that participated in the study were also kept confidential. This was according to the basic ethical principle of confidentiality which states that researchers must protect participant's right to both privacy and confidentiality.[60]

1.12.4 Justice

The principle of justice is governed by the fact that human participants should be treated fairly. [60] Polit and Beck further state that this principle involves the right to fair treatment and the right to privacy.[38] Justice was maintained by recruiting participants using one criteria across all hospitals. The researcher clearly explained to the participants that they were not obliged to participate regardless of any pre-existing relationship there might be between the researcher and them. Participants were told that if they decline they would be treated in the same manner as those who agreed to participate, with respect and without judgement. There were no participants who declined.

1.13 CONCEPT CLARIFICATION

The importance of this section is to define key words that are commonly used in this study so that the reader can easily understand what is being referred to. The key words used in this study are;

Perceptions according to the Oxford English Dictionary are the ability to sense, hear, feel, observe, have a thought, believe, an idea of something, a realisation, an awareness and recognition.[61] In this study perceptions refers to the radiographers' views, insights, opinions and beliefs regarding the establishment of a self-regulatory body for radiography services in Swaziland.

Regulatory body is a public authority responsible for formulating and enforcing laws that protect the safety of patients and set basic quality standards.[62] An example of such an authority is the HPCSA, which was established through an Act 56 of 1974.[60] This entity regulates all health professionals in South Africa in accordance with this act. In this study reference is given to international regulatory bodies such as the IAEA and the ICRP which regulate and provide recommendations for the safe use of ionizing radiation in medical imaging.

Self-regulatory body is a professional organization, unaffiliated with a government and non-legislated which takes oversight of its members' professional practice.[63] One such organisation is the College of Medical Radiation Technologists of Ontario Canada.[64] This organisation self regulates the diagnostic radiography, nuclear medicine, radiation therapists and sonography professions.[64] This body states that the benefit of regulating these professionals is that assurance is provided, that practice standards are met and the public is protected.[64] In this study the self- regulatory body refers to the radiographers that would regulate radiography services with regards to radiation safety.

Quality assurance is a management program used to ensure excellence in healthcare through the systematic collection and evaluation of data and therefore maintaining optimal diagnostic image quality with minimum adverse effects and distress to patients and radiation workers in general.[43] In this study the quality assurance refers to the program that ensures that radiation safety policies are adhered to, quality control tests are performed in radiography departments, corrective action is in place as well as record keeping.

Quality control in this study refers to the part of a QA programme that deals with techniques and tests used in monitoring and maintenance of the equipment in diagnostic imaging that affect the quality of the image.[43]

Radiation protection is the means of protecting people from the harmful effects of exposure to x rays and the means in place of achieving this.[7] Radiation protection and its measures is an important aspect that must be adhered to during radiographic practices and this is advocated for in this study. In this study radiation protection refers to the means that radiographers need to apply in protecting themselves, the patients and the public by keeping radiation doses as low as possible.

Radiation safety refers to safety issues arising from the use and exposure to x-rays.[43] The issues in this study are the non-performance of QC tests in the radiography departments and in application of radiation protection practices by radiographers. In this study these are the issues that have driven the researcher to conduct the study in light of radiation safety concerns for the patients, public and staff.

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The layout of the dissertation chapters is summarised next.

1.14 LAYOUT OF THE STUDY

In this section an overview of each chapter in this dissertation is presented.

Chapter 1 covered an introduction to the study. The introduction included an overview of the research problem and the purpose of the study. The philosophical assumptions which underpinned the study are further presented. An overview of the research design, methodology and data analysis is also outlined. The chapter also includes the clarification of terminology used throughout the dissertation. Ethical considerations are further highlighted.

Chapter 2 lays out the literature reviewed relevant to the study. The reviewed literature began with demonstrating the harmful effects of ionizing radiation including its effects on paediatric and pregnant patients and staff. The radiation protection principles are further explained in detail. The role of radiographers in the performance of QC tests is outlined and further these tests are described in detail. The chapter concludes with demonstrating the importance of regulation and self -regulation in radiography departments.

Chapter 3 outlines the research methodology that was followed during the study. The chapter begins with the justification for the use of qualitative research methods. The research design opted for in the study is explained. The data collection methods are outlined in detail. Data analysis steps taken are described and how the researcher drew conclusions from the data.

Chapter 4 presents the results. The codes and categories that were drawn from the raw data are outlined. These results are then discussed with what is found in literature. Themes that emerged from the categories are presented. These themes are then interpreted in relation to the research objectives.

Chapter 5 presents and discusses the research findings. This is to determine if the study managed to answer the research questions and achieved the aim of the study. The study limitations are outlined. The recommendations and implications for future research are presented. Finally the overall conclusions drawn from the study are presented.

1.15 CONCLUSION

This chapter has provided an overview of the study. The background with regards to the importance of having a regulatory body that will monitor the safe use of ionizing radiation in the radiography departments in Swaziland has been presented. The current situation in Swaziland in terms of legislations for radiation safety has also been described. This then led to the description of the rationale that prompted the researcher to conduct this study. The observations that the researcher noted in the clinical setting are presented and these led to the problem statement which has also been introduced. A summary of the methodology adopted for the study has been presented. An overview of all the chapters has also been laid out. The next chapter discusses the literature reviewed with regards to radiation protection, QC and self-regulation.

CHAPTER 2
LITERATURE REVIEW

2.1 INTRODUCTION

The purpose of conducting a literature review is to survey books, scholarly articles and any other sources relevant to the area of research. This provides a description summary and critical evaluation of the research problem being investigated.[65] Finn further stated that the purpose of a literature review is to demonstrate the researcher's command of the subject area and further evaluate one's research against other studies.[66] Literature was sought from scientific search engines such as Pubmed, Google Scholar, Science Direct and Clinical Key. The key words used in the search included, radiation protection, quality assurance, quality control, radiography, regulation and self-regulation.

In this study, the literature review was conducted to demonstrate the health effects of ionizing radiation in the absence of proper regulatory structures to control the safe use of radiation. The importance of radiation protection and its different measures is also portrayed in this literature review. QA and QC practices are explained and how these affect the radiation dose to the patient, staff and the public. Lastly, the function of regulatory authorities in diagnostic imaging is presented in this review as well as the relevance of self-regulatory bodies. First reference is made to the effects of ionizing radiation.

2.2 IONIZING RADIATION EFFECTS

Ionizing radiation in the form of x-rays can produce detrimental effects to tissues by impairing tissue function if used beyond certain thresholds. It is important that those who work in radiography departments understand these effects in order to protect the public, patients and staff. Regulating the use of x-rays ensures that radiation protection measures are in place and radiation safety policies are adhered to so that these effects are minimized. Radiographers as prescribers of medical radiation exposure to patients have a responsibility to ensure that doses are kept as low as reasonably achievable. This section will outline the cellular effects, deterministic effects, stochastic effects, pediatric exposure to ionizing radiation and effects of radiation exposure on pregnant patients. This is meant to familiarize the reader on the hazardous nature of x-rays in situations where doses are uncontrolled and where patients or staff are possibly subjected to high radiation doses. The cellular effects are discussed first.

2.2.1 Cellular effects

According to Jacobson, if the radiation delivered to a cell is high enough, detrimental effects may occur to the cell in a timeline of events such that the cell is permanently damaged.[67] This author further outlines the events that occur to the cell and states that it begins with excitation and ionization of the molecules following the deposition of the x-ray photon energy. This ionization imposes damage onto the deoxyribose nucleic acid (DNA) of the nucleus. The damage to the DNA can occur in two ways; a) directly with the photon where the photon interacts directly with the DNA and thus affecting the ability of the cell to reproduce and survive or b) indirectly with free radicals produced by the ionization of molecules.[67] These free radicals can be toxic and thus contribute to cell destruction.

Sherer, Visconti and Ritenour state that when the nucleus of a cell is damaged, one of the following effects may occur; a) rapid death of cells within minutes when cells are exposed to high doses of x-rays b) apoptosis where the nucleus and the cell break up and their fragments are normally ingested by neighboring cells c) mitotic or genetic death which occurs when a cell dies after one or more divisions following irradiation d) permanent chromosome abnormalities amongst others.[68] It is particularly important to consider these effects in pediatric radiography where cell growth and organ development is still ongoing. Determining the right dose in these instances is crucial since risk becomes significant from early on in life. There is therefore a longer lifetime during which cancer from radiation exposure can develop.[69] Pediatric radiation effects will be discussed in section 2.2.3 The next section discusses deterministic and stochastic effects.

2.2.2 Deterministic and stochastic effects

Deterministic effects are those effects from ionizing radiation in which the outcome can be determined.[70] These occur above a certain radiation threshold dose where the severity of the effect increases with increasing dose.[71] The threshold dose is defined as the dose above which the signs and symptoms of the effect on a specific organ can be detected.[71]

According to Peck and Samei, deterministic effects will occur if the radiation deposits enough energy in tissue to disrupt the functionality of the whole organ under irradiation.[70] These authors highlight that deterministic effects can be divided into tissue specific changes and whole body effects. Whole body effects occur in extremely high radiation doses, above those doses used in medical exposures.[70] The time at which deterministic effects can be recorded varies among tissues after irradiation. These effects may be early such as skin reactions which may occur a few hours or a few days after exposure. They may also be late such as cataract of the lens of the eye and infertility which may occur months or years following exposure.[70]

Martin and Harbison define stochastic effects as those radiation effects whose probability of occurrence, rather than the severity, is dependent on the dose without a threshold level.[72] In this case, risk increases progressively with increasing dose received without a threshold therefore the lowest amount of radiation received is thought to have a small probability of causing an effect.[72] Stochastic effects can either be genetic due to mutation of reproductive cells and therefore heritable to offspring of radiation exposed individuals or can be carcinogenic due to mutation of somatic cells following exposure to radiation.[70] These effects happen progressively with continued exposure to x-rays. Seeram and Brannan stated that stochastic effects are regarded as the principal health risks from low dose ionizing radiation including exposure to x-rays in diagnostic imaging.[73]

The ICRP mentioned that radiation protection aims to reduce stochastic effects to an extent that is reasonably achievable.[74] This is particularly important in limiting occupational exposure to radiographers as they get exposed to chronic long term low levels of ionizing radiation. Studies have suggested that the risk of chromosomal damage in workers exposed to radiation doses lower than the limit was higher.[75-77] This then emphasizes the need for appropriate use of protective equipment and personnel radiation monitoring in these departments.[78,79] However, if there are no proper regulatory mechanisms such that there is provision of lead protective garments and an effective personnel monitoring program, the advantages of limiting occupational exposure to radiation might not be met. The risks on pediatric patients from exposure to x-rays are discussed next.

2.2.3 Effects of radiation on pediatrics

Risks of exposure to x-rays in children undergoing radiography examinations have been a topic of discussion amongst a number of organizations advocating for the safe use of radiation in these settings. These organizations include the WHO, ICRP, IAEA amongst others.[5,80,81] The United Nations Scientific Committee on Effects of Atomic Radiation (UNSCEAR) concluded that for a given radiation dose infants and children are more at risk than adults of developing a variety of tumors and this risk will not always be immediate but may be seen later in life. This committee reviewed 23 cancer types in their report and children were found to be more sensitive than adults to the development of cancer types such as leukemia, thyroid, breast and brain cancers.[82] This was attributable to the fact that infants and children have smaller body diameters and their organs are less shielded by overlying tissues. This therefore means that if they receive the same radiation exposure as adults, the dose to their internal organs will be higher.[82] The fact that children have a longer life expectancy and their tissues are still maturing and in continuous growth makes them more radiosensitive and increases their chances of developing malignancies later in life .[82]

Zewdu, Kadir and Berhane identified that the entrance skin dose (ESD) for pediatric patients for chest x-ray examinations was higher when compared to recommended diagnostic reference levels [DRLs] which meant the ALARA principle was not being adhered to and patients were receiving higher doses.[83] Measures used in application of the ALARA principle will be discussed later in the chapter. Another study in Nigeria similarly identified that ESDs for pediatric patients were found to be higher than recommended levels.[84] These studies recommended the development of QA programs which encompass establishment of dose reference levels and film reject analysis.[83,84]

The effects of x-rays on the pediatric patient as outlined above indicate that radiographers have a responsibility to limit exposures as much as possible when imaging children while at the same time not compromising image quality. The image gently campaign was initiated in 2006 to raise awareness in the imaging community of the need to adjust radiation doses when imaging children.[85] Imaging gently involves a) taking into account the size and age of the patient and then dose accordingly, b) avoiding unnecessary repeats as most information can be obtained from one study and c) imaging only the indicated area.[86] This can only be achieved with properly laid down justification and optimization protocols. However if there is no regulatory body for radiation protection as is the case in Swaziland, radiographers may not apply these protocols therefore subjecting these patients to increased radiation doses. Justification and optimization will be discussed later in the chapter.
The risks to the fetus due to exposure to ionizing radiation are discussed next.

2.2.4 Radiation exposure and pregnancy

Risks of radiation exposure in pregnancy are usually most applicable to the female radiographer who is chronically exposed to low doses of ionizing radiation in the radiography department. This does not however exclude pregnancy risks associated with the patient undergoing an examination as well as the member of the public who might be assisting in the radiography examination.

Streffer, Shore and Konermann mentioned that the stage of the pregnancy determines the level of risk from radiation to the fetus.[87] The ICRP states that the risk is highest during organogenesis, a period which runs from two to seven weeks after conception.[88] During this period, the Center for Disease Control states that the consequences can be severe even at radiation doses too low to affect the mother. These can include stunted growth, abnormal brain function and deformities which may develop later in life.[89] It was further mentioned that babies who receive a small dose of radiation at any time during pregnancy do not have an increased risk for birth defects, however, there is a slightly higher chance of developing cancer later in life.[90]

A study in Cameroon reiterated these facts by revealing that the dose to the fetus from abdominal and pelvic x-rays was relatively low, less than 100 mGy above which malformations may be suspected, however this dose still presents a risk for cancer and leukemia for children aged 0-15 whose mothers have undergone these examinations during pregnancy.[90] According to a statement published by ICRP, “Prenatal doses from properly done diagnostic procedures present no measurably increased risk of prenatal death, malformation, or impairment of mental development,’’[88] there is a need for appropriate imaging guidelines which can only be achieved with established regulatory mechanisms.

The ICRP recommended some measures to manage pregnant patients in diagnostic imaging. These include the following;[91] a) It should be determined whether a patient is or may be pregnant and whether the fetus will be in the direct beam before any diagnostic examination. b) Notices should be placed where diagnostic equipment is being used to avoid unintentional exposure to the embryo and fetus.

Establishing policies and procedures that will guide employers in protecting the safety of pregnant radiographers is to be considered.. Dauer, Miller, Schueler, Silberzweig, Balter, Bartal *et al.,* recommended that each facility should have a properly documented radiation safety policy for pregnant workers which addresses; declaration of pregnancy, occupational exposure, dosimeter use and readings, duties, and risk/benefit of additional shielding.[92] The authors further mention that policy makers need to take into consideration that declaration of pregnancy is a personal issue however some countries make it mandatory.[92]

The IAEA supports this by stating that employees may not be compelled to declare their pregnancy, however, employers are required to emphasize the importance of early notification of pregnancy so that appropriate actions may be taken in ensuring minimal exposure to the embryo.[7] Such actions include adapting the working conditions in either of the following ways a) changing to an area where radiation is lower b) changing to a job that essentially has no radiation or c) no change in assigned duties.[91] Deciding on the appropriate action must be up to individual employers basing the decision upon established guidelines.

Awareness on the part of the pregnant radiographer with regards to ways of limiting radiation exposure to the foetus is important. These strategies include using personal protective garments, standing behind the control panel, doubling the distance between the radiographer and the radiation source and collimating the beam as tightly as possible to reduce scatter.[92] All of these strategies are aimed at protecting the staff member as well as the foetus from the harmful effects of radiation.
Radiation protection principles are elaborated on in the next section.

2.3 RADIATION PROTECTION

The IAEA defines radiation protection as the protection of people from the harmful effects of exposure to ionizing radiation, and the means established for achieving this.[7] In order for radiation protection to be effective, radiography departments need to have laid down rules and guidelines that will govern the safe use of ionizing radiation.[93] Once these are in place, the International Radiation Protection Association (IRPA) recommends that radiography departments need to develop a strong radiation protection culture for continued compliance to these guidelines. The IRPA further recommends the following stages in the development of this culture;[94]

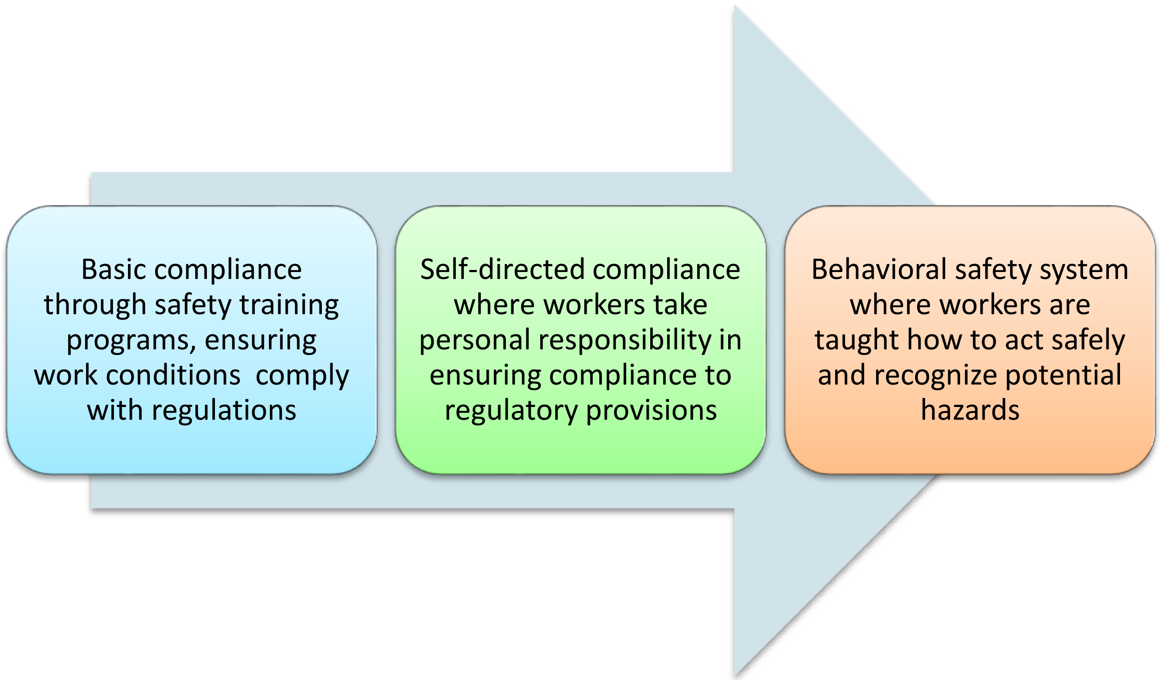

Figure 2.1 Stages in development of a safety culture[94]

As seen in figure 2.1, radiographers have a role in keeping and maintaining a radiation safe environment in the departments by taking personal responsibility for safe practices. There is a need to establish standards for continuous education and training on radiation safety principles and actions. These can only be achieved if those drafting the regulations are aware of the aims of radiation protection. The aims of radiation protection according to the ICRP are; a) to prevent deterministic effects, b) to limit the probability of stochastic effects to levels deemed to be acceptable and c) to ensure that practices involving radiation exposure of persons are justified by ensuring that the benefits outweigh the detriment.[88]

The Bonn Call for Action, a joint position statement by the IAEA and WHO, was established to implement certain actions in order to strengthen radiation protection in medical radiation exposures. The aims of the Bonn Call-for-Action are to a) strengthen the radiation protection of patients and health workers overall; b) attain the highest benefit with the least possible risk to all patients by the safe and appropriate use of ionizing radiation in medicine; c) aid the full integration of radiation protection into health care systems; d) help improve the benefit/risk-dialogue with patients and the public; and e) enhance the safety and quality of radiological procedures in medicine.[95]

Swaziland has no regulations governing medical exposures and could benefit from adopting these objectives as a national strategic plan. Ten actions were highlighted by the Bonn Call for Action as being important to strengthen radiation protection in medicine.[96] Some of these actions include justification of medical exposures, optimization of radiation protection and application of dose limits which are also listed as fundamentals of radiation protection by the IAEA.[7,95] These are discussed further in the next section.

2.3.1 Justification of medical exposures

Diagnostic imaging examinations are very important in the clinical setting however it remains imperative that the procedure is justified.[96] There are growing concerns that about 20-30% of radiological examinations are not necessary in most of the developed countries.[92] The ICRP states that any decision that permits administration of radiation exposure to patients should do more good than harm. The ICRP further states that this should involve reviewing whether the benefits outweigh the risks of the requested examination.[88] The Australian Radiation Protection and Nuclear Safety Agency stated that justification is a necessary practice in radiography due to the hazardous effects in particular stochastic which demonstrate that the risk of cancer and hereditary effects increase linearly with radiation dose.[97] As stated in the previous section, in a bid to reduce unnecessary examinations and therefore unnecessary radiation doses, one of the outcomes labelled as Action one by the Bonn Call for Action is to "Enhance the implementation of the principle of justification".[95]

In Swaziland, without rules and regulations for radiation protection in radiography departments, the principle of justification of medical exposures might not be applied. Application of this principle includes drafting and implementing imaging referral guidelines. WHO mentioned that referral guidelines are useful tools for justification of medical exposures as they provide guidance to physicians so that they can better request radiographic examinations. Figure 2.2 provides recommendations provided by WHO of questions physicians need to consider before requesting an examination.[98]

Figure 2.2 Questions to be considered before requesting an examination[98]

The WHO further advices that no procedure should be performed without consideration of the above questions.[98] In order to effectively partake in the justification of medical exposures, physicians need to be aware of the risks of medical exposures and further adhere to established guidelines. However, there is a growing concern with several studies revealing that there is lack of awareness in radiation risks by referring physicians and further lack of adherence to referral guidelines therefore hindering the justification of examinations.[99-101] Due to these facts and in a bid to improve patient care and further justify examinations, radiography departments need to have their own guidelines aimed at justifying examinations.[96] Radiographers receive request forms which makes them “gate-keepers” between the patients and unjustified examination. They should then be capable of informing the radiologist if examinations are deemed unjustified.[96]

Africa faces a shortage of radiologists and the situation is dire in Swaziland with only one radiologist servicing the whole country. This means radiographers need to take up an active role in justification of examinations. This is supported by the Department of Health

in South Africa which states that radiographers may refuse to perform examinations if good and sufficient grounds exist for the decision.[102] This is in cases such as when the clinical history indicated does not justify the performance of the examination.[102]
ARPANSA further recognizes that the radiographer has a responsibility in the application of justification procedures since they are required to assess the clinical indications, apply their knowledge and demonstrate awareness of how results can influence the diagnosis and management of patients.[97] This benefit to the patient can only be achieved with proper regulatory structures having drafted protocols and procedures for justification of examinations. Once the procedure has been justified, radiation protection needs to be optimized by the radiographer. This is discussed next.

2.3.2 Optimization of radiation protection

The ICRP defines optimization of radiation protection as a process to keep the magnitude of individual doses and the number of people exposed as low as reasonably achievable.[74] Radiographers need to employ techniques that are adjusted to administer the lowest possible dose while maintaining image quality of diagnostic value. This is supported by WHO whereby they published practical tips for radiographers aimed at keeping radiation doses as low as reasonably achievable without compromising image quality. These are discussed further below;[103]

a) High kV (kilovoltage) technique

Changing the kV parameter adjusts the penetrating power of the x-rays and the overall intensity of the x-ray beam. Increasing the kV results in greater penetrating power and therefore reduction in radiation absorbed by the patient.[103] This was confirmed by certain studies. Fauber, Cohen and Dempsey in their study found that using direct digital radiography, increasing the kV by 15% and dividing the mAs by half significantly reduced the radiation dose by half in pelvic x-ray.[104] This necessitates the need to keep updated exposure charts in the department. While using high kV reduces the dose absorbed by the patient, it contributes to increased film density therefore impacting on image quality. Incorporating anti scatter grids greatly reduces scatter radiation.[104] All of these techniques require an awareness on the part of the radiographer towards radiation protection practices.

The presence of documented radiation protection guidelines is also important to consider which will lay down rules for proper selection of technical factors and availability of exposure charts. Without regulations and procedures for standardization however as is the case in Swaziland, it is possible that these are not available within the departments. This therefore means selection of these factors by radiographers varies widely and subsequently patient doses vary as well which is a concern in relation to radiation safety.

b) Beam filtration

The aim of beam filtration is to reduce the low energy x-rays before they reach the patient where they would otherwise be absorbed. This is done through the use of inherent and added filtration. Inherent filtration involves the attenuation of the x-ray beam at the anode as it passes through the tube window, the oil used for cooling the tube and the shield aperture.[103] Ekpo, Hoban and McEntee mentioned that inherent filtration does not completely remove the low energy x-rays and hence the need for additional filtration.[105] WHO described additional filtration as the provision of a shield placed outside the tube aperture.[103] Different materials such as aluminium, copper, titanium and zinc are used and their efficacy in dose reduction has been examined in some studies.[106,107]

Ekpo, Hoban and McEntee identified a dose reduction of 37% without compromising image quality after additional beam filtration was introduced.[106] These results were similar to what Smans, Struelens, Smet et al., found in that there was a 25% reduction in pediatric lung doses after introducing additional filtration.[109] Radiographers have a responsibility to ensure that QC tests on these elements are conducted to ensure their proper functioning as they are essential as part of radiation safety.[104]

c) Collimation

Limiting the primary beam to the area of interest has been recommended as the most effective way to reduce the patient dose while improving the image quality.[109] WHO reported that if the area covered by the primary beam is large, the amount of scatter radiation produced is increased thus contributing to increased radiation dose and increased film density.[103] Bailey and Anderson mentioned that inadequate collimation is the greatest contributor and the most frequent cause of unnecessary patient dose.[110]
A study by Karami and Zabihzadeh found that 62% of lumbar spine radiographs were inadequately collimated with ovaries included within the area of interest.[111] This was a concern since radiographic examination of the lumber spine may increase the cumulative radiation dose due to the use of various views, up to six views and the fact that lumber spine radiography is the third most frequent radiographic procedure performed.[112] The use of gonad shielding is further recommended in addition to collimation in this regard. One study identified that the use of collimation was influenced by the radiographers' awareness and dedication.[113] This further emphasizes the need for regulatory mechanisms in cases like Swaziland where radiographers might not be employing this practice due to lack of dedication and awareness. Hlabangana and Andronikou recommended continuous education for radiographers on a regular basis due to their results indicating poorly collimated images.[114]

d) Automatic exposure control (AEC)

AEC systems are designed to automatically terminate the irradiation at a predetermined time and tube current.[7] These devices detect the amount of radiation reaching the detection system. The signal is then sent back to the x-ray generator to indicate that the detecting device has received enough radiation for an appropriately exposed image.[115] This therefore enables for patients of varying thickness and for different regions of the body to be imaged using optimum exposures while maintaining image quality.[116] The goal here is to keep exposures as low as possible. According to Samei, Seibert, Willis, Flynn, Mah and Junck, incorporating these systems, is the primary means of controlling patient exposures in radiographic systems.[117]

The IAEA recommends that these systems be incorporated in to radiographic equipment.[7] However, the United States Environmental Protection Authority stated that while AEC systems are important in controlling exposures, improper calibration of these systems may lead to unnecessary exposures.[118] Radiographers need to be aware of these systems and recognize the importance of using the automated exposures on the AEC during daily practice. The need for QC tests that ensure these devices terminate exposures at desired image qualities at recommended frequencies is therefore imperative.

e) Use of shielding devices

Personnel and patients can be protected by using shielding wear. These constitute lead aprons, thyroid shields, gonad shields, lead gloves, and protective eyewear. Lead aprons and gonad shields are most commonly used in conventional radiography. Swaziland does not have a lot of specialised departments where examinations such as fluoroscopy and interventional procedures which are known to contribute to high radiation doses are done. Lead aprons and gonad shields are most commonly used in these settings. Lead aprons constitute 0.25 up to 0.5 mm lead thickness and can attenuate over 90% and 99% of the radiation dose respectively therefore making them very effective and important in radiation protection.[119] It is important that shielding apparel should be evaluated for their lead equivalence when purchased. Livingstone and Varghese mentioned that knowledge of the lead integrity of these during purchase is necessary to maintain radiation safety.[120] It is recommended that for x rays up to100 kV, aprons of 0.25 lead equivalence should be used and for x rays over 100 kV, aprons of not less than 0.35 lead equivalence should be used.[121]

The South Africa Department of Health, Directorate of Radiation Control guidelines further supports this and recommends that any person within 1m of an x-ray source or patient when the machine is operated at 100 kV, should wear a protective apron of at least 0.35

mm lead equivalency.[122] They further recommend that protective gloves should also be 0.35mm while gonad shields should be 0.5mm lead equivalence.[122]

It has been mentioned in previous sections that in Swaziland there is no regulatory body for radiation protection therefore no set guidelines in this regard. This then implies that lead equivalence as well as safety of protective wear is not tested at purchase. Further in the absence of QC tests for these garments, their effectiveness to safety is unknown. Cohen found that 52% of lead aprons in a South African hospital did not have adequate lead equivalence as defined by regulations and that 21% had defects severe enough to render them unsafe for use.[123] It is imperative to audit lead aprons at recommended frequencies set by regulatory authorities.

