Radiation protection and safety practices among medical imaging professionals in Addis Ababa, Ethiopia.

By

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RADIATION PROTECTION AND SAFETY PRACTICES AMONG MEDICAL IMAGING PROFESSIONALS IN ADDIS ABABA, ETHIOPIA.

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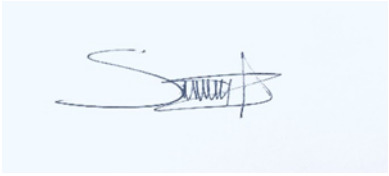

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DEDICATION

This dissertation is lovingly dedicated to my husband, Dr Aron Abera, whose unwavering support and encouragement have sustained me throughout my journey. To my children, Jonadab and Euodia, who are my source of inspiration and my greatest blessing. Thank you, my family.

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ABSTRACT

Background: Radiation exposure in medical imaging poses a potential health risk when safety protocols are inadequately practised. Despite awareness of radiation hazards, compliance with radiation protection measures among medical imaging professionals remains inconsistent across many healthcare settings.

Purpose: The study aimed to assess radiation protection and safety practices among medical imaging professionals in Addis Ababa, Ethiopia, and to identify gaps in their knowledge, attitudes, perceptions, adherence and enabling environmental factors influencing these practices.

Study setting: The study was conducted in four selected healthcare facilities in Addis Ababa, Ethiopia, among radiological technologists and radiographers.

Method: A quantitative, descriptive cross-sectional research design was employed. Data were collected through an electronic questionnaire completed by 82 respondents. Descriptive and inferential statistical analyses, including a Pearson correlation analysis, were conducted.

Results: The study population consisted mainly of Radiologic Technologists (RTs) (91.50%), of whom 64.6% were male, and 86.6% held a bachelor's degree. Knowledge of core radiation protection principles was high (74-85%, $p < 0.001$), but gaps persisted in operational, regulatory and equipment-related knowledge domains. Attitude was generally positive; however, prioritising efficiency over safety practices (47.8%) was reported among respondents. Self-reported practices were inconsistent, with low adherence to shielding use, dose monitoring, and standardised radiation safety protocols. High workload (90%), limited resources (76.8%), inadequate training (72%), and insufficient regulatory guidance (54.9) were key barriers. Practice demonstrated a moderate correlation with attitude ($r = 0.472$, $p < 0.01$), perception ($r = 0.514$, $p < 0.01$) and enabling environment ($r = 0.515$, $p < 0.01$) but not with knowledge ($r = 0.119$, $p = 0.287$).

Discussion: Generally, respondents demonstrated adequate knowledge and positive attitudes. However, deficiencies were observed in safety practices, including inconsistent adherence to shielding equipment, limited implementation of ALARA principles, and inadequate strategies to reduce repeat exposures. Although most respondents perceived their work as hazardous, this perception did not consistently translate into protective practices. High workload, limited resources, and insufficient training emerged as major barriers. Correlation analysis further revealed that attitude, perception and environmental factors had a stronger influence than knowledge alone.

Conclusion: Although awareness and attitude were favourable, the translation into consistent safety practices remains limited. Furthermore, environmental constraints and behavioural factors significantly influenced radiation protection practices, highlighting the need for stronger institutional support, regular training, and improved radiation safety culture.

Keywords: Attitude, Knowledge, Practice, Radiation protection, Radiation safety, Perception, Barriers, Radiographer, Health Belief Model, Enabling environment, Safety culture

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CHAPTER ONE

ORIENTATION OF THE STUDY

1.1 INTRODUCTION

Medical imaging modalities used for diagnosis, therapy, and procedural treatment have become an indispensable tool in modern healthcare. Technological advances in recent decades have driven rapid developments in diagnostic and therapeutic imaging systems, including X-ray, fluoroscopy, mammography, computed tomography (CT), magnetic resonance imaging (MRI), ultrasound, and hybrid imaging techniques. These imaging modalities utilise both ionizing and non-ionizing radiation (Services, Sassis, Kefala-Karli, Christou, Delage, Papapetrou & Heraclides 2020:1). While radiation provides significant benefits when used appropriately, modalities that involve ionizing radiation can pose considerable health risks. The biological effects of ionizing radiation are classified: deterministic effects, such as acute radiation sickness, epilation, and cataracts, caused by high doses of radiation that damage tissues and organs. In contrast, long-term stochastic effects involve genetic impact and an increased risk of cancer. These effects are probabilistic, as their likelihood increases with higher doses (Abuzaid, Elishama, Shawki & Salama 2019:447; International Commission of Radiation Protection (ICRP) 2012:6; Biegon, Cohen & Franceschi 2022:1; Allam, Algany, & Khider 2024:208).

Studies have reported that healthcare personnel who work with ionizing radiation have an increased likelihood of developing cancer compared to those who are not exposed, including patients (Behzadmehr, Doostkami, Sarchahi, Dinparast Saleh & Behzadmehr 2020:223). In medical uses of ionising radiation, it is therefore crucial to carefully weigh the benefits against potential health hazards, as the primary aim of any radiological examination is to produce a diagnostically useful image while minimizing unnecessary exposure. This balance is maintained by following the guiding principle of radiation protection and implementing appropriate safety measures (Kazemi, Hajimiri, Saghatchi, Molazadeh & Rezaeejam 2023:64; Rahman 2020:100).

1.2 BACKGROUND

Radiologic technologists (RTs) and radiographers are medical imaging professionals primarily responsible for ensuring radiation safety and effective use in imaging procedures (Abuzaid et al 2019:447). They optimise imaging techniques to achieve the required

diagnostic quality while minimizing unnecessary radiation exposure to patients, staff, and the public (European Society of Radiology (ESR), European Federation of Radiographer Societies (EFRS): 2019:26).

Imaging professionals' knowledge, attitudes, practices, perceptions and working environment are critical for protecting patients from unnecessary radiation exposure through effective compliance with radiation protection measures. Several studies have examined these aspects among healthcare professionals globally and have reported varied levels of awareness and compliance with safety practices. While some studies report a satisfactory understanding and implementation of radiation protection principles, others highlight significant gaps, including limited knowledge of radiation hazards and inconsistent use of protective equipment (Khamtuikrua & Suksompong 2020:5; Paolicchi, Miniati, Bastiani, Faggioni, Ciaramella, Creonti, Sottocornola, Dionisi & Caramella 2016:235).

In Africa, studies have identified a range of challenges, from resource limitations to inadequate training, that hinder the implementation of effective radiation protection practices (Lewis, Downing & Hayre 2022:56; Maina, Motto & Hazell 2020:636). In Ethiopia, the challenges are further exacerbated by a lack of research on radiation protection practices, with most of the existing studies focused either on patients' or physicians' perspectives (Amare & Dagne 2020:590). These limited available studies have identified several contributing factors to suboptimal radiation protection practices, including lack of ongoing training, negligence, and insufficient enforcement of safety guidelines. A study conducted in 18 public and private hospitals in Addis Ababa, Ethiopia, revealed significant inconsistency in medical imaging staff's choice of exposure factor parameters for the same X-ray procedure (Dellie 2022:12). These inconsistencies highlight the necessity for further research, professional training, and development of standardised operating protocols to ensure safe radiation practice among imaging professionals in Ethiopia.

1.3 RESEARCH PROBLEM

Radiation protection is a fundamental aspect of the professional practice of medical imaging professionals. During imaging examinations, these professionals are responsible for using appropriate exposure parameters and adhering to the ALARA principle of keeping radiation "As Low As Reasonably Achievable" to ensure radiation safety. However, fulfilling these responsibilities depends not only on their technical knowledge but also on their attitude, perception, and working environment. Despite the availability of

established radiation protection measures and safety guidelines, gaps in their implementation still exist, particularly in low-resource settings. Evidence from literature, supported by the researcher's observations during clinical practice, indicates that some imaging professionals continue to neglect radiation safety measures, resulting in avoidable radiation exposure for patients and staff. This is highlighted in a study conducted at Tikur Anbessa Specialised Hospital in Addis Ababa, Ethiopia, which reported that the utilisation of radiation protective equipment (PPE) among RTs and radiographers was unsatisfactory, a situation that was further exacerbated by resource limitations. (Lodamo 2021:20). Another study conducted in southern Ethiopia reported suboptimal radiation protection practices among imaging staff, attributed to a lack of ongoing training, non-use of shielding gear, failure to follow established guidelines, and insufficient supervision and monitoring to ensure compliance with radiation safety measures. The study also reported poor use of radiation-protective devices and personal dose-monitoring badges, providing further evidence of suboptimal radiation safety practices in Ethiopia (Geletu, Abiko & Sahlu 2017:2). The apparent disregard for radiation safety practices in Ethiopia highlights the need for a comprehensive evaluation and targeted interventions. While existing studies have explored radiation protection and safety practices in relation to knowledge, perceptions, and attitudes, there is an inadequate, integrated body of evidence examining how these elements interact with environmental and institutional constraints to influence safety compliance, particularly in resource-constrained settings such as Ethiopia. This gap limits a comprehensive understanding of the underlying causes of suboptimal radiation safety practices and further impedes the development of targeted interventions in Ethiopia.

This issue is of significant public health concern, as radiation protection is not only a technical matter. Repeated or unnecessary scans increase the risk of unnecessary radiation exposure, which may lead to increased cumulative long-term health risks for healthcare workers, patients and the environment. Radiation protection and safety practices in healthcare services align with global public health priorities, particularly the United Nations Sustainable Development Goals (SDGs) 3: Good health and well-being, which emphasises the provision of safe healthcare delivery (Rühm, Applegate, Bochud, Laurier, Schneider, Bouffler, Cho, Clement, German, Hirth, Kai, Liu, Mayall, Romanov, Wojcik 2024:474). Furthermore, these practices are guided by international radiation safety frameworks, including the World Health Organization (WHO) guidelines on radiation safety and patient protection, and the ICRP principles of justification, optimization and dose reduction (WHO 2024:2; ESR & EFRS 2019:27).

Given the impact of imaging professionals' knowledge, attitudes, perceptions and environmental factors on radiation protection practices, and their implications for the outcomes of radiological examinations and public health, this issue warrants further investigation. Therefore, this research aimed to examine imaging professionals' current radiation protection practices by assessing their knowledge, attitudes, perceptions, and environmental determinants influencing compliance. By addressing this gap, the study seeks to generate evidence-based recommendations for targeted interventions to improve compliance with radiation safety guidelines, thereby fostering a stronger radiation safety culture and safeguarding the well-being of both the public and imaging personnel. Furthermore, by aligning with global public health priorities, the study findings will contribute to strengthening the radiation safety culture in low-resource settings such as Ethiopia.

1.4 PURPOSE/AIM OF THE STUDY

1.4.1 Research aim

The study aimed to assess radiation protection and safety practices among medical imaging professionals in Addis Ababa, Ethiopia, and to identify gaps in their knowledge, attitudes, perceptions, adherence and enabling environmental factors influencing these practices.

1.4.2 Research questions

The objectives of this study are:

1. What is the knowledge of medical imaging professionals regarding radiation protection and safety measures?
2. What are the attitudes of medical imaging professionals towards the importance of radiation protection and safety in their daily practices in Addis Ababa, Ethiopia?
3. What are the current practices of medical imaging professionals in implementing radiation protection measures during routine procedures in Addis Ababa, Ethiopia?
4. What are the health perceptions and the environmental factors that influence imaging professionals’ compliance with radiation protection and safety practices?

1.4.3 Research objectives

The study is attempting to address the following questions:

1. To assess the knowledge of medical imaging professionals regarding radiation protection and safety measures in Addis Ababa, Ethiopia.

2. To investigate the attitudes of medical imaging professionals towards the importance of radiation protection and safety in their daily practices in Addis Ababa, Ethiopia.
3. To assess the current practices of medical imaging professionals in implementing radiation protection measures during routine procedures in Addis Ababa, Ethiopia.
4. To identify and analyse the health perceptions and environmental barriers that influence imaging professionals' compliance with radiation protection and safety practices.

1.5 SIGNIFICANCE OF THE STUDY

This study was significant because it provided insights into the current state of radiation protection and safety practices among medical imaging professionals. The study results could offer practitioners in the field a new perspective that enhances their professional development, potentially leading to improving their skills, radiation safety practices, and awareness. The identified gaps and subsequent recommendations aim to guide policymakers in developing targeted interventions such as ongoing education, training, and updated safety guidelines. Additionally, the researcher hopes the study will contribute to the existing body of knowledge in imaging science, particularly in the Ethiopian context, where notable gaps remain in the literature. Finally, the study recommendations can be implemented to create a safer healthcare environment for both patients and medical imaging staff and to enhance the quality of medical imaging services.

1.6 OPERATIONAL DEFINITION OF KEY CONCEPTS

The following terminology is defined to help the reader understand the proposed study. The following essential key concepts are defined and operationalized.

1.6.1 Ionizing radiation

Ionizing radiation is a form of energy composed of subatomic particles or electromagnetic waves that have enough energy to ionize molecules or atoms by stripping off their electrons. X-rays, gamma rays, and some high-energy ultraviolet parts of the electromagnetic spectrum are categorised under ionizing radiation (Talapko, Talapko, Katalinic, Kotris, Belić, Vasilj Mihaljević, Vasilj, Erić, Flam, Bekić, Matić, & Škrlec 2024:2). This study involved medical imaging professionals who operate imaging modalities that utilise ionizing radiation, including conventional and digital X-ray, fluoroscopy, mammography, and computed tomography (CT).

1.6.2 Radiation safety measures

Medical imaging modalities that use ionizing radiation require preventive measures during imaging procedures to minimize unnecessary exposure. Such measures include the use of radiation protection equipment, optimising exposure time without compromising image quality, maintaining a safe distance from the radiation source, and utilising a dosimeter to monitor occupational dose (Awosan, Ibrahim, Saidu, Ma'aji, Danfulani, Yunusa, Ikhuenbor & Ige 2016:7; Kim 2018:145). The study assessed medical imaging professionals' adherence to these radiation safety measures.

1.6.3 Radiation protection

Radiation protection is a set of principles and measures to minimize the harmful effects of ionizing radiation. Imaging professionals' adherence to the radiation protection principles of optimisation and justification plays a crucial role in reducing the adverse effects of radiation hazards (Awosan et al 2016:7). In this study, RTS and radiographers' knowledge and their compliance with radiation protection principles and safety measures were evaluated.

1.6.4 Radiologic technologist and radiographer

The terms radiologic technologists (RT) and radiographers are often used interchangeably in other countries. Both titles apply to medical imaging professionals who are responsible for operating diagnostic imaging machines and administering radiation doses independently (ESR and EFRS 2019: 27). In the context of the study setting, the title RT is used for professionals with a qualification of a bachelor's degree or above in radiologic technology. Radiographers are professionals with a qualification of a diploma in radiography.

1.6.5 Radiation shielding equipment

Radiation shielding equipment is a type of personal protective equipment (PPE) used in an environment where there is the use of ionizing radiation. In the context of this study, imaging professionals use radiation protective gear such as lead aprons, gonad shields, thyroid collars, eye goggles, and lead gloves both in the imaging unit and during mobile X-rays. These shields are designed to block or reduce scatter radiation and provide 75% protection of radiosensitive organs during imaging (Budošová, Horváthová, Bárdyová & Balázs 2022:554).

1.6.6 Knowledge

Knowledge is defined as a justified true belief or fact gained through association or experience (Bolisani 2018:2). In the context of this study, imaging professionals' knowledge was assessed based on their awareness of radiation hazards associated with ionizing radiation, and their understanding of radiation protection and safety measures.

1.6.7 Attitude

Attitude is a psychological tendency to respond with acceptance/rejection of a particular unit based on experience or external reality (Gaiseanu 2020:13). This study assessed imaging professionals' attitudes based on their approach responses towards radiation protection and safety measures, their professionalism, and sense of responsibility towards patient safety.

1.6.8 Practice

Practice in this context is defined as compliance with radiation protection principles, protocols, and safety guidelines set by different organisations and regulatory bodies (ESR & EFRS 2019: e27). This study assessed RTs' and radiographers' adherence to radiation safety measures and principles.

1.6.9 Health perception

Health perception is a cognitive process that influences health behaviours across the disease prevention and health promotion process (Dorri 2025:1). In the context of this study, the health perceptions and behaviours of imaging professionals towards radiation and safety practices were assessed based on the Health Belief Model constructs.

1.6.10 Enabling environment

An enabling environment is a supportive ecosystem that allows individuals to achieve a sense of freedom and progress (Loizeau, Morvillers, Bertrand, Kilpatrick, & Rothan-Tondeur, 2021:2). The study assessed how environmental factors affect Imaging professionals' compliance with radiation safety practices.

1.7 THEORETICAL FOUNDATION OF THE STUDY

1.7.1 Research paradigm

According to Polit and Beck (2022:76), a paradigm is a worldview, a broad lens through which the complexities of the world are understood. Paradigms shape how researchers explore and understand a particular phenomenon or problem. In this study, a positivist

paradigm was adopted because it is grounded in the assumption that reality is objective, measurable and can be scientifically analysed. Positivists believe in objective reality, and their approaches rely on strictly structured, systematic methods to understand the underlying causes of natural phenomena, unlike post-positivism, which seeks probabilistic evidence, and interpretivism, which is limited to subjective meaning (Kelly, Dowling & Millar 2018:9,10; Polit & Beck 2022:109).

Building on these assumptions, positivism reflects a deterministic approach to research, in which causes are assumed to determine effects or results. Therefore, the focus of research within the positivist paradigm is to identify and evaluate the factors that affect outcomes. This aligns with the study's aim of examining radiation protection practices and supports the objectives of assessing knowledge, attitudes, perceptions and environmental factors among imaging professionals. This paradigm was deemed appropriate as it provides a coherent framework for the study, enabling a structured approach to data collection using a standardised instrument and to the quantitative analysis of numerical data for patterns and relationships.

1.7.2 Conceptual framework

The study's purpose and methodology were guided by the Health Belief Model (HBM) and the Knowledge, Attitude, and Practice (KAP) model. HBM's theoretical framework is often used in a wide variety of health behaviours across diverse populations (Abraham & Sheeran 2015:31). The HBM proposes that an individual's perception of the seriousness and likelihood of health threat influences their health-related actions, as well as their motivation to engage in behaviours that reduce the threat (Polit & Beck 2022:109). The HBM comprises constructs that examine the link between health-related behaviours, practices, and healthcare services (Anuar, Shah, Gafor & Ghazi 2020:203). HBM is well-suited to understand medical imaging professionals' perceptions by examining their individual beliefs and behaviours towards radiation risk and benefit, and how their perceptions influence their radiation protection practices (Devi 2023:413). This will be discussed in detail within the purpose of the study in Chapter Two.

The KAP model is a survey-based framework used to assess the relationship between an individual's knowledge of a particular subject, their feelings and beliefs about it, and their corresponding actions. The data obtained from this model assists in identifying knowledge gaps, attitudes, and patterns of practice (Liao, Nguyen & Sasaki 2022:42). By combining both models, the researcher sought to understand the motivation factors underlying the health behaviours identified through the KAP framework.

1.8 OVERVIEW OF RESEARCH METHODOLOGY AND RESEARCH DESIGN

1.8.1 Research approach

Research approaches are comprehensive plans or a series of research procedures that guide the researcher from theoretical assumptions to detailed methods of data collection, analysis, and interpretation (Creswell & Creswell 2018:40). Based on the nature of the research issue, research questions, and objectives, a quantitative approach was used for this study.

1.8.2 Research design

A research design is a structured series of systematic steps a researcher follows to answer a research question or achieve a specific research objective (Brink, van der Walt, & van Rensburg, 2018:92). In this study, a descriptive cross-sectional design was deemed effective for the objectives.

1.8.2.1 Descriptive cross-sectional design

A descriptive design is useful for gaining detailed insights into specific characteristics within a particular population, and for reflecting phenomena as they naturally occur (Aggarwal & Ranganathan 2019:34). This design allows for observing and describing variables, their distributions, and their associations without manipulating variables or establishing cause-and-effect relationships (Polit & Beck 2022:125). This enables the researcher to capture the current state of radiation protection practices within the target population. In a descriptive cross-sectional design, data are collected from diverse individuals at a single point in time rather than repeatedly from the same participants; therefore, it is practical for studies with time and resource constraints (Gray & Grove 2020:185; Capili 2021:62). Descriptive cross-sectional designs are particularly relevant for assessing the prevalence, traits, or attributes within a sample population. This design, therefore, allows researchers to examine the relationship between variables, justify existing methods, develop theories, or lay the groundwork for further research (Setia 2016:262).

1.9 SCOPE OF THE STUDY

The study's scope is limited to evaluating radiation protection practices among imaging professionals at four healthcare facilities in Addis Ababa, Ethiopia. A questionnaire was used as a data-collecting method in this descriptive cross-sectional quantitative study. The study focused solely on radiologic technologists and radiographers, thereby

excluding other healthcare professionals who are part of the medical imaging team. While the findings of this study are specific to Ethiopian healthcare settings, they may also be relevant to other countries with comparable infrastructure and healthcare practices.

1.10 STRUCTURE OF THE DISSERTATION

The dissertation is divided into five chapters, which will be organised as follows:

1.10.1 Chapter One: Orientation of the study

The chapter provides an overview of the study background, outlining the research problem, its significance, aim, objectives, and research questions. The chapter concludes by delineating the scope of the study.

1.10.2 Chapter Two: Literature review

The chapter discusses literature relevant to the study topic and provides theoretical support and rationale behind conducting this study. It also provides insights into research methodologies, which was valuable in guiding the researcher in identifying the most suitable methodology for this study.

1.10.3 Chapter Three: Study design and methodology

The chapter outlines the research design and methodological steps employed in the study. It further details and justifies the study population, the data collection procedure, the measurement tool and the data analytical method applied. In addition, it addressed the ethical considerations and measures taken to ensure rigour and credibility of the research.

1.10.4 Chapter Four: Analysis and presentation of the research findings

This chapter presents data analysis, data presentation, data management and an overview of the research findings.

1.10.5 Chapter Five: Discussion of the research findings

This chapter will provide a detailed discussion of the research findings in relation to existing literature and the stated study objectives.

1.10.6 Chapter Six: Conclusions and Recommendations

This chapter summarises the key study findings and outlines the conclusion, limitations and recommendations arising from the study.