It is also important to care for lead aprons to prolong their safety efficiency. Caring for lead aprons include the following actions a) new lead protective garments need to be tested for attenuating and shielding properties, b) lead aprons and thyroid shields should be hung vertically and never folded because they are susceptible to cracking which might reduce their effectiveness, c) avoid exposing these garments to extreme heat or direct sunlight as they may get damaged and d) periodic inspection and testing of these garments to check for their continued efficiency.[124] One study identified that all of the aprons tested for safety were deemed insufficient for protection with folds noticed in the protective layers of some of them due to improper care.[8] This further emphasizes the need for proper care of aprons as well as policies and procedures in place.

f) Time, distance, shielding

The cardinal principles of radiation protection which are time, distance and shielding should be followed by radiographers to reduce occupational exposure.[43]

Radiographers should keep the time of exposure to radiation as short as possible.[43] The longer the exposure time, the more the exposure to the radiographer, the patient and the public. Exposure time is controlled by the radiographer as he/she chooses appropriate exposure factors or through the time spent screening during fluoroscopy. Proper understanding of the relationship between the milliamperage (mA) and the duration of the exposure is essential for radiographers so that images of diagnostic quality at minimum patient doses are acquired. Varying the exposure time controls the number of x-rays generated for selected mA. Increasing the mA means more x-ray photons are generated and therefore an increase in patient dose and image blackening.[125] In the same manner, long exposure times contribute to more x-ray production.[126] Mantaining a balance between these two factors will significantly affect patient dose. This is achieved by selecting a high enough mA for diagnostic image quality at the shortest exposure time.[126] Radiographers' awareness in this regard is imperative, further exposure charts are important which are drafted according to each examination for each body part are essential so that doses are limited.[126]

A balance is further required in maintaining the kV as well as the mA and time product. As stated in section 2.2.2, a high kV results in in reduction in patient dose as more photons penetrate the patient. If the high kV is used then it constitutes a reduction in the mA and time product due to more x-ray production thus reducing the absorbed dose.[127] This will limit the exposure time to the patient and the staff member who is further required to keep a certain distance away from the x-ray source.

Radiographers should also maintain as large a distance as possible from the radiation source to reduce the intensity of x-rays.[43] This is achievable through the application of the inverse square law. The inverse square law states that from a point source in a non-absorbing medium, the intensity of the radiation varies inversely as the square of the distance from the point source.[128] This means the intensity of the radiation decreases as the distance increases.[128] This happens because the x-ray energy diverges as the distance increases.[128] Therefore keeping a as large a distance as possible from the x-ray source will reduce the amount of exposure received by radiographers.

Callaway recommends that radiographers should stand about two meters from the x-ray source during mobile radiography. The author further recommends that the exposure cord should also be about two meters long and radiographers should use it at full length.[129] The emphasis here lies on the drafting of policies and procedures again for situations like Swaziland. Callaway further recommends that radiographers should never be exposed to the primary beam and keep a distance as far as possible. The author recommends that family members and non-radiology staff should be the first choice where assistance is needed in holding patients.[129] Similar recommendations are provided by the South African Department of Health.[102] Without properly drafted guidelines, radiographers may not be able to defend their actions of non-refusal to holding patients and therefore subjecting themselves to increased exposures. A situation like this is inevitable in Swaziland where regulatory mechanisms are absent.

Maintaining the standardised source to image (SID) distance for various examination is also important. Some studies reported that increasing the SID results in reduced patient doses for patients. Karami, Zabihzadeh, Danyaei and Shams concluded in their study that increasing the SID from 100cm to 130cm during paediatric chest radiography resulted in a 32.2% radiation dose reduction without affecting image quality.[130] Similar findings were obtained by Brennan, McDonnel and O'Leary where increasing the SID from the traditional 100 cm to 130 cm lumbar spine examinations resulted in 33% dose reduction without affecting image quality.[131] In Swaziland where radiographers work under non regulated conditions without guidelines, all these techniques to dose reduction might vary therefore affecting patient and staff doses. The need for technique charts in each department with standardised parameters is further recognised.

Using appropriate shielding devices and barriers from ionizing radiation is important as a means of reducing the dose received. Shielding in diagnostic imaging can be differentiated into the following aspects;

a) The first aspect is x-ray tube shielding

Here the x-ray tube housing is lined with thin sheets of lead to prevent x-rays produced from being scattered in all directions.[132] The intention is to protect patients, staff from leakage radiation transmitted through the tube housing.[132] The Atomic Energy Regulatory Board (AERB) of India requires a permissible leakage radiation dose of not greater than 1mGy per hour per $100cm^2$.[133] A study aimed at investigating the distribution of scatter radiation from a mobile x-ray machine and a c-arm used in theatre fluoroscopy found that at some points the scatter radiation was nine times to the minimum dose. The authors further recommended a safe point for staff without lead shielding.[134]

In Swaziland, in the absence of QC tests, the level of safety of the x-ray machines in terms of radiation leakages is unknown therefore impacting on the safety of everyone in the radiography departments. WHO recommends that comprehensive radiation surveys should be carried out by a medical physicist who can be preferably assisted by the radiographer. The organization explains that radiation surveys are concerned with assessing the level of scattered radiation and the leakage radiation from the x-ray equipment. Corrective and defensive mechanisms against possible leakages suggested are said to be both strategic whereby provision for adequate shielding is maintained and tactical whereby staff procedures are controlled by means of local rules in the irradiated areas.[135] In the absence of regulations as is the case in Swaziland, radiation surveys are probably not conducted. WHO further advices that these surveys should be carried out during the following stages; a) during the planning of the new department b) during construction of the building c) immediately after installation of the equipment d) when additions and alterations are made to the department or equipment e) when personnel monitoring indicates adverse changes and f) at regular intervals when no obvious changes have taken place.[135]

b) The second aspect is structural room shielding

This means walls should be lead lined such that the x-ray rooms act as protective barriers to individuals outside of them.[132] There are two types of barriers; primary barrier which protects directly from the primary x-ray beam and secondary barriers which protects from secondary radiation resulting from radiation leakage from the x-ray tube and scatter radiation from the patient.[132]

X-ray room shielding is meant to protect from the direct primary beam. It is important that this room is located as far away from areas such as the maternity ward and the paediatric wards and other areas not directly involved with radiation.[132] Ismael in Sudan bases his shielding recommendations on the shielding calculations of the NCRP report 147. This author recommends that all secondary barriers in standard diagnostic x-rays shall have a lead equivalence of 1.0 mm with a 10% tolerable allowance. Primary barriers are to have a lead equivalence of 2.0 mm with a 10% tolerable allowance.[136]

It has been reported that well designed radiography departments taking into consideration shielding and distance are rarely achieved in limited resource countries due to low funds as the cost of lead shielding is high.[137] This was identified in a few studies conducted in limited resource settings whereby structural room designs and location of x-ray equipment did not conform to recommended standards due to limited resources.[138,139] Swaziland is a developing country with limited resources. It is possible that departments are probably not conforming to international standards in terms of structural shielding prompting the need to lay down regulations especially since new radiography departments are increasing in numbers.

The control booth is a secondary protective barrier. This area must be located away from the direct primary beam. The viewing window and the walls of this room must have a lead equivalence of 1.5 mm.[132] The AERB of India recommends that the distance between the control booth and the chest stand must not be less than 3 metres for fixed x ray equipment.[133] Further, the IAEA recommends that control booths should be placed outside the x ray room.[140] It is important to consider these parameters during x-ray room design. However, this can only be done with proper technical advice and with laid down rules.

The techniques to be employed by radiographers towards adherence to the ALARA principle and optimizing radiation protection have been described. Further, departmental and equipment adherence with radiation protection standards have been outlined. There have been concerns in some countries with regards to safety conformance to international standards in the departments. Eze *at al* conducted a survey to find out the state of radiation protection in Nigeria and found that 62.5% and 80% of private and public x-ray units respectively had no lead lined walls. He further found out that none of the centers had a medical physicist or radiation safety officer.[8]

According to the CRCPD suggested state regulations, the radiation safety officer is an individual with the knowledge and responsibility to apply the appropriate radiation protection regulations and has been assigned such responsibility by the licensee or registrant. Such an individual as they went on to mention, will thus be responsible for the implementation, coordination and day to day oversight of the radiation protection program.[141]

Singh, Jayaraman and Arunkumar also observed that radiological practices were not exactly in line with safety codes and standards of the IAEA. In this same study it was noted that only 50% of practices had licensed x-ray equipment, 80% of workers did not use radiation protection devices while devices were available and 70% of practices did not carry out routine periodic QC testing of their equipment.[142] Such scenarios are probable in Swaziland since there are no monitoring mechanisms and this compromises the safety of patients, the staff and the public.

According to the ICRP, the optimization process further includes the following three steps;[143]

a) The radiological equipment should work properly such that it delivers the appropriate exposures and is compliant with the established standards of installation and performance during the installation time and after the routine use. This will be discussed later in the chapter.

b) The adequate selection of technical imaging parameters to optimize the radiation exposure level according to the size of the patient should be considered carefully. This has been addressed in section 2.2.2.

c) Implementation of diagnostic reference levels (DRLs) to ensure patient safety. A discussion on this subject is next.

2.3.3 Diagnostic reference levels (DRLs)

DRLs are radiation dose levels not to be exceeded when standard diagnostic procedures are performed. Sharma, Sarma and Agarwal stated that DRLs are not dose limits however they act as a standard for identifying patient doses that are unusually high.[144] The ICRP further supported this and recommended the use of (DRLs) as a means for identifying situations where the level of doses administered are unusually high. They state that if there is a situation where by exposures exceed the set diagnostic levels, staff procedures and equipment should be reviewed to determine if radiation protection is being optimised and appropriate corrective actions taken.[145] Therefore, McCollough states that DRLs act as trigger levels to initiate quality improvement.[146] The use of DRLs should then in essence form a core part of good imaging practise. The IAEA tasked member countries to ensure that these DRLs are in place so as to be able to monitor patient doses.[7]

Meyer, Pitcher and Groenewald conducted a study to review published work on DRLs in low and middle income countries after identifying that most of the published work on the availability of DRLs was from high income countries.[147] These authors identified that there is lack of published data on DRLs from the low and middle income countries with 6% and 25% retrieved respectively.[147] These findings imply that most low and middle income countries probably have not implemented DRLs. This is the case even in Swaziland. The ICRP has recommended that DRLs be set by authorised bodies that will best meet their specific needs and be consistent with the regional, national or local area to which they apply.[145] A need for research studies that will provide the basis for baseline levels in the Swaziland context is recognised. Further, the authorised body as recommended is needed to implement these dose levels.

The next section discusses quality assurance and quality control.

2.4 QUALITY ASSURANCE (QA) AND QUALITY CONTROL (QC) IN RADIOGRAPHY

WHO defines a QA program in radiography as an organized effort by the staff of a radiography department to ensure that the diagnostic images they produce are of high quality so that they consistently provide adequate diagnostic information at the lowest possible cost with the least radiation exposure to the patient.[44] Inkoom, Schandorf, Emi-Reynolds and Fletcher mentioned that the nature and extent of this program varies according to the size and type of facility as well as the type of examinations conducted.[150] Further, these authors state that each facility will determine the factors that constitute high quality images in the QA program.[148] This program involves a series of procedures that will ensure the aim of high quality images at the lowest cost and dose are met and in doing so improve service delivery. According to WHO, these include quality management procedures and QC techniques.[44]

The commitment of top management and the staff in the radiography department is required in order for the QA program to be effective.[9] Papp supported this by stating that QA is an all-encompassing management program. This author further states that the objective of a QA program is to enhance management techniques, departmental policies and procedures, equipment technical effectiveness and efficiency as well as in-service education.[43] Top management is involved in maintaining continuous quality improvement in the hospital as a whole.

Papp defines continuous quality improvement as a structured organizational effort that involves personnel in planning and executing a continuous flow of improvements to provide quality health care.[43] Continuous quality improvements are essential and should include radiography QA programs so that there is maintenance of optimal functioning equipment and monitoring of staff procedures in a bid to maintain patient radiation doses as low as possible. Involvement of radiography staff members in the continuous improvement and maintenance of the QA program is essential for this program to be successful.[43] Radiography departments are often left out of these hospital quality improvement plans and left on their own to maintain quality standards in the departments as is the case in Swaziland. This might be a barrier to the implementation of QA programs due to lack of awareness by top management and inadequate resources.[10]

Management in the radiography departments plays a big role in the administration of the QA program. These administrative procedures in the department include the assignment of responsibility for QA actions, the establishment of standards of quality for the equipment in the facility, the provision of adequate training and the selection of the appropriate equipment for each examination.[44] Papp states that management of quality in the radiography departments should involve these administrative procedures, radiation safety program and QC.[43]

QC is that part of QA that deals with monitoring the techniques set out in the QA program. Monitoring is achieved by a series of tests and activities which evaluate whether or not the relevant variables of the imaging system and conditions meant to reduce patient doses are in agreement with laid guidelines.[10] Ball and Price mentioned that four major areas need to be covered when conducting QC tests and these are the equipment, recording materials, processing area and reject analysis.[149] According to WHO, before the initiation of a QC monitoring program, standards of acceptable image quality must be established.[44] This is done to ensure the department delivers consistent high quality images at the lowest dose as is the aim in diagnostic radiography. Once these standards have been established, continuous assessments need to be performed to ensure consistency of good images. This is achieved through performing film reject analysis as a quality control test and is discussed in the next section.

2.4.1 Film/reject analysis

The analysis of rejected films or images is a subjective evaluation of image quality.[44] Poor quality films or images are rejected therefore leading to repeat examinations which causes unnecessary exposures to patients and staff.[150] Rejected films also lead to wasted time and resources for the department. Eze *et al.,* therefore mentioned that from this analysis of rejected films, the economic impact in terms of wasted resources like consumables, staff time and radiation dose implications can be established.[8] This makes analysing the cause of rejected films an important method of quality assurance in diagnostic radiography.[151] In this process, poor quality images are categorised according to causes such as competence of personnel, equipment problems, difficulties with the examination or in some cases a combination of all of these.[44] Once the cause of the poor quality of images has been identified, corrective action must be taken to reduce repeats as much as possible.

Most of the public hospitals in Swaziland recently incorporated the computed radiography (CR) system. This system involves using cassettes used similar to conventional screen film radiography however in this case the film has been replaced by a specially charged plate. The plate enables the image that has been captured from the radiography examination to be read, stored on a computer and then erased on the plate.[152] CR has the advantage of enabling post processing in terms of under exposed or over exposed images which are the common causes for rejected films especially in conventional film screen radiography.[153] Some radiography departments then do not see the need for conducting the reject film analysis following the introduction of system in this regard.[154] This might be the case in Swaziland.

It is important to note therefore that rejected films are not only due to exposure factors but might be due to wrong positioning, patient positioning, inadequate collimation, double exposure and others which still lead to repeat examinations. Film reject analysis also allows the calculation of the reject rate. The reject rate is defined as the percentage of images that are repeated due to errors or poor image quality.[152] The WHO recommended a reject rate of five percent while the CRCPD recommended a reject rate of ten percent as within normal limits.[155] Calculation of the reject rate can therefore be used to monitor and improve the services within the radiography department.[155] The CRCPD recommends that this test be performed every three months.[141]

Some studies in Africa conducted an audit of the reject rates. Benza, Damases-Kasi, Daniels, Amkongo and Nabusenja in their study aimed at identifying the causes of rejects

and calculating the reject rates in a hospital in Namibia found that positioning errors were the highest causes of reject films even though the reject rate was within recommended limits.[156] This study recommended continuous professional development for staff and students as well as standardised QA to reduce the reject rates even lower.[156] Batuka in Kenya found that after the incorporation of CR in the radiography department, the reject rate did not significantly reduce. This study similarly recommended continuous professional development in terms of radiographic technique as well as regular reject film analysis.[157] In Swaziland, since there are no standardised QA procedures, the state of rejected rates is unknown. This means the cost sustained by departments due to wasted resources and the implications of incurred doses to staff and patients is unclear.
The next section discusses the QC tests that are performed on the equipment of radiographic systems to ensure optimal image quality and reduction in patient and staff doses.

2.4.2 Equipment QC tests

WHO states that when a QA program is initiated, it is essential to establish baseline performance level of the equipment and then keeping a record of the results for future reference against the routine tests.[44] These tests also known as acceptance tests, include verification of all specifications and features of the equipment especially protection and safety features.[140] Once these baseline tests have been established, it is necessary to ensure that simple and speedy routine checks are carried out that provide assurance that the equipment is performing satisfactorily and not compromising image quality and patient doses.[44] WHO further advices that these checks should be conducted routinely and at a frequency pre-determined by the probability of the equipment malfunction and results recorded in an equipment log book.[44]

According to WHO, the responsibility of conducting these routine tests should be delegated to the radiographers themselves who are the daily users of the equipment.[44] This sentiment was echoed by the Department of Health of South Africa which recommended that license holders should ensure that appointed persons who perform routine tests be competent to do so and to ensure that all the QC tests are performed at the prescribed frequencies.[102] These appointed persons according to them should be responsible for the safe use of the equipment, routine performance of QC tests and possess qualifications in either, radiography, radiology, medical physics or chiropractics.[102] The following sections outlines some of the QC tests to be routinely performed on the radiographic equipment as recommended by the Department of Health of South Africa and CRCPD.[25,141]

a) Tube warm up tests

According to the CRCPD, warming up the tube is done to assure that the anode does not experience shock and stress due to sudden and excessive heat load, which would shorten the life span of the x-ray tube.[141] All radiographers should warm up the tube before use, following the manufacturer's specifications.[158] Rooms that are not in constant use, might have to be warmed up several times in a day to reduce the possibility of machine failures caused by a cracking anode. This happens when a cold anode is hit by a heavy technique.[158] The CRCPD and Department of Health of South Africa recommend that this test be conducted on a daily basis every morning before work begins.[25,141]

b) Kilo Voltage (kV) accuracy and reproducibility

As mentioned in section 2.2.2, the kV determines the penetrating power of the x ray beam and therefore the quality of the beam. This test is conducted to ascertain that at one kV setting, there are no variations in the output of the kV when several exposures are taken.[159] A small error in the kV output will have an effect on the eventual radiographic image and therefore patient dose.[43] Papp recommends an acceptable variability of about 5% while the National Radiation Commission recommends a variation of about 10%.[43] According to WHO, this test is performed by the medical physicist with a calibrated dosimeter after installation and after major repair however the radiographer can perform the routine test to check whether there is change in the radiation output using a simple dosimeter.[44] The Department of Health of South Africa recommends that this test be performed on acceptance and from there annually.[25]

c) mAs reproducibility and accuracy

Carlton and Adler stated that the mAs setting is used to control the density of the image.[160] The milliampereage (mA) and time in seconds (s) product setting has a direct effect on the amount of x ray photons reaching the x-ray film. This therefore implies that an increase in the mAs setting increases the amount of exposure reaching the film therefore affecting image quality.[9,160] This test is therefore used to provide assurance that when varying the mA and time for a constant mAs setting, image quality is not affected.[161] WHO stated that it is important to establish minimum exposure times that can be obtained consistently as well as establish that the timing device reliably terminates the exposure over a range of exposure times.[44] Slight differences in the mAs setting can affect the overall image quality which can affect the patient dose.[9] The recommendation is that this test be performed on acceptance and thereafter annually.[43]

d) Beam alignment

Sungita, Mdoe and Msaki state that proper alignment of the x-ray beam and the image receptor lead to accurate centering of the area under examination, reduction in scatter radiation, increase in image contrast and prevents radiation of areas outside the field of interest.[162] Lloyd stated that the central ray of the x ray beam should be perpendicular to the center of the area being examined if properly aligned.[161] Misalignment may result in superimposition of structures, image distortion and geometrical unsharpness.[160,163] The beam alignment test is therefore important to avoid repeat examinations due to unacceptable image quality.

e) Collimation

Light beam diaphragms are used to provide a visual indication of the radiation field size.[160] These devices allow for collimation of the x-ray field size therefore limiting the field to the area of interest.[160] Collimation is achieved when the x-ray beam is congruent with the light field which shows the area of interest.[9,10] Collimation has been known as the most effective way to reduce patient doses.[160] This is because it enables the exclusion of parts not part of the investigation from the radiation field which would otherwise contribute to scatter radiation and unnecessary dose to the patients.[161]

WHO mentioned that the larger the area being irradiated the greater the scatter radiation.[104] Scatter radiation further leads to increased film density which results in unacceptable image quality.[164] The collimation test ensures that there is alignment of the x-ray field and the light field therefore allowing for x-ray beam limiting. Poor alignment results in incorrect centering of the area being investigated thus the area of interest may not be included in the image or unwanted areas may be included which would lead to increased patient doses.[103] WHO recommends that this test be performed every six months to ensure that the x ray field is in alignment with the light field.[103]

f) Protective wear

Protective wear constitute of lead aprons, gonad shields, lead gloves and thyroid shields. These radiation protective apparel provide adequate shielding against scatter radiation.[120] Personnel in the radiography department are required to wear protective apparel against scatter radiation from the patient and the x-ray tube housing during radiography examinations where they are required to be close to the patient.[120] Patients need to be given gonad shields to protect these sensitive organs when they are not part of the x-ray examination. Relatives as well who are assisting in handling the patient need to be given lead aprons to protect them from the scatter radiation from the patient.[165] The lead apparel are the most frequently used in radiation protection and therefore it is vital they provide adequate attenuation of the x-ray beam and the integrity of this function ascertained with regular checks. There have been reports that lead aprons are not cared for properly in the radiography departments therefore leading to a reduction in their effectiveness.[166] This necessitates the need for tests to ascertain the integrity of these lead apparel on a regular basis. It is recommended that the lead apparel tests be performed at purchase to ensure their effectiveness before use and thereafter annually.[141,165] Tests need to be performed using a fluoroscopy unit where the entire garment is screened for cracks and defects or using a radiography unit where the area of defect is imaged to determine any breaks in the lead lining.[141]

g) Viewing boxes

In Swaziland, most radiography departments are still film based and viewing boxes are still in constant use. The viewing boxes are used to view the radiographic images. These boxes need to be tested to ensure that they provide optimum light intensity and uniformity.[167] The CRCPD state that these need to be kept clean and light levels kept consistent throughout the box. They further mention that this is important in that a difference in luminance may affect interpretations and therefore a diagnosis.[141] It has been stated that an accurate interpretation of the radiograph is a function of the viewing conditions and if the viewing conditions are bad the accuracy of the interpretation decreases.[168] One study proved that non optimal viewing conditions decrease the ability to visualise low contrast lesions.[169] Regular cleaning of the viewing box inside and outside, replacement of defective lamps with lamps of the same colour and wattage is recommended[170] to maintain optimal viewing conditions. The CRCPD recommends that testing of these boxes be performed monthly.[141]

h) Cassettes and imaging plates

According to the Ministry of Health of Canada, the conditions of computed radiography (CR) imaging plates and cassettes need to be evaluated on a regular basis. This they state is because these devices can accumulate dust, dirt, scratches and cracks which may reduce image quality. They recommend that these need to be visually inspected on a weekly basis for dust and dirt and cleaned on a monthly basis.[167] As mentioned previously, the CR imaging plates are exposed, read and then erased. The efficiency of erasure needs to be tested as well. If the imaging plate is improperly erased, this can give rise to artefacts on the eventual image.[171]

i) Record keeping Documentation

The QA program should include policies for record keeping of the results of tests conducted, difficulties encountered, corrective measures undertaken and the effectiveness of these measures.[148] This was echoed by the Department of Health of South Africa where they stated that the record should contain information such as results of acceptance testing during equipment installation, results from the routine performance testing, failures and reasons. They further mentioned that with records in place, any deviations from the set standards can be noted during routine QC tests by comparing the results with the compiled reports.[102] Chinamale mentioned that compliance to required standards and equipment performance cannot be traced if there are no records of results from previous tests.[9] Equipment documents such as repair/maintenance user manuals need to be properly kept for that equipment's life time.[10] Further, the QA program should make provisions for continuous education and training of staff with QA responsibilities.[9,148]

The next section presents a review of literature from African countries with regards to implementation of QA and performance of QC tests.

2.5 QA AND QC IN RADIOGRAPHY DEPARTMENTS AFRICA

A number of studies in Africa have been conducted in a bid to evaluate the standard of quality and compliance to international regulations in terms of QC and radiation protection. Ofori, Antwi and Scutt in Ghana conducted a qualitative study which identified that in all the practise settings where the study was done there was lack of QA systems and therefore lack of protocols and procedure manuals as well as exposure charts. Another identified issue was the absence of formal organisational structures in Ghana which in itself does not promote quality service delivery due to the lack of supervision and monitoring of quality.[172] In Tanzania Ngoye, Motto and Muhogora found that QC implementation was inadequate and irregular with reports of QC tests not being done and those that were done not conforming to the recommended schedule. The factors identified to be the cause of this were lack of initiative from radiographers, lack of radiation awareness by hospital managers and lack of enforcement by regulatory authorities.[10] Chinamale similarly found that there are inconsistencies with the QC tests done in Malawi radiography departments and that there is no standardised system or programme in place for hospitals to follow to ensure QC tests are conducted and actions taken if there are any deviations from required standards. There were no specific QA programmes in any of the departments included in his study and only one had a broad documented QA programme for the whole hospital.[9]

Africa is lacking behind with compliance to international standards. Education and training is strongly recommended as well as formulation of regulatory authorities that will enforce quality management systems. The AFROSAFE campaign was launched by the Pan African Congress of Radiology and Imaging (PACORI) and other radiation health workers in Africa.[11] Its main objective is to unite with a common goal to identify and address issues arising from radiation protection in medicine in Africa.[11]
This campaign aims at addressing radiation safety issues primarily in African countries. Enlisting countries like Swaziland could do more benefit to the Swaziland population as it would increase staff awareness on radiation safety by strengthening education and training on radiation protection as well as improve radiation protection measures by the implementation of safety requirements and strengthening the radiation safety culture in the country. The section below discusses the importance of regulation in diagnostic imaging and the relevance of self-regulation.