1.11 SUMMARY

This chapter provided an overview of the study by summarising the current understanding and background information pertinent to this study. It presented the problem statement, significance, research aim, objectives and research questions. In addition, it also outlined the theoretical framework and scope of the study as well as the structure and organisation of the entire research. The following chapter will present the literature review, which supports the background and problem statement of the study.

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION

A literature review is a comprehensive, critical and objective summary of existing literature pertinent to a research question. A good literature review should establish a connection with the research question and guide the methodological frame of the study (Luft, Jeong, Idsardi & Gardner 2022:3). In quantitative research, a literature review directs the research plan and execution by guiding researchers to identify and establish a theoretical or conceptual framework that allows them to select the right methodology, analysis, and research tool for accurately measuring a study's variables (Brink, van der Walt & van Rensburg 2018:43,58).

The previous chapter primarily presented the introduction and the background of the study. This chapter will discuss the relevant literature on general concepts of radiation protection in medical imaging and delve into radiation protection and safety practices of medical imaging professionals, focusing on global, African and Ethiopian contexts. Additionally, the literature review also examined the methodologies and theoretical or conceptual frameworks employed in similar studies. This helped the researcher identify the most suitable approach for the study.

Various search engines, including PubMed, Google Scholar, Scopus, and Science Direct, were used to access articles, books, and journals relevant to the study. The following keywords were used to retrieve articles related to the study topic. The keywords were: Attitude, Knowledge, Practice, Radiation Protection, Radiologic Technologist, Radiographer, Perception, Environmental Barriers, Radiation Safety measures, safety culture and Health Belief Model. During the initial literature search phase, over 130 articles were identified using specific keywords related to the study's focus. To refine the selection, the titles and abstracts of these articles were screened to determine their relevance to the study's objectives. As part of the screening process, articles that are non-medical imaging and older publications were excluded to maintain the quality and relevance of the literature review. Ultimately, 58 papers published in English between 2015 and 2024 were selected for further analysis. These papers were chosen based on their relevance to the study question and objectives. Prioritising recent publications

ensures that the literature review is grounded in recent data and lays a solid foundation for the scope of the study.

2.2 RADIATION PROTECTION IN MEDICAL IMAGING

Medical imaging is the most long-standing application of ionizing radiation in modern healthcare. Despite its significant public health benefits, it also possesses a potential health risk. The application of ionizing radiation in medicine involves different classifications of exposure, each with specific requirements for radiation protection and safety. These categories are occupational exposure (for those involved in performing medical imaging and procedures), medical exposure (for patients undergoing radiological imaging), and public exposure (for accompanying carers in waiting areas) (IAEA 2016:15).

The International Commission on Radiological Protection (ICRP) proposes three general principles that form a foundation strategy for radiation protection and safety: justification, optimization, and dose limitation. These principles serve as a foundation for radiation dose management to protect patients, medical professionals, and the public from the harmful effects of ionizing radiation (ESR & EFRS 2019:27).

These principles are defined as follows:

2.2.1Justification: evaluating the appropriateness of the imaging examination or procedure (Frane & Bitterman: 2023). In medical exposure, a three-level approach is used to apply the principle of justification.

Level 1. The goal of radiation protection is to ensure the safety of patients and others. Therefore, the benefit of any imaging procedure must outweigh the potential risks, with efforts made to minimize the risk.

Level2. The examination should only be performed by qualified imaging professionals and must follow the current standards and imaging techniques.

Level 3. Patient-tailored radiological procedures need to be performed. This process includes determining which imaging modality is appropriate for the patient based on the clinical history (IAEA 2016:17).

2.2.2 Optimization of protection and safety: ensuring that the likelihood of incurring exposure, the number of individuals exposed, and the level of individual doses are as low as reasonably achievable (ALARA) without compromising the image quality (IAEA

2016:18). ALARA is a fundamental radiation safety principle that aimed at minimizing radiation exposure by optimizing three key factors:

1. **Time**: minimizing exposure time reduces the accumulated radiation dose to the patient.

2. **Distance**: increasing distance between the patient and the radiation source decreases radiation exposure.

3. **Shielding**: structures and personal protective equipment (PPE) such as walls, rolling shields lead apron, thyroid collar, gonad shields, and lead gloves act as a physical barrier by absorbing or deflecting radiation during imaging.

In addition to these principles, accurate patient identification, correct recording of details, thorough review of clinical history, and the use of immobilizers, beam restrictive devices and patient positioning aids all play a key role in protecting the patient from unnecessary radiation (Frane & Bitterman: 2023).

2.2.3 Dose limits**:** in planned exposure, the total dose from a regulated source should not exceed the recommended limits by the ICRP. Dose limitation inherently does not apply to medical imaging procedures performed on patients; instead, Diagnostic Reference Level (DRL) are used as a standard dose benchmark (Kyung-Hyun Do 2016:7).

2.3 LITERATURE REVIEW ON RADIATION PROTECTION IN MEDICAL IMAGING

Understanding medical imaging professionals' knowledge, attitudes, practices, perceptions, and environmental factors influencing radiation protection compliance is important for ensuring patient and staff safety as well as for fostering a radiation safety culture. Several global studies have investigated current practices in this area, focusing on medical imaging professionals' radiation protection knowledge, attitudes, practices, perceptions and environmental barriers influencing practices. These observations yielded valuable observations and insights into current practices and factors that influence compliance (Erkan, Yarenoglu, Yukseloglu & Ulutin 2019:456; Behzadmehr, Doostkami, Sarchahi, Dinparast Saleh & Behzadmehr 2020:223).

2.3.1 Knowledge of medical imaging professionals on radiation protection and safety.

Medical imaging professionals have an ongoing responsibility for maintaining radiation safety in all diagnostic procedures. Their knowledge and expertise in radiation protection and safety are essential for delivering safe and high-quality healthcare services (Moolman, Mulla & Mdletshe 2020:117). However, studies have shown varying levels of

knowledge among medical imaging professionals regarding radiation protection and safety. Several studies highlighted a concerning lack of knowledge about radiation protection and dose-related issues in commonly performed imaging examinations (Faggioni, Paolicchi, Bastiani, Guido & Caramella 2017:136,137). These findings are consistent with a study by Talab, Mahmodi, Aghaei, Jodaki, and Ganji (2016:93), in which only 4.3% of participants demonstrated a high level of awareness of radiation protection. Interestingly, recent graduates outperformed their senior counterparts, and a higher level of knowledge was associated with participants holding advanced academic qualifications.

On the contrary, a study by Asadian and Zarghani (2018:224) reported an inverse relationship between radiographers' level of knowledge, practice and work experience, indicating that as their work experience increased, their knowledge and attitude declined. These shortcomings highlight the gap in providing on-the-job training and oversight of medical imaging professionals' performance. After several years of practice, imaging professionals not only fail to acquire new knowledge but may even forget the fundamental concepts and ultimately rely on their experience.

Insufficient Knowledge has been linked with poor radiation safety practices. For example, in the study by El Kherrat Saida, Manar Nadia, El Bouri Hicham, Deschamps Frédéric, and Laraqui Chakib (2024: i483), investigating the radiology staff's knowledge, attitude, and practice on radiation protection found that 29.2% of the staff were unaware of the fundamental principles of radiation protection, and 74% did not understand the objectives of radiation protection. A study conducted in Italy reported that one-third of surveyed imaging professionals were not aware of which tissue was highly susceptible to the effects of ionizing radiation (Paolicchi, Miniati, Bastiani, Faggioni, Ciaramella, Creonti, Sottocornola, Dionisi & Caramella 2016:235). The lack of a fundamental understanding of radiation protection objectives in these studies, coupled with insufficient knowledge of identifying radiation-sensitive anatomical structures, raises concern regarding the implementation of safety measures and dose optimization among imaging professionals.

Dose optimization is one of the fundamental elements of radiation protection practice. Imaging professionals are expected to be familiar with various imaging techniques and image acquisition parameters. These parameters include peak kilovoltage (kVp), tube current-time product (mAs), pitch, slice thickness, automatic tube current modulation (ATCM), signal-to-noise ratio (SNR), detector configuration, and reconstruction algorithms, all of which affect radiation dose and image quality. These parameters are crucial in obtaining a balance between radiation dose, image quality, and diagnostic

accuracy (Dudhe, Mishra, Parihar, Nimodia & Kumari 2024:4). Selecting correct imaging parameters is one of the crucial tasks for imaging professionals for achieving diagnostic image quality that adheres to the principle of ALARA. Mahmoudi, Naserpour, Farzanegan, and Davudian-Talab (2019:43,46) reported that the overall knowledge of imaging professionals regarding the effects of imaging parameters on image quality and patient dose was lower compared to similar studies. In addition, a notable knowledge gap was also found regarding a diagnostic reference level (DRL), with most participants being unable to identify the correct values. Similarly, a study in China revealed inconsistencies in the levels of knowledge regarding radiation protection among participant radiographers. Of the study participants, only 35.22% demonstrated a solid understanding of radiation protection and safety, and only 53.91% strictly followed radiation safety measures. The study further highlighted a positive relationship between knowledge and both education level and work experience, showing that participants with higher qualifications and more experience possessed better knowledge (Liu, Dahlan, Wu & Rahman 2024:391,392).

During computerised tomography (CT) examination, imaging professionals' knowledge of correct patient positioning is crucial for the optimal function of automated dose reduction tools and for obtaining accurate CT values (Al-Hayek, Spuur, Davidson, Hayre, Currie & Zheng 2024:101). However, studies have shown that imaging professionals frequently fail to center the patient within the gantry. This significantly influences the X-ray beam attenuation as well as the perceived dimension of the patient, thus affecting radiation dose and image quality. Patients' mispositioning may be attributed to inadequate knowledge and training, level of education, and limited professional experience (Barreto, Lamoureux, Olguin, Quails, Correa, Rill & Arreola 2019:142). A study by Al-Hayek et al (2024:103) reported that only 21.93% of participants correctly recognised that the localisation direction can affect radiation dose when the patient is incorrectly centered, highlighting a concerning lack of awareness regarding the consequences of patient mispositioning.

Sharma, Singh, Mandal, and Poudel (2019:19,20) found that nearly all participants demonstrated a comprehensive understanding of radiation protection and safety measures required during imaging procedures. However, with respect to personal protection, only 8.7% use their dosimeters. The study further revealed that radiation protection devices were often not utilised either due to unavailability or negligence by the participants. Despite high overall levels of knowledge, the gap between knowledge and

practice necessitates careful attention and further investigation to identify the possible cause of this disparity. In contrast, Radzi and Ananda Raj (2023:15,18) reported a significant positive correlation between the levels of knowledge and practice. Although the study findings revealed high knowledge scores, the low percentage of accurate responses regarding dose limits and radiation exposure is still concerning, as these two concepts are critically significant for ensuring safe radiation practice.

Several studies have been conducted from African perspectives. In Ghana, a study assessing radiographers' knowledge and practices regarding radiation protection revealed a high level of knowledge among participants. Most were well-informed about the safety measures, with over 90% using their dosimeters to monitor radiation dose. Despite these, the use of radiation protective gear such as lead aprons, gloves, and thyroid collars was largely neglected (Fiagbedzi, Gorleku, Nyarko & Asare 2022:150,151). A similar study conducted in Egypt also found a non-significant relationship between awareness and adherence to radiation protection protocols among healthcare workers across various departments. Out of 95 participants who demonstrated satisfactory awareness, only 35 or 36.8% had adequate practice (Salah Eldeen & Farouk 2020: 539).

Although radiation hazards and radiation safety awareness are closely related, a study conducted in Nigeria revealed that most participating radiographers had only an average radiation safety knowledge, despite demonstrating a high awareness of the radiation risks associated with C-arm machines used in operating in theatres (Chiaghanam, Esien-umo, & Effa 2022:24,25). This finding shows that knowledge does not always translate into effective safety practice. This is consistent with a study conducted by Moolman et al (2020:120), where the majority of participants were familiar with the ALARA principle theoretically; only a few were able to apply it within their department. The study found that 72.1% of participant radiographers were unable to identify the cumulative dose for paediatric chest X-rays, indicating limited awareness in dose optimization in paediatric imaging. To address these gaps, the study emphasised the need for on-the-job training and continuous education of radiographers to minimize unnecessary radiation exposure among paediatric patients. These recommendations are echoed by other studies highlighting the need to enhance staff competence through training and continuous education focused on radiation protection and safety practices (Zervides et al 2020:5; Alsleem, Davidson, Al-Dhafiri, Alsleem & Ameer 2019:236).

A study conducted on medical students in Gonder, Ethiopia, reported that only 45.5% of participants had a basic knowledge of medical radiation and its associated health risks.

Inadequate awareness of radiation protection among healthcare professionals was associated with a lack of on-the-job training and continuous education (Amare & Dagne 2020:594). Similarly, a study by Zewdu, Kadir and Berhane (2017:489) highlighted a significant variation in technical parameters selection by radiographers and RTs, which may have adversely affected the radiation dose administered to patients. This variability was ascribed to various factors, mainly to their proficiency, and the absence of adult and paediatric-specific protocols, as described by Dellie (2022:12). In addition to ensuring staff competence through training and targeted education, it is also important to implement radiation protection legislation and designate advisers to monitor radiation safety practices. This approach can improve efficiency, productivity and create a safe imaging environment for the imaging professional, patient, and the general public (Geletu et al 2017:4).

2.3.2 Attitude of medical imaging professionals towards radiation protection and safety.

The attitudes of imaging professionals towards radiation protection and safety are shaped by multiple factors. Evidence from recent studies associates a positive attitude with strong education protection knowledge, in-house training, consistent regulation and a positive departmental safety culture (Rose, Uebel & Rae 2018:9). In Iran, a descriptive cross-sectional study involving 540 participants assessed the status of KAP in radiation safety. The study revealed a strong association between education level, attitude, knowledge, and years of experience. Participants with lower qualifications and limited work experience demonstrated poorer attitudes, highlighting the need for further education and training to improve their performance. Additionally, the study also found that while the average attitude score on radiation safety was much higher, both the knowledge and practice scores fell below average (Mohammad Amin, Mohammad, Emad, Morteza, Salar & Mahsa 2024:299,300). This gap highlights that a positive attitude does not necessarily translate into satisfactory safety practice.

Radiation shielding is an essential component of radiation protection practice. In radiological imaging, lead contact shields are primarily used to protect radiosensitive organs from scattered and extra-focal radiation. However, studies have reported a decline in the use of contact shields among imaging professionals. This is often linked to the absence of departmental protocol guidance, unavailability of equipment, and fear of mispositioning shields (Ahern, McEntee & Moore 2023:416,418). Hayre, Blackman, Carlton, and Eyden (2017:5) reported that the use of radiation protection equipment often followed an ad hoc approach, with radiographers only providing it upon patient request.

They also reported that attitudes and perceptions regarding lead contact shielding were influenced by personal beliefs, cultural norms, and peer discussions more than evidence-based practices, leading to inconsistent and unsafe radiation safety behaviours. This is supported by a study by Ahern et al (2023:417), where 50% of participants believed children should receive different consideration in radiation protection, compared to 34% who thought children should be treated the same as adults and 15% who were unsure of the correct protocol for using lead contact shielding on children. These inconsistencies in radiation safety practices emphasise the urgent need for evidence-based guidance to strengthen the radiation safety culture.

According to Lewis, Dawning and Hayre's (2021:50) study, which assessed radiographers' perceptions of radiation protection practices. Participants reported a strong intention to apply radiation safety measures during examinations. However, there were instances when they felt rushed, leading them to prioritise radiation protection measures less. Participants further reported that implementing radiation protection practices would be easier in a department that fosters a culture of radiation safety. This finding is consistent with a study in Iran, where a lack of standardised protocols and inadequate monitoring by authorities contribute to poor attitudes and adherence to radiation protection practices among radiographers (Asadian & Zarghani 2018:224). Although imaging professionals' attitudes may be influenced by multiple factors such as workload, patient type, time constraints, ineffective monitoring, and absence of departmental protocol, it remains their professional and ethical responsibility to commit and to prioritise safety practices.

At times, negative attitudes towards the use of radiation protective equipment, such as lead aprons, are related to the discomfort and inconvenience associated with wearing them. One study reported that participants expressed a negative sentiment when required to wear lead aprons, citing their heaviness and unpleasant odour (Goula, Chatzis, Stamouli, Kelesi, Kaba, & Brilakis 2021:11). In addition, studies have also reported colonies of pathogenic organisms had been detected in thyroid shield garments due to lack of awareness regarding appropriate disinfection methods without damaging the equipment (Jaber, Harvill & Qiao 2014: s99). The lack of departmental protocol and insufficient training on infection control for these garments led some participants to avoid wearing them during procedures. This is consistent with a study that reports imaging professionals avoiding radiation-protective devices due to hygiene concerns. Their attitude significantly influences their behaviour towards using radiation protective

equipment, resulting in inconsistency in their radiation protection practices (Mohd Ridzwan, Bhoo-Pathy, Isahak & Hum Wee 2019: 5,6).

2.3.3 Radiation protection and safety practices among medical imaging professionals

Evaluating current practices is crucial for identifying gaps and developing appropriate solutions to enhance the healthcare service delivery and foster a strong radiation safety culture. Imaging professionals are responsible for adopting radiation-protective measures during imaging. However, incorrect applications of safety practices may result in an increased patient dose. Non-compliant radiation protection and safety practices have been reported in multiple studies. For example, a study in Finland reported that errors such as incorrect patient identification, equipment malfunction, and the use of wrong protocols resulted in unnecessary radiation doses to patients (Tarkiainen, Haapea, Liukkonen, Tervonen, Turpeinen, & Niinimaki 2020:2,3). A meta-analysis of 11,543 pelvic radiographs found that only 34% of X-rays were centerd accurately (Karami, Zabihzadeh, & Shams 2017:118). Suboptimal practices were primarily attributed to a lack of knowledge or skills in correctly positioning shielding devices, as well as the avoidance of the gonad shield in female patients due to fears of obscuring the anatomy of interest. Additional evidence from a study by Kaplan, Magill, Felice, Xiao, Ali and Zhu (2018:233) confirmed that even when gonad shields are used, incorrect positioning can increase the radiation dose absorbed by ovaries in female patients.

Some medical imaging professionals disregard radiation protection measures, even though they are responsible for communicating the risks and benefits of radiological procedures, obtaining informed consent, and addressing patient questions and concerns (Ketema, Kekana, Essop & Msonza 2021:1025). A study conducted by Maina, Motto, and Hazell (2020:636) in public hospitals in Rwanda revealed a reluctance among radiographers to use available radiation safety equipment. This is consistent with a study conducted in South Africa, which found that despite radiographers' awareness of radiation protection and the legislated principles, compliance was often a matter of personal choice. Imaging professionals reported that increasing workload, limited resources, and challenging patient conditions were reported by radiographers as key contributors to poor adherence (Lewis, Downing & Hayre 2022:56).

Radiation protection and safety practice are essential to enhance diagnosis and treatment, improve patient and personnel safety and reduce unnecessary radiation exposure. However, empirical studies revealed a disparity between theoretical

understanding and the actual situation in practice in clinical settings. Moolman et al (2020:120) reported inconsistent protocol implementation among radiographers, with more than half of the participants being uncertain about the purpose of exposure indicators. And many mistakenly assumed that paediatric exposures should be scaled down as “smaller adults”, which could potentially result in unnecessarily higher radiation dose for paediatric patients. This is in line with a study by Lewis, Pieterse and Lawrence (2019:3,4), which found that only half of the participants had a correct understanding of exposure indicators, despite 91.3% of participants having received training in digital radiography. Furthermore, the study also revealed that about 33% of participants believed that the danger of radiation exposure to patients is grossly overstated, further highlighting the gap between practice, knowledge and perception.

Radiation protection in paediatric imaging requires special attention as children are more susceptible to the harmful effects of ionizing radiation. Imaging professionals must select the correct imaging parameter depending on the patient's age and examination requested (Paolicchi, Bastiani, Negri & Caramella 2020:34). A study conducted in the assessment of radiation exposure among paediatric patients referred for CT imaging in Ethiopia showed that paediatric patients, particularly those under one year old, were exposed to higher radiation doses. The study emphasises that such exposure could be reduced by optimising scan techniques and updated departmental protocols (Tesfaw, Dellie, Legesse, Gebremedhin &Seid 2024:4). A similar study in Jimma, Ethiopia, also found that during routine X-ray examination, the entrance skin dose in paediatric patients was higher than that reported in international studies. The technical parameters selected by the imaging professionals were above recommended levels and failed to adhere to the principle of dose optimization (Zewdu, Kadir & Berhane 2017:489,490).

Although legal frameworks exist for diagnostic and interventional radiology, there are limited studies on radiation protection and safety practices in Ethiopia. The available literature are scares and primarily focuses on RTs and radiographers. Most existing studies on the Ethiopian context examine the perspectives of other healthcare professionals or patients. (Asefa, Getnet & Tewelde 2016:228; Teferi, Zewdeneh & Bekele 2018:383) This further justifies the need to assess medical imaging professionals' radiation protection and safety practices, as they are the final gatekeepers in the radiation protection and safety practice hierarchy.

2.3.4 Health perceptions and environmental barriers that influence imaging professionals' adherence to radiation protection practices.

Imaging professionals' radiation safety compliance can be influenced by behavioural and environmental factors. Their perceptions of risk have a significant effect on the adoption of radiation protection practice. According to the HBM, individuals' health beliefs are based on their perceptions of threat, benefits and barriers in preventative action. Shubayr's (2024:142) study on radiologic technologists' commitment to radiation protection equipment reported that only 63% of participants are committed. This result aligns with their perceived susceptibility mean score (2.89), indicating that participants did not perceive themselves as susceptible to radiation hazards, thereby potentially reducing their adherence to safety practices.

Health perceptions play an important role in shaping behaviour and safety practices, particularly in healthcare settings where risk and workload are high. Studies have reported that healthcare professionals' perceived barriers to poor compliance with clinical practice guidelines are attributed to time constraints, patient compliance, and availability of equipment. Such barriers hinder the consistent applications of safety practices (Smiddy, O Connel, & Creedon, 2015:269; Barth, Misra, Aakre, Langlois, Watine, Twomey, & Oosterhuis 2016:1132). Similarly, a study examining barriers to radiographers' adherence to radiation safety principles identified three main categories that explained non-compliance with practices such as pregnancy confirmation, patient compression and gonad shield use. Participants' perceptions of the barriers contributing to non-compliance with radiation safety measures were influenced by various factors, including patient characteristics, the nature of the examination, the availability and usability of equipment, and the quality of interaction between the imaging professional and the patient (Christensen, Bjällmark, Ndipen, Afram & Bazzi 2024:216,217).

The importance of promoting a strong radiation safety culture in radiology has been highlighted in various studies. It encompasses not only the technical aspect but also organizational factors. While imaging professionals' knowledge, behaviours and attitudes play a crucial role in guiding their radiation protection and safety practices, numerous barriers can impede the development of an effective safety culture. For example, inadequate communication, lack of training, poor staffing, and insufficient management support have all been identified as contributing factors to safety lapses, despite participants showing good awareness of patient safety culture and holding positive views of their safety practices (Wallin, Bazzi, Ringdal, Ahlberg & Lunden 2023:613,614).

Furthermore, the absence of routine quality assurance also serves as a barrier to safety, as it increases unnecessary radiation risks for staff and patients. In Ethiopia, inadequate quality assurance was linked to high radiation exposure, raising occupational doses for staff (Geletu et al 2017:2). A recent study by Alemayehu, Bogale and Bazie (2023:10) focusing on radiation workers in eastern Amhara, Ethiopia, found that the collective occupational radiation exposure among radiology personnel was twice as high as levels reported in similar studies conducted in China, Ireland, and Saudi Arabia. The lower deep-dose equivalent in these countries is attributed to the use of advanced imaging modalities and ongoing staff education and training of radiation workers, highlighting the importance of adhering to radiation protection practices.

Other studies have also reported disparity in safety practices. According to Umaru, Yusuf, Idris, and Hambali (2024:43), 92% of participants demonstrated a strong understanding of radiation protection principles. The study also reported good radiation safety practices and regular quality control assessments of imaging modalities and emphasised the need for up-to-date PPE and imaging modalities. However, outdated radiation protection equipment may compromise compliance with optimal safety standards and potentially affect safety practices despite good knowledge and attitudes. Similarly, a study by Lewis, Downing and Hayre (2023:211) revealed suboptimal radiation protection practices in South Africa. Although participants possess sufficient knowledge and a positive attitude, a disconnect exists in the implementation. This discrepancy underscores the importance of investigating the barriers that lead to suboptimal practices. Therefore, the fourth objective of the current study was to identify and analyse health perception and environmental challenges that influence imaging professionals' adherence to radiation protection and safety practices.

2.3.5 Research methodologies in the reviewed literature

In this literature review, it was observed that most studies employed a quantitative descriptive cross-sectional approach to address their study objectives. Few studies opted for a mixed-method approach to obtain more comprehensive insight. For example, Lewis et al (2023:208) applied a focus group qualitative approach in their second phase of data collection, enabling the researchers to identify strategies to enhance safety practices that might have been overlooked had they solely relied on surveys. A systematic review of 41 studies on radiation protection among healthcare workers' knowledge, attitudes, practices, and clinical recommendations by Behzadmehr et al (2020:223,226) revealed that 46.3 % of studies used convenience sampling and 43.9% employed a census

approach. Regarding data collection, 98% of the studies used a researcher-developed data collection tool, and almost all used self-report. However, during the literature review, the researcher observed an absence of standardised tools despite the existence of similar research conducted globally. Nevertheless, using a researcher-made tool is also a justifiable approach, considering that every research problem is unique to a study setting.

2.4 CONCEPTUAL FOUNDATION OF THE STUDY.

Conceptual models involve assembling relevant abstractions or concepts that are connected to a common theme. They offer a conceptual perspective on interconnected phenomena. A framework serves as a foundational concept for a study. In studies based on a conceptual model, the framework may be referred to as a conceptual framework, reflecting the researcher's understanding of the factors and/or variables of the study and their relationship to one another (Polit & Beck 2018:192; Luft, Jeong, Idsardi & Gardner 2022:3). These relationships serve as a guiding framework for the methodology of a study. The conceptual framework of the study was guided by the Knowledge, Attitude, Practice (KAP) model and Health Belief Model (HBM) to assess knowledge, attitudes, health perceptions and environmental factors influencing compliance with radiation protection and safety practices among imaging professionals. By applying a dual-framework approach, the researcher aimed to gain holistic insights into the factors influencing imaging professionals' compliance with radiation protection and safety practices, extending beyond knowledge and attitudes to include motivational and environmental factors, and recommend a comprehensive targeted intervention.

2.4.1 Knowledge, Attitude, Practice (KAP)

The KAP model enables researchers to examine the understanding of health behaviour and outcomes within a specific population. An individual’s knowledge of a particular health issue, their attitude towards it and their practices related to it are interconnected (Chandler 2024:1). Theoretically, the level of individual knowledge of a certain health issue can shape their engagement in healthier behaviour. However, knowledge does not automatically prompt behavioural responses (Luo, Chen, Yang & Hong 2022:2). For example, a study by Sharma et al (2019:19,20) reported a gap between participants' knowledge and practice on radiation protection, whereby there was a high knowledge score but poor practical application. Attitude is another moderating variable for certain health behaviours. It serves as a guide and motivation for individual behaviours, driving an individual's intention to take a certain action (Rucker 2021: 39). The KAP model provides insight into how knowledge shapes attitude and subsequently influences

behaviour. However, this model may not address the psychological or contextual factors that influence the translation of knowledge into action (Abu Hasan, Abidin, Ganggayah, Jamal, & Abdul Aziz 2022:39). This limitation necessitates the need to integrate the HBM model.

2.4.2 Health Belief Model (HBM)

The HBM provides a detailed analysis of the psychological factors that influence health behaviours through its constructs. It helps researchers gain an in-depth understanding of how individual perceptions and external factors may facilitate or hinder behavioural changes (Skinner, Tiro & Champion 2015:77). The HBM is designed to assess individual health behaviours by analysing their perceptions and attitudes towards diseases and the adverse outcome of a certain action. It is conceptualized around individual beliefs and attitudes structured in four constructs that capture the perceived threat and the overall benefits of taking preventative and corrective action (Mukumbang, Van Belle, Marchal & van Wyk 2017:2). The main assumption of this model is that individuals are likely will act if they perceived a threat to their health and believe the benefits of engaging in health-promoting behaviours outweigh the potential consequences associated with it. Several key factors influence individual motivation to adopt preventative, or health-promoting behaviours. These factors are a) their health perception; b) modifying factors such as demographic factors, socio-psychological factors and structural factors (knowledge, access to healthcare), and c) perceived benefits of preventive measures (Tarkang & Zotor 2015:2). This model therefore offers a comprehensive view for understanding individual perception of susceptibility, severity, benefits and barriers that influence health behaviours.

The HBM constructs are discussed within the purpose of the study below.

2.4.2.1 Perceived susceptibility is an individual's belief about their likelihood of being affected by a particular health condition or disease (Green, Murphy, Sweeny & Gryboski 2020:4). Imaging professionals' perception of their vulnerability to the adverse effects of radiation exposure depends on their awareness of radiation hazards and familiarity with radiation protection and safety guidelines. Furthermore, their personal experiences with radiation-related health issues further shaped their perceived susceptibility.

2.4.2.2 Perceived severity is an individual's belief about the seriousness or impact of a health condition or disease (Devi 2023:415). The perceived severity of radiation-related

health concerns is influenced by imaging professionals' comprehension of the potential long-term effects of ionizing radiation exposure.

2.4.2.3 Perceived benefit is a personal belief in the effectiveness of a recommended health action or behaviour (Green et al 2020:4). Imaging professionals' awareness of safety protocols, knowledge of radiation protective equipment, and understanding of the role of safety measures influence perceived benefit. Their individual beliefs will give them the confidence to engage in a certain preventative behaviour. For example, if imaging professionals believe that using PPE effectively reduces the potentially harmful effects of ionizing radiation, they are more likely to use it consistently.

2.4.2.4 Perceived barriers are an individual's beliefs about the difficulties or costs involved with taking a specific health intervention (Green et al 2020:4). Lack of awareness or training, resource limitations such as PPE, time constraints, and competing priorities can all influence how imaging professionals perceive and assess the challenges in implementing radiation protection and safety practices.

2.4.2.5 Self-efficacy is a person’s confidence in their competency to carry out a prescribed health measure (Adiyoso, Wilopo, Mondry, Nurbaiti & Suprapto 2023:2). Knowledge, previous training and experience in radiation protection, a supportive work environment, and availability of relevant resources can all influence imaging professionals' abilities to undertake radiation protection and safety measures.

2.4.2.6 Cues to Action: These are internal and external factors that encourage people to do something to protect their health (Adiyoso et al 2023:2). The motivating factors that prompt imaging professionals to act to safeguard themselves and others from radiation exposure. Examples of such cues include introducing workplace safety policies, professional guidelines and regulations, continual training, reminders about safety protocols, and supervisor feedback on their actions.

The framework of the study is adapted from the Health Belief Model by Abraham & Sheeran (2015:3).

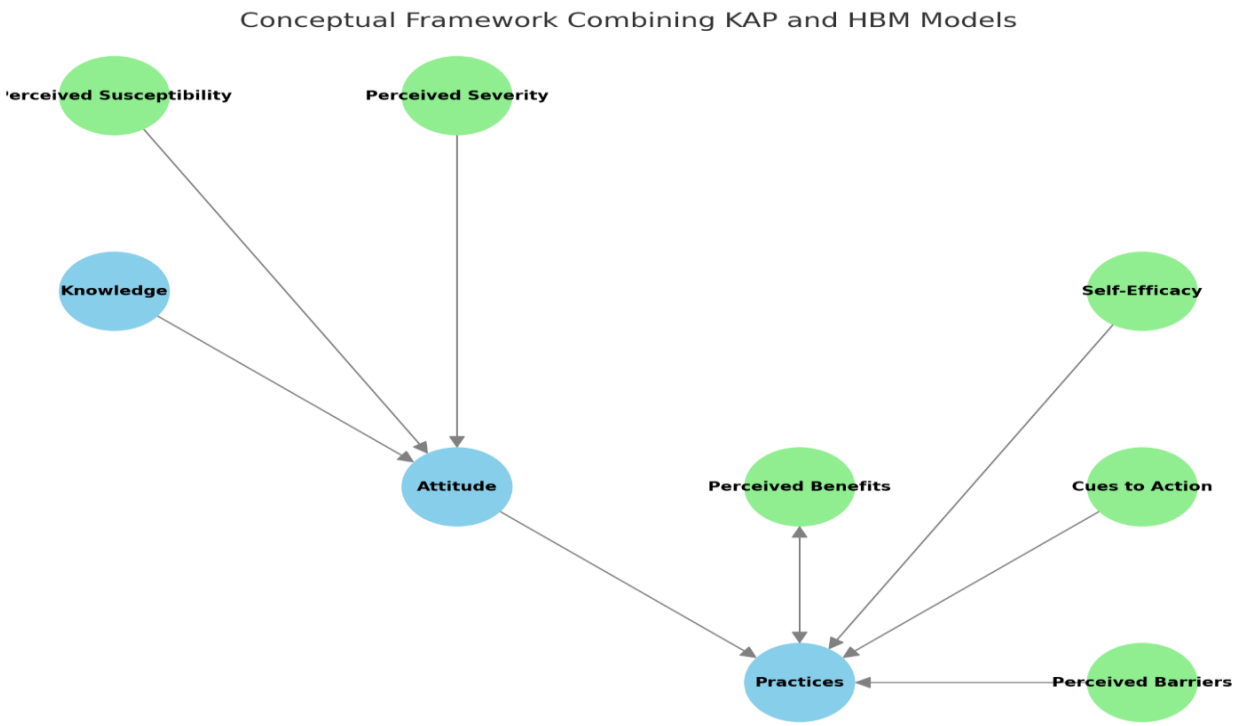

Figure 1.1: The conceptual framework of the study

2.5 SUMMARY

This chapter presented the literature review conducted for this study. It provided an overview of radiation protection in medical imaging and explained the principles and safety measures involved. The literature review revealed a considerable gap in knowledge, attitude, practice and barriers related to radiation protection and safety. These findings highlighted the need for continuous training, improved imaging protocols, implementation of periodic quality assurance and enhancement of facilities' radiation safety culture within imaging facilities to ensure the safety of healthcare professionals and patients. In addition, the chapter discussed the conceptual framework that guided this study. The next chapter will discuss the study's design and methodology.

CHAPTER 3

STUDY DESIGN AND METHODOLOGY

3.1 INTRODUCTION

Chapter two reviewed the relevant literature on radiation protection practices among imaging professionals in global, African and Ethiopian contexts. Furthermore, it examined the research design, methodologies and conceptual framework used in similar studies, guiding the researcher in selecting the most appropriate research design and methodological approach for this study. This chapter will therefore discuss the research paradigm, research approaches, research design and the research methods that were deemed fit for this study. The research settings, population, the overall data collection procedure, analysis, rigour and ethical considerations are also incorporated in this chapter.

3.2 RESEARCH PARADIGM

A paradigm is a worldview or lens comprising a set of assumptions, beliefs, theories, and values that characterise a particular way of viewing the world (Polit & Beck 2022:76). It is a comprehensive philosophical framework that guides the process of creating and understanding scientific knowledge. Thus, paradigms are characterised by their specific ontological, epistemological, and methodological assumptions. Paradigms guide a researcher's approach, focusing on investigating a particular phenomenon or problem (Kelly, Dowling & Millar 2018:9). The research paradigm used in this study is the positivist paradigm. This paradigm reflects a deterministic approach to research, in which causes most likely dictate effects or results. Positivists believe in objective reality, and their approaches rely on strictly structured, systematic methods. Therefore, issues investigated using this paradigm reflect the need to identify and evaluate factors that affect outcomes, primarily through a quantitative methodology to test hypotheses. The trustworthiness of a paradigm is demonstrated through reduced error margins and replicable findings, highlighting its reliability. The primary advantages of the positivist paradigm include its ability to provide generalizability and replicability of the research findings. (Kelly, Dowling & Millar 2018:10; Keong, Husin &Kamarudin 2021:5859).

Research paradigms are described based on the following assumptions.

3.2.1 Ontological assumptions are a set of assumptions about the nature of reality (Keong, Husin & Kamarudin 2021: 5858). Ontologically, positivists assume that there is a single tangible reality that can be approached by removing the researcher's influence on a study and creating more standardised research methods that are built upon meticulous observation and measurement of objective reality that exists (Creswell & Creswell, 2018:44; Park, Konge & Artino 2020:691). In the context of the study, the researcher believed that the existing reality regarding medical imaging professionals' knowledge, attitudes, practices, and perception of radiation protection and safety measures can be quantified, measured, and observed.

3.2.2 Epistemological assumptions refer to beliefs about knowledge and how knowledge is constructed. Therefore, epistemology focuses on how reality can be known. Positivism uses dualist and objectivist epistemologies. The researcher and the phenomenon under study are viewed as separate entities (Park et al 2020:691). In this study, the researcher was not influenced by the underlying assumptions; instead, reality was observed and measured with a data collection instrument.

3.2.3 Methodological assumptions are ways of obtaining knowledge about the described reality (Brink, van der Walt & van Rensburg 2018:19). The philosophical basis for choosing a particular systematic inquiry method is established by methodological assumptions (Mertens 2009:59). For this study, the researcher employed a descriptive cross-sectional quantitative approach to address the research objectives using the KAP and HBM conceptual frameworks. A census method was used. As a data collection tool, the researcher used questionnaires, and once the data collection was finalised, data preparation commenced. Descriptive and inferential statistics were used to analyse the logged data.

3.3 RESEARCH APPROACH

Research approaches are comprehensive plans or a series of research procedures that guide the researcher from theoretical assumptions to the detailed methods of data collection, analysis, and interpretation (Creswell & Creswell 2018:40). Three common research approaches are quantitative, qualitative, and mixed methods. A qualitative approach uses an inductive generalisation technique and focuses on providing an in-depth understanding of the underlying reasons, beliefs, and opinions. In contrast, a mixed method approach integrates both qualitative and quantitative approaches, providing

comprehensive information that cannot be obtained through either type of method alone (Borgstede & Scholz 2021:2; Creswell & Creswell 2018:41).

Based on the nature of the research problem, research questions and objectives, a quantitative approach was deemed suitable for this study. A quantitative approach involves testing objective theories by examining relationships and patterns among variables to gather numerical data for empirical phenomena. It primarily focuses on variables and typically applies a top-down or deductive strategy (Creswell & Creswell 2018:41). Unlike the qualitative approach, which may be prone to researcher bias, quantitative approaches offer objectivity and produce measurable and comparable results that can reveal broad generalisable data or explain a particular phenomenon (Islam, Khan & Baikady 2022:132). These characteristics of quantitative approaches allow researchers to collect data from the population, draw unbiased conclusions, identify patterns and correlations among variables, and lend reliability, credibility, and objectivity to the study findings. In a quantitative approach, tools such as structured questionnaires and statistical software are used for data collection, analysis, and interpretation. This research design was also carefully planned, and results are used to provide a wider context, predict future outcomes, and often test causal relationships (Borgstede & Scholz 2021:7; Matthews & Ross 2010:142; Islam, Khan & Baikady 2022:132).

3.4 RESEARCH DESIGN

A research design is a series of logical steps that a researcher takes to address a research question or accomplish a research goal (Brink, van der Walt, & van Rensburg 2018:92). There are various types of research designs in the quantitative approach; however, the researcher found a cross-sectional descriptive design to be effective in achieving the objectives of the study.

3.4.1 Cross-sectional descriptive design

A cross-sectional study is a research design that is conducted at a single point in time and collects data from the same respondents simultaneously. Cross-sectional designs are focused on a specific phenomenon. They are particularly relevant for assessing the prevalence, traits, and attributes of the sample population (Brink, van der Walt & van Rensburg 2018:89). Cross-sectional studies can be classified as descriptive and analytical. A descriptive cross-sectional design is a non-experimental research design that allows researchers to observe, define, and describe variables and their distribution

without establishing a cause-and-effect relationship among variables (Polit & Beck 2022:125).

Descriptive designs are applied when more details regarding certain qualities are needed in a particular field, or study population and by giving a picture of the phenomena in specific settings as they naturally occur (Aggarwal & Ranganathan 2019:34; Brink, van der Walt & van Rensburg 2018:96). In addition, these designs determine how often a phenomenon occurs, categorize its attribute, measure how much of each attribute is present in each category, and determine its quantity when a phenomenon can be described in terms of quantity (Gray &Grove 2020:178). In a simple descriptive cross-sectional design, data collection occurs from diverse individuals once rather than from the same respondents on multiple occasions.

This study employed a cross-sectional descriptive design, which was particularly important as it enabled a single point in time data collection to investigate and describe radiation protection and safety practices among imaging professionals. Given that the study aimed to examine respondents' knowledge, attitude, practice, perception and environmental barriers, this design was ideal, because it provides a snapshot of these variables without the need for prospective or retrospective follow-ups or long-term observation. In addition, because the data collection occurred at a single point in time, issues such as participant attrition were not a concern, making the research approach more time-efficient and cost-effective (Capili 2021:62). However, while a cross-sectional descriptive design identifies associations, establishing causal relationships between the outcome and exposure variables is difficult since both variables are measured simultaneously. Despite this limitation, this approach provides critical baseline data that can justify further study to explore trends over time (Wang & Cheng 2020: s65,66). Overall, a single-phase data collection method allowed the researcher to obtain an accurate and practical representation of imaging professionals' characteristics and traits within their current work environment.

3.5 RESEARCH METHODS

Research methods are the strategies and techniques that researchers employ to organise their studies and collect and analyse relevant information necessary to accomplish the research objectives. They encompass the planned strategies for data collection, analysis, and interpretation, enabling researchers to address research questions systemically and rigorously (Polit & Beck 2022:41; Creswell & Creswell 2018:53).

3.5.1 Study setting

A study setting refers to the location or place where a study will be carried out (Gray & Grove 2020:185). The present study was conducted in Addis Ababa, Ethiopia, where healthcare system is structured into a three-tier system: primary, secondary and tertiary levels of care. Evidence indicates that there are four tertiary referral hospitals run by the Federal Ministry of Health in Addis Ababa (Senbato, Wolde, Belina, Katiso, Medhin, Amogne & Eguale 2024:2). The study was carried out in four hospitals, namely St. Paul Specialised Hospital, ALERT Comprehensive Hospital, Tikur Anbessa Specialised Hospital (TASH), and Aabet Hospital) are referred to as hospital A, B, C & D, respectively, throughout the study.

Phase one: sampling of the hospitals

A purposive sampling technique was employed to select these hospitals. This sampling technique was deemed appropriate because it allows the researcher to intentionally select study settings with characteristics essential to assessing radiation protection and safety practices among medical imaging professionals. The selected facilities are all tertiary-level hospitals under the Federal Ministry of Health, collectively serving between 3.5 and 5 million people each year (Debie, Khatri & Assefa 2022:2). Hospitals A and C are academic hospitals with high patient volumes and complex caseloads. While all four selected hospitals have well-equipped diagnostic radiology departments that accommodate most of the public in the Addis Ababa region and surrounding areas, compared to other hospitals (Alebachew & Waddington 2015:5). The selection of these hospitals was also driven by the researcher's prior professional practice and clinical internships, which indicated potential gaps in radiation safety practices, making them an information-rich setting for the study. Despite operational challenges, these hospitals serve as a hub for advanced treatment across the country. These characteristics make the selected hospitals relevant to assess the radiation protection and safety practices of imaging professionals.

Figure 2.1: Map of Addis Ababa and location of the study setting

Source:(From:https://www.researchgate.net/publication/327024130/figure/fig1/AS:659719098224641@1534300698882/Map-showing-Addis-Ababa-Sub-cities-Source-Shapefile-from-Ethiopian-Karta-Agency.png(accessed 02 May 2025).

3.5.2 Study population

The study population comprised all medical imaging professionals (Radiographers and RTs) working in the four selected hospitals in Addis Ababa, Ethiopia. The total number of imaging professionals across the four hospitals was 93, distributed as follows: Hospital A (n=26), Hospital B (n=24), Hospital C (n=27) and Hospital D (n=16).