2.6 REGULATION IN DIAGNOSTIC IMAGING

The roles of the regulating body in radiography departments include ensuring appropriate legislation is in place in order to ensure the safety for all concerned from the harmful effects of ionizing radiation. This was confirmed by the IAEA where they recommended that the regulatory body should establish a system of regulations that ensures that radiation exposures in radiography departments are carried out in compliance with the requirements of the Basic Safety Standards. These regulations should be flexible enough to permit easy adaptation to evolving technologies and should not hinder the delivery of healthcare. The agency further mentions that these regulations should also be consistent with international or national guidelines.[15]

A set of recommendations outlining the responsibilities of the regulatory body with regard to radiation protection and safety was published by the IAEA. It was stated that the regulatory body shall establish a system for protection and safety that includes the following;[15]

a) Notifications and authorisations

The IAEA states that any person intending to conduct a radiography practice should notify the regulatory body. The body agency further states registration as a form of authorization should be done when the applicant has ensured safety of the facility in terms of its design and safety of the equipment to be used.[15] The Department of Health of South Africa states that installation of radiography equipment may only begin once a license has been granted and the licensee has the responsibility to ensure acceptance tests are conducted.[102]

b) Inspection of facilities and activities

The IAEA recommends the regulatory body to carry out regulatory inspections which verify that radiography practices operate according to relevant regulations.[15] These inspections according to this agency are to ensure that amongst others a) facilities, equipment and work practices meet all necessary requirements b) persons employed by the operator possess the appropriate qualifications and therefore competent to work safely and c) the operator is managing safety in a proper manner.[15] The methods of inspection should include a) direct observation of working practices and equipment which includes whether personnel follow documented procedures appropriately and whether suitable warning signs are displayed at required locations b) discussion and interviews with employees c) examination of records and documents and d) tests and measurements to verify those tests done in the radiography departments.[15]

c) Enforcement of regulatory requirements

A regulatory body is to ensure that in the event there are reports of unsafe practices in the radiography departments, corrective actions must be taken in the form of enforcement actions.[15] According to the IAEA enforcement actions take different forms. These include a) written warnings or directives where in cases of minor safety violations the regulatory body issues a written warning to the radiographer in question b) orders to curtail specific activities in cases where there is deterioration in the level of safety c) modification, suspension or revocation of authorization and d) impose penalties such as fines.[15]

National regulatory bodies are governed by comprehensive laws and requirements and may take longer to establish. Another problem is lack of enforcement from external regulatory bodies. A study in Nigeria identified that despite the presence of a regulating body, many hospitals had never conducted QC on their equipment and this was attributed to lack of enforcement.[173] This is why the researcher sought to investigate the radiographers' views in Swaziland towards self-regulation. The next section discusses the role of self-regulatory bodies.

2.6.1 Self-regulatory bodies

A self-regulating profession involves professional peers in establishing and monitoring professional standards.[174] In the U K the practice of self-regulation is followed where the healthcare system is built on the basis of self-regulation with over 13 self-regulating organisations that are related to medicine including separate organisations for physiotherapists and nurses.[175] Randall mentioned that self-regulation acknowledges that a profession itself is in the best position to regulate its members because of their specialised body of knowledge.[176] As it has been seen in the previous sections, regulating safety in the radiography departments is a complex procedure requiring specific knowledge which common regulatory authorities such as government entities may not be familiar with.

Self-regulating organisations keep control of their standards including determining the conditions and rules for their activities.[176] WHO stated that some countries are interested in introducing minimum enforceable standards of practice for health professions who provide a service that is not regulated.[63] In this study, the researcher sought to determine if radiographers would be willing to establish a body that will regulate safety in the radiography departments which remain unregulated in Swaziland.

Protecting staff members, patients and the public from the harmful effects of radiation is the reason for regulating radiography departments. As seen in the literature review in previous sections, the activities in the radiography departments that the study proposes monitoring in are radiation protection practices and QA programs which include QC tests. The AFROSAFE implementation tool matrix mentioned that it encourages self-regulation in the radiography departments through the promotion of a safety culture.[11] Further, Yeusem and Beuchamp state that QA and QC are generally informal and self-regulated requiring self-monitoring and self-assessments.[22]

The situation in Swaziland is such that, there is no evidence of QC being done and also of radiation protection measures in place in the absence of a regulatory body. This literature review has demonstrated the need to have a body that will oversee the implementation of QA programs and thus QC tests which it has been shown are important for reducing patients' doses and also radiation protection protocols which it will make sure are being adhered to. All of these structures are important as part of patient care in the health sector. The next section provides a conclusion of the chapter.

2.7 CONCLUSION

This literature review has demonstrated the harmful effects of ionizing radiation in cases where it is not controlled. The radiation protection measures which radiographers are required to adhere to in justification of examinations and optimizing radiation protection in the radiography departments have been outlined. It has further been demonstrated that it is important to have QA programs which encompass equipment QC tests in place as part of ensuring safety in the radiography departments. The function of regulatory authorities in diagnostic imaging has also been demonstrated. The next section will discuss the methodology that underpinned this study.

CHAPTER 3

RESEARCH DESIGN AND METHODOLOGY

3.1 INTRODUCTION

The previous chapter presented the literature reviewed to demonstrate the importance of quality assurance procedures, radiation safety measures and regulation of radiography departments. This chapter focuses on the research design and methodology that was used in the study. This will include research setting, data collection instrument and processes involved as well as data analysis. Liamputtong states that health sciences researchers conduct qualitative research for several reasons. One of the reasons may be due to a problem or issue that needs to be explored. This in turn allows the researcher to hear more silenced voices. The author further highlights that qualitative research is essential when there is a need to understand the contexts or settings that play a crucial role in the lives of the research participants.[49]

It is for these reasons that the qualitative research approach was adopted for the study. In chapter one, the research problem was presented. Radiography departments in Swaziland are not being regulated in as far as radiation protection and QC are concerned. It was not clear to the researcher as to what extent radiographers perform QC tests and apply radiation protection measures. The researcher then deemed it necessary to explore the perceptions of radiographers regarding establishing a self- regulatory body for radiation control purposes in the radiography departments in Swaziland. This was because the researcher needed to obtain an in depth understanding of the participants' perceptions regarding this phenomenon. The research design is discussed next in detail.

3.2 RESEARCH DESIGN

Polit and Beck define the research design as the overall plan for addressing the research question and it includes the strategies for enhancing the integrity of the study.[177]

According to De Vaus, the research design chosen must integrate the different components of the study in a coherent and logical manner and thereby addressing the research problem effectively and must constitute the blueprint for the collection and analysis of data.[178]

A qualitative, exploratory and descriptive research design was employed in this study in order to obtain an understanding of radiographers' perceptions regarding establishing a self-regulatory body for radiation control purposes in the radiography departments in Swaziland. Each of these components of the study design are discussed in detail below. Qualitative research is explained first.

3.2.1 Qualitative Research Design

According to Gray, Grove and Sutherland qualitative research is a scholarly approach used to describe life experiences, cultures and social processes from the perspective of the persons involved.[179] Brink, Van der Walt and van Rensburg state that qualitative research allows the researcher to explore the in-depth, richness and complexity of the phenomenon under the study.[35] Furthermore, Denzin affirmed that qualitative researchers study phenomena in their natural settings and interpret them in the meaning that the people bring to them.[36] In this study, the researcher sought to describe the in-depth perceptions of the participants with regards to the issue being investigated in their natural settings and hence the choice of this design.

Qualitative research takes an interpretive approach. Intepretivism assumes that reality is constructed by the individuals acting in it.[180] Denzin further states that since the interpretive method places its emphasis on experience and meaning, judgements must be made from the point of view of the persons most directly affected.[36] The researcher cannot detach themselves from the reality and interacts with the investigation process.[181] Other authors however suggest that the researcher needs to stand back and let the participant's voice be heard.[35] In this study, the researcher allowed participants to express their sentiments freely without any influence.

To further justify why qualitative research approach was found to be appropriate for this study, Denzin states that qualitative research can contribute immensely to social justice. This author mentions that through the use of personal experience narratives, different perspectives of the problem being investigated can be identified and thereafter an agreement can be made that change is required.[36]

Qualitative research became appropriate to answer the research questions in this case. This was because the aim was not make statistical inferences as is in quantitative research but rather to gain in depth understanding of radiographers' views and perceptions towards their QC and radiation protection practices as well as their perceptions towards self-regulating these practices in the radiography departments. The reader is reminded of the research questions which were;

- What are the views of radiographers with regards to the performance of QC tests and radiation protection practices in the radiography departments in Swaziland?

- What are the perceptions of radiographers regarding establishing a self-regulatory body that will monitor radiation protection practices and QC test performances in the radiography departments in Swaziland?

Most studies conducted on QC and radiation protection practices by radiographers focused on determining the frequencies of these practices in the radiography departments.[9,10] The researcher found it appropriate to focus on describing the views of radiographers regarding these practices so that an understanding regarding how they perceive their own practices in terms of QC tests and radiation protection will be obtained. This is supported by Lichtman who mentioned that the critical elements of qualitative research are describing, understanding and interpreting human behaviour.[182]

Exploratory research is discussed further in the next segment.

3.2.2 Exploratory Research Design

Gray *et al.,* define exploratory research as research conducted to gain new insights, discover new ideas and/or increase knowledge of a certain phenomenon.[179] Further, Polit and Beck state that exploratory research investigates the full nature of a phenomenon, the manner in which it manifests, and the factors to which it is related to.[30] The exploratory design in this study was used to gain new insights into the perceptions of radiographers in Swaziland regarding establishing a self-regulatory body for radiation control purposes in the radiography departments.

In this study, individual in-depth interviews were conducted with registered radiographers to explore the phenomenon under investigation. A number of facts were established during the interviews and this enabled the researcher to then describe what these participants narrated. The following section justifies the use of descriptive research in this study.

3.2.3 Descriptive Research Design

Grove and Gray state that the purpose of descriptive research is to describe situations as they naturally occur. These authors further state that complete and accurate information about a phenomenon is obtained through observation, description and classification.[39] A descriptive design is used in this study to depict accurately and completely the perceptions of radiographers regarding establishing a self-regulatory body for radiation control purposes in the radiography departments in Swaziland. These were perceptions by radiographers in the situation of non-regulation of these departments as they naturally occur. Meanings were derived from what the participants relayed and rich descriptions were presented. The steps undertaken during this process will be elaborated on and described in detail in the data analysis section (section 3.7).

3.3 STUDY SETTING

Polit and Beck define a study setting as the physical location and conditions or circumstances where and within which a research study takes place.[30] As previously explained, in qualitative research, situations are described by participants in the manner in which they naturally occur. It therefore becomes important to collect data in the natural setting where the problem under investigation occurs.[29] The study took place in the radiography departments in Swaziland of the hospitals that agreed to participate. These hospitals included one hospital from the Lubombo region, three hospitals from the Manzini Region and two hospitals from the Hhohho region. Two of these were private hospitals and the other four were public hospitals.

The following sub section explains how access was negotiated in these settings.

3.3.1 Negotiating access

As explained in chapter 1, section 1.13.1, an invitation was sent to the Swaziland Ministry of Health to gain access to the radiography departments of the hospitals in the country. The Director of health services in the Ministry of Health granted permission in the form of a written letter (Annexure C). Before any researcher begins data collection in Swaziland, the National Health Research Review Board must grant permission. The proposal was sent to them together with the ethical clearance letter from the University of Pretoria (Annexure D). Permission was received as seen in Annexure D. Once permission was received, the researcher further sought permission from individual hospital managers to conduct the interviews in their departments. Those that agreed also provided permission letters. These letters are not included in the appendices as the researcher undertook to maintain anonymity of the hospitals that took part in the study. Once these hospitals granted access formal data collection began with radiographers that agreed to participate. The next section describes the research participants.

3.3.2 Research participants

Creswell states that the researcher should utilize criterion based sampling when selecting participants. The author further highlights that in order to obtain the most credible information relevant to the study, qualified candidates who will be willing to share information openly and honestly must be selected.[180] A small heterogeneous group of participants was selected. This is also known as maximum variation sampling according to Polit and Beck whereby participants with wide range of variations are purposely selected.[30]

All the participants in the study were fully qualified radiographers possessing qualifications such as diplomas or degrees as shown in chapter 4 section 4.1. This made them aware of the problem that was being explored and therefore they were able to provide thick rich descriptions. The aim was not to recruit participants based on age and experience and so they varied in terms of these. This diversity allowed for different perspectives from the participants on the issue of regulating QC and radiation protection in the radiography departments in Swaziland. Participants that agreed and gave written consent to be interviewed and audio recorded were included in the study. Participants were then contacted a week before to set up an appointment for the interviews. Interviews were conducted in the radiography departments in a quiet area. The researcher also made sure not to disturb work flow in the departments and therefore interviews were conducted at a time predetermined by participants. The delimitation of the study is discussed in the next section.

3.4 DELIMITATION

The purpose of the study was to explore the perceptions of radiographers regarding the establishment of a self-regulatory body that will regulate QC and radiation protection in the radiography departments in Swaziland as previously mentioned in chapter 1. The study was therefore delimited to perceptions by qualified radiographers since they are well trained in these practices. It was also delimited to radiographers currently practicing in Swaziland since they are well aware of the situation regarding the non-regulation of radiography departments in the country. The study was not delimited to a certain age and level of experience by these radiographers. The inclusion and exclusion criteria is further described below.

3.4.1 Inclusion criteria

The inclusion criteria as defined by Polit and Beck are subjects who have specific characteristics relatable to the problem being studied.[30] In this study, participants who were included were radiographers both male and female who were qualified as diagnostic radiographers and registered with the Swaziland Medical and Dental Council. Further, radiographers who were willing to participate in the study and had agreed to be audio recorded were included.

3.4.2 Exclusion criteria

Participants who have specific characteristics that are not relevant to the study fall under the exclusion criteria.[30] In this study, radiographers who were still in training were excluded. Radiographers who were in retirement were also not included as part of the study. Population and sampling are discussed next.

3.5 POPULATION AND SAMPLING

According to Polit and Beck, a population is an entire group of people who have common characteristics that are of interest to the researcher as well as meets the criteria that the researcher is interested in studying.[30] The authors further define a target population as the entire population which a researcher is interested in and to which he or she would like to generalize the study results to. The target population in this study included all radiographers registered with Swaziland Medical and Dental Council who were working in government and private hospitals in Swaziland. From the target population a sample was extracted and this is elaborated on in the coming sections.

3.5.1 Sampling strategy

Saldana describes sampling as a strategic, referred, random and/or serendipitous selection of participants.[34] There are two main sampling strategies namely; probability and non-probability sampling. Probability sampling uses random selection of participants to ensure that all members of the population have an equal chance of being selected to participate in the study.[179] In non-probability sampling, the participants are selected based on the researcher's subjective judgement rather than random selection. Patton mentioned that qualitative research relies heavily on purposive sampling strategies which are non-probability sampling techniques.[183] In this study purposive sampling was undertaken.

According to Grove and Gray, in purposive sampling, the focus is on insight, description and understanding of a phenomenon or situation with specially selected participants who are representative of the area of study.[39] Creswell states that purposive sampling refers to selecting participants that will help the researcher understand the problem and gain insight into the research question by sharing their knowledge.[184] Purposive sampling strategies further involve the selection of specific individuals because of the crucial information they can provide which cannot otherwise be obtained through other individuals.[55] This then implies selecting participants that will provide rich information about the problem under investigation.

Radiographers are trained in QC and radiation protection practices that must be performed in the radiography departments and therefore are knowledgeable on how to ensure a safe working environment in the radiography departments.[43] This means that they are able to provide information regarding the idea of self-regulation and setting down their own regulations that will monitor these services. The next section discusses the sample size.

3.5.2 Sample size

The sample size, as defined by Polit and Beck, is the number of subjects, events, behaviour or situations that were examined in the study.[30] Patton mentioned that qualitative research typically relies on relatively small samples[183] with the focus being on whether the sample provides enough data to allow the research questions or aims to be thoroughly addressed.[185]

In qualitative research the size of the sample is not predefined at the beginning of the study but it is determined by the saturation of data during the data collection process.[49] Data saturation is the point at which new data begins to be redundant with what has already been found and no new themes can be identified.[56] Saldana states that a small group of 3 to 6 people may provide a broad spectrum for data analysis however in other studies, a minimum of 10 to 20 people may be needed to ensure more credible and trustworthy findings.[34] This author further emphasises that how many participants are enough can depend on many factors, what is important is to have sufficient data for analysis be it from 1 or 20 people.[34] In this study a total of 18 radiographers were interviewed. Data was saturated at the 18th interview. The next section focuses on data collection.

3.6 DATA COLLECTION

According to Grove and Gray, data collection is the process of gathering data from the participants so as to provide the evidence the researcher wants in order to address the research problem.[39] These authors further state that in qualitative research, data is collected from the participants through unstructured narrative descriptions.[39] Creswell however states that when conducting interviews in qualitative research, a certain degree of logical rational approach must be considered and this can be in the form of semi structured interview guides prepared beforehand.[180] In this study, this approach was found appropriate for this study. The researcher conducted individual interviews with radiographers using an interview guide prepared beforehand. Data was collected between January 2019 and February 2019. This was after receiving ethical approval from the National Health Research Review Board in Swaziland and the University of Pretoria, Faculty of Health Sciences Research Ethics Committee. The next section focuses on the research instrument (interview guide) and how it was developed for this study.

3.6.1 The research instrument

As explained in the introductory chapter to this study, this was a qualitative study. Individual semi structured interviews were used to collect data. The interview according to Kvale and Brinkmann is a specific form of conversation where knowledge is produced through the interaction between the interviewer and the interviewee.[186] Liamputtong states that individual interviews usually mean face-to-face and one-on-one interaction between the researcher and the participant. This author further highlights that the aim of these interviews is to capture participant's thoughts, perceptions, feelings and experiences in their own words.[49]

According to Liamputtong, the use of individual interviews has a number of advantages; a) researchers are able to examine perceptions of participants and how they give meaning to their experiences b) the researchers are able to gain understanding to issues that are important to the participant as the researcher captures participants' own words c) the opportunity for probing is provided which then allows the researcher to gain more in depth information and d) the researchers are able to record non-verbal behaviour during the interview.[49] In order to effectively explore the topic of interest in the study, the researcher must prepare well thought out questions which address certain aspects of the topic.[38]

In this study, the topics were prepared to address QC performances by radiographers, application of radiation protection measures in the radiography departments, perceptions towards establishing a self-regulatory body and recommendations to improve these practices. The interview guide can be found in Annexure E. Questions were developed by the researcher and verified by the supervisor. These questions were developed so as to answer the research questions and further meet the objectives of the study. The questions were predetermined so as to guide the interview process while engaging with the participant. While questions were predetermined for individual participants, follow up questions to answers given were also asked to probe further before moving onto the next question.

The researcher deemed it necessary to conduct a pilot test of the questions before data collection of the main study began. This is discussed further in the following section.

3.6.1.1 Pilot testing

A pilot study is defined by Polit and Beck as a small scale of a complete study or a pre-test of a particular research instrument such as an interview guide in this case.[30] Some literature discourages the use of pilot studies in qualitative research. Van Teijlingen and Hundley state that in qualitative research, researchers often use some or all of their pilot data as part of the main study. This is because qualitative data collection and analysis is progressive.[187] It might be necessary that after reviewing the first interview data collected, the researcher gains new insights and thus makes an improvement on the research questions or interview schedule. Therefore the need for pilot studies becomes unnecessary.

Other researchers however emphasise the need for pilot studies. Kvale and Brinkman state that a pilot test should be conducted to assist the researcher to determine if there are any flaws, limitations or other weaknesses with the interview design.[186] This then allows the researcher to make any necessary changes prior to beginning the formal data collection. Furthermore De Vos, Strydom and Delport assert that pilot testing allows the researcher to practice and review the interview skills.[188] A pilot study was conducted with a radiographer coming from another country and not practicing in Swaziland. The participant was conveniently selected because of similar interests in the study because of the fact that she came from a country where there is no regulation of radiography departments with regards to quality control and radiation protection. All questions posed to the participant were well understood. There was no need to make adjustments on the interview guide. The following section discusses the data collection process.

3.7 DATA COLLECTION PROCESS

The researcher arranged an appointment with the participants who had agreed to participate at a day where they generally had less patients. Other participants requested to be interviewed during their lunch hour. The researcher then travelled to the individual hospitals. An area free from distractions was requested and allocated to the researcher by the head of departments.

A short briefing session was held with participants before the actual commencement of the interview in order to develop rapport as well as alley their anxiety.[182] The purpose of the study was clearly explained. The researcher explained that the interview will be audio taped in order to capture the responses of participants verbatim and that the researcher will be taking notes during the course of the interview. Voluntary participation was then sought as previously explained and participants signed an informed consent form (Annexure E). Interviews lasted about 30 minutes per participant. Participants were assured of their anonymity and that their results will not be communicated to any other participant. As soon as each participant was ready to begin the interview, the audio recorders were turned on and the interview started. The prepared semi structured questions which guided the interview process were then posed to the participants. All participants agreed to conduct the interview in English.

3.7.1 Audio recording

The researcher used two audio recorders, one was used as back up. Liamputtong states that it is important to audio record in depth interviews as researchers need to pay attention to what participants are saying and taking extensive notes may be distracting and interrupt the free flow of the conversation. This author further highlights that recording interviews is crucial for detailed analysis as participant's' responses are captured in their own words including the tones and pauses. It is important that researchers ensure that the room is free from distractions and background noise. The quality of the audio recorder is also essential in that if it is bad, a researcher may end up with bad transcripts.[49] In this study, the audio recorders were tested before the interview began and the audio quality was deemed to be fine. Participants were made aware that they are being audio recorded and interviews were conducted in quiet areas. The recorded interviews were supplemented by field notes.

3.7.2 Field notes

Field notes are defined by Polit and Beck as notes taken to record unstructured observations made in the field.[177] Birks and Mills state that these should be made after the interview and should contain details of the physical environment, responses from participants and also capture participants' non-verbal behaviour which the audio recorder would not capture.[189] However, Saldanha suggests that as the interview proceeds, brief notes such as key words or phrases must be taken for follow up and probing.[34] As advised by the latter author,, during the interview process the researcher took field notes continuously during the interview making sure that it did not distract her from listening attentively to each participant. An excerpt of the field notes is seen in Annexure A.

3.7.3 Role of the researcher

As is the nature of qualitative studies, the researcher became an active part of the data collection process. The interviews were conducted by the researcher herself. The role of the researcher during the interview process is discussed further in terms of various communication skills used and bracketing.

3.7.3.1 Communication skills

Qualitative research interviews require that the interviewer has various communicating skills in order to elicit as much information as possible from the participant.[188] Rubin and Rubin state that a systematic effort to really hear and understand what the other person is telling you needs to be taken into consideration by the interviewer.[190] The communication skills that the researcher used during the interview processes are outlined below.

a) Probing

Probing is used during the course of the interview to elicit more information about a particular topic.[181] De Vos *et al*., state that it is a technique used to persuade the participant to give more information about an issue under discussion.[188] This author further states that probing deepens the responses to the question posed thus increasing the richness of the data obtained.[188] In this study follow up questions were posed to participants to elicit more information where the researcher felt the answer was inadequate. Examples of the probing questions were; can you tell me more about that or what do you mean by that statement?

b) Active Listening

It is important for the researcher to possess good listening skills in order to get rich information during the interview.[188] The researcher should let the interview flow as naturally as possible, participants should not be interrupted and should be allowed to finish their stories even if they may be articulating something irrelevant at that moment. This irrelevant responses may be followed with more relevant responses as they continue their accounts.[49] Undivided attention was given to the participants as they narrated their answers with minimal verbal response from the researcher. Examples of the minimal verbal responses, included; okay, I see. This was to show the participants that the researcher was listening attentively and also maintaining constant interaction with them.

c) Paraphrasing

Gray, *et al* explain that paraphrasing simply means reiterating ideas clearly in one's own way. In other words the researcher enhances meaning by stating the participant's own words in another form but with the same meaning.[179] In this study the researcher used this skill by repeating the participant's statement in her own words but without changing the meaning. This allowed the participants to elaborate further on what they were talking about and thus getting more information.

d) Clarification

This is a technique that is used to get clarity on unclear statements.[188] The researcher used this technique where she felt the answer given was vague. This allowed the participant to clarify what they were saying in order for the researcher to get a clear understanding what was said. Clarification allows for the correct interpretation and understanding of what is being relayed by participants so that the aim of the interview is met. In this study examples of clarifying questions were; so what you mean is…, if I understand you correctly you are saying…

e) Summarising

This is when participant's relayed ideas, thoughts and feelings are being summarised to ensure that the researcher understood what the participant was saying, usually at the end of a session.[188] The main themes that emerged during the interview session are highlighted in summary when the researcher closes the interview.[188] This researcher summarised the interview at the end of the session and this allowed some participants to elaborate more on what they were saying.

f) Reflection

According to De Vos, *et al*, reflection is a process of reflecting back on the feelings, thoughts, ideas the participant has just communicated in order to get them to expand on the idea.[188] This means the researcher relays back to the participant in her own words what the participant has just said in order to get more information regarding that idea. In this study examples of reflecting questions included, so you mean there is lack of support from management, so what you are saying is you have no time.

3.7.3.2 Bracketing

Polit and Beck define bracketing as a process of identifying and holding in abeyance any preconceived beliefs and opinions about the issue being investigated.[30] In this process the researcher identified any assumptions or personal perceptions that may influence how she views the study data and brackets them for the time being.[191] This then allows the researcher to remain unbiased throughout the interview process as well as the data analysis stage. In this study the researcher suspended her own preconceived perceptions during the interview process in the way the questions were posed to the participants. She also allowed the participants to express themselves freely without interruptions. During the data analysis process, the researcher immersed herself in the data and findings were presented according to what was reported by participants.

3.7.4 Transcription

Transcription is the initial stage of data analysis. Flick defines transcription as any graphic representation of selective aspects of verbal, prosodic and paralinguistic behaviour.[192] This author further states that the most basic part of any transcript is the verbal component and it remains up to the competency of the transcriber which behavioural aspects must be included in the transcription of the verbal interaction.[192] Liamputtong suggests that the researcher or those who performed the interviews should be the ones transcribing the data as they will have the social and emotional aspects of the interview reawakened and this will help in the data analysis. [49]

Liamputtong further recommends that each interview should be transcribed verbatim, word by word, keeping all emotional expressions such as poses, emphases, laughter and sighing.[49] During this step, the researcher listened and re listened to the audio tapes, thus familiarizing herself with the data. This led to the transcribing process. All interviews were transcribed verbatim including all emotional expressions by the researcher. One transcribed interview was 3-4 pages. An excerpt of the transcripts is provided in Annexure A. The researcher then searched and identified common concepts that were coming up and noted them on the margin of the transcripts highlighting them according to the question they were common in. This was the beginning of the data analysis process which is further explained below.

3.8 DATA ANALYSIS

Polit and Beck define data analysis as systematic organization and synthesis of research data.[38] This process is described by Corbin and Strauss as examining and interpreting data in order to obtain meaning, understanding and develop knowledge.[193] Saldana states that qualitative data analysis occurs concurrently with data collection.[34] After each interview, the researcher listened to the audio recordings, making sense of what was being said and in preparation for the next interview.

Qualitative content analysis was used to analyze the data. This is a systematic coding and categorizing approach that is used for exploring large amounts of textual data so as to determine trends and patterns of words used.[194] Flick states that one advantage of using content analysis is that it helps with reducing the large amounts of data and therefore allowing the researcher to focus on answering the research question.[192] Another advantage mentioned by this author is that this method is systematic and yet at the same time flexible. It requires a sequence of steps to be followed regardless of the research question. It is flexible in that different categories within different coding frames can be combined while maintaining the description of what is in the data.[192] Elo and Kyngas state that content analysis can be used in either quantitative or qualitative studies in a deductive or inductive way.[195] In this study the qualitative content was analyzed using an inductive approach and this is explained further below.

3.8.1 Inductive approach

De Vos *et al.,* mention that qualitative data analysis follows an inductive way of reasoning. The primary purpose of inductive reasoning is to allow findings to emerge from the raw data.[188] Analysis is done by the development of categories from the raw data into a model that captures key themes deemed to be important by the researcher. Further the inductive approach aims to establish clear links between the research objectives and the findings found in the raw data.[196] In this study, the researcher read and re read the transcripts in a bid to try and gain understanding of what the results were revealing. The researcher did not have any preconceived ideas of what the results would reveal before the study began.[38] Findings were therefore derived from the raw data and clear links between these findings and the research objectives were established. The next section describes how the researcher analyzed the data.

3.8.2 Qualitative content analysis process

Different researchers present slightly different steps that must be followed in the analysis of qualitative data. Vaismoradi, Turunen and Bondas refer to manifest analysis as the first step to qualitative content analysis. In this case development of codes and categories are the primary focus of the analysis.[194] Hsieh and Shannon present three approaches to content analysis.[47] These are; a) conventional content analysis, b) directed content analysis and c) summative content analysis. These authors clarify that in conventional content analysis categories emerge from the analysis rather than preconceived categories being imposed on to the data. In directed content analysis conceptual categories are applied into a new context.[47] The first step that was used in the analysis for this study involved the use of the summative content analysis. Summative content analysis as described by Hsieh and Shannon begins with identifying and counting certain words in the content.

This process of quantifying the number of times certain words appear is done so that it can be explored from different speakers the underlying meaning of the usage of the words.[47] This means then as the researcher counts the number of times a word appears, the speaker must also be identified so as to compare the underlying meaning. In this study, this step was done and the researcher identified that words from similar speaker had similar underlying meaning. This was attributable to the similar educational backgrounds participants had with regards to QC and radiation protection. Once this step was completed, a process called latent content analysis then began whereby the underlying meaning of content is interpreted. The following section outlines the steps taken by the researcher in giving meaning to the data as recommended by Zhang and Wildemouth.[48]

Step 1: Prepare the data and define unit of analysis

Preparing the data involves transforming the data into written text before the analysis can begin.[48] As previously explained data was first transcribed verbatim by the researcher as a first step to data analysis. This step further involved selecting the unit of analysis. Zhang and Wildemuth define the unit of analysis as the basic unit to be classified during content analysis.[48] Graneheim and Lundman mentioned that the most suitable unit of analysis is whole interviews that are large enough to be kept as a whole and also small enough to be kept in mind as a context for meaning during the analysis process.[197] The researcher decided that the unit of analysis would be the whole interview transcripts in this study.

This step further involved that the researcher become immersed in the data.[35] This means reading and re reading the transcripts such that the researcher becomes thoroughly familiar with them. The researcher is a qualified radiographer herself and therefore did not have a problem understanding the concepts that the participants were referring to in the interviews however the transcripts were read several times to get what Polit and Beck describe as a sense of a whole.[30]

Step 2: Open coding

In this step, the researcher followed the open coding scheme in coding the data. Blair states that open coding in content analysis involves creating labels or codes derived from the data in order to develop meaningful categories that can be analyzed and interpreted.[198] Elo and Kyngas state that open coding means that notes and headings are written in the text while reading it.[195] They further recommend that the transcripts should be read through again and as many headings as necessary be written down in the margin describing all content of the data.[195] In doing this, the researcher read the transcripts thoroughly and labels or codes were written down on the margin. Similar codes were highlighted in a similar color in preparation for categorization. As mentioned previously, the frequency of appearing codes was counted and the speaker identified in accordance with the summative content analysis recommended by Hsieh and Shannon.[47] The researcher followed this step using a sample from the data set. The transcripts were given to the supervisor who independently revised them. A meeting was then arranged with the supervisor in order to assess coding consistency between the supervisor and the researcher.[48] The coding consistency was then validated by the supervisor and the researcher went on to code all the text.

Step 3: Development of categories

Following coding, categorizing was done. Elo and Kyngas point out that the purpose of creating categories is to provide a means of describing the phenomenon, increase understanding and generate new knowledge.[195] Green, Willis, Hughes, Small, Welch, Gibbs *et al.,* reiterate that data usually contain contradictions and excerptions and therefore needs to be sorted into categories.[199] Form the open coding, similar codes were grouped together and assigned a category. This was done by reviewing the transcripts and checking which codes link together. Green *et al*., state that some researchers may stop here and present their findings from the categories.[199] The categories that emanated from the analysis are presented in chapter 4. The next step involved validating the codes and categories.

Step 4: Testing and validating coding system

In this step the researcher tested and validated the coding system with the supervisor. Zhang and Wildemouth recommend that coding consistency needs to be checked through an inter-coder agreement. They further recommend that doubts and problems concerning definitions of categories need to be addressed and resolved within the research team.[48] A meeting was then arranged where both the researcher and the supervisor reviewed the codes and categories. A consensus was then reached. Appendix B provides an insert of the notes from this meeting. The next step involved deriving meaning from the categories and identifying emerging themes.

Step 5: Drawing conclusions from coded data

This step involved identifying patterns across the categories and drawing meaning from them to form themes. Zhang and Wildemuth mention that this step involves exploring the properties and dimensions of categories identifying relationships between categories, uncovering patterns and testing categories against the whole data set.[48] Green, et al., state that a theme is more than just a category. They further mention that generating a theme requires moving beyond a description of categories and shifting to an explanation or interpretation of the issue being investigated. These authors further say that the identification of themes produces stronger evidence.[199] In this study, inferences were made from patterns identified from categories and meanings reconstructed to form themes.[199] These were reviewed by the supervisor and a consensus was reached. The themes that emerged from the analysis in conjunction with the findings are discussed in chapter 4. The next step is the reporting of results.

Step 6: Reporting of results

This is the final step in the analysis process. It is important for the researcher to clearly define the coding process and extensively describe the findings. Zhang and Wildemuth point out that an interesting and readable report provides sufficient description to allow the reader to understand the basis for the interpretation and also provide sufficient interpretation to allow the reader to understand the description.[48] Results can be presented supported by quotations, charts and conceptual networks depending upon the goals of the study.[51] In the next chapter results will be presented. The categories that emanated from the analysis will be described supported by quotes from participants. The themes and findings derived from these categories will be introduced at the end of the chapter.

3.9 CONCLUSION

This chapter has presented the research design and methods that were used in the study. Qualitative data was collected using an exploratory, descriptive study design to find out the perceptions of radiographers regarding establishing a self-regulatory body for radiation control in the radiography departments in Swaziland. It has been demonstrated how participants were recruited and sampled as well as how the data was collected and analysed. Measures to ensure trustworthiness of the study findings have also been explained. The next chapter presents the results in terms of the categories that were derived from the analysis of the data. Themes that were drawn from these categories will be introduced at the end of the chapter and will be discussed in conjunction with what is found in literature.

CHAPTER 4

RESULTS, DISCUSSION AND INTEPRETATION

4.1 INTRODUCTION

In the previous chapter, the research design was discussed and the methods used in collecting the data were also described. Content analysis, the approach taken to analyze the raw data was also explained in detail. This chapter focuses on the description of what was revealed by the data. A summary of the data analysis process undertaken in the study is presented. Following this summary, the codes and categories that emanated from the data analysis process are described. These results will then be discussed and integrated with what was found in literature. Themes that emerged from these categories will then be presented. At the end of this chapter, an interpretation of these themes will follow and findings will be presented. The reader is reminded that throughout the study, participants were given numerical codes to maintain their anonymity and confidentiality. This will also apply in this chapter as results are described. The next section presents a summary of the data analysis process.

4.2 SUMMARY OF DATA ANALYSIS PROCESS

As explained in chapter three, section 3.5.2, qualitative content analysis was used to analyze the data. Hsieh and Shannon define content analysis as a method for interpreting the content of text data through the systematic classification process of coding and identifying themes or patterns.[47] The activities undertaken in the study included the process of coding. Once coding was completed, similar codes were grouped together to form categories. In order to obtain an underlying meaning, patterns were identified across the categories and from these, themes emerged. The summary of the activities undertaken as informed by content analysis process is presented in table 4.1.

Table 4.1 Summary of content analysis process

Content analysis steps	Activities undertaken in the study
a) Search for identified words	As described by Brink, van der Walt and van Rensburg[35] the researcher immersed herself in the data in order to identify the issues that relate to radiation protection, QC tests and regulation of the profession as these were the areas of concern that informed the research problem and therefore formed the key words in the study.
b) Word frequency counts with speakers identified	An inductive strategy was used to form categories from the identified key words therefore moving from the particular to the general. This was according to what is described by Elo and Kyngäs as well as Saldana. These authors mentioned that induction is what is being explored and inferred to be transferable from the particular to the general.[34, 195]
c) Identification of patterns in the data	Patterns across categories were then identified in order to extract themes. The process of looking for themes according to Hsieh and Shannon entails determining the relationship between the categories.[47] This step was necessary in this study as it made it possible to extend the process of interpretation and construction of new meaning.
d) Interpretation of context	The themes were then interpreted so as to present the research findings. Interpretation of context falls within the communication chain where the research findings must be presented to the community in a transparent and clear way so as to be understood, challenged or put into practice. As stated by Denzin, there is a need to represent the voices of the participants in a way that goes beyond the qualitative researchers as just interpreters of the world, to rather changing the world.[36]

Hsieh and Shannon talk about considering manifest and latent content analysis in the summative content analysis process.[47] These authors further explain that in manifest content analysis, the aim is to analyze for the appearance of a particular word in textual material.[47] Latent analysis entails what Zhang and Wildermouth recommend as deriving meaning in order to obtain themes.[48] As seen in table 4.1 these steps were followed in analyzing the textual data.

The next section presents the demographic profile of participants.

4.3 DEMOGRAPHIC PROFILE OF PARTICIPANTS

As mentioned in the previous chapter, the population comprised of all radiographers that were registered with the Swaziland Medical and Dental Council at the time of data collection. The sample, following data saturation comprised of 18 qualified radiographers.

A heterogeneous sample of participants was obtained. Gender was distributed evenly. There were nine males and nine females. The age groups varied from 20 to 60 with the majority between 30-40 years old. Participants possessed either a diploma or degree in diagnostic radiography. This was also distributed evenly as nine participants possessed a diploma and nine participants possessed a degree. Years of experience varied from less than a year to more than 30 years with the majority of participants falling in the five years or less of work experience. This diversity in the demographic profiles of participants allowed for different views from different perspectives and therefore rich information was obtained.

Table 4.2 presents a summary of the demographic profile of participants.

Table 4.2 Demographic profile of participants

Criterion	**Characteristics**	**Participant frequency**
Gender	Male	9
	Female	9
Age	20-30	4
	30-40	9
	40-50	1
	50-60	3
	60+	1

Years of experience	0-5 5-15 15-25 25-30 30+	6 5 4 1 2
Qualification	Diploma Bachelor's degree	9 9
Hospital	A B C D E F G	5(MG 1 to MG 5) 5(RF 1to RF 5) 2(MC 1 and MC2) 2(GS 1 and GS 2) 1(MK 1) 1(MBC 1) 2(TB 1 and TB 2)

The following section presents the codes and categories that were identified in the raw data.

4.4 CODES AND CATEGORIES IDENTIFIED

The reader is reminded that the questions asked during the interviews were structured in a way that attempted to answer the research questions. The results are therefore presented and discussed as such. In order to address the first research question, the researcher wanted to describe the views of radiographers with regards to the performance of QC tests and radiation protection practices in their radiography departments. The following results emanated during the discussions with participants in this regard.

4.4.1 Views regarding QC tests performances

As described in chapter two, conducting regular, periodic QC tests in the radiography departments is part of maintaining safety from ionizing radiation. The researcher deemed it important to explore radiographers' views towards these practices in the absence of monitoring mechanisms.

The following interview question was posed to the participants.

Can you tell me about the QC tests that you perform in your department and what you do with the results?

In Chapter 2, section 2.4.2, the reader was introduced to the QC tests that radiographers need to perform to ensure optimal functioning of the equipment. These included tube warm up, beam alignment, collimation, protective wear, viewing boxes, cassette and imaging plates as well as kV and mAs accuracy. The importance of maintaining records of these tests was also mentioned. It was further revealed that in the event that equipment performance is not monitored, staff, patients and the public might be subjected to unnecessary radiation doses. The codes and categories identified from the analysis process indicate that some of the participants do perform a few of the QC tests. There were a few radiographers who mentioned that some QC tests were performed in their departments, most of them mentioned that these tests were not done in their departments. They gave their reasons with regards to this. All of them seemed to be aware of the implications of not doing these tests which is possible exposure to unnecessary radiation. From the results with regards to the performance of QC tests, three categories were identified. The identified codes and categories are presented in table 4.2.

Table 4.3 Views regarding the performance of QC tests

Categories	**Codes**
QC tests performed in some departments	Warm up tests. External companies. Visual inspection of lead aprons. Film/ reject analysis. Visual equipment checks.
Reasons for non-performance of QC tests in some radiography departments	Lack of support from middle and higher management. Lack of test tools. Short staffed. Time consuming. No policy regulating QC/ No motivation to do. Untrained staff.
What radiographers regard as implications for not doing QC tests	Safety. Monitoring. Increased dose.

Table 4.2 has outlined the codes and categories that emanated from the analysis of radiographers' views regarding the performance of QC tests in the radiography departments. As seen in this table, there are few QC tests that were mentioned to be performed in some departments while most of them were not being performed. Some radiographers indicated that the QC tests are not being performed at all in their departments. Reasons as to why the QC tests are not being performed were outlined by participants. Radiographers seem to be aware of the implications for not performing these tests. Each of these categories are discussed in detail in the next sections starting with the QC tests being performed.

4.4.1.1 QC tests performed by radiographers

The results revealed that some of the QC tests are being performed by radiographers in the radiography departments. Table 4.3 provides a presentation of the QC tests that radiographers indicated to be performing. Direct excerpts are provided as a way of providing supportive evidence from participants.

Table 4.4 QC tests performed by radiographers

Code	**Quote**
Warm up tests	*We just do the warm up of the machine every morning…. What we do is after you switch on we do test exposures, like maybe four exposures with different kV and mA… we don't record, they are just to check for ourselves before we start working in the morning [MC 1]*
Film reject analysis	*We do also reject analysis, you indicate the reason why it hasn't been done properly, was the reason because of movement, motion I mean, or exposure factors or wrong marker…some records are kept some are not really kept as such [MBC 1]*
Visual checks	*We do visual inspections on the aprons for any tears or cracks and that's it... [GS 1]* *…. So what I did was I took a coin and exposed it using the lead apron.. [MC 2]* *…On a daily basis. When you switch on you have to look at the control panel first, what information it's showing there…. [MC 2]*
External companies	*As far as I know it's done by the service guys when they come to service the machines. I have no idea what QC tests they do… [MG 3]*

As noted in table 4.3 only a few QC tests were indicated as being done in some departments. This was despite the fact that there is no monitoring system. As presented in Table 4.3, participants revealed that they do the warm-up tests and visually inspect their equipment every morning. Participants mentioned that they do this just to check the equipment and therefore do not keep any records. With regards to film reject analysis, only one participant mentioned this was done in their department. Analyzing the cause of rejected films is an important part of QC in all departments. It is one way of reducing unnecessary repeats.[44] Some participants relayed that even though they do not do the standard QC on their lead aprons, they do occasionally visually inspect them. Participants have also revealed that they use the services of external companies. The following section shows an integration of these views with what was found in the literature.

a) Discussion on performance of QC tests

In chapter two, the reader was introduced to the QC tests that are meant to be performed in the radiography departments. Radiographers, engineers and physicists all play a role in the QA/QC testing program. This is seen in the three levels of a QC testing program as recommended by Papp[43] in figure 4.1.

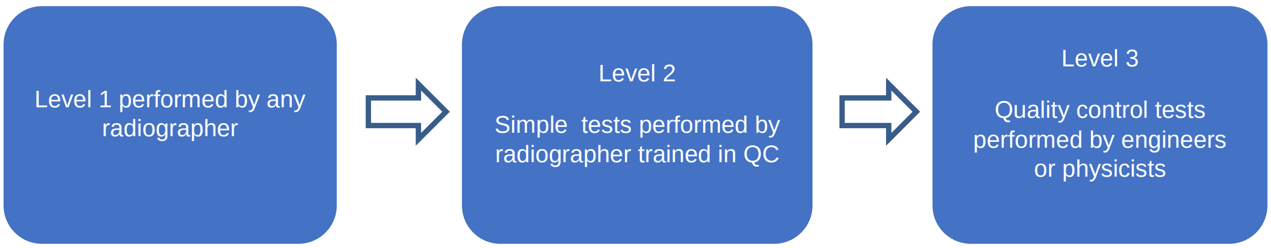

Figure 4.1 Levels in the performance of QC tests

In addition to the three levels of QC tests that must be performed, Papp further mentioned that there are three types of QC tests that must be performed at each of these different levels namely; a) acceptance tests which are performed on new equipment or old equipment that has undergone major repairs, these are aimed at establishing baseline performance of the said equipment which can be used as reference in future QC tests, b) routine performance evaluations which are done at specific frequencies in order to continuously monitor performance and finally c) error correction tests which evaluate equipment that is malfunctioning, identify the cause so that proper repair can be done.[43]

The Directorate of Radiation Control in South Africa advices that acceptance tests be carried out by an inspection body approved by the Department of Health or an appropriately trained professional registered as a medical physicist by the HPCSA.[102] According to figure 4.1, these will be level three tests.[102] This body further states that the routine tests be carried out by the licence holder or a person appointed by the licence holder who is properly qualified in radiation protection such as a radiographer.[103] These will be level one tests as shown on figure 4.1. WHO concurred with this recommendation and stated that the responsibility of the routine tests must be delegated to the radiographers themselves who are the daily users of the equipment while the engineers and physicists deal with the more advanced tests.[44] Once the equipment has passed all acceptance tests, performance needs to be monitored periodically to ensure it is still performing according to the manufacturer's specifications and this is where radiographers take up the role of QC in their work scope.[43,44]

The routine QC tests that are to be performed on radiographic equipment by radiographers as per recommendations of the department of health of South Africa, and the CRCPD were described in chapter two.[25,141] The participants in this study as it has been seen, mentioned to be doing a few of these QC tests while most of the recommended tests were not done. The veracity of these claims could not be ascertained however since that was not the focus of the study. This is further because of the fact that keeping of records was further found to be inconsistent. There seemed to be no formal documentation procedures as seen in the statements; "*we don't record, they are just to check for ourselves" [MC 1]* and "*some records are kept some are not really kept as such" [MBC 1].* Ngoye, Motto and Muhogora in their study found similar results where there was poor keeping of records and lack of documented procedures for QC.[10] Another study corroborated these results where it was found that records on x-ray equipment were missing.[162] As alluded to by theses authors, the absence of records make it difficult to track equipment performances and this can be attributable to a lack of a standardised QC testing program.

Though these participants mentioned to be doing these tests, some ignorance was noted with regards to the value or actual knowledge of the tests. This is seen in statements such as "*As far as I know it's done by the service guys.. I have no idea what QC tests they do" [MG 3].* From this statement, it is unclear whether there is awareness of which tests should be performed by whom and for what. Van der Merwe, Kruger and Nel mentioned that the ignorance by radiographers with regards to radiation safety requirements including quality testing of the equipment was a serious cause for concern.[23] These authors further mention that since radiographers are responsible for the routine tests, it is important that they are equipped to perform these tests, interpret the test results and adjust necessary parameters to maintain safety on a daily basis.[23] The ISRRT further promotes competence in QA and QC as part of the scope of practice of radiographers and reiterate that radiographers need to be able to recognize, record and report situations of significant over or under exposure to radiation.[200] This prompts the need for adequate training for radiographers in order to promote safety within the departments.

Participants mentioned that they do visual inspection and warm up tests of the equipment. The absence of standardised procedures is further recognised here as participants seem to be doing these procedures by chance and not with firm knowledge on the proper procedures. Participant MC 2 mentioned to be visually inspecting the control panel for error messages. Papp says that visual inspection of the control panel should further involve verifying proper functioning of panel lights and switches and further ensure an unobstructed view of the examination table form the control panel. The presence of an up to date technique chart should also be verified at the control panel.[43] Participants did not mention these components and it is unclear whether they are aware of them as part of inspecting the control panel. Papp further says visual equipment checks should include checking the main components of the equipment for proper functioning and mechanical faults; these include the radiographic table, miscellaneous equipment as well as protective apparel.[43]

Participants further mentioned to be visually inspecting their lead apparel for tears and cracks. This concurs with the recommendation by WHO which states that there should be monthly visual checks for lead apparel to identify cracks and splits.[103] Livingstone and Varghese identified defects such as cracks in unused newly acquired aprons which were not visible to the naked eye but were noticed in fluoroscopy screening.[120] This indicates that a mere visual inspection may not be enough to determine the safety of the lead apron.

There is a need to properly screen these apparel before use and at determined frequencies to ensure their continued effectiveness in attenuating the radiation. The

CRCPD recommends using a fluoroscopy unit to screen the whole apron for cracks and splits.[141] The WHO as well as CRCPD, further recommend the radiographic test, where areas suspected to be defective, are radiographed in case there is no fluoroscopy unit.[103,141] One participant mentioned to have done the radiographic test on one lead apron, however it was unclear whether the test was done according to recommendations looking at this statement "*I took a coin and exposed it using the lead apron… that falls under QC I think" [MC 2].* Although there seems to be uncertainty regarding the procedure and whether it is part of QC, the participant however seems aware of the need to determine safety of these apparels.

Participants further mentioned to be doing warm up tests on their equipment. It is important that radiographers do this every morning before they begin work. Though participants mentioned to be doing the warm ups, it was not clear whether the tests were performed as often as participants claimed in the absence of monitoring mechanisms. Participants seemed to be following recommended procedures for the warm up tests, however, a level of uncertainty could be recognised from what participants relayed according to this statement by MC 1 "*after you switch on we do test exposures, like maybe four exposures with different kV and mA".* This statement indicates that there are no clear set procedures for the warm up tests in the departments. The CRCPD recommends that in the absence of manufacturer recommendation procedures for warm up tests, 3 exposures at a standard kV of 70, 2 seconds and 100mA should be made at 10 second intervals.[141] On the contrary, Panichello recommends making four exposures at the lowest mA at different kVp of 80, 90, 100 and 120 at 30 second intervals.[201] Conducting warm up tests on a daily basis prolongs the lifespan of the x ray tube[141,201] however, without properly documented procedures and guidelines to follow it becomes difficult to monitor when the test were performed and what the outcomes of the tests were.

The services of external engineers were utilized as records of tests performed. Radiographers seemed to rely on the service engineers for QC tests. Some form of ignorance or not taking responsibility is noticed in this regard as participants seemed unsure which QC tests these engineers were doing. This is seen in this statement "…*I* *think they calibrate the tube" [MG 3].* Sungita, Mdoe and Msaki stated that using external service engineers for QC is not a viable option as they are not readily available at short notice and they can be quite expensive.[162] WHO recommended that there should be two routine, scheduled equipment maintenance visits every year. During these visits, generator output tests, beam alignment tests, lead apron inspections should be conducted as part of routine maintenance by these professionals. WHO further recommends that radiographers should perform these six monthly tests and should there be any problems they can then send for the services of an engineer.[202] It has been recognized in these results that radiographers might not be performing these tests and responsibility is shifted to the service engineers to perform these QC tests.

Another participant reported on the film/reject analysis as one of the tests that is being performed in their department. WHO mentions that reject analysis may be used to evaluate problems leading to poor image quality as well as used as a self-assessment tool.[44] Rejected images lead to repeat examinations, this then leads to unnecessary radiation exposure to patients as well as wasted time and resources.[203] It is therefore important for departments to incorporate this test into their QC to limit unnecessary exposure to patients as well as assess usage of resources. According to Owusu-Banahene, Darko, Hasford *et al.,* analyzing the reject rate and cause is a major QC tool in diagnostic radiography service delivery.[204] The participant in this study seemed to be well aware of this test, however in the absence of records as stated by the same participant it is unclear whether this test is being performed according to specified frequencies or whether it was just being mentioned. It is recommended that reject rates should be analyzed and documented at least quarterly but preferably monthly.[204] Arbese, Abebe and Mesele in their study analyzing film reject rates in Ethiopia and identified the main causes of reject rates as selecting wrong technical exposure factors and suboptimal equipment performances. This study recommended a regular QC program with properly documented policies and procedures.[205] There is therefore uncertainty with regards to rates of repeated examinations in the departments and therefore the extent of unnecessary examinations due to these repeats in the absence of properly documented QC programs.

The number of tests that were mentioned to be performed have been discussed with reference to literature. The next section presents the radiographers' views with regards to why some of the QC tests were not done. This is the second category that was identified.

4.4.1.2 Reasons there are no QC tests performed in some departments

As indicated in the preceding section, some radiographers indicated that in their departments, they do not perform any QC tests. This section focuses on the reasons given by radiographers, for not performing the QC tests.

Participants expressed concern over the fact that immediate supervisors as well as hospital management seemed not to support them when it comes to the QC tests. They expressed that while they may do the tests, nothing seems to get done about the results especially if there is a need for corrective action or replacement. Participants further proclaimed that in some cases these tests are not being done because the staff members working in the departments are untrained to practice as radiation workers. This then means they might not be aware of the QC tests they must do. Another challenge faced by participants was the unavailability of instruments for QC.

These reasons are presented in table 4.4 with direct excerpts from participants.

Table 4.5 Reasons there are no QC tests in some departments.

Code	Quote
Lack support	*Even now if we could just go do a test to the collimator it's very off, … the company that services…gave recommendations that we need a new collimator box but nothing has been done till now. … [GS 1]*
Untrained staff	*Some of the people we have are not trained radiographers. So they are not well conversant with some of these tests [GS 2]*
No test tools	*The other thing is we don't have the tools. If maybe there was something I was given like a book as in film analysis where we write this was rejected because of poor positioning, exposure and such... [MG 1]* *We don't have that equipment. The QC equipment. [RF 1]*
Short staff/ time consuming	*…we are short staffed. The moment we come in we are already packed with patients [MG 4]* *The person who will be allocated for the QC, will be spending more time on that instead of patients. [MG 1]*
Policies	*There is no policy which is regulating the QA within the department. Even if I can do it, you can find that I'll be the only one who is doing it. [MG 5]*
Motivation	*..they are also demotivated by these salaries they are getting. So you just work so that you can get a salary at the end of the month. [MG 5]*

Participants further expressed the issue of staff shortage as one of the reasons they are unable to do their QC tests. Another reason given by participants was that without a policy regulating QC then performing the tests becomes a challenge. Further, participants seemed to be demotivated to perform these tests due to unsatisfactory salaries. A discussion with what is found in literature in relation to these results is next.

a) Discussion on reasons for non-performance of QC tests in some departments

A number of African countries have reported challenges similar to what this study has exposed in terms of QC implementation by radiographers.[10,206] The AFROSAFE implementation tool matrix has reported that Africa faces challenges in the application of radiation safety practices. These include; inadequate awareness of policies, poor attitude and practice in radiation safety practices such as QC and absence of regulatory bodies.[11] Swaziland is no exception as seen in the reasons given by participants for the non-performance of QC tests.

Participants mentioned that they encounter difficulties when it comes to managerial support in terms of QC. There seems to be inadequate awareness in terms of QC in the managers leading to poor support. This is evidenced by the statement "*it gets done you see there's a problem and nothing will be done about it…" [GS 1]* Studies in Nigeria and Tanzania found similar results where lack of support from management was found to be one of the challenges towards effective QC implementation by radiographers.[10, 206] This is a cause for concern as these results contradict the fact that leadership for a strong safety culture must come from management but with strong and active support.[207] Support from management at all levels is crucial in maintaining quality standards in the departments. It is important that they understand the importance of QC tests and the importance of radiation protection for the staff, the patients and the public. It is said that the lack of understanding of radiation risks by some key players is a major hurdle towards the establishment of an effective radiation protection culture.[207] Johnson, Krecke, Miranda, *et al.,* stated that involving management in the QC program is vital so that there will be provision of adequate resources as well as time and personnel allocation for the effective running of the program.[208]

One other reason given by participants is that some of the staff members in the departments might not be properly qualified to practice as radiographers and therefore unaware of the need to perform QC tests. This claim by the participants could not be ascertained as this was not the focus of the study. It could not be determined the extent of training of those staff that were considered to be improperly qualified as radiographers. The claim however cannot be completely disregarded as it has been noted in neighboring South Africa as well as Nigeria.