Phase two: sampling of the respondents

A census (Total population sampling) was employed due to the relatively small and well-defined total population. A census involves collecting information from every member of a population, rather than from a sample of that population. This method reduces sampling error and ensures complete representation of the study population (Harding 2006:25). A complete list of radiologic technologists and radiographers in each of the four hospitals was first obtained from departmental records and used as a sampling frame. The inclusion and exclusion criteria were then applied to identify the eligible respondents. Out of the total population (N=93), a total of 82 imaging professionals met the eligibility criteria and consented to participate, yielding the final sample size. All eligible respondents who were invited to participate in the study, and all 82 consented and completed the questionnaire, resulting in a 100% response rate among the eligible population. There was no further selection, and no randomization was performed, as the study aimed to include the entire accessible population.

The use of the census method is particularly appropriate for studies involving small and well-defined populations, thus improving the completeness, applicability and generalisability of a study's findings without the need for probability-based estimation and without the risk of missing out on important perspectives that would have been easily overlooked when using a sample plan (Trochim, Donnelly & Arora 2016:80). Therefore, all RTs and radiographers working in the selected hospitals and fulfilling the inclusion and exclusion criteria were included in this study.

3.5.2.1 Inclusion criteria

Inclusion criteria are essential characteristics that the element or the subject must possess to be part of the target population. These criteria usually stem from literature review, the research problem, the purpose of a study, and the study variables (Gray & Grove 2020:1074).

To be included in this study, the imaging professionals should meet the following criteria.

- All qualified RTs and radiographers aged 18 years or older.
- Professionals with at least 6 months of work experience in radiation-based modalities in the radiology department of four selected hospitals.
- RTs and radiographers who agreed and consented to participate in the study.

3.5.2.2 Exclusion criteria

Exclusion criteria are characteristics of a subject or element that meet the inclusion criteria but have certain factors that can exclude them from the target population (Patino & Ferreira 2018:84).

- RTs and radiographers exclusively working with non- ionizing radiation modalities such as Ultrasound and MRI were excluded.
- Student RTs and radiographers were excluded as they do not practice independently, and some may be under 18 years old.
- RTs and radiographers who were on annual or study leave during the data collection period.

3.6 DATA COLLECTION INSTRUMENT

Gray and Grove (2020:501) defined a questionnaire as a written self-report form designed to determine facts regarding respondents' levels of knowledge, attitudes, opinions, or beliefs. Questionnaires are widely used primary data gathering tools, in which people are asked to respond to the same set of questions in a pre-determined order. The researcher used a self-developed questionnaire that contained open-ended and closed-ended questions, with some sections using a Likert scale format. It was designed in the English language. The KAP and HBM frameworks were used to guide and structure the questionnaire, ensuring alignment with the objectives of this study. The preliminary step in developing the questionnaire was identifying the construct of interest. Once the constructs were identified, the next step was a literature review to find a pre-existing validated questionnaire (Tsang, Royse & Terkawi 2017:83). However, the available tools either did not align with the study constructs or required a translation; therefore, the researcher opted to design a new questionnaire tailored to the study context.

When developing the questionnaire, the researcher followed established guidelines to ensure a well-structured and high-quality instrument. A thorough literature review was conducted to identify the key concepts that should be included in the questionnaire to fulfil the study objectives. Therefore, Items were constructed to align with the study objectives and align with the conceptual frameworks (Christen, Johnson & Turner 2015:345). Questions were written using a simple, appropriate, comprehensible and unambiguous language, ensuring clarity for all respondents (O'Leary 2014: 437). To minimise response set bias, it was important to include both negatively and positively worded questions.

Leading questions, double-barred questions, and double negatives were avoided. (Yaddanapudi & Yaddanapudi 2019: 335). A mix of closed-ended and open-ended questions was used to engage respondents and maintain a high response rate. Close-ended questions provided standardised data, as all respondents were exposed to the same response categories, while multiple items or questions were used to measure complex or abstract ideas (O'Leary 2014: 437). To preserve respondents' anonymity and minimise social desirability bias, personal identifier items were excluded. Additionally, the questionnaire was pre-tested to identify ambiguous items and other issues in completing the questionnaire. Once the initial pool of questions was prepared, the researcher reviewed the items for clarity, accuracy and grammar before sending them to the supervisor and experts.

The questionnaire included six sections: Section A was demographic information, section B focused on respondents' knowledge of radiation protection and safety, section C aimed to assess the attitude of respondents regarding the importance of radiation protection in their routine work, section D focused on current safety practice in routine clinical practice, section E was on how imaging professionals perception of radiation risks and safety practices and section F focused on environmental factors influencing the implementation of radiation safety practices in their respective radiology department (see Annexure F).

Given imaging professionals' busy schedules, an electronic questionnaire was the most practical option for ensuring timely data collection. Using an electronic questionnaire as a data collecting tool has proven effective, as it is quick, cost-efficient and ensures respondents with the possibility of remaining anonymous (Polit & Beck 2022: 147). This approach allowed respondents to access and complete the questionnaire on their phones at any time of the day, offering convenience and flexibility. Moreover, the use of a digital system prevented duplicate entries and enabled automated data entry to Excel, significantly reducing errors.

3.7 PRE-TESTING THE DATA COLLECTION INSTRUMENT

Before commencing the main study, it was necessary to pre-test the data collection instrument. This methodological step was crucial to assess the reliability and validity of the tool. The researcher conducted a pre-test to assess the validity and reliability of the instrument. To ensure that respondents and the study setting for the pre-test were not part of the main study. The pre-test study was done in June 2024 at Zewditu Hospital in Addis Ababa. This approach preserved the integrity of the population for the main study,

preventing any potential bias or influence. The researcher first requested permission from the management to conduct the pre-test study. Once access was granted, the information on the information leaflet was explained to all imaging professionals by the researcher with the assistance of the data collector and all their questions were adequately addressed. The electronic questionnaire was then distributed to respondents who had signed a written consent form, and the purpose of the pre-test was explained to the respondents. A total of 12 respondents were willing to participate in the pre-test study, representing more than 10% of the study population. Data was prepared, and the responses were analysed using the Statistical Package for Social Sciences (SPSS), IBM version 29 (2023) software package program. To assess internal consistency of the data instrument, Cronbach's alpha was calculated, with a total Cronbach's alpha value of 0.817 exceeding the minimum acceptability threshold of 0.7, showing good internal consistency of the scale. The results were shared with the supervisor. In addition, respondents' feedback was examined, and a few questions were reworded for clarity and to enhance the validity of the data instrument for the main data collection. The data gathered during the pre-test were not included in the main study; all responses, together with the tools that were used to collect data, were discarded.

3.8 DATA COLLECTION PROCEDURE

Data collection commenced between August and December 2024, following obtaining ethics approval from the University of South Africa (UNISA), ethics approval from the Ethiopian Public Health Association (EPHA) (Annexure A & B respectively), a support letter from the Ministry of Health in Ethiopia (MOH) for each hospital (Annexure C), as well as a support letter from the UNISA regional office (Annexure D). Once these approvals were secured, the researcher approached each hospital administrator with the relevant permission letters. After access was granted from the respective hospitals, the researcher contacted the head of the radiology department to gain access to the respondents' information. Lists of all radiologic technologists and radiographers were obtained from departmental records. These lists served as a sampling frame. The researcher recruited the respondents by individually approaching eligible imaging professionals to avoid disrupting workflow in their respective departments. This procedure was applied consistently in each hospital. An information leaflet form and a consent form (see Annexure E) were embedded as links in the questionnaire. Additionally, a written consent form was also provided to each participant. The information leaflet clearly outlined the study's purpose, the nature of the study, the expected commitment and its

processes, as well as what was expected from the respondents. This was done to ensure participation in the study was fully voluntary, and respondents could make informed decisions regarding their involvement. Only those who provided a signed informed consent form were included in the study. A total of 82 respondents who met the eligibility criteria and consented to participate in the study. The electronic questionnaire (Annexure F) was distributed to respondents via a link, and they used their mobile phones to complete the questionnaire. Throughout the data collection period, the researcher, alongside the data collectors, facilitated the data collection procedure to ensure confidentiality and transparency. All 82 respondents completed and submitted their electronic questionnaires, resulting in 100% response rate among the eligible population. The raw data was securely stored in a password-protected computer according to the university guidelines, with access restricted to the researcher.

3.9 DATA ANALYSIS

Data analysis in quantitative research is the process of organising, summarising and statistically evaluating collected data to induce meaningful and trustworthy findings (Gray & Grove 2020:63). The process of data preparation began after the completion of data collection in each hospital. The data was exported from Google Forms to Excel and cleaned. Once the data were prepared for analysis, variables were constructed and defined, and the data set was then imported into the Statistical Package for Social Sciences (SPSS), IBM version 29 (2023) software package program for analysis.

The study employed descriptive statistics data analysis method, which is a type of quantitative data analysis approach to identify and summarise variables in a data set. This approach helped to organise responses, illustrate and sum up the observed patterns and generate summaries that quantify the distribution of variables (Cooksey 2020:61). The choice of analysis method was guided by the type of variables and the number of variables being analysed. In addition to descriptive analysis, the study also applied Inferential statistics methods to draw meaningful conclusions about the study population. Specifically, Cronbach's alpha coefficient was calculated to assess the internal consistency and reliability of the scale. A binomial test and a one-sample proportion test were conducted to determine whether the binary responses significantly differed from expected proportions. In addition, a one-sample t-test was applied to evaluate whether the mean scores of items in the variable differed from the expected proportion. The study findings will be presented in the next chapter in the form of charts, tables and diagrams

and described based on frequency distribution to provide a clear overview and summarise the main characteristics of the data.

3.10 RIGOUR

Rigour in quantitative research is ensuring the legitimacy of the research process through discipline, adherence to detail and accuracy. To ensure rigour, a researcher must clearly explain how the data is gathered, analysed and how study findings are attained. In quantitative research, the quality of measurements that are used to ensure rigour is reliability and validity (Gray & Grove 2020:52).

3.10.1 Reliability

Reliability is defined as the consistency and stability of an observation. The reliability of an instrument refers to the extent to which repeated applications of measurement deliver consistent results for the same population (Trochim, Donnelly & Arora 2016:115). Although it is not possible to precisely measure reliability, it can be estimated through qualities such as homogeneity (internal consistency), stability and equivalence (Heale & Twycross, 2015:1). Cronbach's α is widely used to test internal consistency of an instrument. This test applies to instruments that have two or more responses. The outcome of Cronbach's α value is between 0 and 1, and it is considered an acceptable reliability score when it is 0.7 or higher (Heale & Twycross 2015: 2).

To ensure reliability, the researcher defined the research objectives, constructs and variables precisely. Questionnaire items were aligned with the research objectives and conceptual frameworks. The pilot study was conducted in one healthcare facility that was not part of the main study. This approach ensured that the population for the main study settings remained unaffected. The researcher selected a smaller, yet representative sample of medical imaging professionals to pilot-test the questionnaire. The feedback from the pilot study was used to refine and improve the data collection instruments and procedures before the main study commenced. The researcher recruited a data collector with relevant backgrounds in medical research and radiography. The data collector was trained to understand the study's objective and the specific data collection method to avoid introducing errors and to ensure respondents' confidentiality is maintained. An automated data-capturing method further reduced manual error. The researcher performed a double-check of all data entries and statistically assessed the reliability of the tool using Cronbach's alpha. The tool contains 56 items, and a total Cronbach's alpha

coefficient value of 0.817 was obtained, indicating a good internal consistency of the scale.

3.10.2 Validity

Validity is a measure of accuracy; it is the capacity of an instrument to give a true result. For an instrument to be valid, it must be tested repeatedly and demonstrated to be accurate in the same population (Bruce, Pope & Stainistreet 2018:165). The use of an accurate measuring instrument ensures the research findings are valid. There are different forms of empirical validity in quantitative studies. However, the researcher used content validity and face validity in this study to evaluate the questionnaire.

3.10.2.1Content validity

Content validity examines how adequately the measuring instrument represents the main elements that are significant to the construct being measured (Gray & Grove 2020:464; Bruce, Pope & Stainistreet, 2018:166). To establish content validity, the researcher conducted a thorough literature review of similar studies and pre-existing questionnaires to ensure relevant concepts are included. This step helped to identify the crucial elements in the variables. The supervisor reviewed the questionnaire for comments and input on the stability of the instruments and the representativeness of the questions.

3.10.2.2 Face validity

Face validity is a subjective evaluation that is performed by researchers and experts to verify whether the instrument is measuring what the researcher wants it to measure. It is the weakest form of validity as it does not involve rigorous or statistical measures of validity (Trochim, Donnelly & Arora 2016:130; Gray & Grove 2020:464). In this study, face validity was employed to determine the readability and clarity of the questionnaire. The researcher reviewed whether the questions were relevant to the objectives of the study. This was to ensure the questionnaire's clarity and suitability. Experts in medical imaging and public health evaluated each item using a scoring rubric to assess its clarity, relevance, and appropriateness for the intended purpose. The questionnaire was refined based on this feedback and sent to the supervisor for final feedback and suggestions.

3.11 METHODOLOGICAL BIASES

Bias refers to any factor that introduces error or distortion that may affect the quality of evidence in research (Brink, van der Walt & van Rensburg 2018:83). Despite the strength of the study design, several potential sources of bias should be considered.

3.11.1 Selection bias: the study was only conducted at four tertiary-level public hospitals in Addis Ababa. These hospitals have well-resourced imaging facilities and may not represent other healthcare settings in other regions of Ethiopia, particularly primary and secondary-level health facilities. Furthermore, respondents were selected from these facilities; therefore, the findings may not be fully generalisable to all imaging professionals in the country.

3.11.2: Response bias: data were collected using a self-administered electronic questionnaire, which may result in over-reporting desirable practices or under-reporting poor practices, particularly regarding adherence to radiation protection and safety practices in routine imaging procedures. This is also related to social desirability bias, where respondents provided professionally acceptable answers rather than reflecting the actual behaviour, and this is highly relevant in studies that examine safety standards.

3.11.3 Non- response bias: Non- response was minimized in the current study, as a census approach (Total population sampling) was employed with 100% response rate among eligible imaging professionals. However, it is important to acknowledge that the exclusion of 11 individuals who did not meet the eligibility criteria may influence the overall representativeness of the findings.

To minimise these biases and enhance the credibility of the study, the researcher clearly defined the research questions, objectives and design. As highlighted by Kang and Hwang, maintaining ethical principles of anonymity and confidentiality is essential for protecting participants, reducing bias and ensuring the credibility of research outcomes (Kang & Hwang 2023:2).

3.12 ETHICAL CONSIDERATIONS

Ethics is a discipline or theory that focuses on social principles and moral conduct, which guides the norms of behaviour and social relationships within a society (Burkhardt & Nathaniel, 2013:35). In any research, the protection of human subjects is of utmost importance. Ethical consideration needs to be thoroughly anticipated and addressed throughout the research process. To ensure this study adhered to ethical and legal standards, the research was commenced after ethical approval from the College of Human Sciences Research Ethics Review Committee (CREC) of the University of South Africa (UNISA) (reference no. 20991371_CREC_CHS_2024) and in-country clearance from the Ethiopian Public Health Association (EPHA) (reference no. EPHA/06/45124) and a support letter from the Ministry of Health to each hospitals.

The study adhered to the following ethical principles:

3.12.1 Informed consent and autonomy

Autonomy is the principle of respecting an individual's right to self-determination without outside control (Burkhardt & Nathaniel 2013:440). The researcher ensured autonomy by providing full disclosure about the study process. Respondents were provided an information sheet and an informed consent form (see Annexure E) which clearly outlined the study procedures, anticipated risks and benefits, time commitment and the point at which respondents could withdraw from the study. This allowed respondents to make informed consents. Respondents who agreed to take part in the study were required to sign a written informed consent. Respondents were assured that the information they provided would be used solely for research purposes and would be reported in a manner that does not identify them.

3.12.2 Right to privacy and dignity

Gray and Grove (2020:203) defined the right to privacy as the freedom of an individual to choose how, when and under what circumstances their private information is shared or withheld from others. Privacy was maintained through anonymity, confidentiality, and informed consent. There was no coercion, deception, or covert means of data collection used. The researcher removed personal identifiers, and the anonymity of respondents was secured by assigning a code. In addition, the researcher made sure that the questionnaire did not contain invasive questions that could cause embarrassment or undermine their dignity.

3.12.3 Confidentiality

In the research process, a researcher ensures confidentiality by securely managing all the gathered private information, which should not be divulged to any unauthorised person (LoBiondo-Wood & Haber 2018:248; Turcotte-Tremblay & Sween-Cadieux 2018:6). The researcher ensured the information gathered from respondents would remain confidential and that respondents would not be linked to the data. This was achieved by creating a categorisation scheme, where the data was coded according to the site where it was collected. Each hospital was assigned an alphabetical code (A, B, C and D) and each participant was given a numerical code. Respondents' confidentiality and anonymity will be protected when the research outcome is published in the future. In addition, the external research team were required to sign a confidentiality agreement

form (Annexure G). The researcher also safeguarded the raw data by storing it on a password-protected computer.

3.12.4 Beneficence

Beneficence emphasises the importance of promoting well-being. This principle obliges researchers to protect respondents from discomfort and harm while ensuring respondents experience a favourable balance of benefit compared to the potential harm (Gray & Grove 2020:194). The information leaflet included information on how the study could provide valuable insights into the understanding and implementation of radiation protection and safety practices among radiologic technologists and radiographers. The study may also offer perspectives that contribute to their professional development, potentially leading to enhanced skills, practices, or awareness. The findings and subsequent recommendations aimed to strengthen radiation safety culture and enhance imaging services provided to the public. Additionally, the study would address existing gaps in the literature, as outlined in the participant information leaflet. In this study, all respondents had the right to withdraw from the study if they felt any discomfort.

3.12.5 Nonmaleficence

The principles of nonmaleficence require one to avoid intentional harm, risk of harm and harm because of beneficial acts (Burkhardt & Nathaniel 2013:71). The researcher ensured that respondents were not exposed to any known harm. The potential risks associated with this study were clearly outlined in the information leaflet, allowing respondents to make informed decisions. The questionnaire was carefully designed to avoid any discriminatory, offensive, or unacceptable language that could cause harm to the respondents.

3.12.6 Justice

Justice is an ethical principle that strives to ensure fairness and equity among people (Varkey 2021:20). The researcher ensured justice in this study by applying clear selection criteria and a sampling plan that provided all respondents with an equal opportunity to participate. The researcher upheld the agreements made when the respondents signed the consent form. There was no discrimination, and each RT and radiographer, willing or unwilling to participate in the study, was treated with respect.

3.12.7 Data Security

All data collected was securely stored and protected from unauthorised access. Data will be retained for the period required by institutional policy and will then be securely disposed of after the period recommended by the university.

3.13 SUMMARY

This study design and methodology were discussed in this chapter. Various types of research approaches were reviewed, and justification was provided for why a quantitative research methodology was deemed appropriate for this study. The study employed a descriptive cross-sectional design with clearly defined inclusion and exclusion criteria. Data was collected using an electronic questionnaire. The data collection procedure, the ethical considerations during data collection and the measures taken to ensure rigour were also discussed. The next chapter presents the research findings derived from the data analysis.

CHAPTER 4

ANALYSIS, PRESENTATION AND DESCRIPTION OF THE RESEARCH FINDINGS

4.1 INTRODUCTION

The previous chapter outlined the research design and the methodological steps applied in this study. This chapter presents and interprets the study findings obtained from the data analysis. The results are presented as follows: the demographic profile of the respondents, professional background, Knowledge assessment on radiation protection, respondents' attitude towards radiation protection, current practices, respondents' perception of radiation protection practices and enabling environment. These results are presented through charts, tables, and diagrams and are described based on frequency distributions to provide a clear overview and summarise the key characteristics of the data. The purpose of this study was to investigate and describe the practice of radiation protection and safety measures among radiologic technologists and radiographers in Addis Ababa, Ethiopia.

The following were the objectives of the study:

- To assess the knowledge of medical imaging professionals regarding radiation protection and safety measures in Addis Ababa, Ethiopia.
- To investigate the attitudes of medical imaging professionals towards the importance of radiation protection and safety in their daily practices in Addis Ababa, Ethiopia.
- To assess the current practices of medical imaging professionals in implementing radiation protection measures during routine procedures in Addis Ababa, Ethiopia.
- To identify and analyse the health perceptions and environmental barriers that influence imaging professionals' compliance with radiation protection and safety practices.

4.2 DATA COLLECTION AND ANALYSIS

Data were collected using self-administered questionnaires from 82 respondents across four federal hospitals in Addis Ababa, Ethiopia, as discussed in detail in Chapter Three. The data was captured and analysed using SPSS (IBM version 29.0.2.0). To ensure consistency and clarity of the data, each variable was defined, and each value was appropriately labelled. Subsequently, the data were entered into the SPSS software for

analysis. The data was cleaned and checked for missing values to ensure the reliability of the results. The data analysis primarily involved descriptive statistics, and inferential statistics were used to further examine and interpret the data. The study findings are presented in this chapter in the form of tables, figures and frequency distribution.

4.3 RESEARCH RESULTS

This section presents the results of the data analysis. The findings are organised according to the main variables of the study: Demographics, Knowledge, Attitude, Practice, Perception and Enabling environment.

4.3.1 Demographics profile of the respondents

This section outlines the demographic characteristics of the study respondents. Key variables include age, gender, profession, level of education, and years of professional experience. A descriptive analysis of frequency was used to analyse this section.

4.3.1.1 Age of the respondents

A total of 82 respondents were included in this study, with ages ranging from 22 to 51 years. Data shows that the largest proportion of respondents (35.4%) were aged between 32 and 36 years, followed closely by 34.1% in the 27 to 31 age group. Additionally, about 13.4% of respondents were between 37 and 41 years old, about 9.8% were between the ages of 22 and 26, and 4.9% fell within the 47 to 51 age range. The smallest group, comprising only 2.4% of respondents, was between 42 and 46 years old. Table 4.1 and Figure 4.1 below present the details of the age distribution.

Table 4.1: Demographic characteristics of the respondents by age (n=82).