The HPCSA mentioned that there were cases brought to their attention where it was reported that there were practices which were employing unqualified personnel to perform radiography examinations because qualified radiographers are not available or because the practice owner does not want to employ a fully qualified radiographer.[209] Similarly, in Nigeria there were reports of unqualified people working in private and public radiography departments.[210] Swaziland faces a serious shortage of radiographers and hiring unqualified staff to work in the departments could be attributable to this shortage. This is a serious cause for concern, however as it subjects patients, the public and staff themselves to possible unnecessary radiation exposure. This can be classified as improper care and compromises quality health service delivery. Unqualified staff working in radiography departments may subject patients and themselves to increased radiation doses due to lack of knowledge and lack of adherence to the ALARA principle.[210]

Participants highlighted the issue of staff shortage as another contributing factor to the non-performance of QC tests. They mentioned that there is no time to do the tests because of the workload. This is seen in the statement; "*we are short staffed. The moment we come in we are already packed with patients" [MG 4].* The issue of staff shortage in healthcare delivery is a worldwide concern and the radiography profession is not excluded in this.[211] Radiographers tend to get overworked as they strive to handle workloads that should be distributed amongst a larger workforce.[212] However, that being said, not doing QC tests poses a risk to everybody exposed to radiation as previously demonstrated in chapter two. The situation as presented by the participants, is not entirely unique to Swaziland, staff shortage was also considered as a challenge to QC implementation by one study in Tanzania.[10]

Staff shortage can also be associated with workload and low remuneration which have been reported to contribute to staff members being demotivated.[211] In this study participants expressed that there was lack of motivation for them to perform QC tests. Participants seemed unsatisfied with their salaries. This demotivation seems to lead to a lack of interest from participants to perform the tests as seen in the statement; "*So you just work so that you can get a salary at the end of the month." [MG 5]* This result concurs with the statement that any program lacking interest form its members is unlikely to produce optimal results.[14] Thambura, Swindon and Amusa reported that salary is the greatest motivation for employees.[211] While this may be the case, radiographers are not expected to wait for salary increases in order to perform the QC tests. Performing these tests should be something that is documented as part of the work scope of the radiographers in a bid to improve on radiation safety as seen in work scope outlined by the ISRRT and the HPCSA.[200, 213]

Participants mentioned another reason that was hindering the performance of QC tests as being the unavailability of test tools. There seemed to be an unavailability of the standardized as well as the local and simple test tools such as coins, pins and books as stated by this participant; "*If maybe there was something I was given like a book as in film analysis" [MG 1].* This shows a lack of initiative from radiographers in performing the QC tests. This lack of initiative is further emphasized by the fact that one participant mentioned to be doing this test even though there is no monitoring system as seen in section 4.4.1.1.

The CRCPD mentioned that most of the QC tests can be performed with local and simple test tools.[141] Lack of proper leadership from immediate supervisors, who it is expected would support implementation of the documented QC program and ensure provision of at least these local test tools in an orderly manner is noted. Cole, Hallard and Broughton stated that frontline managers play a crucial role in setting up local priorities and standards.[207] In the absence of documented procedures and proper leadership, these tests may not get done even if these tools may be present. This is seen in one study where it was found that local and simple test tools were available however there was still poor implementation of the QC program.[10] The standardized test tools for the routine tests are said to be inexpensive[141] and if there is proper cooperation between hospital management and the radiology management these could be acquired thus prompting the conducting of the QC tests.

Participants also highlighted the lack of policies and standards to follow as another reason that makes it difficult to conduct the QC tests. Due to the absence of these policies and procedures, participants mentioned that not every radiographer might be involved in the conducting of these tests as seen in this statement; "*Even if I can do it, you can find that I'll be the only who is doing it." [MG 5]* This further means that performing the tests is also left to each individual radiographer's knowledge. Individual knowledge maybe variable and questionable. Irving stated that documented policies and procedures reduce practice variability that may result in substandard care and patient harm. The author further says that policies and procedures promote workplace safety as well as the delivery of safe, high quality patient care.[214]

Periard and Chaloner stated that a radiography department should develop a QA program which clearly outlines amongst others the following; a) guidelines for equipment acceptance testing b) schedule of QC testing for each equipment c) guidelines for recording equipment performance and d) guidelines for the reject-repeat analysis program.[14] Documenting policies and procedures in a QA program which encompass clearly outlined QC practices to be followed by staff is important if proper QC tests are to be conducted. This is especially important in the absence of regulatory structures where the initiative to monitor safety is left up to each radiography department. The following section describes what radiographers mentioned to be the implications of not doing the QC tests. This is third category that addressed research objective one.

4.4.1.3 Implications for not doing QC tests

As indicated in the background to the study, the researcher noticed the inconsistencies with regards to performance of the QC tests by radiographers in Swaziland. It was also mentioned that most of the tests were not being done in some radiography departments. The researcher therefore deemed it appropriate to determine if participants were aware of the impact of not performing these tests. The following interview question was posed to the participants.

How do you think not doing QC tests impacts on radiation protection?

Participants seemed to be aware of the ramifications that would be brought about by the non-performance of the QC tests.

As can be noted from the excerpts in Table 4.5, participants expressed that they were unsure of the safety of the environment they worked in. This can be translated to being concerned with the absence of QC tests. Participants further expressed concern over the absence of proper follow ups and lack of feedback regarding the personnel radiation monitoring devices. This further demonstrates that a formal system of regulating quality in the departments is important to ensure that dosimeters are read and regular feedback with regards to readings is relayed to radiographers. Participants relayed that if QC is not being done, radiation doses might get increased. They further recognize the need for set policies to manage incidences of over exposure to radiation in the departments and this can only be achieved with properly set protocols and procedures such as the radiation leave as suggested by these participants.

The following table demonstrates the categories identified from what participants regarded as the implications brought about by the non-performance of QC. These results are supported by direct quotations from participants.

Table 4.6 Implications for not doing QC tests

Codes	**Quotes**
Safety	*… we are not sure if the environment we are working in is safe or not….. ever since I got here no one has ever come to test the walls, the aprons…[MG 1]* *Even if you're pregnant it's too risky to work here. These walls we are really not sure… [MG 4]*
Monitoring	*..we hardly get the results …I personally I end up not even wearing them because I don't see the use.. I went to the ministry to check the result when it came back… [MG 4]*
Increased dose	*... a lot of people starting from the patients, the workers will have quite some higher radiation dose. [MC 2]*
Radiation leave	*I had a higher dose of radiation accumulated…I know you're supposed to be away from the radiation field for some time…[MC 2]*

The following section discusses these results in detail with reference to literature.

a) Discussion on implications for not performing QC tests

The lack of QC tests in radiography departments imposes various negative effects on the staff, patients and the public. Korir, Wambani and Ochieng mentioned some of these effects as being high patient doses and increased costs.[163] Participants in the study seemed to be aware of some of the negative effects of not conducting QC tests.

As seen in table 4.5, participants mentioned that there is uncertainty regarding the safety of the working environment. Reference was made to the non-measurement of the level of scatter radiation from the walls as well as the functioning of the equipment as seen in these statements; "*ever since I got here no one has ever come to test the walls, the aprons…"[MG 1]* and "*we don't know if radiation is leaking" [MG 4].* Simon and Wightman stated that care must be taken to ensure that staff does not receive excessive radiation in radiography departments.[215] Ensuring safety in the workplace is the responsibility of every employer. This is affirmed by the Occupational Health and Safety Act of Swaziland which mandates all employers to secure safe and healthy conditions of every employee in the workplace.[21] This included safety in the radiography departments.

The concern radiographers raised in terms of the uncertainty of the work area is valid since there is no regulatory body for radiation control in Swaziland as previously stated. The Ministry of Health grants authorization licenses for radiology practices however it is unclear who approves work premises and based upon which regulations. Careful consideration needs to be taken in the design of the x-ray room in terms of distance from the x-ray source and effective shielding of walls and doors in order to optimize radiation protection for the staff.[216, 217] This is a challenge in developing countries where there is limited resources and a paucity of funds as provision for lead shielding can be quite expensive as stated by other authors.[139, 218] A study that was conducted in Ghana aimed at assessing scatter radiation in the radiology department found that all selected locations were safe for staff, patients and the public due to adequate shielding.[217] This could be attributed to the presence of the regulatory body, the Radiation Protection Institute of Ghana.

One participant even further raised concern that safety is not guaranteed even for pregnant staff members; "…e*ven if you're pregnant it's too risky to work here" [MG 4].* The risks to the fetus due to uncontrolled radiation doses were discussed in chapter 2. A radiation safe environment for pregnant patients and staff is of utmost importance. According to the ICRP, if safety of the x-ray department is guaranteed in terms of scatter radiation and there is assurance that the fetal dose can be kept below 1mGy, the pregnant worker can continue to work in the department.[91] It is however important that there be laid down policies for when the worker declares her pregnancy to her employer which according to the IAEA she may not be compelled to.[219]

The management however has a responsibility to inform employees of the importance of early declaration of pregnancy so that working conditions can be modified. The agency further recommends that the employer is obliged to review the dose received by other employees in the department where the pregnant worker is working, and then decide based on those doses on 3 possible strategies such as; a) no change in assigned work duties b) change to another job area where radiation exposure is considered low or c) change to an area that has essentially no exposure.[219] This emphasizes the importance of an effectively running personnel radiation monitoring program.

Participants went on to express that in the absence of QC, personnel radiation monitoring was inadequate. Participants seemed concerned regarding the fact that there was no feedback regarding radiation doses accumulated as mentioned in this statement; *"we hardly get the results to know how much radiation we received per month" [MG 4].* These results concur with a study in Ghana where it was found that some participants did not receive any feedback regarding the doses they accumulated.[220] This contravenes the recommendations by the IAEA which states that employers are required to provide workers with access to records of their own occupational exposure.[7] It was further noted from the results that some participants do not wear the monitoring devices; "*I personally I end up not even wearing them coz I don't see the use actually" [MG 4].* Similar results were noted in a study where it was found that 86% of participants did not always wear their monitoring devices.[220]

The IAEA states that it is a requirement for any individual worker who may be occupationally exposed to ionizing radiation to be monitored.[7] The agency further states that monitoring is not just about measuring accumulated doses but also about interpretation of results, investigations and reporting which may then lead to corrective actions if necessary.[7] This means where there are situations of over exposure for staff, causes need to be investigated and corrective actions taken. While records were not readily available to radiographers, it seemed the Ministry of Health did keep some sort of records of the doses accumulated. This is seen in the statement; "*I went to the ministry to check the result when it came back, it was zero…" [MG 4].* Employers are required to keep detailed records of occupational exposure which can be used for purposes such as assessing the effectiveness of the optimization of protection and safety in the departments and evaluating the varying trends in exposure.[7]

It was further mentioned that in the absence of QC tests in the departments, there might be increased radiation doses to the staff, patients and the public as evidenced in the statement; "*... a lot of people starting from the patients, the workers will have quite some higher radiation dose" [MC 2].* These results concur with what Sungita, Mdoe and Msaki as well as Muhogora and Nyanda state in their studies where they mention that when the equipment is operated without adequate QC and maintenance, higher radiation risks are inevitable because of an increased dose in a single exposure as well as repeated exposures due to low image quality.[162,221]

In a study by Yacoob and Mohammed evaluating patient doses in hospitals that lacked the requirements of QC standards, it was found that for chest and cervical the entrance skin dose was much higher than the diagnostic reference levels. The same study recommended a quick action towards the implementation of QC programme in the evaluated hospitals.[222] Furthermore Aghahadi, Zhang, Zareh *et al.,* found that after using QC parameters and optimising the exposure factors the mean entrance skin doses in abdominal x rays can be reduced by 65%.[12] Radiation workers can also be exposed to increased doses if working with faulty equipment which could lead to high radiation output and increased scatter.[10] These studies confirm what participants in this study stated in that without QC patients may be receiving higher radiation doses.

It is a cause for concern that staff, patients and the public might be subjected to increased radiation doses with the lack of QC in radiography departments in Swaziland. Participants further raised concerns with the fact that there are no situations to correct situations of over exposure to staff as confirmed by the statement; "*I had an incident where I had a higher dose of radiation accumulated.. I know when you have got some high radiation dose you're supposed to be away from the radiation field for some time… but there was nothing like that…" [MC 2].* It was unclear the level of high radiation dose this participant was referring to in the absence of locally documented dose limits. The ICRP recommends a limit on effective dose of 20mSv/ year and this averaged over five years.[223]

High radiation doses of staff could be as a result of flaws from departmental design and also operational failures of equipment.[7] Even if that may be the case, it is important that there are properly documented investigation procedures. These may include; a) checking validity of dosimeter reading b) checking if dosimeter was worn properly c) was there change in workload and d) assessing work practices that could possibly result in high radiation doses. Once the culprit has been identified, dose reduction strategies should be implemented, forced limitation of workload is generally not needed.[224] This contravenes what participants believe in that they are supposed to spend time away from the radiation in cases of over exposure.

The next section describes the results representing the views of radiographers regarding the radiation protection measures in the radiography departments in Swaziland.

4.4.2 Radiographers' views regarding radiation protection measures

The researcher further sought to describe radiation protection measures applied by radiographers in the radiography departments. This was deemed appropriate by the researcher to determine if radiographers are knowledgeable and aware of these practices in the absence of regulatory structures.
The question below was posed to the participants.

What radiation safety measures do you apply in protecting yourself, your patients and the public?

Participants mentioned that they were applying radiation protection measures in their daily work routines. However, there were some irregularities and concerns raised by radiographers in how these measures were being applied. It is important that as professionals, radiographers are aware of the radiation protection measures and further apply these in their daily work routines. Table 4.6 summarizes the codes and categories that emanated from the analysis process.

Table 4.7 Views regarding radiation protection measures

Categories	**Codes**
Radiation protection measures	Time, distance, shielding Lead aprons, collimation, closed doors ALARA, high KV technique Dosimeters Reduce unnecessary exams
Irregularities and concerns	Shielding X-ray room doors

As can be noted in Table 4.6, two categories were identified. The table shows that there is knowledge about the radiation protection as seen in the radiation protection measures participants mentioned to be applying. Some information gathered from other participants, raised some concerns as to the level of application of some of these measures. Each category as shown in the table is presented in detail below and these are supported by the narratives from the participants. The category ‘radiation protection measures’ is presented first.

4.4.2.1 Radiation protection measures

Participants gave their descriptions with regards to the radiation protection measures they apply in the departments. Table 4.7 presents the results regarding these descriptions. Direct excerpts from participants are presented to support these results.

Table 4.8 Radiation protection measures applied by radiographers in clinical practice

Code	**Quote**
Time, distance, shielding	*We use the time, distance and shielding. [GS 1]*
Lead aprons, closed doors	*We use lead aprons, making sure the doors are closed when exposing for the public, [RF 5]*
ALARA, collimation, high KV technique	*I always use the high KV technique. And then collimation, and ALARA principle I use those. [MG 5]*
Reduce unnecessary repeats	*We receive request forms from nurses, it means the patient gets a lot of unnecessary x-rays. [RF 5]* *Some doctors request too many studies, and when you get to ask the patient, you get to know which part of the body to focus on, [MG 1]*

Participants described the radiation protection measures that they apply in the radiography departments. Participants demonstrated that they are aware of the time, distance, shielding principle and mentioned to be applying it in their daily practices. Most participants mentioned to be applying the ALARA techniques in their daily practices. These techniques included; collimation, high kV technique, giving patients lead aprons and closing doors during examinations. Participants further mentioned that they apply their discretions in reducing unnecessary examinations for patients as a radiation protection measure. The following section discusses in detail these results with reference to literature.

a) Discussion on radiation protection measures

The time, distance, shielding principle was elaborated on in chapter two. It is applied in limiting occupational exposure to radiation. Participants mentioned to be applying this principle in order to limit exposure for themselves in the work place. This is in accordance to WHO recommendations which state that there are three important practical aspects of achieving dose reduction for staff members as well as the patients and these are; time of exposure; distance from sources; and the use of shielding.[135] Kim mentions that radiation exposure can be accumulated over longer periods and therefore reducing the duration of radiographic exposures lowers the radiation dose.[225] With regards to distance, it is said that the amount of exposure is inversely proportional to the square of the distance and therefore doubling the distance from the x-ray source can reduce the exposure by a factor of a quarter.[225]

The IAEA recommends that the x-ray tube should be about 1 meter from the control panel.[140] Doubling the distance or making rooms larger during room designs is therefore important so that less scatter radiation reaches the walls and the operator booth.[226] In this study, the researcher observed during data collection that some of the departments were unusually small however the reader must note that no measurements were conducted to confirm this as this was not the focus of the study. This compromises the safety of everyone in the radiography departments more so the staff members who might be subjected to high levels of scatter radiation over long periods of times.

In terms of shielding WHO advises that personnel should regularly use all protective apparel available.[135] Structural shielding in the departments should adhere to recommendations set by a regulatory body and dimensions calculated by a medical physicist.[167] Structural shielding uncertainty as mentioned by participants was discussed in section 4.3.3.1. Participants mentioned that they make sure doors are closed during radiographic examinations as stated by RF 5 and MG 2. This is in accordance with recommendations by WHO.[103]

The IAEA recommends three radiation protection principles for staff and patients namely; justification of medical procedure, optimization of protection and safety and application of diagnostic reference levels.[96] Justification of the procedure entails ensuring that the benefits of the radiation exposure outweigh any radiation detriment that might occur.[96] This requires that the requested examination be evaluated and further determine whether the patient fits the recommended criteria for the examination.[96] Del-Rosario Perez states that the responsibility for justifying a particular procedure lies with the relevant health professional trained in radiation protection.[227] The Radiation Control Directorate of South Africa states that it is primarily the role of the radiologist to justify medical exposures however it acknowledges that due to the severe shortage of radiologists, the radiographer may refuse to perform any examination that he/she strongly believes is an unsubstantiated request for example where clinical history does not justify the performance of the examination.[228] In this study, participants mentioned to be applying their own discretion in applying the justification principle by reducing unnecessary examinations as seen in this statement; "*Some doctors request too many studies, and when you get to ask the patient, you get to know which part of the body to focus on" [MG 1].*

However, from this statement it seems radiographers are merely interested in reducing the number of examinations requested as there is no mention of weighing the benefits of the procedure against the risks as recommended by the IAEA.[7] It is worth noting that there is no radiologist that services the public hospitals in Swaziland and further there is a shortage of doctors. This then leads to x ray requests being done by the nurses as mentioned by participant "*We receive request forms from nurses" [RF 5].* The responsibility of requesting examinations lies with the primary physicians, however several studies have shown that referring doctors and other health professionals including nurses have poor knowledge when it comes to radiation protection and this might be the cause for the trend of requesting too many examinations some of which might be unnecessary as noticed by the participants in the study.[99-101]

The absence of written referral guidelines and appropriateness criteria however may pose problems where doctors may feel radiographers have no basis for refusing to perform certain examinations. Ighodaro and Igbinedion in Nigeria noted that there is often conflict between clinicians and radiologists caused by the latter refusing to perform examinations they deem inappropriate.[99]The IAEA states that once the examination has been justified, it is necessary to optimize the protection and safety by keeping the radiation exposure to the minimum.[229] Participants demonstrated knowledge of the ALARA principle and stated some of the techniques they use in keeping exposures to the minimum for the patients as seen in this statement; "*Ok I, what I do is with the chest X ray for example, I always use the high KV technique and then collimation" [MG 5].* These techniques are in accordance with WHO and Papp who recommend them as some of the principles that are to be adhered to in order to reduce exposure to the patients. [43,103] The high kV has greater penetrating power therefore reducing absorption of scattered radiation by the patient.[106] A study in Khartoum revealed that the high kV technique is particularly useful in the chest x-ray where the heart, hilar region, great vessels and lymph nodes are demonstrated well while reducing the visibility of the bones.[230] It is demonstrated here that the radiographer selecting appropriate exposure factors is important in reducing radiation doses to the patient.

Collimation entails confining the primary beam to the area of interest for the examination. If the area covered by the primary beam is large, the amount of scatter radiation produced is also large. This contributes to more doses for patients and further an increase in image density which might obscure important details thus warranting a repeat in the examination.[103] It is important to remind the reader that the aim of diagnostic radiography is to produce high quality diagnostic images at a minimum dose to the patient. Studies confirmed that collimating the primary beam to the area of interest reduces the effective dose to the patient and improves image quality. [231,232] This emphasizes the need for regular QC on the equipment. In section 4.3.2, Table 4.4, participant GS 1 mentioned that

"*Even now if we could just go do a test to the collimator it's very off, it's too off even".* This implies that patients are receiving high radiation doses in this instance due to poor collimation, a situation that can be rectified with regular QC and prompt corrective measures. The next section presents the results in terms of irregularities and concerns raised by participants in the application of radiation protection measures.

4.4.2.2 Irregularities and concerns regarding radiation protection measures

Even though participants demonstrated that they apply some of the radiation protection measures, irregularities and concerns in applying these measures were gathered from what participants relayed. The need for monitoring services is reiterated in this regard as it is seen that not all radiographers apply radiation protection practices.

Participants are aware of what must be done and they further demonstrate awareness of the wrongs that are happening already. These radiographers revealed that they did not use lead aprons as often as they should even though some of them mentioned that they have ?enough. Some of them mentioned that they do not have enough lead apparel. Further the participants revealed that in some departments there were no doors in the x ray rooms, making it difficult to protect the public outside.

Table 4.8 summarizes these irregularities and concerns as mentioned by the radiographers. Direct quotations are used to support these results.

Table 4.9 Irregularities and concerns regarding radiation protection measures

Codes	**Quotes**
Lead aprons	*I don't know… if they are still in good condition and to tell you the truth it's not every patient that we shield. [GS 1]* *We do have enough but for me some of them I personally do not trust them... [MG 5]* *..we don't have enough like thyroid protection, gonad shields, like the protective shields are not enough. The lead aprons we have are old. [MG 4]*
X-ray room doors	*…they will be exposed because we don't have doors, we are using the curtains so it's not easy to protect them. [RF 2]*

The section below integrates these results with what is found in the literature.

a) Discussion on irregularities and concerns

Lead aprons are an important measure in radiation protection especially for the parts in the body which are most sensitive to radiation such as the gonads.[106] In the absence of QC, participants expressed concern with regards to the condition of the lead aprons as evidenced by this statement; "*I don't know… if they are still in good condition" [GS 1]*. This is a valid concern whereby some studies identified defective lead aprons in radiography departments where QC tests were not being done. Daniel and Xaviero in Nigeria in a study assessing the integrity of lead aprons in a radiography department found that 80% of the aprons were defective with most of the defective parts in the lower regions at the level of the gonads, the most sensitive parts of the body. Regular QC and proper handling were recommended in this regard.[165] In the case of this study, defective lead aprons are very much probable as QC tests on these apparel are not being done and handling procedures are questionable as stated by this participant; "*Sometimes you find that the way they are stored, they are not according to how we were trained.." [MG 5]*. An expression like this raises concern regarding what one knows and applies in practice.

The researcher notes though that there is an awareness that lead aprons need to be handled properly however because there is no monitoring of safety practices, correct procedures are not being followed. Oyar and Kislalioglu found that personnel were not aware of the importance of preservation and storage conditions of lead aprons, and therefore did not adhere to rules for preserving the aprons.[124] Education on proper handling and the importance there of is very important in this regard. Radiographers need to be aware that lead aprons are easily damaged, merely folding it can damage the apron as to render it ineffective.[233,234] Recommendations state that lead aprons should not be laid on a flat surface but should rather be hung up by the shoulder on approved apron hangers.[122]

While some participants mentioned to be utilizing the lead aprons as stated by RF 5 in section 4.4.2.1, there were those that admitted to not regularly using the lead apparel even though these were available to them.This is evidenced by this statement; "*to tell you the truth it's not every patient that we shield" [GS 1]*. This is in contravention of recommended standards by the ICRP which state that shielding should be a priority for patients particularly gonad shielding when the pelvis is not part of the examination process. [235] The poor practice by radiographers is worrying particularly since shielding of women of child bearing age for example is important especially where pregnancy is suspected.[8] Similar results were obtained in a study in Nigeria where radiographers were found to be deliberately ignoring shielding apparel during radiographic examinations. This was attributable to regulatory agencies not taking supervision of radiation protection practices seriously.[8]

As it was seen in section 4.4.2.1, some participants demonstrated awareness that doors need to be closed during radiographic examinations, some of them however raised concerns with regards to the absence of lead doors leading to the x-ray rooms in some of the radiography departments as mentioned by this participant; "they (the public) will be exposed because we don't have doors, we are using the curtains so it's not easy to protect them" [RF 2]. This observation was further noted by the researcher, lead doors were absent in some departments and one department was using movable lead shield while another was using normal fabric curtains. In view of this situation, one wonders if lead lining was taken into consideration in the design of such departments if there was no consideration towards putting up lead doors.

In the absence of QC for the equipment, the amount of scatter which may affect staff and the public outside is unknown. The Radiological Protection Institute of Ireland states that the structural design for departments where there are radiation sources should meet the required minimum radiation protection specifications.[236] Joseph, Ibeanu, Zakar *et al.,* reported in their study that some radiographic rooms were converted from other buildings not primarily meant for radiographic examination purposes.[226] In the absence of regulatory authorities and proper authorization practices, this situation is possible in

Swaziland and therefore prompts other studies to investigate structural shielding integrity of some of the departments. The following section presents the codes and categories that describe the perceptions of radiographers with regards to forming the self- regulatory body in this situation.

4.4.3 The perceptions of radiographers regarding the establishment of a self-regulatory body.

As demonstrated in chapter one, the problem identified by the researcher was that radiography services remain un-regulated in Swaziland. The state of QC and radiation protection measures in the departments was unknown. It was therefore necessary to explore the perceptions of radiographers with regards to establishing a self-regulatory body that will monitor these radiation safety practices in the radiography departments. The question posed to participants in this regard was as follows;

What are your perceptions with regards to establishing a self- regulatory body for radiation control purposes in the radiography departments in Swaziland?

The results from the preceding sections have demonstrated the perceptions of radiographers with regards to the performance of QC and radiation protection in the radiography departments. These results have revealed inconsistencies in the application of these very crucial measures which are meant to protect the staff, patients and the public from the harmful effects of ionizing radiation in the radiography departments. Table 4.9 presents the codes and categories where the focus was on gaining insight on how radiographers perceived establishing a self-regulatory body.

Table 4.10 Perceptions of radiographers regarding establishing a self-regulatory body

Category	**Codes**
Support for self-regulatory body	Safety checks Dosimeters Policies/standards New practices Qualified people Monitoring
Radiation safety awareness	Radiation awareness Refresher trainings Trained staff/ students
Support needed by radiographers	RP bill Management structures Staff recruitment QC equipment RP officers Association

The first category is elaborated in the next section.

4.4.3.1 Support for the establishment of a self-regulatory body

In light of the current situation, as demonstrated by the views of the participants in the preceding sections, all participants expressed that they were in support of the idea to establish a self-regulating body that will monitor the safe use of ionizing radiation in the radiography departments. They all perceived this idea to be a good move. Participants relayed that there is a need for regular safety checks. They believe this can be ensured by the establishment of this self-regulatory body. Participants further expressed that if this self-regulatory body were to be established, one of the things they wished it would address was the personnel radiation monitoring program. They revealed that having this service offered in the country would help solve the irregularities currently experienced.

Another factor noted by participants was that it is important that in a working environment there are policies and standards that are being followed and therefore having this body would ensure these are in place. Some radiographers expressed concern over the current situation with regards to newly opened radiology practices. They emphasized that having a self-regulatory body would ensure that all practices are authorized and safety is ensured for everybody in those departments. Concerns were raised over the fact that new practices are not authorized and therefore safety from ionizing radiation in these departments cannot be guaranteed.

Participants mentioned that they hoped if the self-regulatory body was to be established it would look into the issue of recruiting qualified people to handle radiation since they mentioned some departments hire unqualified people and therefore compromising on the safety of all concerned in the departments. Participants further reveal that in each department there should be people or a person responsible for ensuring that QC is undertaken, these people would then report to the established self-regulatory body all the QC results. They acknowledged that regulation needs to start at departmental level. They further mentioned that there is a tendency to do wrong things while they are fully aware of the repercussions. They revealed that the presence of the self-regulatory body would serve as a reminder to stick to safety practices at all times. All these results revealed that radiographers recognized the importance of regulating the radiography departments in terms of QC and radiation safety.

Table 4.10 presents the reasons radiographers gave in support of establishing the self-regulatory body. Direct quotations from participants are used to support results.