Age	Percentage (%)	Frequency
22-26	9.8%	8
27-31	34.1%	28
32-36	35.4%	29
37-41	13.4%	11
42-46	2.4%	2
47-51	4.9%	4
Total	100.0%	82

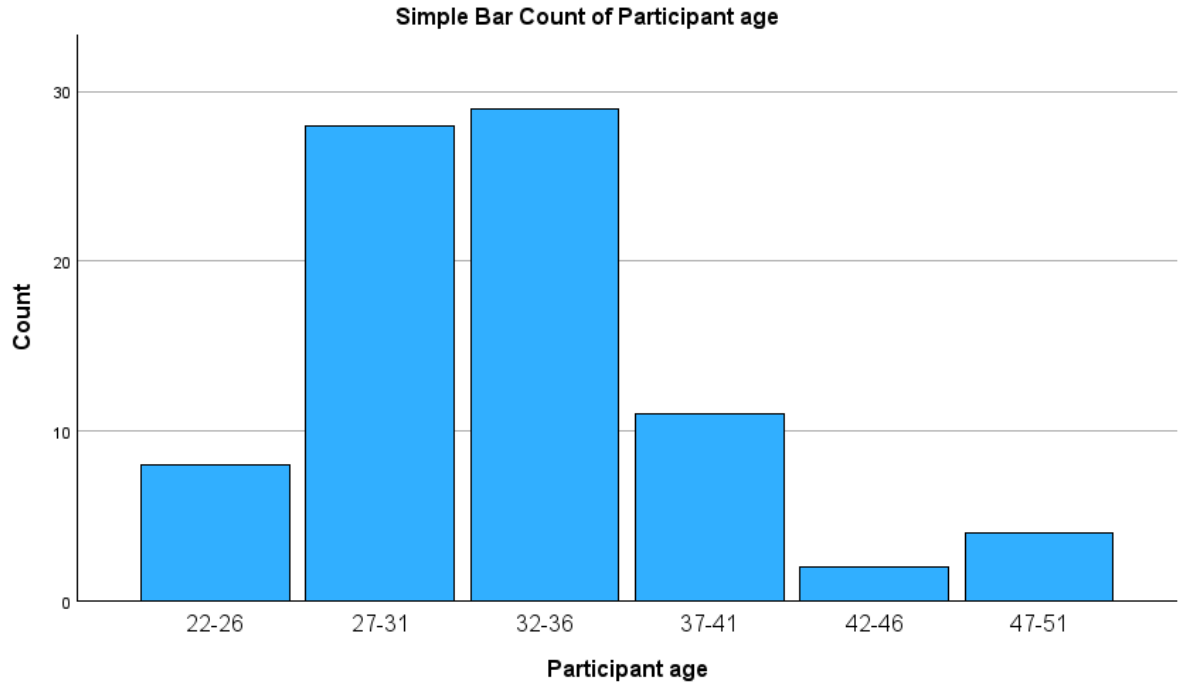

Figure 3.1: Presentation of respondents' age distribution (n=82).

4.3.1.2 Gender of the respondents

Data shows that the majority of respondents were male (64.6%, n=53), while females comprised 35.4% (n=29) of the sample (see figure 4.2).

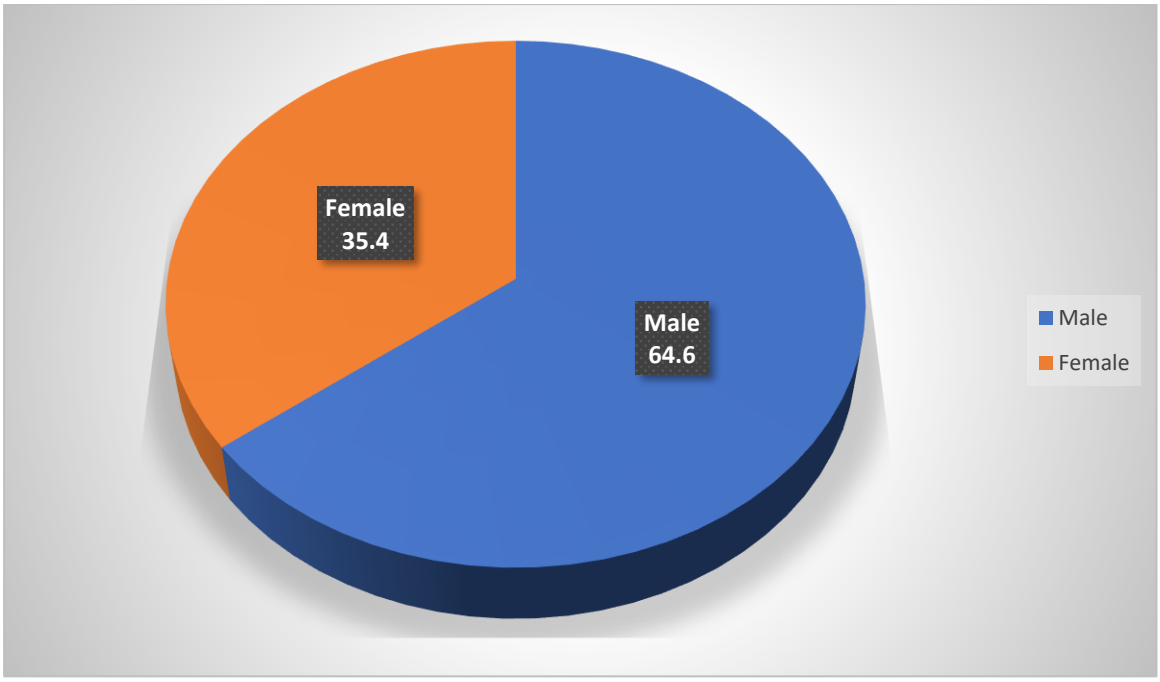

Figure 4.2: Gender distribution of the study respondents (n=82).

4.3.1.3 Occupational profile

Out of all respondents, 91.5% (n=75) were Radiologic technologists, while 8.5% of respondents (n=7) were radiographers (see figure 4.3).

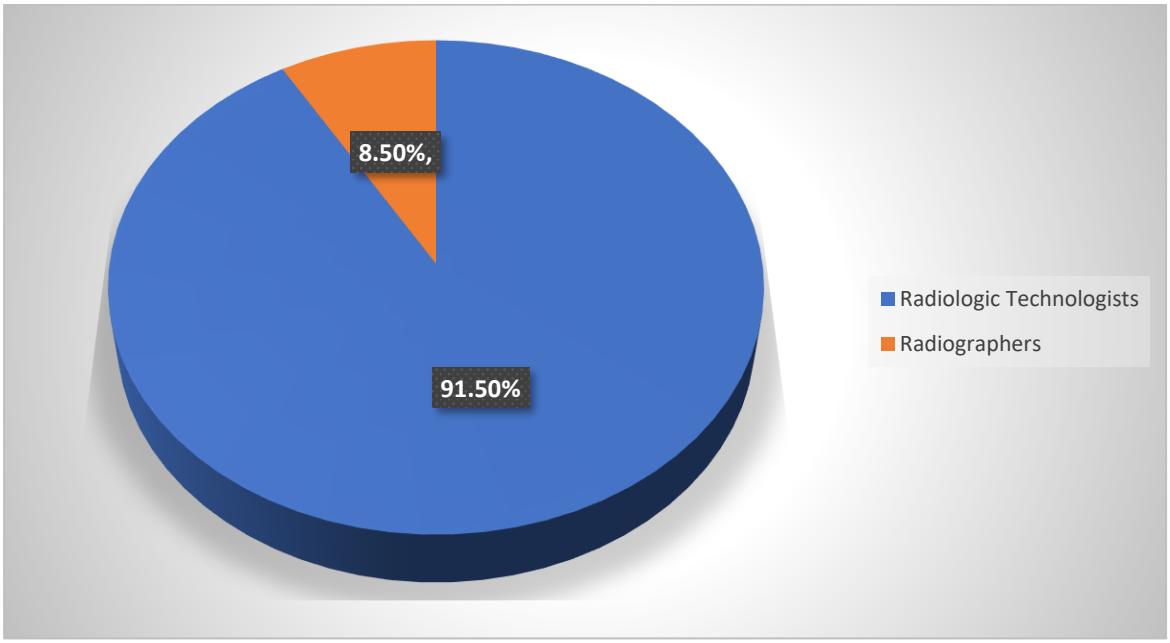

Figure 5.3: Occupational roles of study respondents (n=82)

4.3.1.4 Educational background of respondents

The data on respondents' educational level showed that about 86.6% of respondents held a bachelor's degree, followed by 8.5% who had a diploma, and 4.9 % had a master's degree. None of the respondents held a PhD (see Table 4.2).

Table 4.2: Highest Level of Education Among Respondents (n=82).

Highest level of education	**Frequency**	**Percentage%**
Diploma	7	8.5%
Bachelors	71	86.6%
Masters	4	4.9%
Ph.D.	0	0%
Total	82	100.0%

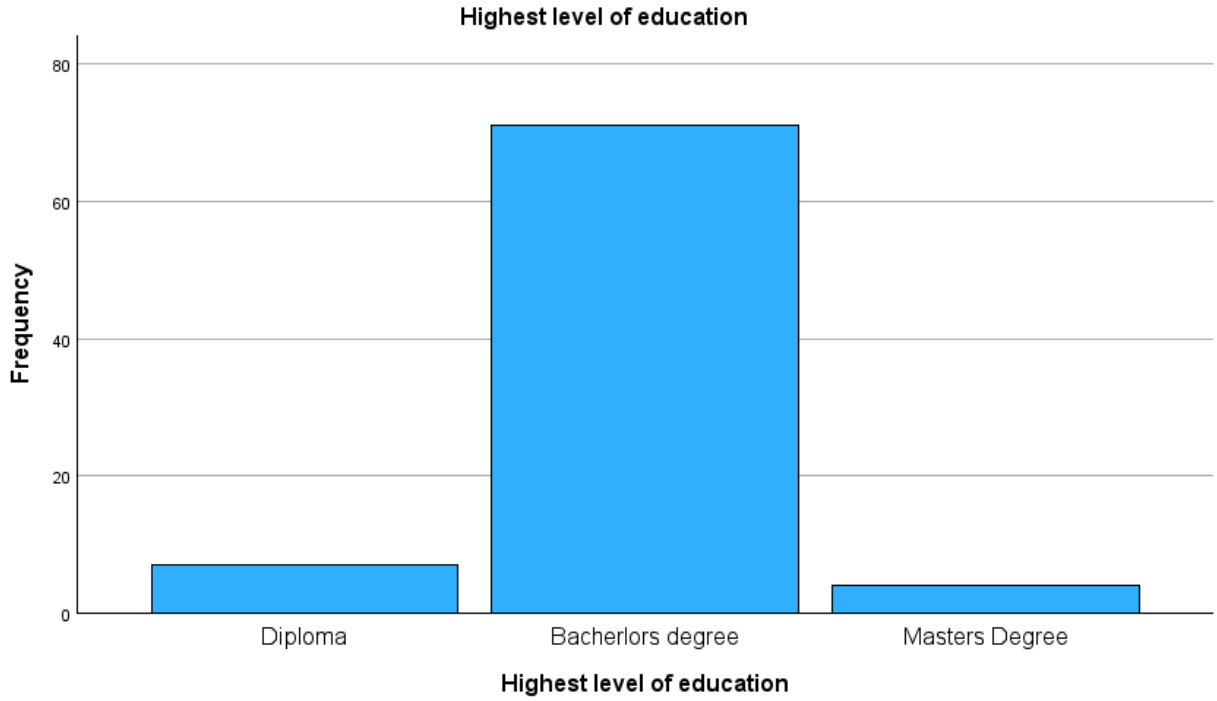

Figure 6.4: Educational qualification of the study respondents(n=82).

4.3.2 Professional background

Respondents' professional background, including work experience, formal training in radiation protection, exposure to internal radiation protection training and their current hospital of employment, are presented below.

4.3.2.1 Professional work experience of Respondents

Among all respondents, 47.6% reported having 6 to 10 years of work experience, followed by 19.5% with 11 to 15 years, 15.9% with 1 to 5 years, 13.4% with 16 to 20 years, 2.4% of respondents with more than 20 years of experience, and 1.2 % with less than a year of experience (see Figure 4.5).

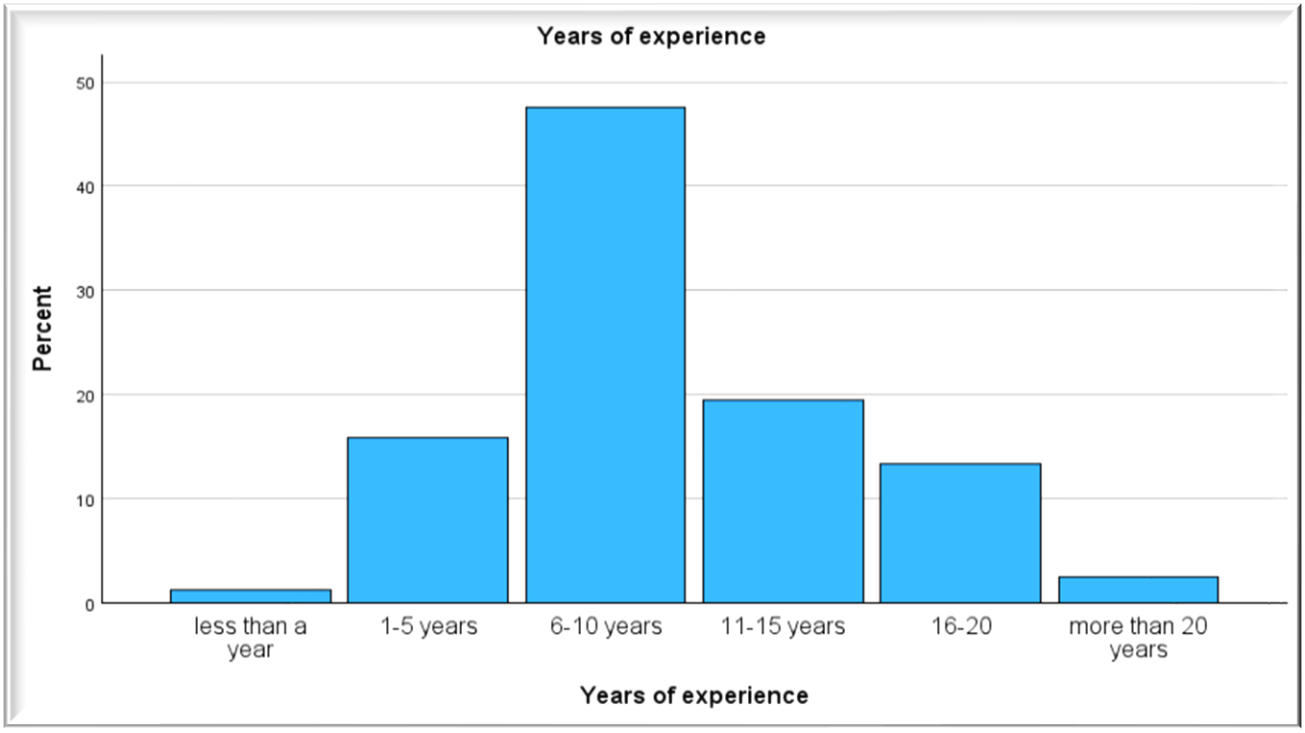

Figure 7.5: Work experience of study respondents (n=82).

4.3.2.2 Respondents' formal training on radiation protection

Most respondents (76.8%) acknowledged receiving formal radiation safety and protection training, compared to 23.2% who had not (see figure 4.6).

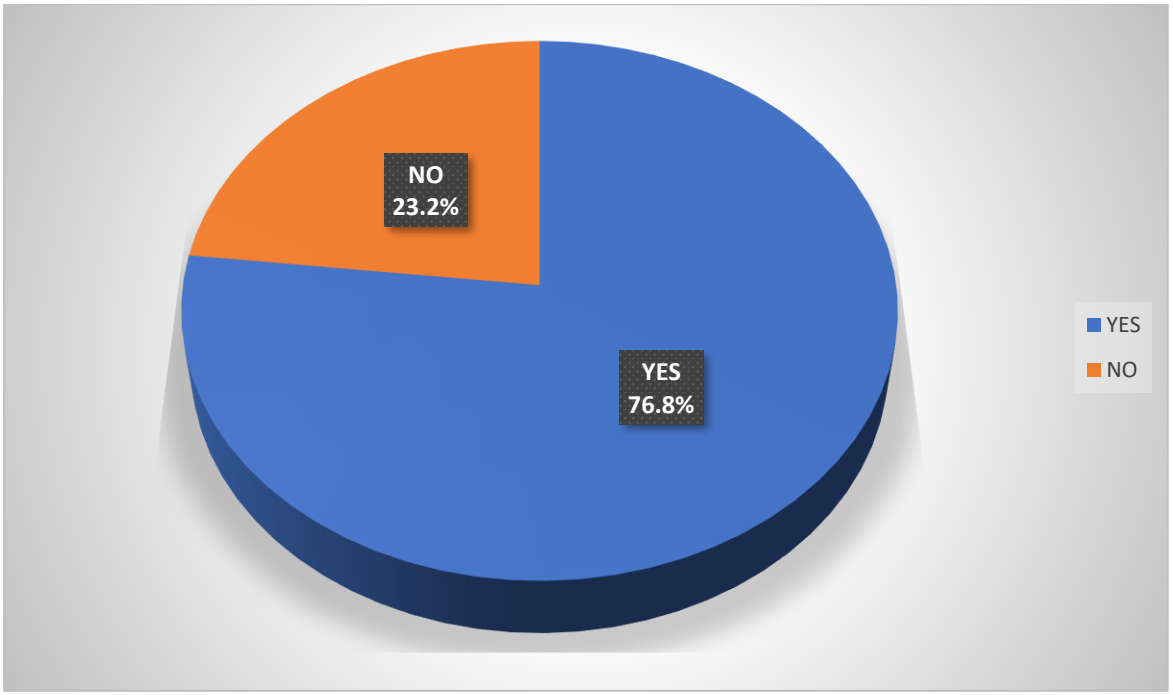

Figure 8.6: Participation in formal radiation protection training (n=82).

4.3.2.3 Respondents' exposure to internal radiation protection training

Of the respondents, 56.1% (n=46) reported not receiving in-house training on radiation protection at their institution, whereas 43.9% (n=36) reported receiving it (see figure 4.7).

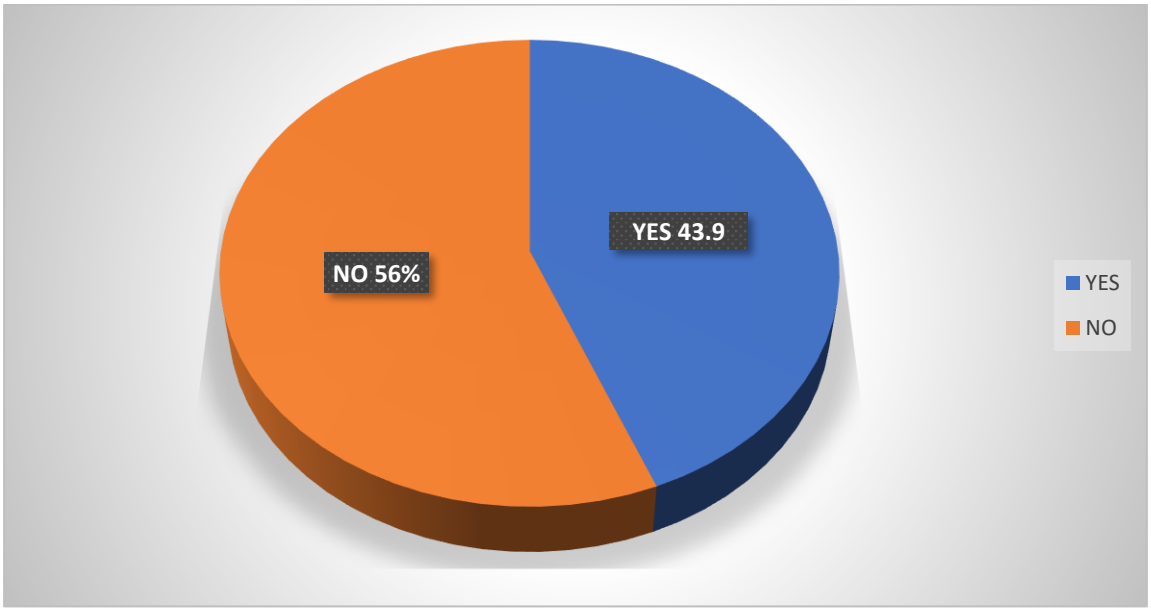

Figure 9.7: Radiation protection training at respondents' institutions (n=82).

4.3.2.4 Coverage of radiation protection during tertiary education

Among the respondents, 76.8% (n=63) reported that radiation safety and protection were adequately covered during their tertiary education, while 23.2%(n=19) reported that the topic was not sufficiently addressed (see Figure 4.8).

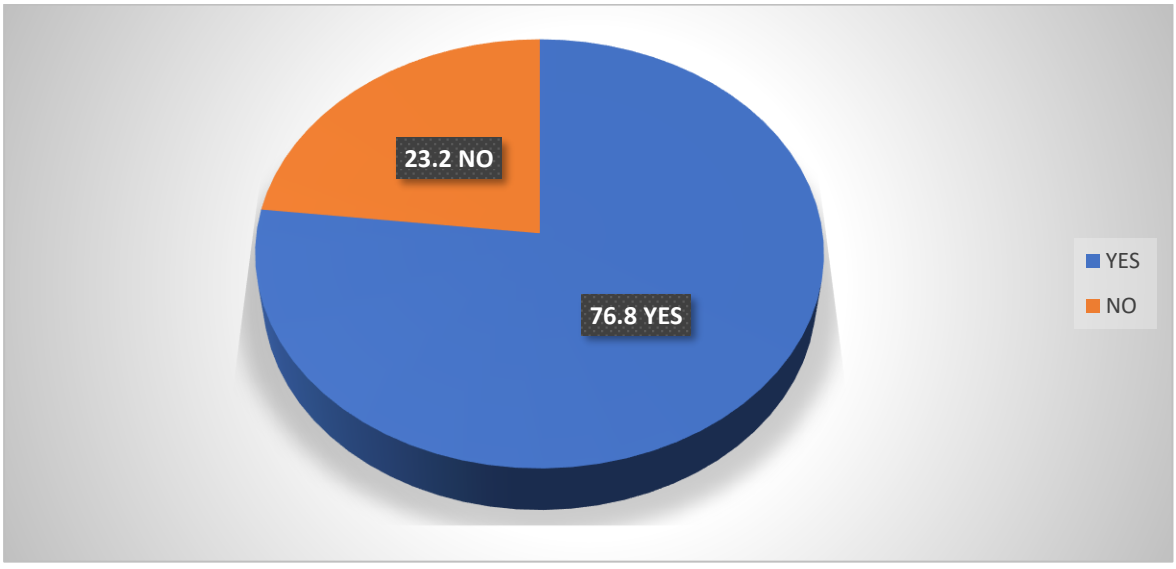

Figure 10.8: Tertiary education coverage of radiation protection (n=82).

4.3.2.5 Distribution of respondents by Hospital

Respondents were drawn from four hospitals. Hospital C had the highest number of respondents with 31.7%(n=26), followed by Hospital A with 26.8% (n=22), Hospital B with 22% (n=18) and Hospital D with about 19.5%(n=16) (see figure 4.9).

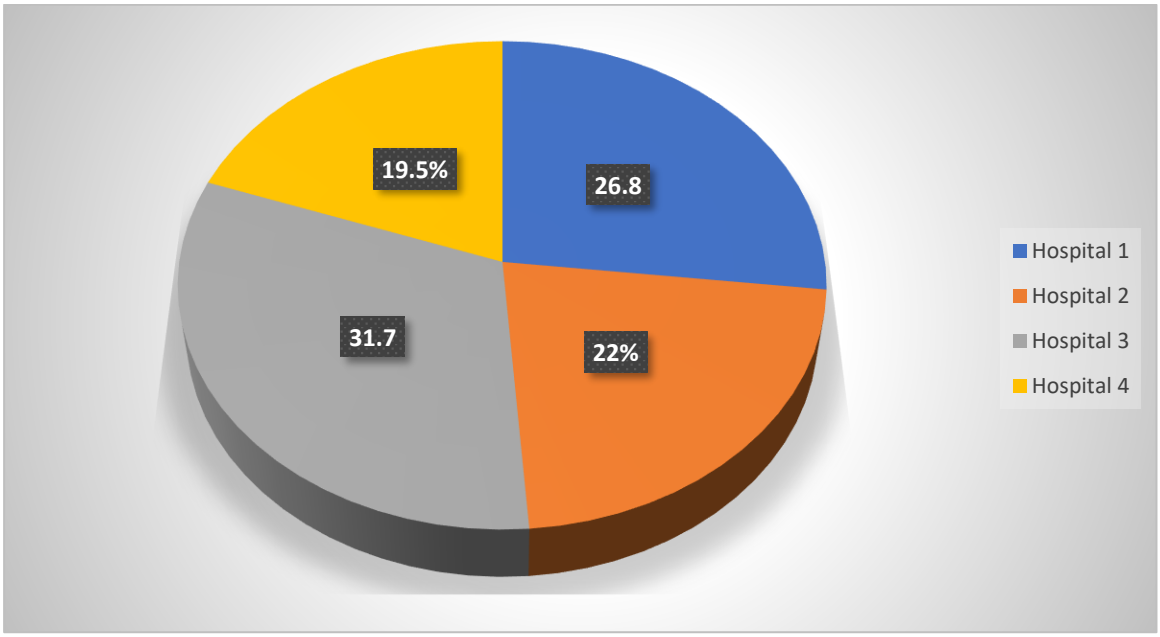

Figure 11.9: Distribution of respondents by hospital (n=82).

4.3.3 Knowledge Assessment on Radiation Protection

This section presents the results from knowledge-based assessments conducted with 82 medical imaging professionals across four hospitals. Respondents were evaluated across multiple domains of radiation protection knowledge, including radiation safety concepts, occupational protection, dose reduction techniques, and shielding and positioning. These domains represent distinct areas of knowledge rather than a single unidimensional construct. Because the knowledge items assessed different content areas, calculating an overall Cronbach's alpha would not have provided an accurate measure of internal consistency. Reliability coefficient such as Cronbach's alpha are most appropriate for unidimensional continuous scales, and in tools involving multiple contents, Cronbach's alpha may be underestimating reliability (Tavakol & Dennick 2011:54). Additionally, knowledge assessment often encompasses various content areas, making it difficult to achieve a high internal consistency (Edelsbrunner, Simonsmeier & Schneider 2025:4). Therefore, Cronbach's alpha was not calculated for the overall knowledge scale, as it may not provide a valid measure of internal consistency. Instead, analysing and reporting individual items or sub-scales was performed to provide meaningful insight.

A binomial statistical test was conducted to determine whether there is a significant difference in knowledge performance using a test proportion of 0.5 for each item. The items were categorised into four sub-scales for interpretation. Table 4.3 presents the 12 items within four subscales included in the knowledge assessment, along with the frequency and percentage of correct and incorrect responses, and the corresponding p-values from the binomial test. A p-value of < 0.05 was considered statistically significant.

4.3.3.1 Paediatric safety and patient-centred protection practice.

This subscale consisted of three items that evaluated respondents' general awareness of radiation safety. Among the 82 respondents, 73% correctly identified the most effective way to protect radiosensitive organs in paediatric patients ($p < 0.001$). However, 27% of respondents answered incorrectly, indicating a persistent knowledge gap. Responses on proper patient positioning were evenly distributed, with 46% answering correctly and 54% incorrectly ($p = 0.581$). The result was not statistically significant, indicating insufficient evidence of a meaningful difference in the knowledge level of this item. The distribution of responses also shows a variability in the understanding of proper positioning in relation to image quality and radiation dose. Regarding the optimal use of shielding during examinations, approximately 60% of respondents provided a correct answer, 40% responded incorrectly. Although more respondents selected the correct answer, the difference was not statistically significant ($p = 0.097$), indicating that the evidence to conclude that knowledge in these areas is adequate. These findings highlight variability in paediatric safety and patient-centerd practice and the need for targeted training (see Table 4.3 and Figure 4.10).

4.3.3.2 Radiation protection principles and technical knowledge.

This subscale contained four items that focused on general radiation protection principles and respondents' technical knowledge of radiation safety. All items yielded significant results ($p < 0.001$), confirming a meaningful difference in respondents' knowledge levels. Regarding the most effective way to reduce patient dose, 82% of respondents responded correctly, while 18% responded incorrectly. This reflects a general high level of understanding of technical factors in dose-minimising practices. However, the presence of incorrect responses indicates that the understanding is not uniform across respondents. Similarly, a high proportion (74%) of respondents correctly answered the item describing dose optimisation, reflecting respondents' familiarity with one of the core principles of radiation protection. However, the remaining 26% of incorrect responses highlight the existence of variability in conceptual understanding of dose optimization. In

addition, 77% correctly identified the factor with the greatest impact on the amount of radiation a patient receives during a radiologic procedure. This result implies that respondents are well-informed on dose determinants, although not consistently across all respondents. Lastly, 85 % of respondents correctly identified the goal of implementing radiation protection measures in medical imaging. This finding suggests that the majority have a strong understanding of fundamental radiation protection concepts, with a limited but present knowledge gap. In general, this subscale show respondents have high knowledge of radiation protection principles with some variability across the technical aspects (see Table 4.3 and Figure 4.10).

4.3.3.3 Operational and regulatory knowledge.

This subscale evaluated respondents' operational and regulatory knowledge. Only 35% of respondents correctly identified the International Commission on Radiological Protection (ICRP) recommended 1-year maximum permissible dose limit for declared pregnant radiation workers, while 65% responded incorrectly ($p = 0.011$). The association was statistically significant, indicating a notable knowledge gap in regulatory limits for the vulnerable population. In contrast, when asked about the best method to reduce scatter radiation to staff, 67% answered correctly, whereas 33% responded incorrectly ($p = 0.003$). This result suggests that while most are well-informed regarding how to minimise operational hazards, there is a considerable proportion still lacking a correct understanding. Similarly, 67% correctly identified the annual dose limit for occupational exposure to radiologic technologists and radiographers, as per Ethiopian Radiation Protection Authority (ERPA) regulations ($p = 0.003$). While this indicated moderate regulatory knowledge, the proportion of incorrect responses necessitates further regulatory training to ensure comprehensive awareness of national regulations among imaging professionals. Overall, these findings suggest that respondents have moderate operational and regulatory knowledge, with some gaps in international regulations. (see Table 4.3 and Figure 4.10).

4.3.3.4 Radiation monitoring and equipment safety.

This subscale assessed respondents' knowledge of radiation monitoring and equipment safety. Regarding the frequency of checking and maintaining radiation protection equipment, only 12% of respondents responded correctly, while 88% provided incorrect responses ($p < 0.001$). This significant finding reflects a critical gap in routine radiation protective equipment monitoring, which may compromise overall safety practices. Additionally, for the item assessing factors affecting dosimeter performance, 56%

answered correctly (p = 0.320). This is statistically insignificant, indicating insufficient evidence of consistent knowledge. The mixed response suggests that a significant proportion of respondents still lack essential knowledge of factors that influence the accuracy and reliability of dosimeter readings. Overall, this subscale showed imbalanced knowledge levels and a critical gap in equipment monitoring practices (see Table 4.3 and Figure 4.10).

Table 4.3: Knowledge Items on Radiation Protection (Binomial Test) (n=82).

Subscales	Items	Frequency (%)		n	p-value
		Correct	Incorrect		
Paediatric safety and patient-centred protection practice.	Q1. What is the most effective way to protect radiosensitive organs in paediatric patients during radiographic procedures?	60 (73%)	22 (27%)	82	<.001
	Q2. Which of the following does not highlight the importance of properly positioning the patient during radiographic procedures?	38 (46%)	44 (54%)	82	.581
	Q3. Which of the following actions best optimizes the use of shielding during radiographic procedures?	49 (60%)	33 (40%)	82	.097
Radiation protection principles and technical knowledge	Q4. Which of the following is the most effective way to reduce patient dose?	67 (82%)	15 (18%)	82	<.001
	Q5. Which of the following best describes the concept of “dose optimisation”?	61 (74%)	21 (26%)	82	<.001
	Q6. Which factor has the greatest impact on the amount of radiation a patient receives during a radiologic procedure?	63 (77%)	19 (23%)	82	<.001
	Q7. What is the main goal of implementing radiation	70 (85%)	12 (15%)	82	<.001

	protection measures in healthcare settings?				
Operational and regulatory knowledge.	Q8. From the International Commission on Radiological Protection (ICRP) Recommendation: What is the 1-year maximum permissible dose limit for a declared pregnant radiation worker?	29 (35%)	53 (65%)	82	.011
	Q9. Which of the following actions can best reduce scatter radiation exposure to radiologic technologists/radiographers?	55 (67%)	27(33%)	82	.003
	Q10. What is the annual dose limit for occupational exposure to radiologic technologists and radiographers according to the Ethiopian Radiation Protection Authority (ERPA) guidelines?	55 (67%)	27 (33%)	82	.003
Radiation monitoring and equipment safety.	Q11. How often should technologists/radiographers check and maintain radiation protection equipment?	10 (12%)	72 (88%)	82	<.001
	Q12. Which of the following factors does not affect the performance of a dosimeter?	46 (56%)	36 (44%)	82	.320

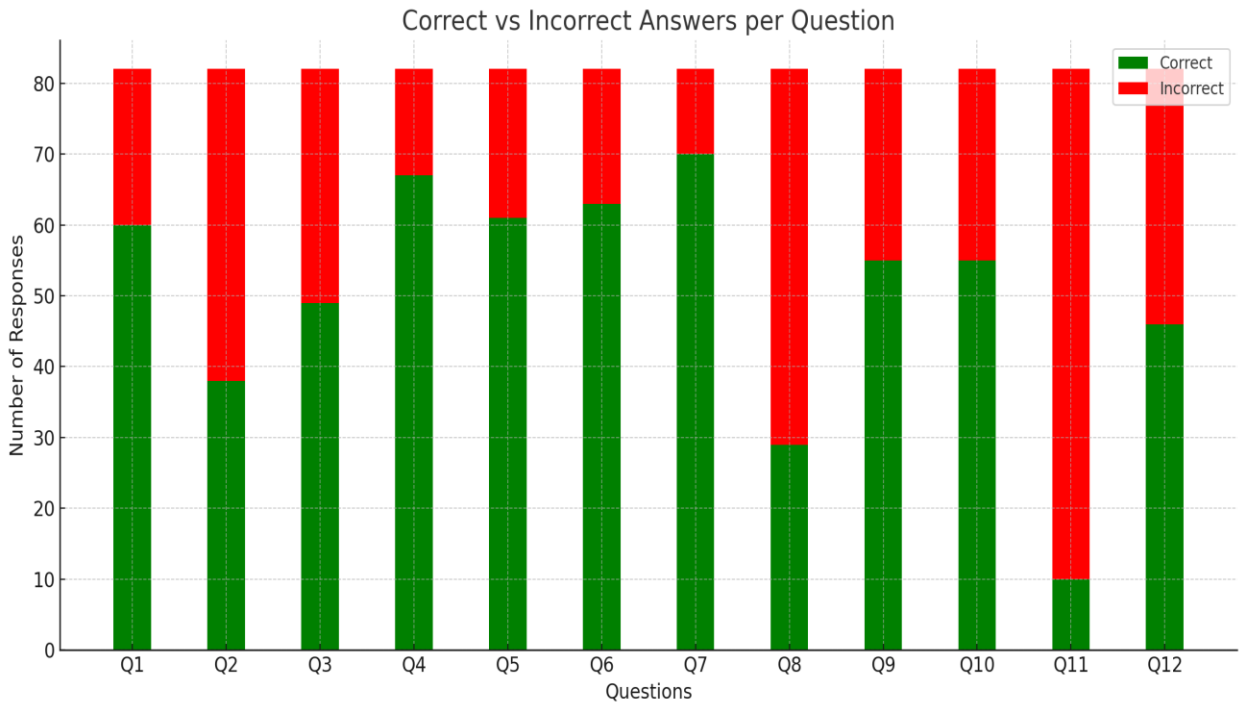

Figure 12.10: Correct and incorrect responses for each knowledge item (n=82).

4.3.4 Attitude assessment on radiation protection

This section presents the findings on respondents' attitudes towards radiation protection and safety practices. Understanding medical imaging professionals' attitudes towards radiation protection and safety practices is essential, as it directly influences their compliance in clinical settings. A total of ten items that are both positively and negatively worded statements were included in this section. A descriptive analysis of frequencies and percentages was conducted across each attitude item to examine and describe the distribution of responses across a five-point Likert scale, ranging from "strongly disagree" to "strongly agree." This analysis provided insights into respondents' level of agreement with various statements related to radiation protection safety practices. The results are summarised in Table 4.5.

To determine whether respondents held an overall positive or negative attitude towards radiation protection, the direction and statistical significance of the mean scores were examined using a one-sample t-test. For positively worded items, mean scores significantly higher than three reflected a positive attitude, and lower mean scores of less than three suggested a mixed or negative perception. For negatively worded items, scores were reversely coded so that the original response of 1 (strongly disagree) became 5 and the original response of 5 (strongly agree) became 1. Therefore, positive attitudes were indicated by significantly higher disagreement with the negative statements

and a mean score greater than three. On the contrary, a mean score less than three suggests a considerable agreement, reflecting a negative attitude. Table 4.6 illustrates the mean, standard deviation and p-value of each item. P-value was used to descriptively indicate respondents' responses from the mid-score, thus providing the direction and strength of a behaviour.

Cronbach's alpha test was performed to evaluate the attitude scale's internal consistency in the main dataset. The Cronbach's alpha for the attitude items was 0.796, indicating good internal consistency of the scale. This suggests that the items consistently measure the underlying construct, respondents' attitude toward radiation protection. When standardised items were used, the alpha slightly increased to 0.801, further supporting the reliability of the scale (see Table 4.4).

Table 4. 4: Cronbach's alpha score for Attitude Scale (n=82)

Cronbach's alpha	**Cronbach's Alpha based on standardised items**	**No. of Items**
0.796	0.801	10

4.3.4.1 Description of respondents' responses on attitude-related responses from Tables 4.7 and 4.8.

To assess attitudes towards regular training, respondents were asked to indicate their level of agreement with the statement "Regular training in radiation protection is essential for enhancing my radiation safety practice." Most respondents agreed (41.5%) or strongly agreed (45.1%). The one-sample t-test yielded a mean score of 4.21 (SD = 0.96, $p < 0.001$), indicating a statistically significant positive deviation from the neutral midpoint. These results suggest that respondents have a positive attitude towards ongoing training as a critical factor in safe radiation protection practice. Respondents also expressed strong beliefs about the impact of safety compliance on patient care. When asked whether "Strict adherence to radiation safety practices improves the overall quality of patient care," 39% strongly agreed, 41.5% agreed, and a few disagreed. The mean score was 4.08 (SD = 1.01, $p < 0.001$), indicating a statistically significant positive attitude towards recognising the relationship between radiation safety and the quality of patient care. However, the disagreement responses show that not all respondents hold this view strongly (see Tables 4.5 and 4.5,4.6, and Figure 4.11).

On operational routines, the respondents were asked about the necessity of safety checks and maintenance: “Routine safety checks and maintenance are necessary for effective radiation protection in my department.” With a total of 83% agreement, 9.8% neutral response and 7.4% total disagreement. The mean score was 4.19 (SD = 1.01, $p < 0.001$). This statistically significant result reflects respondents' positive attitudes and strong consensus on the necessity of periodic safety checks and equipment maintenance for effective radiation protection practices, with few variabilities. Regarding their views on institutional influence, *“Departmental radiation safety culture influences commitment to radiation safety among staff,”* less than 10% of respondents disagreed, with 86.6% overall agreement. A mean score of 4.03 (SD = 0.95, $p < 0.001$). These results highlight a statistically significant positive attitude with low variability among respondents that institutional safety culture is crucial for promoting staff adherence to radiation safety practices (see Table 4.5,4.6, and Figure 4.11).

Perception of workflow burden related to shielding practice was explored using the statement, “Using radiation shielding equipment for every patient is time-consuming.” Only 14.6% of respondents strongly disagreed, and 24.4% disagreed with this statement. 46.4% showed overall agreement, while neutral responses were 14.6%. The t-test showed a mean score of 2.96 (SD = 1.28, $p = 0.797$), indicating no statistically significant difference from the mid-point. This shows that respondents do not hold significant group-level attitudes, with almost half of the respondents considering this safety practice time-consuming. Regarding ALARA principles, the statement “ALARA principles are not applicable in my routine work.” Most respondents (83.2%) disagreed with this statement, while 22.2% expressed general agreement. The mean was 3.50 (SD = 1.12, $p < 0.001$), indicating a statistically significant positive attitude. Although most respondents disagreed with the statement, some agreement responses may indicate variability in understanding and interpretation of the ALARA principles in their daily safety practices (see Table 4.5,4.6 and Figure 4.11).

In response to the statement “Radiation protection and safety practices only benefit patients,” 59.7% of respondents disagreed with this statement, whereas 28% showed agreement and 12.2% neutrality. The mean was 3.80 (SD = 1.38; $p < 0.001$), indicating a statistically significant positive attitude in recognising the benefit of radiation protection and safety practices in routine work. However, the presence of a higher proportion of neutral and agreement responses may signal inconsistency and a gap in recognising the mutual benefit of safety practice for both patients and medical imaging professionals.

Views on patient education were assessed with the statement, “Informing patients about radiation hazards and safety measures is a waste of time.” Among all respondents, 63.4% disagreed, 13.4% had neutral responses, and 30.5% had agreed. The mean score was 3.64 (SD = 1.25, and $p < 0.001$), indicating a statistically significant positive attitude. While many reject the statement, a significant percentage of agreement and neutral responses may indicate variability in perception regarding communication (see Table 4.5,4.6 and Figure 4.11).

Assessing efficiency with safety, respondents were asked, “Efficiency in completing imaging exams should outweigh concerns about radiation safety.” 47.8% of respondents agreed with this statement, 33% disagreed, and 19.5% had neutral responses. The mean was 2.78 ($p = 0.126$), suggesting no statistically significant deviation from the central midpoint agreement. However, the distribution of agreement and neutral responses may reflect a lack of consensus, which may suggest some prioritising efficiency over radiation safety. Lastly, the value placed on personal dosimeters was explored with the statement, “Using a personal dosimeter does not have any value in my routine work.” While 68.3% disagreed, 24.4% agreed, and 7.3% were neutral. The mean average score was 3.61 (SD = 1.28, $p < 0.001$), suggesting a statistically significant positive attitude. However, the proportion of agreement, 24.4%, suggests variability in the perceived importance of personal dose monitors in radiation safety (see table 4.5,4.6 and figure 4.11).

Overall, respondents demonstrated a positive attitude towards radiation protection, particularly in the importance of regular training, departmental safety culture, ALARA principle, and patient safety. However, variability was also observed in shielding equipment use, safety vs efficiency, personal dose monitoring and safety communication practices.

Table 4.5: Frequencies and Percentages of Participant Responses to Attitude Items on Radiation Protection (n=82).