Table 4.11 Reasons for support of a self-regulatory body by radiographers

Code	**Quotes**
Safety checks	*Well it's a good idea in the sense that when it is done locally, the frequency of checking radiation safety will be done on a regular basis. [RF 3]*
Dosimeters	*The readings of dosimeters should be the same… If the board can come up with a place within Swaziland it's going to be easy for all the hospitals to have the dosimeters read and be given on time to the radiographers. [MC 2]*
Policies/standards	*I support it, if we had a policy that will guide and protect me as a radiographer [RF 2]* *I think we need such a body. We need guidance, we need to follow necessary steps, [MK 1]*
New practices	*..if we install a new machine, it must meet certain requirements.. right now since we don't have a regulatory body, if I have the capital I can open a private practice in town. [MG 5]*
Qualified people	*..we have people that are doing radiography who are not trained radiographers. But if there is a body…and the people are properly trained to handle radiation then everything will be done properly. [GS 2]* *it will help to regulate as to who is eligible to handle radiation [RF 4]*
Monitoring	*At hospital level, the body would constantly remind the radiation workers like ourselves to stick to the safety measures when it comes handling of radiation. [RF 4]* *..sometimes we do wrong things knowing very well that we shouldn't be doing this yet if we have a body… [MG 5]*

The following section presents a discussion on these results with reference being made to literature.

a) Discussion on support for establishment of a self-regulatory body

This study was conducted following observations by the researcher on the irregular QC and radiation protection practices which are probably having negative effects on staff, patients and the public. These irregular practices are attributable to the absence of monitoring and supervision in terms of radiation safety. It is acknowledged that forming any regulatory body must be according to established legislations however in the absence of these, some sort of intervention is still needed. The AFROSAFE implementation tool matrix mentions that it encourages self-regulation by medical professionals in radiology through promoting a radiation safety culture.[11]

According to Yousem and Beuchamp, QA/QC programs in diagnostic radiography are generally informal and self-regulated requiring self-monitoring and self-assessments.[22] This implies that regulating these practices does not require extensive rules and regulations. It is only a case of laying down guidelines for QC tests and radiation protection practices and having an established internal body effectively ensuring these are adhered to. The NCRP defines self-assessment as a process that an institution uses to critically review its own activities and performances in relation to standards and internal policy documents. They further define the specific purposes of a self-assessment program in radiography departments. One of these purposes is ensuring a safe working environment by identifying unsafe practices, equipment and working conditions that could lead to incidents and accidents and radiation exposures that are not compliant to the ALARA principle.[237] These self-assessments could be initiated and monitored by a self-regulatory body within the radiography departments.

Participants mentioned that a self-regulatory body is needed so that there will be local and regular safety checks as stated by RF 3. The WHO states that radiographers may concentrate on employing good radiation protection practices during procedures without realizing that some of the basic safety precautions may have been overlooked.[135] These include ensuring equipment and premises are radiation safe.[135] The IAEA states that safety assessments should include assessing all relevant areas of radiation protection and safety for a medical radiation facility, including the siting, design and operation of the facility.[7] As part of radiation safety, radiation surveys and inspections of radiography departments should be compulsory.[238]

WHO states that radiation surveys should be conducted on installation with assessments of radiation leakages and the overall radiographic system conducted.[135] Further, inspection of existing systems which have not been inspected in a long time can also be conducted taking into account outstanding problems with the equipment, premises and records of personnel monitoring. From here, regular surveys should be scheduled preferably annually.[135] These surveys, should involve inspecting for proper facility infrastructure, radiation protection and safety practices, imaging equipment QC processes, optimization in clinical practice and dosimetry.[239] WHO mentions that these surveys should be performed by a medical physicist assisted by a radiographer.[135] Radiographers are required to demonstrate their working methods in terms of records for QC tests and radiation protection practices so that recommendations can be made by the medical physicist.[135]

It is worth mentioning that Swaziland has a serious shortage of medical physicists and at the time of this study there was no medical physicist servicing the hospitals in the country. This implies the need to further train radiographers appointed to the regulatory position so that they can effectively carry out these inspection roles since they have basic training in radiation safety. The situation cannot be left as it is as it compromises safety for staff, patients and the public.

Participants further mentioned that if there is a body for radiation safety, then it means there will be policies and standards to follow as seen in this statement; "*we need guidance, we need to follow necessary steps" [MK 1]*. Policies well documented in a radiation safety manual for the radiography departments are important and need to be adhered to. The California Department of Public Health recommends that in the radiation safety program there should be included amongst others a) documented QA program which clearly outlines procedures to comply with the ALARA principle b) personnel monitoring program and c) provision for continuous education and training on radiation safety of employees.[240] However, in this study it has been revealed that while participants seemed to know of some of the radiation protection practices to comply with ALARA they seemed ignorant of the QC tests in the departments as only a few tests were being done.

This necessitates further training for radiographers on QC to be able to set standards and self-regulate.

Participants seem to need to be pushed by some authoritative body towards the adherence to safety practices. This is affirmed by this statement; "*sometimes we do wrong things knowing very well that we shouldn't be doing this" [MG 5].* This statement concurs with observations by Chinangwa, Amoako and Fletcher who mention that regulatory authorities in some countries act as watchdogs in making sure that operational and protection standards are not compromised.[241] Some studies identified that radiographers were not adhering to protection standards due to lack of supervision by the regulatory authority where it is present.[8,220] This could be the result of external radiation protection authorities who do not provide strict compliance rules. It has been said that in some countries regulations set by external bodies have no strong influence.[220] This therefore implies that the tendency by radiographers to ignore safety compliance prompts the need for internal strict safety adherence procedures.

The personnel radiation monitoring service is currently being offered by the SABS as explained in chapter one. Concerns were raised over irregular follow ups and lack of feedback regarding the doses accumulated. Participants expressed that a locally established personnel radiation monitoring program by this self-regulatory body would improve the services that are supposed to be offered by this body as stated "*If the board can come up with a place within Swaziland it's going to be easy for all the hospitals to have the dosimeters read and be given on time to the radiographers" [MC 2].* This is not always the case though as in some countries where this service was provided locally by established regulatory bodies was not satisfactory. These are also external regulatory bodies. In Ghana and Nigeria it was found that participants were not satisfied with the personnel radiation monitoring program provided by the radiation protection boards in these countries. This was attributable to the lack of radiation safety officers within these departments.[220,242] This further shows the need for some level of self-regulation within these departments in order to ensure regular supply of dosimeters, ensure they are always worn correctly and further ensure proper feedback.

Authorization of new practices was further cause for concern by participants. They expressed that the body is needed in order to look into making sure all new practices adhere to safety requirements as stated by MG 5. The IAEA states that prospective owners of x-ray facilities should apply for a registration or a license from a recognized regulatory body. This agency further states that license or registration should be granted on condition that a) safety can be ensured by the design of the facilities and equipment; b) the operating procedures are simple to follow; and c) the safety training requirements are minimal.[140] This necessitates the need for inspecting compliance of new practices and ensuring staff is properly qualified. In Swaziland this procedure seems to be lacking in the radiography departments in Swaziland as evidenced by this statement; *if I have the capital I can open a private practice in town. [MG 5]* This is a concern as safety is not ensured and puts everyone in the department at risk.

Authorization further entails the person applying for the license demonstrating that all staff operating the radiation producing equipment is properly qualified. The IAEA recommends that the following information be submitted to the regulatory body in this regard; a) the qualifications in radiation protection of the medical practitioners applying for the authorization; (b) a statement that only persons with qualifications in radiation protection will be permitted to administer medical radiation exposure using the sources to be authorized.[15] The Radiation Control Directorate of South Africa states that persons appointed by the license holder must be qualified in either of these categories; radiography, radiology or medical physics.[27] This then shows that the regulatory body is important in ensuring all persons working in the departments are properly qualified.

In Swaziland since there is no regulatory body, verifying qualifications is not followed according to procedures stipulated by other regulatory bodies. This then means departments might hire unqualified people as stated by this participant; "*we have many unqualified people in Swaziland who are dealing with radiation" [RF 4].* The need for the self-regulatory body was further recognized by participants in this regard as evidenced; "*it will help to regulate as to who is eligible to handle radiation" [RF 4].* In further supporting the idea of establishing the self-regulatory body, participants outlined their views as to how they believe the radiation safety practices could be improved in the radiography departments. The next section describes these views.

4.4.3.2 Radiographers' views regarding radiation safety awareness

Radiographers reiterated that ensuring everybody involved in the handling of patients in the hospital setting is aware of the radiation hazards is an integral part of maintaining the standards of radiation protection.

The participating radiographers emphasized that; other health professionals, the Ministry of Health and the general public need to be made aware of the effects of ionizing radiation. It has also been indicated that radiographers themselves need frequent reminder trainings in order to maintain standards in radiation protection.

The following table presents the results that were given by participants in this regard. Direct excerpts are used to support these results.

Table 4.12 Participants' views on radiation safety awareness

Code	**Quote**
Workshops	*I think we need to have workshops for doctors to learn about radiation itself…Management itself as well as Ministry of Health. They need to understand what ionizing radiation is and its effects… [GS 1]*
Refreshers	*I think we need to have frequent refresher trainings on the roles and responsibilities of a radiographer when it comes to radiation protection. [TB 2]* *First of all I think we need proper training, reminders.. [MK 1]*
Trained staff	*We should get all people working with radiation properly trained. [GS 2]* *They should also emphasize for the students as well because most of the students know nothing about radiation protection… they don't know about dosimeters…you ask them about a dosimeter, very few will explain to you its usage [MC 2]*

As seen in the previous sections, radiographers expressed concern that there are unqualified people working as radiographers in the radiography departments. This then led to some of them recommending that it is important that staff working as radiographers are appropriately trained to do so in order to be able to handle radiation safely for themselves, the patients and the public. It was also recommended that students still in training need proper training in radiation protection. The next section discusses these recommendations.

a) Discussion on radiation safety awareness

From what could be deduced from the participants, radiation safety awareness should include hospital management and even the officials from the Ministry of Health. When participants were providing reasons for the non-performance of QC tests, one of the reasons was that there is lack of support from the management structures, middle and higher. Literature revealed that this might be due to lack of awareness of radiation safety by these entities.[207] Participants recommended that there should be radiation awareness workshops for the Ministry of Health and hospital management so that they understand radiation and its effects.

The IAEA recommends that training for managers should include basic principles of radiation protection, the concept and principles of maintaining a safety culture in the departments and the principal elements of a radiation protection program in diagnostic radiography.[15] The Image Wisely and Image Gently campaigns seek to create awareness on the risks and benefits of ionizing radiation in medical imaging and can be used as reference in this regard.[243] The IAEA further recommends that management should be committed to provide an effective protection and safety policy and further demonstrate support for those persons whose responsibility is radiation protection.[140] This can only be achieved with full awareness of the benefits and detriments brought about by ionizing radiation.

Participants further recommended that workshops on the effects of ionizing radiation for referring doctors should be conducted. This came in view of the situation of unnecessary examinations requested by these professionals as mentioned by the participants. Literature revealed that referring doctors lacked adequate knowledge on radiation protection and further proper knowledge on referral guidelines.[100,101] This might be the situation even in Swaziland and hence this recommendation.

Continuous education and training for radiographers in QC and radiation protection was recommended. Training is considered to be an important tool to upgrade competence for radiation workers. According to the IAEA competence is acquired through regular refresher training.[245] To boost their competence in these practices and further promote the probability of the performance of the QC tests, participant TB 2 recommended; "*I think we need to have frequent refresher trainings".* In the absence of regular training, radiographers' basic knowledge regarding QC tests in the radiography departments might dwindle out of their minds as the years go by.

The Tanzania Atomic Energy Agency developed a training model as a follow up to basic knowledge which included the following; general warm ups and checks, collimation and beam alignment tests, lead protective wear tests and other tests for radiographers which are deemed to use simple inexpensive tools.[246] Frequent refresher trainings in these as well as other radiation protection principles could improve the safety culture within the radiography departments in Swaziland.

Participants further recommended that radiation protection should be emphasized for students. Swaziland has just established its first radiography school and it seems there are concerns with the students' knowledge on radiation protection as stated by this participant; "*the students know nothing about radiation protection" [MC 2].* Van der Merve, Kruger and Nel stated that from the first year of training students need education and training in radiation safety before being occupationally exposed.[23] The authors in their study noted that while students might get monitored for radiation doses, training in safety requirements in the work area was not confirmed before they were allocated to their respective clinical sites.[23] The researcher observed that students in clinical practice in the radiography departments were not part of the monitoring program as they were not supplied with dosimeters. This further supports participants' concerns that they might not know what a dosimeter is and further have questionable knowledge on radiation protection as seen in this statement; "*they don't know about dosimeters" [MC 2].*

Radiographers' views on support needed from management are presented next.

4.4.3.3 Support needed by radiographers

In order to provide proper service delivery in health care, it is important that the government, in this case the Ministry of Health provides the necessary support. Firstly as previously mentioned it is imperative that they properly understand what is entailed in the day to day running of all departments. In this case, understanding what ionizing radiation is and its effects is important so that proper structures can be put in place to provide safety for all concerned. These results demonstrate that participants take support from managerial structures as an important aspect to improving safety practices in the radiography departments.

Table 4.12 summarizes the results on the kind of support participants deemed is needed in order to improve the situation. Direct quotations are used to support these results.

Table 4.13 Support needed by radiographers

Code	Quote
Radiation control bill	*..we expect government to come up with the relevant legislation, because everything is governed by law [RF 4]*
Hierarchy structures	*Introduce proper management structures within radiology departments… And of course proper grades that will go with the posts, [RF 4]*
Staff recruitment	*Personnel recruitment since we have a shortage of staff. [TB 1]*
QC equipment	*I think it's to get the QC equipment and be doing the tests ourselves, [TB 1]*
RP officers	*I think if each and every hospital could come up with radiation protection officers, people to look into the issues of radiation protection, [MC 2]*
Association	*Radiographers must have a society or an association where they have to meet once in a while and look at their challenges …then you come up with a regulation that can help to control radiation in these facilities. [MBC 1]*

As seen in table 4.12, it was recommended that it is important for government to enact the radiation protection bill which will guide all radiation protection operations. Furthermore, the present structure with regards to hierarchy and salary scales in the radiography cadre needs to be revised. They recommended that government needs to put in proper management structures and further improve the salary scales. One reason given by the participants for not doing the QC tests was that they are short staffed. Participants then recommended that to address the shortage of staff, government should support them in recruiting more radiographers. The participants also suggested that hospital management should make sure that they procure the QC equipment. This will make sure that QC tests get done.

Participants went on to recommend that there should be people responsible in overseeing radiation protection measures at departmental or even regional level. These radiation protection officers within the departments can take up the role of ensuring that QC tests get done and radiation protection measures are being applied efficiently and effectively according to the participants. Further it was recommended that it is necessary for radiographers in different hospitals to interact with each other in terms of radiation protection. This according to participants will help recognize common challenges and then in turn come up with solutions to these challenges in a bid to optimize radiation protection in Swaziland as a whole. Radiographers attitudes when it comes to radiation protection can have a huge impact on the optimization of radiation protection and the performance of QC tests. A discussion on these results follows.

a) Discussion on support needed by radiographers

From the results, it is noted that participants consider the support from all stakeholders as crucial towards establishing a self-regulatory body. These stakeholders include the Ministry of Health, hospital managers and radiography department managers. Participants recommended that the Ministry of Health needs to consider enacting the radiation control bill as per the recommendations of the IAEA.[16] The IAEA states that government is to establish a legislation which allows for the beneficial use of ionizing radiation and further regulates the safety of facilities and their activities.

The agency further states that through this legislation, a regulatory body designated by the government to regulate the introduction and conduct of practices involving the use of ionizing radiation is to be established.[15] This is what participants hope will happen as evidenced by this expression; "*will enable the development or formation of the radiation control authorization body" [TB 2]*. The absence of a regulatory body for radiation protection is attributed to the absence of appropriate legislation and further ignorance on the relevant officials. This situation is not unique to Swaziland as Malawi studies have reported the absence of QC and personnel radiation monitoring in the radiography departments due to the fact that there is no regulatory body for radiation protection.[9,241]

Government plays a big role because without appropriate legislation it is difficult to set down any regulations as recognized by participants in this statement; *everything is governed by law [RF 4].* This view by participants is therefore important towards moving forward in radiation safety. The government needs to consider incorporating radiation safety in the medical sector in the laws they put in place.

As seen in section 4.3.1.2 participants expressed their disappointment with regards to the management structures currently in place. This, according to these radiographers, makes them demotivated to do the QC tests. It was then recommended that government needs to put in proper hierarchy structures for the development of the radiography profession as the situation currently does not allow for professional growth. Several studies revealed that the radiography profession is plagued by professional stagnation and therefore there is a need for management roles. This stagnation was further seen to affect patient care[212,247] as it was recognized in this study with radiographers feeling demotivated to conduct the safety tests on the equipment.

Recruitment of staff to balance the workload situation was further recommended. This was in view of the dire shortage of radiographers in the country. It was previously explained that the issue of staff shortage is a recognized problem in the health sector, however that being said government is encouraged to continue recruiting radiographers in a bid to improve the situation. Procurement of QC equipment was further recommended. The lack of QC equipment was reported in other studies as explained previously however it was established that most of the QC equipment for the routine tests by radiographers requires simple inexpensive tools.[9,10,141] This highlights a lack of leadership from radiography department managers who it is expected would make a provision of these simple test tools and ensure the QC tests are conducted.

The appointment of radiation protection officers in the radiography departments was further recommended by participants. Radiation protection officers according to the AAPM are responsible for implementing and overseeing the radiation protection program within the radiography departments.[248] Further, radiography department management participation is recognized here as it is their responsibility to appoint the radiation protection officer and further make sure the appointed individual is appropriately trained to carry out their duties by engaging with hospital managers.[248] Problems with inconsistent QC practices and ineffective personnel monitoring can be solved by having a person overseeing these practices and hence this recommendation.

Interaction between radiographers was perceived as important as participants suggested that it is a platform where experiences can be shared and therefore rules set down. A professional society such as an association was therefore recommended. A professional society is defined as an association of people who come together to promote progress in a specific area and further promote interaction between interested parties.[249] WHO states that professional societies are expected to promote concepts of QA in radiography, collaborate with the national organization, participate in training activities and provide guidelines.[44] This would be a good move by radiographers in a bid to promote progress in the radiography profession. The following section presents how themes emerged.

4.5 EMERGING THEMES

The purpose of drawing themes from the categories is to derive meaning from what was obtained during the analysis of data. Zhang and Wildermouth state that this step involves making sense of the categories and further presenting the researcher's own reconstructions of the meanings that have been derived from the data.[48] These reconstructions are presented as themes. Erlingsson and Brysiewicz state that a theme can be seen as expressing latent content that is found in two or more categories.[250] Following the analysis of data in this study it was therefore important that the researcher discusses the categories so that themes can emerge that provide an underlying meaning of participants' narratives.

Table 4.14 Linking categories to emerging themes

Categories	**Themes**
QC tests being performed	Awareness of the need for QC tests
Reasons there are no QC tests in some departments	
Implications for non-performance of QC tests	
Radiation protection measures	Radiation protection and safety in the department Radiographers' responsibilities towards radiation protection
Irregularities and concerns	
Radiation safety awareness	The need for the self-regulatory body Education and training in radiation safety Support from governmental and management structures
Support needed by radiographers	
Support for self-regulatory body	

Table 4.14 shows how the themes that emerged from the different categories. As seen from the table, six themes emerged from the discussion of the different categories namely; a) awareness of the need for QC tests, b) radiation protection and safety in the department, c) radiographers' responsibilities towards radiation protection, d) education and training in radiation safety, e) support from management structures and f) the need for the self-regulatory body. These themes are interpreted in the next section.

4.6 INTEPRETATION OF THEMES

The explorative nature of qualitative research leads to an interpretation of social reality. Participants' lived experiences must be described in a way that can be understood.[36] During this step, the researcher raises the participant's perspective to a higher level of conceptualization and seeks the underlying meaning from what was relayed.[251] In this section, the themes are interpreted in relation to the research objectives. This is to show that the results addressed the aim of the study. The reader is hereby reminded of the three research objectives as were outlined in chapter one.

- To describe radiographers’ views towards the performance of QC tests in the radiography departments in Swaziland.
- To establish whether radiographers apply radiation protection measures in the radiography departments in Swaziland.
- To describe radiographers’ views regarding establishing a self-regulatory body that will monitor radiation protection and QC test performances in the radiography departments in Swaziland.

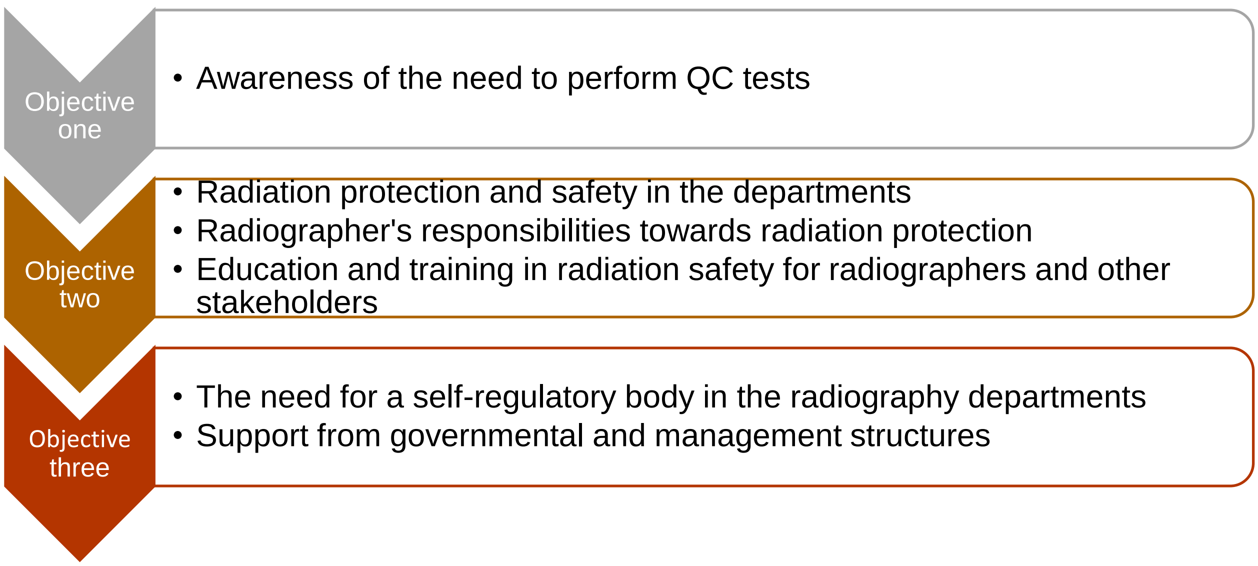

Figure 4.2 Linking research objectives with themes.

As it can be seen in figure 4.2, the themes addressed each research objective. The next section provides an interpretation of each of these themes in relation to the research objectives.

4.6.1 Awareness of the need to perform the QC tests.

As seen in figure 4.2, one theme emerged from the participants narratives regarding their views on the performance of QC tests. The theme named ‘awareness of the need for QC tests’ addressed the first research objective which was;

Research objective one;

To describe radiographers views towards the performance of QC tests in the radiography departments in Swaziland.

The theme is discussed further in the next section.

4.6.1.1 Radiographers are aware of the need for QC tests.

As shown in table 4.14, this theme was extracted from different categories namely; a) QC tests being performed, b) reasons there are no QC tests, c) implications for non-performance of QC tests and d) support needed by radiographers. It became evident that there were some radiographers who were performing tests, who knew the value of performing tests as well as the impact that non-performance of these tests has on the patients, members of the public as well as the staff in the departments. It was gathered therefore that there is an awareness of the fact that QC tests need to be performed in the radiography departments.

The IAEA emphasizes that QA and QC should be an integral part of quality systems in medical imaging.[140] This is because in some countries often equipment is left without any performance evaluation tests as it has been observed in this study as well as other studies in developing countries.[9] This therefore leads to machines not performing well and therefore poor quality images and subsequently an increased repeat rate. Machines may also with age have radiation leaks if performance is not monitored. This can contribute a lot to increased radiation doses for the patients and the staff.[252]

4.6.1.2 Radiographers are aware of the implications for not performing the QC tests

Participants in this study demonstrated awareness of these negative implications brought about by the non-performance of QC tests which included unsafe working environment and increased radiation doses. They further perceived themselves to be at high risk of radiation exposure in the absence of these tests. This perception is not unfounded as studies have confirmed that QC test performances in some African countries are not consistent therefore compromising safety in the department.[9,10] Another author mentioned that most radiography departments in developing countries are not designed based on recommended standards therefore contributing to increased radiation doses within the departments.[139] Such situations could also be attributable to lack of awareness from hospital management who are often oblivious of radiation hazards and the requirements for maintaining a radiation safe working environment. It became apparent that radiographers realize the importance of these tests.

4.6.1.3 Reasons given for not performing QC tests

In this study, the results reveal that radiographers were not performing the QC tests according to the recommended standards. The reasons given indicate that radiographers regard the lack of appropriate support as an important contributing factor. Reasons given include lack of support from management, lack of QC test tools, lack of policies, untrained staff and lack of motivation. All these factors point to the need for an active and supportive management structure. This further depicts that radiographers are aware that these tests need to be done however due to this important constraint it is difficult. This lack of support reveals that hospital management might not be aware of the need for these QC tests. This was supported by Ngoye *et al.,* who stated that hospital management who are not aware of the benefits of a QC program tend to disregard it at the cost of radiation risks.[10] This therefore reiterates the importance of promoting radiation safety awareness for these managers which includes the need for a QC program in the departments.[10] This will in turn evoke the support that is needed by radiographers if hospital managers are aware of the risks associated with the non-presence of safety practices such as the QC tests. That having been said, the responsibility to conduct these tests rests with the radiographers[44], initiative needs to come from them. The IAEA supports this and states that simple tests requiring minimal equipment can be performed by radiographers.[140]

Ngoye *et al.,* stated that if radiographers take the first initiative, the QC program would get the required support from the hospital managers when there is evidence of improved service delivery.[10] This therefore prompts that radiography department managers take up leadership roles in the implementation of the QC program. Radiography department managers further have a role in promoting radiation safety awareness for the hospital managers and thereafter liaise with them for support. Support can be in terms of provision of education and training for radiographers as well as provision of necessary resources for the successful implementation of the program. The reader is reminded however that there are no proper hierarchy structures in the radiography departments as confirmed by participants.

4.1.1.4 Radiographers expect some support and intervention from management

In this study, a lack of initiative to implement the QC program was observed from the views expressed by some participants. This was noted in the fact that participants seemed to be waiting for management to supply them with simple test tools such as recording books for reject analysis. Ngoye *et al.,* in their study found that radiographers did not take QC procedures seriously enough to implement them therefore similarly showing a lack of initiative.[10] This can be attributable to the lack of proper hierarchy structures and therefore lack of appropriate leadership in the radiography departments. Mihic *et al.,* stated that lack of enthusiasm from staff are quite common and often present an obstacle for setting up the QC program.[1] However, ignoring safety mechanisms such as the QC tests may lead to a significant increase in radiation exposure for the patients, the staff and the public.[253]

The indication in this study was that radiographers know there needs to be QC in the departments, however most of the tests are not being done. It can therefore be further stated that, radiographers' support for the need to establish the self-regulatory body, is informed by the radiographers' awareness for the need to have QC tests performed in the radiography departments. While radiographers demonstrate this awareness, it seemed there is a lack of awareness of the associated radiation risks from hospital managers and therefore they do not provide support. This prompts the need to actively promote radiation safety awareness for these managers.

The next section discusses an interpretation of the themes which addressed research objective two. It will be noted from the narratives provided that this research objective alone is addressed by three themes, namely; radiation protection and safety in the department, radiographers' responsibility towards radiation protection and education and training in radiation safety. Each of these themes are discussed separately in the next sections.

4.6.2 Radiation protection and safety in the radiography department.

Participants narrated their views on the radiation protection measures they apply in the radiography departments. These views addressed the second research objective which was;

Research objective two; To establish whether radiographers apply radiation protection measures in the radiography departments in Swaziland.

4.6.2.1 Knowledge of radiation protection and safety in the radiography department.

It was gathered that there is a general knowledge of radiation protection principles that radiographers need to apply in the radiography departments. This was seen in the radiation protection measures that participants mentioned to be applying during radiography examinations as means to reduce unnecessary radiation exposures. This theme was drawn from the categories named; a) radiation protection measures, b) irregularities and concerns regarding radiation protection, c) radiation safety awareness and d) implications for non-performance of QC tests and e) support needed by radiographers.

Participants mentioned that they do attempt to reduce unnecessary examinations in a bid to reduce radiation doses to patients. This can be seen as a good practice by the radiographers. The IAEA stated that medical exposures need to be properly justified with risks and benefits weighed against the procedure.[140] The extent of proper application of this radiation protection principle could not be gathered however in the absence of proper justification and referral guidelines. Del Rosario Perez states that justifying a radiography examination requires consultation of the practitioner in the radiography department and the referring physician.[227] It was unclear if radiographers attempt to consult the referring doctors in this regard as they seemed to rely on information given by the patients in an attempt to limit unnecessary examinations.

4.6.2.2 There is a need for imaging referral guidelines for physicians

While radiographers recognize the need to reduce unnecessary examinations, the absence of the referral guidelines compromises the safety of staff and patients from unnecessary radiation. As participants mentioned, there is a tendency to request unnecessary examinations from the referring team. There is therefore a need to educate referring doctors on the appropriateness of the requested examinations and the risks associated with unnecessary exposure to radiation. Richards, Tins and Cherian *et al.,* in their study stated that about 58% of unjustified radiographic procedures could be prevented by using referral guidelines therefore improving on the safe use of ionizing radiation in the radiography department.[252] Del Rosario Perez emphasized the use of referring guidelines and explained that they are meant to provide referring doctors with information regarding which procedure is most likely to yield the most informative results, and whether another imaging modality could possibly be equally or more effective, and therefore more appropriate.[227]

4.6.2.3 There is awareness of radiation protection techniques that radiographers must apply

Participants further mentioned that they apply the techniques used in compliance to the ALARA principle and therefore optimizing radiation protection. These techniques included applying the high kV technique, using lead apparel and collimation. These techniques correlate with recommendations for ALARA protocols.[43,103] This demonstrated an awareness of the importance of radiation protection by radiographers. It further confirms that radiographers are trained and knowledgeable of radiation protection practices. The irregularities mentioned by radiographers in the application of these practices, also demonstrates that radiographers are aware of what needs to be done correctly. However because there are no policies to follow and there is no monitoring system then it becomes difficult to adhere to these practices.

4.6.2.4 Application of radiation protection practices is not consistent

Inconsistencies in practice when it comes to actual application of radiation protection techniques were admitted by radiographers. They admitted that protecting patients using lead apparel was not consistent to all patients. This resulted in the researcher wondering if what they mentioned to be applying in practice was actually being practiced or if participants were just demonstrating knowledge. Further, in the absence of QC tests the effectiveness of the lead apparel is uncertain. The importance of shielding areas outside of the radiation field particularly those sensitive to ionizing radiation was reiterated by international organizations.[135] This is further emphasized for pediatric patients where there is greater probability of radiation risks manifesting. Studies conducted in other developing countries in Africa demonstrated poor adherence by radiographers to radiation practices even though participants were aware and knowledgeable of these.[124,137] An assumption could be made that this could be the case in Swaziland. The non-adherence of radiographers to radiation protection practices such as not using the lead aprons consistently compromises the safety of patients. The fact that lead aprons are not being tested regularly for efficiency, further puts radiographers and patients at risk as they might be using deficient ones.

Some radiographers admitted that there were no lead barriers to protect the public outside of the x-ray room during radiographic procedures. This brings about the issue of the radiography room design and questions if the departments in Swaziland are constructed according to standards recommended by international agencies especially in the absence of guidelines for QC. WHO states that careful attention must be paid in ensuring that areas around, below and above the radiography room have adequate lead thickness to prevent stray radiation from reaching the public outside. The organization further states that an open door of the radiography room during an examination is an overlooked source of unnecessary irradiation to the public. They further advice that local rules should include instructions to ensure that doors are always closed during examinations.[135]

Radiographers in the study seemed aware of this precaution as a protection measure for the public as most of them mentioned to be applying it. This is further seen in the concern raised by those that work in the departments without doors. The need for support from hospital management is further reiterated in this instance in ensuring that departments are radiation safe and this can only be achieved if they are aware of the hazards ionizing radiation brings to those exposed to it. The importance of laid down rules and guidelines for QC and radiation protection practices and hence the support for the self-regulatory body was further emphasized by participants so as to maintain radiation protection and safety in the departments. Reference is made to the next theme that addressed research objective two in the next section.

4.6.3 Radiographers' responsibilities towards radiation protection.

As stated by Papp and the WHO, radiographers have a responsibility to conduct QC tests and further adhere to the ALARA principle during radiography examinations so as to optimize radiation protection for themselves, the patients and the public.[43,44] The categories that informed this theme were; a) QC tests being performed b) implications for non-performance of QC tests, c) radiation protection measures, d) irregularities and concerns regarding radiation protection and e) support needed by radiographers.

4.6.3.1 Some radiographers embrace their responsibilities with regards to radiation safety.

Some radiographers seemed to embrace the responsibility they bear when it comes to radiation safety within the departments. The few tests conducted indicated that some radiographers are genuinely concerned for their safety and that of the patients as well as the public. The ISRRT states that it essential for radiographers to deliver safe, cost effective and high quality diagnostic imaging services.[200] They further mention that this necessitates for the establishment of a routine equipment QC testing program which includes reject film analysis whereby radiographers will be able to recognize and report situations of increase or under exposure to radiation.[200] From the results it was revealed that from the few QC tests being conducted there was no documentation. The responsibility of documenting and maintaining equipment performance records lies with the radiographers.[200] Documentation is important in that radiographers can track equipment failures, reasons for failure and any interventions that were done or need to be done for future reference.[10]

Radiographers highlighted the implications of not conducting the QC tests and were aware that this contributes to increased radiation doses for staff members, the patients and the public. Radiographers have a responsibility to keep radiation doses as low as reasonably achievable (ALARA) during the radiographic examinations. This is supported by Sherer, Visconti, Ritenour and Haynes who state that radiographers should perform their occupational practices in compliance with the ALARA principle.[68] In this study the results revealed that radiographers are well aware that they need to keep radiation doses to patients and themselves to the minimum and were well aware of their roles and the techniques to go about in achieving this. However the need for laid down guidelines and supervision as well as assessment of practices is imperative to ensuring that all radiographers maintain safety practices. This is emphasized by the fact that safety practices are not consistent as confirmed by the participants. This further highlights the need for support from radiography department managers by providing appropriate leadership.

4.6.3.2 The need for a professional association

It was further highlighted that radiographers need to take responsibility in forming an association or a society. Professional associations are described by the University of Sydney as organizations that act as a peak body for professionals working in a similar field. This university further mentions that these help maintain standards of the profession through continuous professional development, quality control and research.[254] This is echoed by established associations of radiographers. The American Society of Radiologic Technologists in its mission statement states that it aims to advance the medical imaging profession and to enhance the quality and safety of patient care.[255] The Society of Radiographers of South Africa provides access to continuing education for radiographers in the country and recognizes that through this, practice and ethical standards can improve within the profession.[256] The responsibility lies with the radiographers in forming this association and delivering quality and safe standards as participants in this study have suggested. The theme education and training is discussed next.

4.6.4 Education and training in radiation safety for radiographers and other stakeholders

Education and training in radiation safety is necessary for all individuals concerned with ensuring patient safety in the radiography department. This includes radiographers, hospital management as well as the Ministry of Health. Ensuring continuous education creates awareness and it is believed that awareness is the first step before adoption, compliance and adherence.[257] This theme was extracted from the categories namely; a) QC tests being performed, b) reasons for non-performance of QC tests, c) irregularities and concerns regarding radiation protection, d) radiation safety awareness and e) support needed by radiographers. From the results, education and training in radiation safety seemed to be needed in the aspects outlined in the next sections.

4.6.4.1 Knowledge of how to perform the QC tests

Conducting QC tests is an important part of maintaining a radiation safe environment for radiographers, the patients and the public. This is because QC tests ensure proper functioning equipment which will provide quality diagnostic images at the lowest possible radiation dose.[44] Radiographers in this study demonstrated an awareness of the fact that conducting these tests is important in the radiography department. However, when looking at the results from the analysis process of the few QC tests that participants mentioned to be doing, there was doubt as to the actual knowledge of how these tests are to be conducted. Van der Merwe, Kruger and Nel stated that since radiographers are responsible for performing the routine QC tests, advanced training in the conducting of these tests must be included in the radiography curriculum.[23] This was supported by

Inkoom, Schandorf, Emi-Reynolds and Fletcher who stated that adequate training should be provided for persons with QC responsibilities and such training should be specific to the equipment in use at that facility.[148] Therefore, it is important to note that most of the departments in Swaziland are diagnostic imaging and have common characteristics in terms of equipment used. Training can be standard going beyond what radiographers were taught at undergraduate level.

4.6.4.2 Knowledge of radiation protection practices

Participants demonstrated knowledge that can be deemed as adequate when it comes to the radiation protection techniques used in protecting themselves, the patient and the public. Participants mentioned to be applying these techniques even though there were inconsistencies in practice. Authors form another study mentioned that even though radiographers are trained in radiation protection and safety, non-compliance in clinical practice is often observed.[23] This could be attributable to a possible lack of competence on the part of radiographers therefore necessitating regular education and training regarding proper practices. The lack of standardized exit level outcomes pertaining to radiation safety training for radiography students in South Africa is another concern.[23] Radiographers in Swaziland were predominantly trained in South Africa at different institutions and therefore their level of knowledge regarding radiation safety varies. This then brings about the issue of frequent refresher trainings for radiographers in order to standardize and improve radiation protection practices. The IAEA describes refresher training as that which is provided at regular intervals to ensure that competence is maintained.[245] This agency further encourages this training and mentions that it stimulates interest on the participants.[245] Continuous education and training as well as assessment of radiographer practices was emphasized by another study as a means of ensuring professional standards.[258]

4.6.4.3 Radiation awareness for hospital managers and other staff members

Participants mentioned it would be a good strategy to promote radiation awareness for hospital management and the Ministry of Health as these would lead to appropriate support from these entities. This view was supported by one study where it was stated that awareness of radiation risks and support in optimization of radiation exposure among hospital management is vital for the improvement of radiation protection and QC procedures.[10] Chougule supported this and stated that it is common that radiation safety strategies are not effectively implemented due to lack of knowledge amongst the relevant stakeholders.[259] This study has confirmed that support from management is vital in maintaining the standards of radiation safety and the practices associated with it. It is a concern therefore that support from management is lacking due to lack of awareness. There is therefore a need to raise awareness and educate these entities regarding radiation hazards from medical use and why it is necessary that safety practices are implemented and monitored so that the necessary support is comprehended.

While radiographers demonstrate knowledge regarding the issue of reducing unnecessary examinations, the absence of proper justification procedures for examinations and guidelines for referral still remains a fundamental issue. Educating referring physicians about radiation hazards and development of referral guidelines is needed. This was seen in the concern raised by participants that some examinations are unnecessary and are being requested by nurses. Referring physicians must be aware of the radiation hazards of the examination they request in order to be able to justify it.[100] This brings about the need for hospital management support in order to raise radiation safety awareness for all hospital staff and further in developing and implementing the referral guidelines. The next section discusses the themes that addressed research objective three.

4.6.5 Support from governmental and management structures.

As seen in figure 4.2, two themes address research objective three. These are a) support from governmental and management structures and b) the need for the self-regulatory body. These views addressed the third research objective which was;

Research objective three;
To describe radiographers' views regarding establishing a self-regulatory body that will monitor radiation protection and QC test performances in the radiography departments in Swaziland.

Each of the themes named above are discussed separately in the next section. From the participants' narratives, it was gathered that there was general support for the establishment of a self-regulatory body. Participants however viewed the support from the government and the hospital mangers as important in improving the situation with regards to radiation safety in Swaziland. The theme "support from governmental and management structures" is discussed first.

4.6.5.1 Radiographers need support from governmental and hospital management structures.

As seen in table 4.14, this theme emerged from the categories a) reasons there are no QC tests in some departments, b) irregularities and concerns regarding radiation protection measures, c) radiation safety awareness, d) support needed by radiographers and e) support for the self-regulatory body.

In healthcare institutions, there are hierarchies and different people having different responsibilities. At the top there is the Ministry of Health which is the overseer of all the health institutions in the country. There is also the hospital management which deals with day to day running of the hospital. It happens in most situations that the officials in these management positions are not fully aware of the activities that are being carried out in the radiography department. Radiography departments are often left to monitor their own operations due to these management structures lacking understanding of the activities going on in the departments and lacking awareness of the hazards that radiography departments may bring to the population.

From the results, it was gathered that a collaborative effort from these entities is essential in maintaining safety standards in terms of ionizing radiation in the radiography departments. Participants in the study recognized that in the idea of establishing a self-regulatory body, government support in terms of appropriate legislation enactment, implementing proper hierarchy structures for radiographers and staff recruitment is important. Appropriate legislations are important in guiding operations of any entities. The IAEA concurred with this and stated that proper implementation of radiation protection standards requires that an independent regulatory authority be established by government through appropriate legislation.[15] It is further recognized that there needs to be education provisions in terms of raising awareness for the policymakers in the government in order for them to realize the seriousness of implementing a radiation control bill.

The Ministry of Health employs the majority of radiographers in Swaziland and is responsible for the hierarchy structures of all the cadres in health care. Participants in the study mentioned that the radiography profession lacks recognition and therefore has no proper hierarchy structures. The absence of proper hierarchy structures means there are no defined roles and responsibilities for different members of staff which therefore makes it difficult to monitor the radiation safety practices. Support in terms of implementing these structures in the radiography departments can enable defined roles for supervision of staff practices and safety procedures. However this can be achieved further with clear policies and guidelines.

4.6.5.2 The need for policy development and implementation

Participants further disclosed that there is a need to implement safety policies and guidelines. WHO states that the government needs to collaborate with various stakeholders including international organizations and health facilities in developing, coordinating and motivating the implementation of policies, recommendations, regulations, guidelines, standards and requirements generated by regulatory authorities and international bodies such as IAEA and ICRP in this case.[44] Chinamale found that QC tests were not being performed in the absence of a regulatory structure, similarly recommended that government should implement radiation safety policies.[10] The Ministry of Health of Swaziland has an established National Health Policy document which does not cover safe use of ionizing radiation in radiography departments.[17] This questions the awareness of the policy makers on the hazards of the uncontrolled use of ionizing radiation in the radiography departments and further their lack of support in maintaining safety in these departments.

Participants in the study viewed immediate support from radiography department managers and hospital management as integral in the implementation of an effective QC program. Most of the QC tests were not being done one of the reasons given was to the effect that there is lack of managerial support and therefore lack of QC test tools, shortage of staff, lack of guiding policies and lack of motivation. WHO recommended that hospital management structures need to support the implementation of QC in the radiography departments such as providing adequate staffing, provision of QC test tools and in the laying down of safety policies.[44] A study in Malawi corroborated this and recommended that hospital management structures should ensure all departments have adequate tools and equipment for the maintenance of safety in the department.[9]

4.6.5.3 Lack of support due to unawareness of radiation hazards

The results revealed that hospital management seemed not to take issues relating to QC seriously possibly due to unawareness of the radiation hazards brought about by defective equipment. They seemed only concerned with continued workflow and unaware of the hazardous working environment. Authors of a study in Tanzania mentioned that hospital managers who are not aware of the benefits of maintaining QC in the radiography department tend to disregard it and perceive it as a financial drain which is at a cost of compromising image quality and increased radiation doses.[10] Support from radiography department managers was further recognized in that there needs to be appointment of radiation protection officers within the departments to implement and oversee radiation protection practices. QA programs are easily coordinated by the presence of a radiation protection officer.[9] The AAPM recommended that a licensee that uses ionizing radiation may be required to implement a radiation protection program which can be directly overseen by the radiation protection officer within the departments. This professional organization further mentions that the radiation protection officer has the authority to enforce radiation policies and procedures regarding radiation safety.[248]The radiography department manager can facilitate the appointment of the radiation protection officer. This can be a good start towards establishing safety in the radiography departments if all departments can have at least one radiographer trained in radiation in radiation protection and appointed as a radiation protection officer. The support of hospital management in this regard is important in provision of training resources for such persons as stated in the preceding section. The theme regarding the self-regulatory body is discussed next.

4.6.6 The need for a self-regulatory body in the radiography departments.

This theme comes as a reminder to the reader of the aim of the study which was to explore and describe the perceptions of radiographers in Swaziland regarding the idea of establishing a self-regulatory body that will monitor QC and radiation protection practices in the radiography departments in Swaziland. The theme emerged from the categories namely; a) reasons there are no QC tests, b) irregularities and concerns, c) implications for non-performance of QC tests, d) radiation safety awareness, e) support needed by radiographers, and f) support for the self-regulatory body.

4.6.6.1 There is need for change in the radiography departments

Positive perceptions were identified as participants narrated their responses. It was gathered that there is a need for such a body which would bring about change in the current situation within the radiography departments. The IAEA recommended that a regulatory system needs to be established and regulations developed in accordance with the national health care regulations when it comes to safety in terms of ionizing radiation in the radiography departments.[7]

The need was identified in terms of regular safety checks as participants mentioned that the work environment might not be as safe in the absence of QC tests and monitoring mechanisms. It is recommended that compliance monitoring in the form of regular on-site inspections be conducted by the regulatory body. Inspections should include ensuring compliance to the QC program and adherence to radiation protection practices by radiographers. The European Council states that establishing QC programs which include audit and inspection of radiography departments is necessary for the delivery of safe health care.[260] Audits should follow laid down rules and guidelines and should be performed by persons with extensive knowledge of the radiography departments.[260] To concur with this, the IAEA states that an adequate inspection program can be implemented using staff with basic training in radiation safety.[7] This shows that radiographers who are knowledgeable about the radiography departments and have basic training in radiation protection can perform this task. It is however recognized that in the context of this study, there is a need for further education and training in order to effectively carry out this task.

4.6.6.2 There is need to address concerns regarding the personnel radiation monitoring service

Further, a need by such a body to address the personnel radiation monitoring program which was currently failing to provide an effective service was recognized by participants. The responsibilities of the appointed regulatory body include acquiring a dosimetry service for workplace and individual monitoring.[7] Personnel monitoring is not a radiation protection practice however it is a way of monitoring staff radiation doses as a safety precaution. Okaro, Ohagwu and Njoku stated that radiographers' measurements of radiation doses are essential to ensure that dose limits are not exceeded.[242] Further, an effective personnel monitoring program becomes a measure of verifying that radiation protection practices are adequate and acceptable in that if radiographers' doses are within limits then it means safety practices are acceptable.[260] The verification can be valid however if QC tests are being carried out regularly and radiation protection practices are monitored.

4.6.6.3 The need to standardize operating procedures

The need to draft standardized policies and procedures for QC and radiation protection practices is of utmost importance by such a body as it is difficult to maintain safety in the departments without these guidelines. This is emphasized by the results of this study which indicate that QC tests are not being performed adequately and that there are irregularities and concerns in terms of radiation protection practices. Instituting guidelines for implementing and monitoring QC is one way used by regulatory bodies to strengthen compliance and enforcement.[10] Participation of hospital management in incorporating these policies into the hospital quality improvement plans is of vital importance so that they are implemented effectively.

Participants further recognized that there is a need for the body in terms of standards for proper authorization of new practices and ensuring proper qualifications of persons hired to work in the radiography departments. These are requirements by other regulatory bodies before any radiography department can operate in any premises[102] and could be adopted into the proposed body in Swaziland. There was an overall positive perception towards the establishment of a self-regulatory body from these narrations. It is gathered from these results that participants recognize the need for establishing regulatory structures within the radiography departments, however, in order to achieve this aim support from management structures as well as provision of regular education and training for radiographers in radiation protection is recognized as seen in the previous themes.

From the interpretation of themes, the following three findings are brought forward, namely; a) there is awareness that radiation safety practices are necessary in the radiography departments, b) education and training can improve radiation safety in the radiography departments and finally c) a self-regulatory body can be established with support from the government and hospital management. These findings will be elaborated on in the next chapter.

4.7 CONCLUSION

In this chapter, the results from the data analysis were presented and discussed. These were in line with the qualitative content analysis process. The codes, categories and themes from the analysis process were clearly outlined. Categories were first discussed in relation to the questions used during the interviews. In order to gain understanding to the underlying meaning of the collected data, six themes emerged from this s process. These were named; a) awareness of the need for the performance of QC tests b) radiation protection and safety in the radiography departments c) radiographers' responsibilities towards radiation safety d) education and training in radiation safety for radiographers and other stakeholders e) support from management structures and f) the need for a self-regulatory body in the radiography departments. The emerging themes were interpreted and related to the research objectives. The interpretation of themes was essential as it led to the derivation of the research findings. These findings will be presented in the next chapter.

CHAPTER 5

RESEARCH FINDINGS, CONCLUSIONS, LIMITATIONS AND RECOMMENDATIONS

5.1 INTRODUCTION

Chapter four provided a detailed description of the results, discussion of the categories and interpretation of the emerging themes so that findings can be drawn. Defining the findings from the emerging themes is one way of giving meaning to what is revealed by the results. This step can be considered as one way of making sense of the data.[38] Denzin states that it is important to place the voices of the oppressed at the center of the qualitative inquiry.[39] The author further mentions that qualitative research contributes to social justice by identifying different aspects of a situation being investigated and thereby coming to some agreement that change is required. Furthermore, qualitative inquiry must affect social policy by getting critiques heard and acted upon by policy makers.[39] Looking at the themes that emerged from the collected and analyzed data, the researcher can confidently say that participants' voices were represented. It can also be stated that the sites for change were identified and the participants acknowledged that there is need for change. The focus of this chapter is to give a brief presentation of the research findings, outline the conclusions drawn from the study, outline the limitations as well as the recommendations that this study is making.

The next section presents the findings drawn from the study.

5.2 PRESENTATION OF THE RESEARCH FINDINGS

Three major findings were made following the interpretation of the themes. These are;
a) there is awareness that radiation safety practices are necessary in the radiography departments, b) education and training can help improve radiation safety practices in the

radiography departments and c) a self-regulatory body can be established with support from governmental and management structures.

The finding with regards to awareness of radiation safety practices is presented first.

5.2.1 There is awareness that radiation safety practices are necessary in the radiography departments.

QC tests and radiation protection measures during radiography examinations are practices meant towards maintaining radiation safety in the radiography departments. Radiographers were aware of the importance of these safety practices. QC tests are discussed first.

5.2.1.1 Awareness of the need for QC tests

Radiographers have a responsibility towards conducting the QC tests.[23,44] QC tests ensure continued well-functioning equipment. Well-functioning equipment provides assurance that there is minimized risk of exposure to unnecessary radiation to radiographers, patients and members of the public. Some authors mentioned that malfunctioning equipment may contribute to increased radiation doses for the patients and the staff members.[9,10]

In chapter four, section 4.3.1, the results revealed that radiographers perform a few of the QC tests recommended by international regulatory agencies. In chapter two, section 2.3.2 the QC tests recommended by international regulatory agencies were presented and described. Looking at the QC tests radiographers mentioned to be performing, though it is only a few of them as compared to recommendations by international regulatory authorities, participants demonstrated that they are aware of the QC tests and further that these need to be performed in the radiography departments. The fact that most of these tests were not done indicates the need for establishing guidelines and monitoring of this service. There is further a need for education and training of radiographers in the conducting of these tests so that they are performed competently, interpreted and corrective actions taken.[23]

The awareness was further demonstrated in the concerns raised by participants due to the absence of the QC tests. Participants mentioned that without QC tests in the radiography departments, radiation doses to the patients as well as staff members might increase. The safety with regards to the working environment is further compromised due to uncertainty over the possible presence of radiation leaks from equipment and walls which are never tested. This finding indicated that radiographers are aware that safety is compromised if safety practices are not monitored. This was further noticed in the support for the establishment of a self-regulatory body where radiographers indicated that there is a need to regularly inspect the departments and conduct the tests to check for continued compliance. It is widely recognized that while there may be awareness in this regard there is a need to improve services in terms of education and training and further a need for established policies to be adhered to. Awareness of radiation protection measures is presented next.

5.2.1.2 Awareness of radiation protection measures

The IAEA states that the justification of radiography examinations and optimization of radiation doses are fundamental aspects of radiation protection.[7] Radiographers seemed aware of these principles. The results further indicated that radiographers are aware of their responsibilities in limiting radiation doses during radiography examinations. It was found that radiographers are aware that unnecessary examinations need to be reduced.

WHO states that justification of examinations involves weighing the benefits against the risks of the examination requested.[98] This should be done in consultation with the referring doctor and the radiologist where present.[227] Further this should be done according to specified guidelines where alternative imaging modalities are suggested to avoid unnecessary radiation to the patients.[227] In this study, while radiographers seemed aware of the need to reduce unnecessary examinations, there was uncertainty as to whether referring doctors were being consulted in the decision to limit examinations. There is a need to educate radiographers as well as referring doctors regarding the appropriate use of justification procedures. There is further a need to educate the physicians on the use of referral guidelines.

Radiographers are further supposed to adhere to the ALARA principle by applying radiation protection techniques during radiography examinations.[43] The techniques applied which are meant to optimize radiation protection were found to be within the recommendations by international regulatory authorities and certain authors.[43,103] This implied that radiographers are aware of the need to keep radiation doses as low as reasonably achievable. The knowledge demonstrated can be seen as a positive factor and supports the notion that radiographers get trained in radiation safety and therefore are knowledgeable of what standards to follow to maintain safety in the radiography departments.

This knowledge means therefore that radiographers can be able to set standards to be followed in terms of radiation protection practices. However, there were doubts regarding actual application of these practices. This was seen in the inconsistencies that were mentioned by participants in the application of these practices. This meant that while radiographers are aware of what needs to be done there might be lack in actual practice therefore, necessitating continued education and training to improve competencies and keep radiographers updated of the need to keep applying radiation protection techniques during the radiography examinations.

The conclusion that can be drawn from these results is that participants are aware that radiation safety is necessary and they seem concerned with their safety in the absence of rules and regulations. There is however a need for continued education and training as demonstrated. The next section focuses on the second finding.

5.2.2 Education and training can help improve radiation safety in the radiography departments.

The need for education and training in terms of radiation safety was widely recognized throughout the results of the study. The participants deemed this to be necessary for both radiographers as well as the relevant stakeholders who provided support in the effective running of the radiography departments. The need for education and training for radiographers is discussed first.

5.2.2.1 Education and training for radiographers

According to the IAEA, continued education and training is necessary for radiographers in order to improve on their competence.[7] The results highlighted that radiographers are aware of the importance of conducting QC tests in order to reduce the radiation doses incurred. The responsibilities that radiographers carry in maintaining a radiation safe environment through performing these tests however was not being carried out effectively. Knowledge regarding the performance of these tests was further found to be questionable. It was further revealed that frequent refresher trainings were needed in order to improve and maintain standards in performance of these tests.

Radiographers were knowledgeable of their roles in the application of the ALARA techniques however they admitted that these were not always consistent. This also necessitates the need for continued education with regards to the importance of maintaining radiation protection for staff, patients and the public. The ever changing techniques in radiography and the ever increasing use of ionizing radiation require that radiographers be up to date with radiation protection strategies in practice. This can be emphasized through frequent continuous education programs which can motivate radiographers to adhere to radiation protection practices.

Continuous professional development (CPD) programs for radiographers have been developed in various countries. Radiographers in South Africa attend CPD events that reinforce their basic knowledge to radiation protection principles.[20] A study conducted in

Europe concluded that all stakeholders including management and regulators should collaborate in ensuring that CPD positively impacts the patients, service delivery, the profession and the individual radiographer.[261] In Sudan, radiographers agreed that CPD is important in improving practice and ensures better practice.[262] The need for strengthening radiation protection principles for radiography students at the newly established medical university in Swaziland was further recognized by participants as a means for improving radiation safety. This requires further research into the radiography curriculum at the university and identifying the needs for improving the curriculum.

It is recognized therefore that continuous education and training as well as advancing radiographer roles in terms of radiation safety can bring a great deal of improvement towards the safety practices in the radiography departments. Raising awareness for other stakeholders in terms of radiation safety is discussed next.