Item Statement	**Responses as Frequency (%)**					**N**
	Strongly disagree	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**	
Regular training in radiation protection is essential for enhancing my radiation safety practice.	3 (3.7%)	2 (2.4%)	6 (7.3%)	34 (41.5%)	37 (45.1%)	82
Strict adherence to radiation safety practices is necessary to improve the overall quality of patient care	4 (4.9%)	1 (1.3%)	11 (13.4%)	34 (41.5%)	32 (39%)	82
Routine safety checks and equipment maintenance are necessary for effective radiation protection in my department	3 (3.7%)	3 (3.7%)	8 (9.8%)	29 (35.4%)	39 (47.6%)	82
Departmental radiation safety culture influences the commitment to radiation safety among staff	4 (4.9%)	2 (2.4%)	5 (6.1%)	47 (57.3%)	24 (29.3%)	82
Using radiation shielding equipment for every patient is time-consuming.	12 (14.6%)	20 (24.4%)	12 (14.6%)	29 (35.4%)	9 (11%)	82
The ALARA principles are not applicable in my routine work	34 (41.5%)	26 (31.7%)	3 (3.7%)	10 (12.2%)	9 (11%)	82

Radiation protection and safety practices only benefit patients	16 (19.5%)	33 (40.2%)	10 (12.2%)	22 (26.8%)	1 (1.2%)	82
Informing patients about radiation hazards and safety measures is a waste of time	25 (30.5%)	27 (32.9%)	11 (13.4%)	14 (17.1%)	5 (6.1%)	82
Efficiency in completing imaging exams should outweigh concerns about radiation safety	9 (11%)	18 (22%)	16 (19.5%)	24 (29.3%)	15 (18.3%)	82
Using a personal dosimeter does not have any value in my routine work.	25 (30.5%)	31 (37.8%)	6 (7.3%)	14 (17.1%)	6 (7.3%)	82

Table 4.6: Attitude items on radiation protection- one-sample T-test results (n=82)

Item Statement	**M (SD)**	**t (df)**	**P value**	**Conclusion**
Regular training in radiation protection is essential for enhancing my radiation safety practice.	4.21 (.96)	39.96 (81)	< 0.001	Significant agreement (positive attitude)
Strict adherence to radiation safety practices improves the overall quality of patient care.	4.08 (1.01)	36.68 (81)	< 0.001	Significant agreement (positive attitude)
Routine safety checks and maintenance are necessary for effective radiation protection in my department.	4.19 (1.01)	37.56 (81)	< 0.001	Significant agreement (positive attitude)

Departmental radiation safety culture influences the commitment to radiation safety among staff.	4.03 (.95)	38.53 (81)	< 0.001	Significant agreement (positive attitude)
Using shielding equipment for every patient is time-consuming.	2.96 (1.28)	20.95 (81)	0.797	Mixed perception
ALARA principles are not applicable in my routine work.	3.50 (1.12)	28.17 (81)	< 0.001	Significant disagreement (positive attitude)
Radiation protection and safety practices only benefit patients.	3.80 (1.38)	24.92 (81)	< 0.001	Significant disagreement (positive attitude)
Informing patients about radiation hazards and safety measures is a waste of time.	3.64 (1.25)	26.40 (81)	< 0.001	Significant disagreement (positive attitude)
Efficiency in completing imaging exams should outweigh concerns about radiation safety.	2.78 (1.29)	19.57 (81)	0.126	Mixed perception
Using a personal dosimeter does not have any value in my routine work.	3.67 (1.28)	26.03 (81)	< 0.001	Significant disagreement (positive attitude)

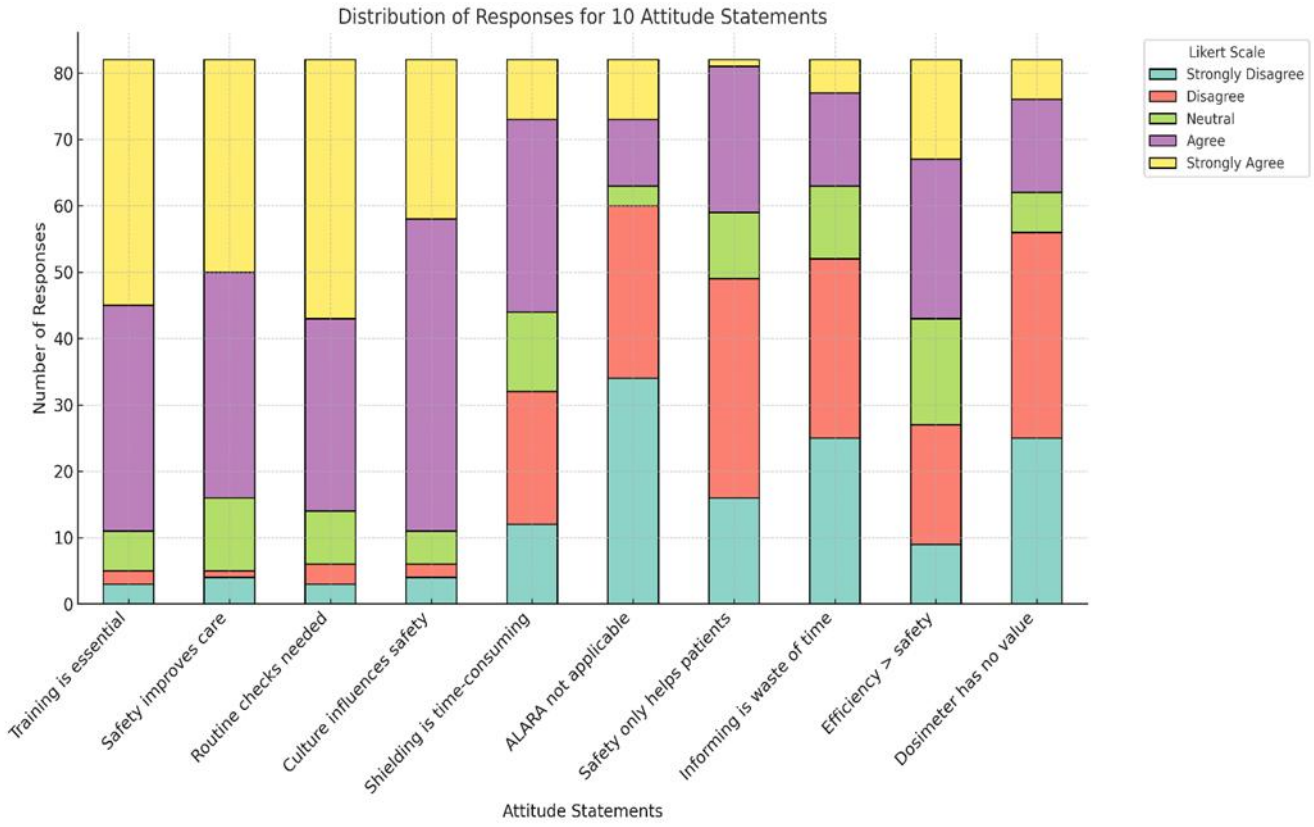

Figure 13.11: Frequency of responses across attitude statements(n=82).

4.3.5 Practice of radiation protection and safety

This section presents the results of respondents' radiation protection and safety practices. A total of ten Likert-scale items and multiple binary-response items were included. Five items used a five-point Likert scale ranging from 5 (Always) to 1 (Never). A descriptive summary of compliance with radiation protection practices is presented for the five-point Likert scale items in Table 4.8, expressed in terms of frequencies and percentage responses. Furthermore, to estimate the proportion of respondents selecting each response item, a one-sample proportion test using Wilson's score method, along with a confidence interval, was applied. This provided insights into the relative compliance frequency of each form of radiation protection practice as illustrated in Table 4.9. This analysis was done for five items that allowed multiple selections; each response option was treated as a binary variable (selected=1, not selected=0) and analysed accordingly. Although no formal hypothesis has been defined, a benchmark value of 50% adherence was set as a reference for their adherence level. Additionally, to assess the reliability of the items included in the practice section, Cronbach's alpha was calculated for items with different scale formats. The Likert scale items yielded a Cronbach's alpha of 0.851, indicating good internal consistency of the scale. The second binary scale response item

statements resulted in a Cronbach's alpha of 0.702, indicating acceptable reliability of the scale (see Table 4.7).

Table 4.7: Cronbach's alpha score (Practice)

Item type	Cronbach's alpha	No. of Items
Likert scale	0.851	5
Binary scale	0.702	28

4.3.5.1 Description of respondents' practice-related responses from Tables 4.8.

To evaluate adherence to safety protocols, respondents were asked, "How frequently do you follow recommended safety protocols when operating imaging modalities?" 35.4% of the respondents reported always following safety protocols, 18.3% often, and 35.4% sometimes, indicating inconsistent adherence. Furthermore, the remaining 11% reported rarely following safety protocols, reflecting low practice. These findings showed that only about half of the respondents consistently adhere to standard safety protocols, suggesting a gap in routine safety compliance (see Table 4.8 and Figure 4.12).

To understand how often radiation protective equipment is provided to patients, respondents responded to the question "How frequently do you provide radiation protection equipment for your patients?" 23.2% of the respondents reported that they always provide radiation protection equipment, 19.5% often, and 39% stated they provide it sometimes, indicating inconsistent practice. Additionally, 17.1% rarely offered the equipment, and 1.2% never did. The results indicate a gap in the routine use of shielding equipment during routine examinations (see Table 4.8 and Figure 4.12).

To assess patient-centred communication practices, respondents were asked, "How frequently do you address your patients' concerns regarding radiation?" Only 29.3% of the respondents reported always addressing patients' concerns, 15.9% said they do so often, and 36.6% reported doing so sometimes. In addition, 17.1% rarely address them, and 1.2% never do. The prevalence of "sometimes" and "rarely" responses indicates that communication with patients is not consistently practiced. Respondents were also asked about their regular use of safety monitoring devices: "How frequently do you wear a dosimeter?" In response, 37.8% reported always wearing a dosimeter and 14.6% often. Meanwhile, 34.1% wear it sometimes. 11% rarely, and 2.4% never. Around 47.5% of

respondents did not wear their dosimeters consistently, reflecting a gap in occupational radiation safety compliance. Lastly, to assess precautionary practices before examination, respondents were asked: “Before performing a radiological examination, how frequently do you ask if a female patient is pregnant?” About 42.7% of respondents reported that they always ask a female patient before a radiological examination, 15.9% said they often do, 26.8% sometimes, and 14.6% rarely. Around 41.4% of respondents do not consistently verify the pregnancy status before imaging procedures, which may compromise patient safety (see Table 4.8 and Figure 4.12).

Table 4.8: Frequencies and percentages of participant responses to Likert scale practice items on radiation protection. (n=82)

Item Statement	**Responses as Frequency (%)**					**n**	**M (SD)**
	Always	**Often**	**Sometimes**	**Rarely**	**Never**		
Frequency of following safety protocols.	29 (35.4%)	15 (18.3%)	29 (35.4%)	9 (11%)	0	82	3.78 (1.05)
Frequency of providing radiation safety equipment.	19 (23.2%)	16 (19.5%)	32 (39%)	14 (17.1%)	1 (1.2%)	82	3.46 (1.07)
Frequency of addressing patient concerns.	24 (29.3%)	13 (15.9%)	30 (36.6%)	14 (17.1%)	1 (1.2%)	82	3.55 (1.12)
Frequency of wearing a dosimeter.	31 (37.8%)	12 (14.6%)	28 (34.1%)	9 (11%)	2 (2.4%)	82	3.74 (1.15)
Frequency of asking female patients about pregnancy before imaging.	35 (42.7%)	13 (15.9%)	22 (26.8%)	12 (14.6%)	0	82	3.86 (1.13)

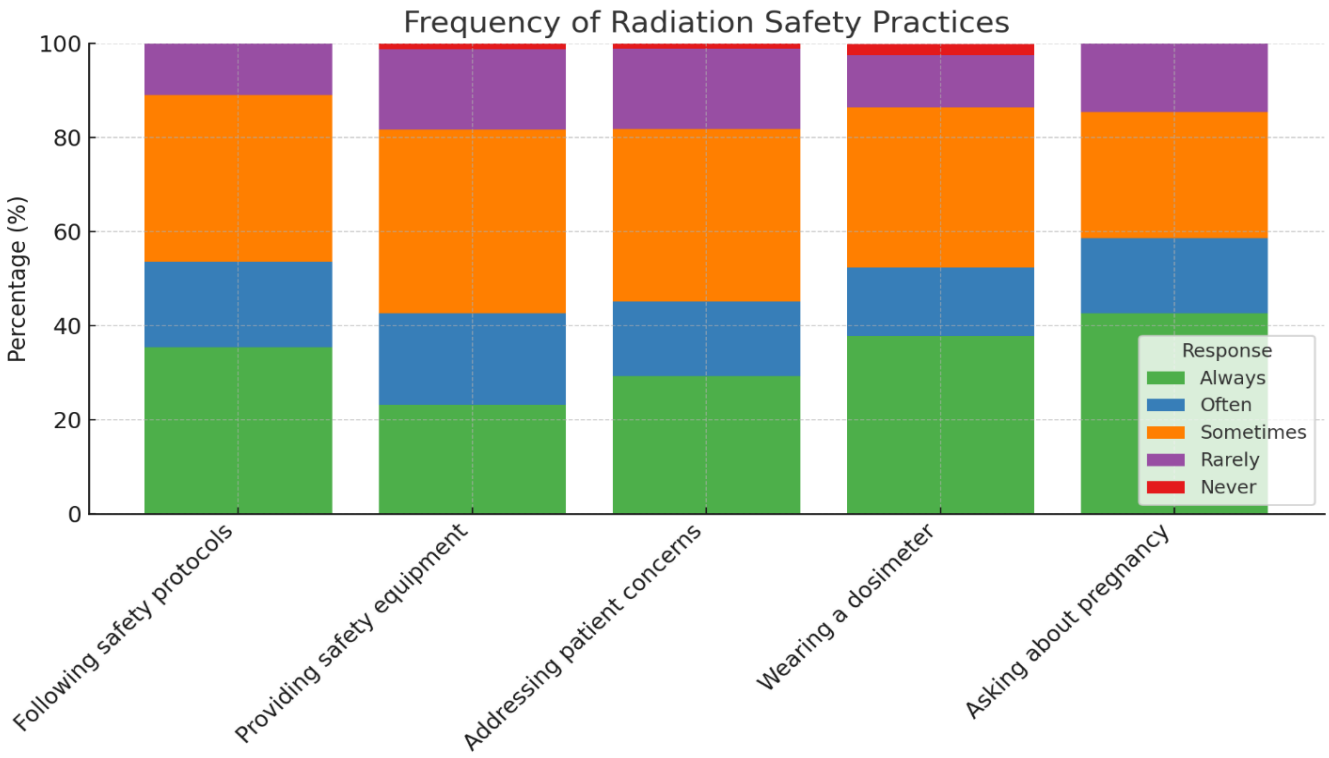

Figure 14.12: Distribution of respondents' responses for Likert practice items, n=82.

4.3.5.2 Description of respondents' practice responses as reflected in Tables 4.9.

To identify routinely used radiation protective tools, respondents were asked, *"What type of radiation shielding equipment do you regularly use in your department?"* Most respondents (81.7%, 95% CI: 72–88.6) reported frequently using lead aprons, making them the most used equipment among respondents compared to other tools. 39% of respondents reported using a gonad shield, 6.1% lead gloves, 11% lead glasses, and 15.9% using radiation glasses. The lower reported use of these safety gears indicates variability in the utilisation of radiation safety equipment and highlights limited adoption of protective equipment beyond lead aprons.

To explore measures used to minimize repeat exposures, respondents were asked, "What steps do you take to minimize repeat exposures during imaging?" The most frequently reported practices among respondents were ensuring correct positioning and selecting the right exposure factors (89%, 95% CI: 80.4–94.1) and verifying patient identity and exam details before the procedure (87.8%, 95% CI: 79–93.2), indicating a consistent adherence to key procedural checks. In addition, 69.5% of them reported using collimation to limit the X-ray field. However, low adherence was seen (29.3%, 95% CI:

20.5–39.9) for regularly maintaining and calibrating the imaging machine and (37.8%, 95% CI: 28.1–48.6) for providing appropriate shielding for patients. This inconsistency suggests strong procedural awareness but weaker engagement with equipment-related safety measures, which are equally critical for reducing repeated exposure.

To examine how respondents evaluate the effectiveness of radiation shielding tools, they were asked, “How do you assess the effectiveness of radiation shielding equipment in your department?” (31.7%, 95% CI: 22.6–42.4) of respondents reported employing objective measures such as dose measurement and monitoring, (20.7%, 95% CI: 13.4–30.7) reported regular inspection and maintenance. Some respondents used informal approaches, 20.7% (95% CI: 13.4–30.7) depended on visual inspection for wear and damage, and 11% (95% CI: 5.9–19.6) asked their colleagues for assessment. Notably, 45.1% (95% CI: 34.8–55.9) reported never having conducted a formal assessment, and 8.5% (95% CI: 4.2–16.6) did not know how to assess the effectiveness of the tools. These results indicate a substantial gap in routine quality assurance practices and awareness, raising concerns about the reliability of protective equipment in practice.

To assess strategies used to reduce unnecessary radiation during routine examination, respondents were asked, “What methods do you use to minimize radiation exposure to patients, yourself and your colleagues?” The majority of respondents, 87.8% (95% CI: 79-93.2), applied the fundamental radiation safety principles of time, distance, and shielding. Optimising exposure setting was reported among 62.2% (95% CI: 51.4-71.9) of respondents, while 30.5% (95% CI: 21.6–41.1) modified protocols, and a similar percentage used monitoring devices. Participation in radiation protection and safety trainings was reported by 20.7% (95% CI: 13.4–30.7). These results indicated that while core safety principles are practised, lower engagement is reported in optimising exposure factors, and training reflects variability in depth of safety practice and limited institutional emphasis on continuous education.

Lastly, management of patients undergoing repeated imaging studies, respondents were asked, “How do you manage radiation protection for patients undergoing repeated imaging studies?” Only 14.6% (95% CI: 8.6–23.9) recorded the cumulative radiation dose, and 13.4% (95% CI: 7.7–22.4) arranged a follow-up exam at appropriate intervals. 35.4% (95% CI: 25.9–46.2) reported applying dose reduction techniques and protocols, and 28% (95% CI: 19.5–38.6) reported using alternative imaging modalities such as MRI or Ultrasound to avoid unnecessary radiation. However, 40.2% (95% CI: 30.3–51.1) acknowledged repeating the procedure without taking specific measures, and 7.3% (95%

CI: 3.4–15.1) stated not knowing how to manage such situations. The low percentage across responses indicates inconsistency and a lack of standardised radiation protection safety practice and structured approaches for minimizing cumulative dose in repeat examinations across imaging departments.

Table 4.9: Distribution of radiation protection practices based on Willson scoring, interpretation, and statistical significance (n = 82) items were aggregated into overall practice levels, classified as high ≥ 75%; moderate 50- 74% and low <50%.

Practice items		**n (Yes)**	**Total (n)**	**Proportion (%)**	**95%CI (upper, lower) Willson score**	**P-value**	**Interpretation to Practice**
What type of radiation shielding equipment do you regularly use in your department?	Uses a lead apron	67	82	81.7 %	[72, 88.6]	< .001	high adherence
	Uses lead gloves	5	82	6.1%	[2.6, 13.5]	< .001	Low adherence
	Uses gonad shields	32	82	39%	[29.2, 49.8]	.048	Low adherence
	Uses Lead glasses	9	82	11%	[5.9,19.6]	< .001	Low adherence
	Uses a thyroid collar	12	82	14.6%	[8.6,23.9]	< .001	Low adherence
	Uses radiation Glasses	13	82	15.9%	[9.5, 25.3]	< .001	Low adherence
What steps do you take to minimize repeat exposures during imaging?	Verify patient identity and exam details before starting	72	82	87.8%	[79,93.2]	< .001	high adherence
	Ensure correct positioning	73	82	89%	[80.4, 94.1]	< .001	high adherence

	and select the right exposure factors						
	Use collimation to limit the X-ray field	57	82	69.5%	[58.9,78.4]	< .001	Moderate
	Regularly maintain and calibrate the imaging machine	24	82	29.3%	[20.5,39.9]	< .001	Low adherence
	Providing appropriate shielding for patients	31	82	37.8%	[28.1,48.6]	.028	Low adherence
How do you assess the effectiveness of radiation shielding equipment in your department?	Regular inspections and maintenance	17	82	20.7%	[13.4,30.7]	< .001	Low adherence
	Dose measurement and monitoring	26	82	31.7%	[22.6,42.4]	< .001	Low adherence
	Asking colleagues for an assessment	9	82	11%	[5.9,19.6]	< .001	Low adherence
	I have never done a formal assessment	37	82	45.1%	[34.8,55.9]	.380	Low adherence
	Visual inspection for wear and damage	17	82	20.7%	[13.4,30.7]	< .001	Low adherence
	I do not know	7	82	8.5%	[4.2,16.6]	< .001	Low adherence
What methods do you use to minimize radiation	Applies time, distance, and shielding principles	72	82	87.8%	[79,93.2]	< .001	high adherence

exposure to patients, yourself and your colleagues?	Attend radiation protection and safety training	17	82	20.7%	[13.4,30.7]	< .001	Low adherence
	Uses monitoring devices	25	82	30.5%	[21.6,41.1]	< .001	Low adherence
	Optimise exposure settings	51	82	62.2%	[51.4,71.9]	.028	moderate
	Modify protocols to minimize radiation exposure	25	82	30.5%	[21.6,41.1]	< .001	Low adherence
How do you manage radiation protection for patients undergoing repeated imaging studies?	Records the cumulative radiation dose	12	82	14.6%	[86,23.9]	< .001	Low adherence
	Schedules follow-up exams at intervals	11	82	13.4%	[77,22.4]	< .001	Low adherence
	No specific measures, just repeat the exam	33	82	40.2%	[30.3,51.1]	.078	Low adherence
	Uses alternative imaging (MRI, Ultrasound)	23	82	28%	[19.5,38.6]	< .001	Low adherence
	Applies dose reduction techniques and protocols	29	82	35.4%	[25.9,46.2]	.008	Low adherence
	I do not know	6	82	7.3%	[3.4,15.1]	< .001	Low adherence

4.3.6 Respondents' perception assessment towards radiation hazards, radiation protection and safety practices

This results section presents respondents' health perceptions regarding the seriousness of radiation risks, the effectiveness of radiation protection and safety measures, and the barriers faced during practice, framed within the constructs of the Health Belief Model (HBM). A total of eight items, a five-point Likert scale, were included in the data analysis, with response options ranging from strongly agree to strongly disagree. To ensure the tool's reliability, Cronbach's alpha was calculated (See Table 4.10). The Cronbach's alpha for perception items was 0.711, indicating acceptable internal consistency of the scale.

Table 4.10: Cronbach's alpha score (perception) n=82

Cronbach's alpha	**No. of Items**
0.711	8

Additionally, A descriptive analysis was conducted to explore response trends, providing a better understanding of potential gaps in awareness or behavioural intentions regarding radiation protection and safety practices among medical imaging professionals. Frequency and percentage were analysed for each perception item. This aimed to examine the distributions of responses indicating agreement and disagreement with a particular health behaviour. Table 4.11 presents a descriptive summary of imaging professionals' perceptions regarding the practice of radiation protection and safety measures based on HBM constructs.

4.3.6.1 Description of respondents' perception responses as reflected in Table 4.11

This section summarises Table 4.13 and describes the results in terms of HBM constructs. **Perceived susceptibility**: 52.2% of respondents believed that they were likely to experience health problems due to radiation exposure during their routine work. 25.6%were neutral, indicating uncertainty about whether the daily exposure had an Impact on their health. About 22% of respondents disagreed. These findings suggest a moderate variability in perceptions of susceptibility, with a substantial proportion recognising risk but other uncertain or dismissive of potential health impacts.