5.2.2.2 Education and training for other stakeholders

The results revealed that the need for education and training should not be limited just to radiographers as maintaining a radiation safe environment is a collaborative effort among various stakeholders. Promoting radiation awareness for the Ministry of Health officials as well as hospital management was found to be important. This is to ensure that these stakeholders understand the importance of radiation protection in the radiography departments and are therefore in a position to provide the necessary support. With this awareness, the urgency needed to draft radiation protection guidelines can be recognized and be incorporated into the hospital quality improvement plans. Educating referring physicians of the importance of justifying radiographic procedures was further found to be an important necessity in order to reduce unnecessary examinations. The IAEA advocates for the education and training of different categories of persons involved in radiation work.[245] These categories include amongst others qualified radiographers, radiation protection officers, other health professionals and employers.[245]

The IAEA further rests the responsibility of ensuring education and training for these different categories on government. They state that government is to ensure training services required for building and maintaining the competence of persons and organizations with responsibilities relating to protection and safety are arranged and in place.[245] The IAEA made recommendations for education and training in radiation safety for medical staff in their publications.[245] Establishing standardized requirements for Swaziland radiographers based on these recommendations is therefore of utmost importance. As it can be seen, education and training in radiation safety can be a start towards improving radiation safety practices for radiographers. Making policymakers in the Ministry of Health as well as hospital managers aware of radiation hazards can help in gaining the support of these stakeholders in drafting rules and guidelines which they can accept. The next section discusses the finding which relate to management support.

5.2.3 A self-regulatory body can be established with support from the government and management structures

A self-regulatory body was proposed to participants as a means for radiographers to take responsibility in ensuring safety in the radiography departments by monitoring staff adherence to radiation protection practices and monitoring the performance of QC tests. It was evident that participants believe that support from the Ministry of Health is needed in terms of ensuring proper legislation for radiation protection is drafted. The main problem with the lack of legislation that deals with the safe use of radiation is that regulation becomes non-existent. Regulations in radiation protection are important for improving safety of persons exposed to ionizing radiation and in-response to failures to monitor radiation protection functions.[263]

In this study radiographers realized that in order for the appropriate regulations to be put in place, appropriate legislation is required and this can be achieved if government entities realize the importance of enacting a radiation control bill. The IAEA requires that the establishment of a regulatory body be independent of any other organization or government departments especially in states where there are no nuclear regulations however it further realizes that absolute independence is impossible as functions must be within a national system of legislation and policies as it has been seen in this study.[15]

The researcher could further draw from the results that participants realized the importance of support from hospital management in maintaining radiation safety in the departments. Support in terms of providing the necessary resources such as provision for continuous education and training and allocation of budgets is important.[10] The researcher could determine from the results that there is a need to conduct regular safety assessments in the radiography departments. WHO states that operating x-ray equipment without conducting safety assessments is an invitation for disaster.[135] The organization further mentions that an authority needs to determine if equipment is being operated safely and premises are safe.[135] This necessitates further education and training for radiographers appointed to self-regulate the safety practices in order to effectively carry out the inspection functions. Employer and management support in this regard is therefore considered vital.

The absence of laid down policies and procedures outlining the performance of the QC tests and scope of practice for radiation protection was another challenge mentioned by participants. QC tests need to be performed according to laid down procedures at specified frequencies.[141] Hospital management plays a vital role in provision of budgets for test tools and repairs to malfunctioning equipment. Further, there is a need for standardized guidelines for radiation protection practices. If there are no guidelines outlining the performance of these activities, then they might not be done or further not done correctly as it has been revealed in this study. The aim of proposing a self-regulatory body to radiographers was so that policies and procedures for QC test performances and radiation protection practices can be laid down and these adhered to. It has been recognized that a collaborative effort is needed in this regard. Hospital management and other medical staff need to be aware of these policies and co-operate in their implementation. Such policies include the use of justification and referral guidelines. Hospital management plays an important role in the dissemination of these policies and in promoting adherence to them.

Lack of motivation due to the absence of proper hierarchy structures and low remuneration was another challenge that arose. The lack of proper hierarchy structures means that there is no proper leadership and therefore lack of supervision. The researcher drew the conclusion that participants perceive this as a factor towards improved service delivery. A self-regulatory body cannot carry out this function as it is not the employer, however it would only oversee adherence to radiation safety practices. The employer in this regard is needed so that staff members are motivated and service delivery is improved. Gunderman and Willing stated that if workers see that leadership is neglecting their workplace, commitment to their job suffers.[264] These authors further advice that employees can be greatly motivated by the following strategies from the management;[264]

a) Work- highlighting the importance of the radiography profession and its employees on the lives of the people they serve which is the public.
b) Achievement- providing regular feedback on the work being done in a way that challenges employees to improve their efficiency and productivity.
c) Recognition- recognizing employees for job that is well done.
d) Responsibility- assigning responsibility to an employee for a certain section of work, assigning more challenging work while enabling individuals to develop expertise.
e) Growth- investing in opportunities for enhancing professional and personal growth through ongoing education and training of employees.

It is concluded from these authors that keeping employees motivated is important in improving service delivery. This brings about the issue of low remuneration. Gunderman and Willing advised that one way of motivating employees in this regard is by introducing performance based compensation systems. This however according to these authors comes with its own challenges as workers shift focus towards the rewards they are receiving instead of paying attention to the quality of the work they are delivering.[264] The important thing to draw here is that employers and management structures need to look into the issue of improving staff morale so as to improve service delivery in terms of radiation safety.

It is concluded therefore that the proposed self-regulation can only be successful with participation from the Ministry of Health and the hospital managers. The summary of the findings has been presented in this section. The next section presents the study limitations.

5.3 STUDY CONCLUSIONS

This study has addressed the issues of radiation protection and safety in the radiography departments in Swaziland. To the researcher's knowledge there is lack of research conducted on radiation safety in the radiography departments in Swaziland. This study has provided baseline evidence and an overview of the current situation with regards to radiation safety in these departments. It has been gathered that safety practices by radiographers need to be improved in the radiography departments. Continued education and training has been cited as an important contribution towards the improvement of radiation protection practices. This is a very important revelation taking into account the harmful effects of ionizing radiation.

The continued rise in radiography examinations and the emergence of new different technologies in the radiography profession prompts the need for continued education and training in radiation protection. The IAEA states that without appropriate support, this increase and advancement in technologies can significantly increase the population's unnecessary exposure to ionizing radiation.[265] Continued refresher trainings are therefore necessary to keep radiographers up to date and improve on their competence on safety practices. It is therefore important that the Ministry of Health takes note of this need for education and training in radiation protection and safety for radiographers and adopts the guidelines recommended by the IAEA so that safety practices are maintained in the departments. It is further hoped that resources and budget for further education and training will be provided by the Ministry of Health following the results of this study.

The aim of the study was to explore radiographers' perceptions regarding establishing a self-regulatory body for radiation control purposes in the radiography departments in

Swaziland. It has been established that there is a need to regulate the radiography departments and control the safe use of ionizing radiation. Aldridge stated that self-regulation aims to address the imbalance of knowledge and power between the patient and the service provider.[266] The author further states that this imbalance exposes the patient to some degree of risk as most lay persons are unable to completely assess the competency or fitness to practice of the relevant health professional.[266]

This is mostly the case in radiography departments as some studies in Africa reported that one barrier to implementation of safety practices is the issue of ineffective regulation by outside regulators.[10] Further, government regulators are known to be ineffective in carrying out credible monitoring of their regulations.[267] To make matters worse, in developing economies often the government has no clear oversight over the operations of their different cadres. Further, there is often little capacity to make appropriate regulations or to enforce them.[267] The radiography departments in Swaziland have been privy to these situations thus compromising safety from radiation and quality of health services. One way to bridge this gap according to the researcher was the idea of self-regulation. The AFROSAFE campaign has its main objective listed as "To unite with a common goal to identify and address radiation safety issues arising from the use of radiation in medicine in Africa." One of the main challenges towards radiation safety identified in Africa by this campaign is lack of policies and regulation in the practice of radiography profession.[11] The results of this study have confirmed this challenge whereby radiation safety practices in the radiography departments are compromised due to the absence of regulation and laid down guidelines.

This brings about the issue of self-regulation whereby radiographers need to consider taking up a responsibility to regulate their own practices in order to deliver safe health care. Radiographers in this study acknowledged the need for a self-regulatory body in the absence of any regulatory mechanisms in the departments. The participants further acknowledge that this can be achieved with support from the government of Swaziland. Norman argued that effective self-regulation can be doubtful if there are no legal sanctions as is the case in Swaziland.[267] This author however further states that regardless of the absence of these legal sanctions earnest self-regulation requires co-operation from government in some of the following ways; a) the government can mandate reporting of internal regulatory plans, b) publicize self-regulatory performance and c) facilitate the professionalization of regulatory officers.[267] The last point was raised by radiographers in the study as a necessity fueled by the need for monitoring and inspection in the radiography departments. Government can facilitate professionalization of regulatory officers by providing further education and training for them in order to effectively carry out these roles. Therefore, it can be concluded that self–regulation can succeed if there is support from the other stakeholders. Self-regulation supported by government can provide a genuine improvement to the delivery of safe health services in the radiography departments.

Conducting this study, also provided a response to the call by WHO which is "to promote the safe and appropriate use of radiation in health care".[268] WHO recommends that the following steps be followed in minimizing the dangers of radiation, namely a) assess the risk, b) manage the risk and communicate the risk. This is schematically presented in figure 5.1.

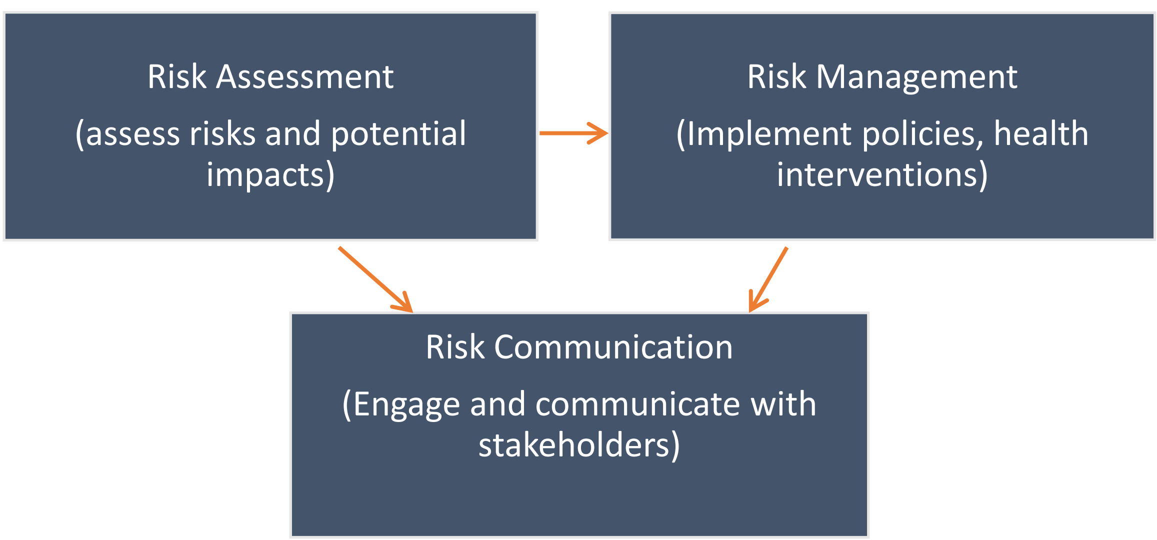

Figure 5.1 Steps in promoting safe use of ionizing radiation[268]

Looking at the three steps outlined in Figure 5.1, the researcher can say this study has provided a pathway towards attaining a radiation safety culture in the radiography departments in Swaziland. In this study it was revealed that radiographers are not conducting the QC tests to the required standards. The absence of QC tests compromises safety for staff members, patients and the public in terms of radiation doses which might be higher. Radiographers are also not consistent with their radiation protection practices during radiography examinations. This was attributed to the lack of laid down policies and procedures. It can be concluded therefore that the study has provided baseline evidence of the potential risks and impact thereof associated with the lack of monitoring structures in the radiography departments. Further, the need to communicate and engage the stakeholders such as the Ministry of Health and the hospital managers in implementing and drafting policies for these safety practices has been clearly outlined. It is hoped that the results of this study will provide insight to the Ministry of Health in terms of the need to regulate radiation safety in the radiography departments and therefore support provided in drafting and implementing the appropriate policies.

5.4 STUDY LIMITATIONS

As stated in Chapter One, section 1.8, the study was limited to exploring the perceptions of radiographers with regards to establishing a self-regulatory body that will monitor the safe use of ionizing radiation in the radiography departments in Swaziland. The study was not focused on determining if radiography departments comply with internationally recommended standards. The study was further not focused to determining how often radiographers perform the QC tests as well as use radiation protection measures in the departments.

Individual one-on-one interviews were conducted instead of focus group interviews. This was due to the wide distribution of the health facilities in the country. It was therefore difficult to bring radiographers together on a specific day. The limited number of radiographers in each department also made it difficult to conduct focus group interviews as in some institutions there is only one radiographer. The researcher did not want to compromise service delivery.

The nature of the qualitative study renders the researcher as an insider who has the potential to influence the participants. In this study as it has been seen, it became an advantage because the researcher could gain rich in depth information, delving into the issues related to the non-regulation of the radiography departments in Swaziland and the needs that radiographers deem can improve radiation safety within these departments.

The next section presents recommendations for further research.

5.5 RECOMMENDATIONS FOR FUTURE RESEARCH

Having gone through this study, up to the point where the major conclusions are presented, the researcher recommends that a quantitative survey of all radiographers in Swaziland be conducted. The survey will determine who is conducting QC tests, the needs for education and training in QC testing and the QC test tools needed. It is further recommended that radiation inspectors from internationally recognized agencies advocating for radiation safety such as the IAEA and WHO be invited to determine the safety of the radiography departments in Swaziland. The researcher recommends that further studies should be conducted on the following topics;

- Radiographers demonstrated knowledge of the optimization of radiation protection principle through application of the ALARA techniques and mentioned to be applying these. It could not be proven however if this was what was happening in actual practice as this was not the focus of the study. The recommendation therefore is that an observational study that will investigate radiographers' application of radiation protection in the work place be conducted.
- A concern was raised by radiographers that they were uncertain of the safety of the working environment since QC tests were not being done on the equipment. The researcher therefore recommends a study that will investigate the status of the radiographic equipment by conducting QC tests.

- A study that will investigate if radiography departments adhere to radiation safety recommendations by international standards in terms of location and design is further recommended. This is in light of the absence of proper authorization of new practices' policies and procedures as mentioned by the participants as well as observations by the researcher of unusually small departments during data collection. It is possible that some radiography departments in Swaziland were not constructed according to internationally recommended standards.

The next section provides the overall conclusion to the study.

5.6 CONCLUSION

The process followed in this study fully addressed the research questions and objectives. The researcher managed to determine that radiographers view QC tests and radiation protection practices in the radiography departments as important measures to controlling radiation doses in the radiography departments. It was further determined that radiographers can improve on their responsibilities to radiation safety with the provision of education and training. The aim of the study was also addressed and achieved. In exploring the views of participating radiographers, they alluded that there is a need for a self-regulatory body that will monitor the safe use of ionizing radiation in the radiography departments in Swaziland. They however indicated that this can only be achieved with a collaborative effort from the Ministry of Health and the hospital managers. It is acknowledged that time is needed to raise awareness in terms of radiation safety for these stakeholders so that there will be an understanding of the need to regulate the radiography departments. In the meantime, the researcher hopes that radiographers in Swaziland will take the initiative towards engaging these stakeholders in laying down radiation safety policies and procedures.

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Annexure A

Interview transcripts and field notes

INT: Thank you so much for your time. Let me explain again the purpose of the study. So we want to see if radiographers are willing to have a body of people that will look into radiation safety in all the radiography departments in the country. So that will be people within ourselves making sure that all the quality control tests are being done and all the departments are compliant to safety requirements. So you have understood the purpose of the study.

MG 5: Yes I have understood the purpose of the study

INT: So the first question I would like to pose to you is can you please tell me about any kind of QC tests that you do in your department beside the CT one particularly in the general X ray department.

MG 5: QC, eish currently we don't do any kind of QC.

Comment [d21]: No QC

INT: Can you maybe tell me why you don't do any?

MG 5: I think we don't do them because we are busy, fine it doesn't take too long but we don't do them because we are busy.

Comment [d22]:

Comment [d23R2]: busy

INT: Ok, Is that the only reason why?

MG 5: And there is no policy which is regulating the QA within the department. Even if I can do it, you can find that I'll be the only who is doing it. My colleagues are the kind of people who just don't care so there is nothing which is motivating me to do it.

Comment [d24]: No policy

INT: Why do you think they don't care?

MG 5: I think they are also demotivated by these salaries they are getting. So you just work so that you can get a salary at the end of the month.

Comment [d25]: demotivated

INT: So you do you get any external people who come and do the QC tests maybe.

MG 5: I think they only come when they fix the machines or to service the machines and I think then they do the QC tests. I'm not sure though.

Comment [d26]: Engineers, not sure

INT: What do they do with the results they get?

MG 5: I'm not sure, we don't even have a head of department if I can put it that way. Not to be misinterpreted there is someone but he doesn't have the powers of being the head of department.

INT: Ok, what do you mean by powers?

MG 5: I mean if maybe that person was only doing administrative work. He's an acting head of department and he also attends to patients. Like in South Africa the head of department only sits in the office doing administrative work, policies things like that.

INT: How do you think not doing QC tests impacts on radiation protection?

MG 5: Eish. It impacts it in a very negative way. For example we do these tests so that we can see if there is a problem. Like for example if maybe the tube is misaligned, so we'll continue working and we see those artifacts which are not being

MG 05

DEMOGRAPHICS

GENDER Male

AGE 40

HIGHEST QUALIFICATION Bachelors

YEARS OF EXPERIENCE 15

INTERVIEW GUIDE

QUESTION 1

Tell me about the QC tests that you perform in your department.

We dont do any QC. Busyness

No policy regulating QA within

department. Colleagues dont care. Nothing

motivating ~~me~~ to do it. Demotivated by

salaries Work so that you get Workload is too much

Only come to fix, service. ~~No~~ Acting head of department present

but no powers

What do you do with the results?

No Qc tests, no results

QUESTION 2

Annexure B

Consensus notes discussed with supervisor

PERCEPTIONS TO ~~SELF~~ establish REGULATE

YES

NO

- Body [illegible]

~~NO NEED TO MONITOR SAFETY OF DEPARTMENTS~~

QC ~~Re~~ Support for establishing Reg Body,

- regular Safety checks
- Monitoring program within the country
- Availability of protection gadgets
- Policies/standards to follow
- Authorization of new practices

Only Qualified people will do radiography exam.

~~Radiation - safety officers within the~~

Role of radiographers within the department / in relation to QC Tests

Some should be Radiation safety officers

QC officer

- All radiographers get involved (Rotation) in doing QC
- Tendency to do wrong thing / Need for Supervision
- Constant reminder to stick to safety
- Need to meet international standards

The know + understand wh radiation

Rotation

Annexure C

Permission letter from Ministry of health in Swaziland

Telephone: (+268 404 2431)
Fax: (+268 404 2092)

MINISTRY OF HEALTH
P.O. BOX 5
MBABANE
SWAZILAND

THE KINGDOM OF SWAZILAND

28th May 2018

To Whom It May Concern

Dear Sir/Madam

PROVISIONAL PERMISSION FOR MS LUNGILE DLAMINI TO CONDUCT STUDY IN DIAGNOSTIC IMAGING

This letter serves as a **provisional permission** for Ms Lungile Dlamini, to conduct a study on **"Radiographers' Attitudes Towards Establishing a Self-Regulatory Body for the Monitoring of Medical Imaging Services in Swaziland"** in our health facilities. This permission is granted provided she receives ethical approval from the National Health Research Review Board of Swaziland.

Ms Lungile Dlamini is a Swazi Citizen and pursuing studies towards a Masters Degree in Medical Imaging at the University of Pretoria. She is a Diagnostic Radiographer employed by the Ministry of Health and posted to the Mbabane Government Hospital.

The study is relevant to the Ministry of Health as it's findings will contribute towards the improvement of Medical Imaging services in Swaziland through providing evidence that will assist the country towards the establishment of proper Quality Systems for the department.

Please assist her in any way possible.

Yours Sincerely

DR. VELEPHI OKELLO

Acting Director of Health Services

DIRECTOR OF HEALTH SERVICES
MINISTRY OF HEALTH
28 MAY 2018
P.O. BOX 5, MBABANE
SWAZILAND

Annexure D

Ethical approval letters

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Health Sciences

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

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

27/09/2018

Approval Certificate
New Application

Ethics Reference No: 465/2018

Title: PERCEPTIONS OF RADIOGRAPHERS REGARDING ESTABLISHING A SELF-REGULATORY BODY FOR RADIATION CONTROL PURPOSES IN SWAZILAND

Dear Lungile Dlamini

The **New Application** as supported by documents specified in your cover letter dated 13/09/2018 for your research received on the 18/09/2018, was approved by the Faculty of Health Sciences Research Ethics Committee on its quorate meeting of 26/09/2018.

Please note the following about your ethics approval:

- Ethics Approval is valid for 1 year
- Please remember to use your protocol number (**465/2018**) on any documents or correspondence with the Research Ethics Committee regarding your research.
- Please note that the Research Ethics Committee may ask further questions, seek additional information, require further modification, or monitor the conduct of your research.

Ethics approval is subject to the following:

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

Additional Conditions:

- Approval is conditional upon the Research Ethics Committee receiving permission from health research review board in Swaziland

We wish you the best with your research.

Yours sincerely

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

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

Research Ethics Committee
Room 4-60, Level 4, Tswelopele Building
University of Pretoria, Private Bag X323
Arcadia 0007, South Africa
Tel +27 (0)12 356 3084
Email deepeka.behari@up.ac.za
www.up.ac.za

Fakulteit Gesondheidswetenskappe
Lefapha la Disaense tša Maphelo

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Health Sciences

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

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

14/11/2019

Approval Certificate
New Application

Ethics Reference No: 465/2018

Title: PERCEPTIONS OF RADIOGRAPHERS REGARDING ESTABLISHING A SELF-REGULATORY BODY FOR RADIATION CONTROL PURPOSES IN SWAZILAND

Dear Lungile Dlamini

The **New Application** as supported by documents specified in your cover letter dated 28/10/2019 for your research received on the 14/11/2019, was approved by the Faculty of Health Sciences Research Ethics Committee on its quorate meeting of 14/11/2019.

Please note the following about your ethics approval:

- Ethics Approval is valid for 1 year
- Please remember to use your protocol number (**465/2018**) on any documents or correspondence with the Research Ethics Committee regarding your research.
- Please note that the Research Ethics Committee may ask further questions, seek additional information, require further modification, or monitor the conduct of your research.

Ethics approval is subject to the following:

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

We wish you the best with your research.

Yours sincerely

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

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Research Protocol clearance certificate

Type of review	Expedited: X; Full Board:
Name of Organization	STUDENT (MASTERS)
Title of study	**Radiographers' attitudes towards establishing a self regulatory body for radiation control purposes in the diagnostic imaging departments in swaziland**
Protocol version	1.0
Nature of protocol	New: X; Amendment: ; Renewal:
List of study sites	Radiography Departments in all Four Regions of Eswatini.
Name of Principal Investigator	Ms Dlamini Lungile
Names of Co- Investigators	N/A
Names of steering committee members in the case of clinical trials	N/A
Names of Data and Safety Committee members in the case of clinical trials	N/A
Level of risk (Tick appropriate box)	Minimal: X; High:
Clearance status (Tick appropriate box)	Approved: X; Disapproved:
Clearance validity period	Start date: 26/11/2018; End date: 26/11/2019
Signature of Chairperson	
Date of signing	27/11/2018
Secretariat Contact Details	Name of contact officers: Ms Babazile Shongwe
	Email address: babazileshongwe@gmail.com
	Telephone no.: (00268) 24040865/24044905

MINISTRY OF HEALTH
27 NOV 2018
HEALTH RESEARCH REVIEW BOARD
SWAZILAND

Annexure E

Participant information leaflet and interview guide

PARTICIPANT'S INFORMATION & INFORMED CONSENT DOCUMENT

Researcher's name: Ms Lungile N. Dlamini.

Student Number: 25083075

Department of Radiographic Sciences

University of Pretoria

Dear Participant

I am a Masters student in Diagnostic Radiography in the Department of Radiographic Sciences at the University of Pretoria. You are invited to volunteer to participate in the research project on **PERCEPTIONS OF RADIOGRAPHERS REGARDING ESTABLISHING A SELF-REGULATORY BODY FOR RADIATION CONTROL PURPOSES IN RADIOGRAPHY DEPARTMENTS IN SWAZILAND**.

This letter gives information to help you to decide if you want to take part in this study. Before you agree you should fully understand what is involved. If you do not understand the information or have any other questions, do not hesitate to ask me. You should not agree to take part unless you are completely happy about what is expected of you. The purpose of the study is to explore the perceptions of radiographers regarding establishing a self-regulatory body that will control the safe use of ionizing radiation in the radiography departments in Swaziland. One to one interviews will be conducted using semi structured questions.

I will be conducting the interviews myself. The Research Ethics Committee of the University of Pretoria, Faculty of Health Sciences, telephone numbers 012 356 3084 / 012 356 3085 has granted written approval for this study.

Please note that your participation in this study is voluntary. You can refuse to participate or stop at any time without giving any reason. The information that you share on this interview will not be shared with any of the other participants and confidentiality will be maintained at all times. You will also not be identified as a participant in any publication that comes from this study.

In the event of questions asked which cause emotional distress, the researcher will able to refer you to competent counselling. The researcher has not included any questions that might cause, harmful risks, distress or discomfort to you. In case where one, feels that the questions asked are sensitive and cause distress, counsellors will be organised in each hospital to assist.

Note: The implication of participating in the interview is that informed consent has been obtained from you. Thus any information derived from you (which will be totally anonymous) may be used for e.g. publication, by the researchers. Anonymity will also include the names of the hospitals.

I sincerely appreciate your help.

Yours truly,

Ms Lungile N. Dlamini.

CONSENT FOR PARTICIPATION IN THE STUDY.

This study will involve the use of one to one interviews. This will take about 30 to 45 minutes. The purpose of the interview is to explore the perceptions of radiographers towards establishing a self-regulatory body that will oversee the safe and controlled use of ionizing radiation in the radiography departments in Swaziland.

I have read or had read to me in a language that I understand the above information before signing this consent form. The content and meaning of this information have been explained to me. I have been given opportunity to ask questions and am satisfied that they have been answered satisfactorily. I understand that if I do not participate it will not alter my management in any way. I also know that the interviews will be audio recorded. I hereby volunteer to take part in this study.

....

Participant's signature Date

INTERVIEW GUIDE

1. Can you tell me about the QC tests that you perform in your department and what you do with the results?
2. How do you think not doing QC tests impacts on radiation protection?
3. What radiation safety measures do you apply in protecting yourself, your patients and the public?
4. What are your perceptions with regards to establishing a self- regulatory body for radiation control purposes in the radiography departments in Swaziland?
5. What recommendations would you suggest to improve the current situation with regards to monitoring compliance and ensuring safety in all the radiography departments in the country?

Annexure F

Declaration of storage of research date

Principal Investigator Declaration for the storage of research data and/or documents

I, the Principal Investigator, Lungile N. Dlamini of the following study titled **RADIOGRAPHERS' ATTITUDES TOWARDS ESTABLISHING A SELF-REGULATORY BODY FOR THE MONITORING OF MEDICAL IMAGING SERVICES IN SWAZILAND.** I will be storing all the research data and/or documents referring to the above mentioned study at the following address: UNIVERSITY OF PRETORIA DEPARTMENT OF RADIOGRAPHY HW SNYMAN BUILDING NORTH LEVEL 4 ROOM 4.48

[*Please note:* The address must be at the Department where your research is performed and not your residential address]

START DATE OF TRIAL/STUDY: AUGUST 2018
END DATE OF TRIAL/STUDY: OCTOBER 2019
[This period includes the time needed for performing the research as well as writing up the results]

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

Until which year will data will be stored: My data will be stored for 15 years.

START OF STORAGE DATE: AUGUST 2018 until

END OF STORAGE DATE: AUGUST 2033

Name: LUNGILE N. DLAMINI

Signature: LDlamini **Date:** 4 JUNE 2018