Perceived severity: A majority of respondents (76.9%) expressed concerns about the potential long-term health consequences of radiation exposure. About 14.6% of respondents were neutral, and fewer than 10% disagreed with the item statement. This

indicates the majority of respondents recognise the seriousness of the health risk associated with their profession.

Perceived benefits: a strong consensus on the importance of radiation protection and safety measures was reflected. 82.9% of respondents showed agreement, with 14.6 % neutral responses and 3.7% disagreement. These findings highlight that most respondents recognise the value of radiation safety practices, reflecting widespread belief in their benefit.

Perceived Barriers: Four items were included to assess potential barriers to practising radiation safety. 73.1% of respondents agreed that a high workload prevents them from consistently following safety practices, 9.8% were neutral, and 17.1% disagreed. These response distributions indicate that workload is commonly perceived as a constraint, although not uniformly across all respondents. Similarly, 79.3% of respondents reported resource constraints as a hindering factor for effective radiation protection practices; 13.4% had neutral responses, while 17.1% did not consider resource constraints to be a reason for poor practices. This suggests that respondents perceived resource constraints as a barrier to safety practices. Insufficient training on radiation safety practices was also reported as a barrier, with 63.4% agreeing that it prevents them from applying the necessary protective measures, alongside 15.9% neutral responses and 20.7% disagreement. These findings highlight the variability in perceived adequacy of radiation safety training among respondents. Institutional safety culture also emerged as a barrier, with 51.2% of respondents reporting not following radiation safety measures because such practices are not commonly observed in their department, while 15.9% remained neutral, and the remaining 33% disagreed. This distribution of responses shows differences in perception among respondents regarding departmental safety culture and practice norms, suggesting institutional safety culture influences practice unevenly.

Self-efficacy: Despite the presence of several barriers to respondents' safety practices, respondents expressed confidence in their ability to follow radiation safety measures to reduce unnecessary radiation exposure. 76.8 % agreement, with 22% neutral responses and only 1.2% strongly disagreed. This indicates a general high level of self-efficacy in their radiation protection and safety practices, suggesting respondents believe they can apply safety practices even in challenging contexts.

Table 4. 11: Frequency and percentage distribution of imaging professionals' perceptions toward radiation protection and safety measures based on health belief model constructs (n = 82).

Item Statement	Responses as Frequency (%)					Mean (SD)	n
	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree		
I am likely to experience health problems due to radiation exposure in my job as a radiologic technologist/radiographer.	5 (6.1%)	13 (15.9%)	21 (25.6%)	34 (41.5%)	9 (11%)	2.65 (1.07)	82
I am concerned about the potential long-term health consequences of radiation exposure in my profession.	4 (4.9%)	3 (3.7%)	12 (14.6%)	45 (54.9%)	18 (22%)	2.15 (0.97)	82
I believe radiation protective measures (e.g., lead aprons, shielding, selecting the right protocol, and dose optimization) are important in reducing radiation exposure.	2 (3.7%)	0 (0%)	12 (14.6%)	38 (46.3%)	30 (36.6%)	4.15 (0.85)	82
A high workload prevents me from consistently following radiation safety measures.	8 (9.8%)	6 (7.3%)	8 (9.8%)	38 (46.3%)	22 (26.8%)	2.27 (1.3)	82
Resource constraints (staff shortage, old equipment, lack of radiation safety guidelines, protective gear) in my facility hinder effective radiation safety practices.	3 (3.7%)	3 (3.7%)	11 (13.4%)	35 (42.7%)	30 (36.6%)	1.95 (0.99)	82
Insufficient training on radiation safety practices	7 (8.5%)	10 (12.2%)	13 (15.9%)	22 (26.8%)	30 (36.6%)	2.29 (1.3)	82

prevents me from applying the necessary protective measures.							
I tend not to follow radiation safety measures because they are not commonly practised in my department.	9 (11%)	18 (22%)	13 (15.9%)	23 (28%)	19 (23.2%)	2.69 (1.33)	82
I am confident in my ability to follow radiation safety measures to reduce unnecessary radiation exposure.	1 (1.2%)	0 (0%)	18 (22%)	48 (58.5%)	15 (18.3%)	3.92 (0.71)	82

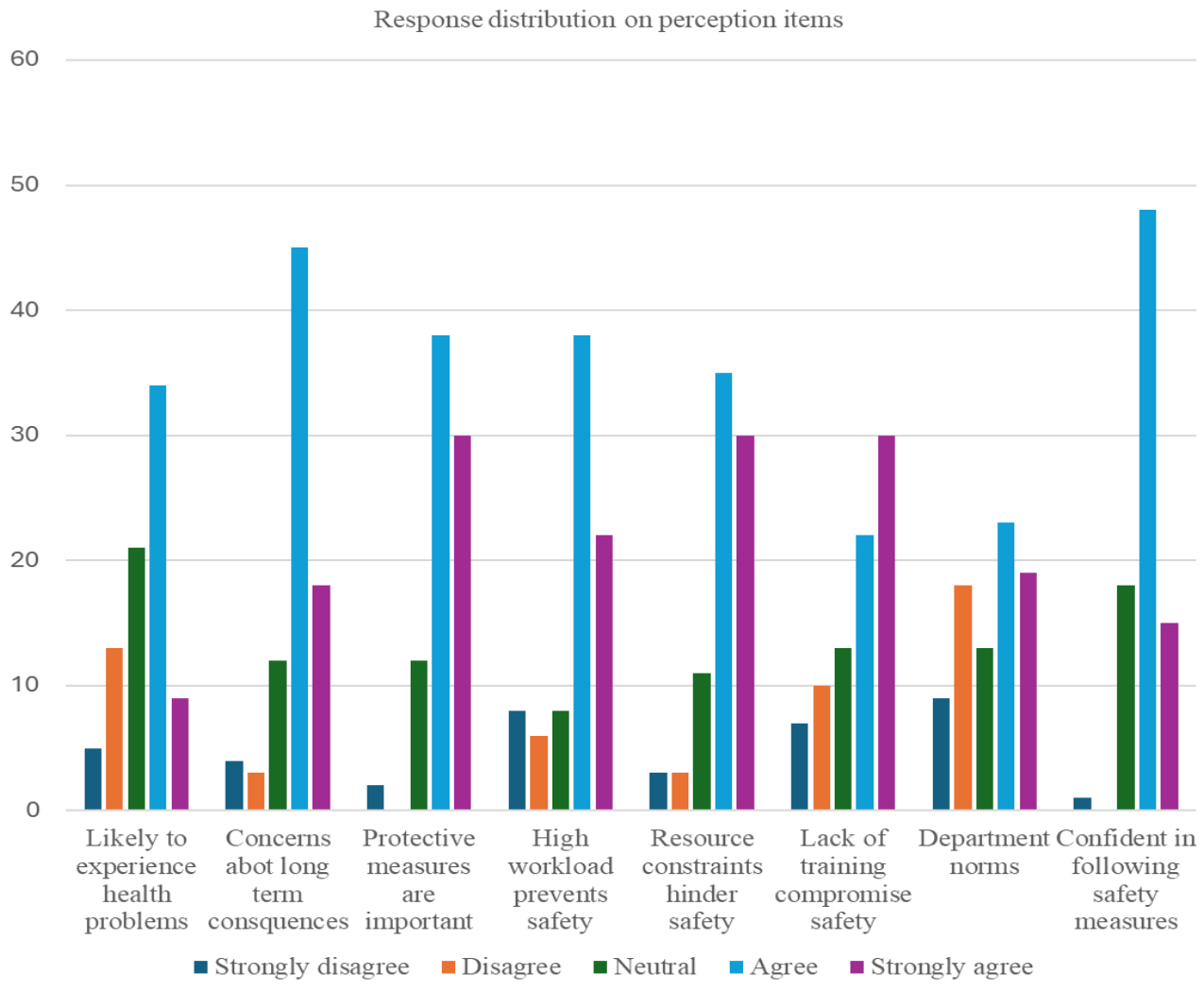

Figure 15.13: A bar chart showing response distribution for each perception item.

4.3.7 Enabling environment

This results section discusses the environmental barriers influencing radiation safety practices among medical imaging professionals. Items were developed to understand and analyse key factors, including resource availability, institutional oversight, accountability mechanisms, the presence of a safety culture, regular monitoring of radiation exposure, and access to continuous professional development and training. A total of seven items were assessed: five using a Likert scale, and two items were analysed as multiple binary response variables (selected/not selected). Cronbach's alpha was employed to assess internal consistency. The Likert scale items yielded a Cronbach's alpha of 0.851, and the binary response items produced a Cronbach's alpha of 0.841, both indicating good internal consistency of the scale (See Table 4.12).

Table 4.12: Cronbach's alpha score for Likert scale and binary scale items (enabling environment), n=82.

Item type	**Cronbach's alpha**	**No. of Items**
Likert scale	0.845	5
Binary scale	0.841	14

4.3.7.1 Description of respondents' environment-related responses as reflected in Table 4.13

To assess resource availability, respondents were asked, "Radiation protection resources are easily accessible in my workplace." A total of 63.4% of respondents disagreed. Only 20.7% agreed, and 2.4% strongly agreed with the statement, while 13.4% remained neutral. The results indicate that radiation protection resources are not consistently accessible across the study settings, suggesting systemic gaps in resource provision that may hinder safe practice.

Regarding the availability of regular access to safety audits or inspections, 32.9% of respondents strongly disagreed, and 24.4% disagreed. 12.2% remained neutral, resulting in a total agreement of 30.5%. These findings highlight limited access to audit and inspection within radiology departments, pointing to a weak institutional oversight mechanism.

Respondents' responses regarding the overall radiation safety culture in their respective radiology departments showed a balanced distribution. Most respondents (47.5%) agreed that their department has a positive safety culture, while 36.6% expressed disagreement and 15.9% remained neutral. Although the mean score is 3.01, indicating a moderately positive perception, the overall neutral and disagree responses indicate that this may not be consistent across departments, reflecting how safety culture is embedded institutionally.

To assess the regular inspection of dosimeter readings, respondents were asked, “My dosimeters are taken for measurement regularly.” 62.2% reported that their dosimeters are measured regularly, while 18.3% were neutral, and 19.5% disagreed with the statement. These results generally suggest good compliance with occupational radiation monitoring. However, there is still an inconsistency among respondents regarding personal dose monitoring, which may compromise comprehensive staff protection.

A majority of respondents (65.8%) indicated a lack of continuous education or training to update imaging professionals on current radiation safety practices within their institutions. Only 18.1% reported receiving regular training, while 17.1% remained neutral. These findings indicate limited access to ongoing professional development, suggesting that institutional investment in continuous training is insufficient to sustain updated safety practices.

Table 4.13: Frequencies, percentages and mean score of participant responses to Likert scale enabling environment items on radiation protection, n=82.

Item Statement	**Responses as Frequency (%)**					**Mean (SD)**	**n**
	Strongly disagree	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**		
Radiation protection resources (e.g., guidelines, safety manuals, radiation protection equipment) are easily accessible in my workplace.	26 (31.7%)	26 (31.7%)	11 (13.4%)	17 (20.7%)	2 (2.4%)	2.30 (1.19)	82

The radiology department has regular access to safety audits or inspections to assess radiation protection practices.	27 (32.9%)	20 (24.4%)	10 (12.2%)	21 (25.6%)	4 (4.9%)	2.45 (1.31)	82
The overall safety culture regarding radiation protection in my workplace is positive.	14 (17.1%)	16 (19.5%)	13 (15.9%)	33 (40.2%)	6 (7.3%)	3.01 (1.26)	82
My dosimeters are taken for measurement regularly.	6 (7.3%)	10 (12.2%)	15 (18.3%)	33 (40.2%)	18 (22%)	3.57 (1.17)	82
I often receive training or updates on radiation safety practices at my workplace.	27 (32.9%)	27 (32.9%)	14 (17.1%)	11 (13.4%)	4 (3.7%)	2.21 (1.15)	82

4.3.7.2 Description of respondents' response to enabling environment binary items as reflected in Table 4.14.

To assess the challenges regarding implementing radiation protection and safety practices, respondents were asked to identify the main barriers in their respective radiology departments. Most respondents (90%) reported that high workload prevents them from consistently following radiation protection protocols and safety measures. 76.8% mentioned a lack of resources, while 72% of respondents noted inadequate staff training as a major barrier. These results suggest that workload, financial and educational constraints are reported as barriers to safe radiation protection practices.

Additionally, 54.9% respondents reported insufficient regulatory guidance, and 48.8% reported a general lack of awareness of the importance of radiation protection. Consistent radiation protection practices are also hampered by other obstacles, including difficulties in enforcing compliance among staff (45.7%) and poor patient cooperation (39%). Collectively, these findings indicate that radiation protection and safety practices are influenced by multiple interrelated barriers at both individual and institutional levels, highlighting systemic challenges (see Table 4.14).

In terms of areas for improvement, respondents were asked to suggest measures to enhance overall radiation safety practices in their department. Most (86.6%) endorsed increasing the use of protective equipment, such as lead aprons and thyroid shields, for both patients and staff. 76.8% recommended regular radiation safety training for all staff

members. Around 75.6% agreed that departmental radiation protection guidelines should be regularly reviewed and updated to align with national and international standards.

Other commonly identified measures included implementing stricter safety protocols to prevent repeat examinations and optimise radiation doses (70.7%), upgrading imaging modalities (63.4%), and enhancing dose monitoring and reporting systems (59.8%), which were also widely endorsed. Lastly, 56.1% stressed the importance of promoting patient education on radiation safety and establishing a multidisciplinary radiation safety team to oversee safety practices, review incident reports, and suggest improvements. Overall, these findings revealed a consistent pattern in which respondents identify both practical and policy-oriented strategies associated with enhancing radiation protection and safety standards within their institutions (see Table 4.14).

Table 4.14: Total yes response frequency, percentages and mean score of respondents to binary scale variables (enabling environment), n=82.

Items		**n (Yes)**	**Total (n)**	**Percentage (%)**	**Mean (SD)**
What are the main challenges you face in implementing radiation protection measures in your department?	Lack of adequate training for staff	59	82	72	0.72 (0.45)
	Lack of resources	63	82	76.8	0.76 (0.42)
	A general lack of awareness about the importance of radiation protection among staff members	40	82	48.8	0.48 (0.50)
	High workload	74	82	90.2	0.90 (0.29)
	Insufficient regulatory guidance	45	82	54.9	0.54 (0.50)
	Poor patient cooperation	32	82	39	0.39 (0.49)
	Difficulty enforcing compliance among staff	35	82	42.7	0.42 (0.49)
What improvements do you think your imaging department could make to improve	Implementing regular training sessions on radiation safety for all staff members.	63	82	76.8	0.76 (0.42)
	Upgrading imaging equipment to newer models with lower radiation exposure	52	82	63.4	0.63 (0.48)

radiation protection practices?	Encouraging the use of protective gear, such as lead aprons and thyroid shields, for patients and staff.	71	82	86.6	0.86 (0.34)
	Introducing stricter protocols for minimizing repeat scans and optimizing radiation dose.	58	82	70.7	0.70 (0.45)
	Promoting patient education on radiation safety and establishing a multidisciplinary radiation safety team to oversee safety practices, review incident reports, and recommend improvements.	46	82	56.1	0.56 (0.49)
	Regularly reviewing and updating radiation protection guidelines in line with the local regulations and international standards.	62	82	75.6	0.75 (0.43)
	Enhancing dose monitoring and reporting systems for radiation exposure levels.	49	82	59.8	0.59 (0.49)

4.3.8 Correlation analysis

To examine the associations among respondents' knowledge, attitudes, practices, perceptions, and the enabling environment, a Pearson correlation analysis was conducted. Table 4.18 summarises the correlation coefficients (r) among these variables.

The correlation between knowledge and attitude scores showed a moderate positive relationship ($r = 0.403$, $p < 0.001$), suggesting that higher knowledge is directly associated with a more positive attitude towards radiation protection. Similarly, a weak but statistically significant correlation was observed between knowledge and perception ($r = 0.228$, $p < 0.05$), suggesting a relationship between knowledge levels and individuals' health- related perceptions. However, knowledge did not show statistically significant correlations with practice scores ($r = 0.119$, $p = 0.287$) or enabling environment ($r = 0.077$, $p = 0.490$), indicating that there is no evidence of meaningful association between these variables. This suggests that knowledge alone may not be sufficient to influence reported safety

practices or perceptions of the working environment, highlighting the importance of other behavioural and contextual factors.

Attitude demonstrated moderate positive correlation with practice ($r = 0.472$, $p < 0.01$), perception ($r = 0.484$, $p < 0.01$), and enabling environment ($r = 0.302$, $p < 0.01$). These findings indicate that more positive attitudes are associated with better radiation safety practices, stronger health beliefs and supportive environmental conditions. This underscores the role of attitudes as a key driver of behaviour and perception in radiation safety.

Practice demonstrated a moderate correlation with all variables except knowledge. A moderate positive correlation was observed with perception ($r = 0.514$, $p < 0.01$), indicating a statistically significant relationship between these variables. Similar results were found between practice and environment ($r = 0.515$, $p < 0.01$). These findings suggest that reported practices are more strongly influenced by individuals' attitudes, health beliefs and environmental conditions than by knowledge alone. Higher levels of reported practices are closely associated with positive health beliefs and more supportive working environments, supporting the multidimensional nature of safety compliance.

Finally, perception (HBM) is moderately and positively correlated with all variables. The correlation between perception and environment ($r = 0.414$, $p < 0.01$) indicates that more positive health beliefs are associated with a favourable perception of the working environment. This highlights the central role of perception in shaping both individual behaviour and the view of institutional support.

Overall, attitudes, perceptions and environmental factors demonstrated a stronger association with practice compared to knowledge. This pattern suggests that behavioural and contextual factors are more closely related to radiation protection and safety practices than knowledge alone. However, these findings only indicate statistical associations between variables, and due to the cross-sectional design of the study, causality cannot be inferred, and the direction of influence between variables cannot be determined.

Table 4.15: Correlation analysis on knowledge, attitude, practice, perception and enabling environment scores, n=82.

		Knowledge	Attitude	Practice	Perception (HBM)	Environment
Knowledge	Pearson correlation	1	.403**	.119	.228*	.077
	Sig.(2-tailed)		<.001	.287	.039	.490
	N	82	82	82	82	82
Attitude	Pearson correlation	.403**	1	.472**	.484**	.302**
	Sig. (2-tailed)	<.001		<.001	<.001	.006
	N	82	82	82	82	82
Practice	Pearson correlation	.119	.472**	1	.514**	.515**
	Sig. (2-tailed)	.287	<.001		<.001	<.001
	N	82	82	82	82	82
Perception (HBM)	Pearson correlation	.228*	.484**	.514**	1	.414**
	Sig. (2-tailed)	.039	<.001	<.001		<.001
	N	82	82	82	82	82
Environment	Pearson correlation	.077	.302**	.515**	.204	1
	Sig. (2-tailed)	.490	.006	<.001	<.001	
	N	82	82	82	82	82

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed)

4.4 SUMMARY

This chapter presented the findings on knowledge, attitudes, practices, perceptions, and the enabling environment. Both descriptive and inferential analyses were used to examine these key variables. The results from the knowledge section indicated that respondents possessed adequate knowledge of radiation protection and safety; however, important areas such as patient positioning, dose limits for pregnant staff, and equipment checks and maintenance require further attention. Although the attitude section showed that respondents generally held a positive attitude towards radiation protection, the findings also revealed a tendency to prioritise efficiency over safety, with some considering shielding equipment during routine examinations as time-consuming. In terms of radiation protection and safety practices, while the Likert scale responses demonstrated moderately good adherence, the knowledge-based binary items revealed significant gaps in technical understanding and practice, including inconsistent use and maintenance of shielding equipment, limited implementation of the ALARA principle, and inadequate strategies to reduce repeat exposures. Constructs from HBM further revealed that respondents perceived their work as hazardous and may lead to potential long-term health consequences. Reported barriers included high workload, resource constraints, insufficient training, and poor institutional radiation safety culture. The role of the environment in radiation protection practices was assessed under the enabling environment variable. Key challenges identified by respondents included high workload, lack of resources, and insufficient staff training. Respondents also suggested the need to improve the use of radiation protective equipment during routine work, regularly review safety guidelines, and implement stricter safety protocols. Finally, a correlation analysis was conducted to explore the relationships between variables. A multi-dimensional relationship was observed between practice and the other variables. Practice was moderately correlated with attitude, perception and environment. The results also showed that knowledge mainly correlates with attitude and perception. The next chapter will discuss the study findings in relation to the study objectives and relevant literature.

CHAPTER 5

DISCUSSION OF RESEARCH FINDINGS

5.1 INTRODUCTION

The previous chapter presented the results obtained from the data analysis. This chapter discusses the research findings in relation to the research questions and objectives set within the KAP and HBM frameworks, alongside existing literature. The discussion examines the extent to which the study findings align with or differ from previous research and how knowledge, attitudes, health perceptions and environmental factors influence radiation protection practices among imaging professionals.

5.2 DEMOGRAPHIC CHARACTERISTICS OF RESPONDENTS

A total of 82 respondents were included in this study from four federal hospitals in Addis Ababa, Ethiopia. As the study used a descriptive cross-sectional design, demographic characteristics were analysed using descriptive statistics to provide a contextual understanding of the sample without exploring inferential relationships with other variables.

The sample was mainly composed of Radiologic Technologists, with radiographers comprising 8.50%. The gender distribution was male-dominant, which is consistent with the gender variation of the entire imaging professionals' population in Ethiopia. Furthermore, studies in similar settings align with this observation (Kebede, Dawud, Kejela, Gannamo, &Mammo 2025:5). Respondents' ages ranged from 22 to 51 years, with nearly 70% of the sample falling within the age range of 27-36, indicating that most respondents are early to mid-career professionals. This demographic profile suggests that most respondents were working in their peak professional years, potentially supporting adaptability to new technologies and evolving radiation safety standards. However, in Ethiopia, limited in-house training and postgraduate education mean that even practitioners in their peak years risk stagnation, adopting suboptimal practices over time.

Education data showed that about 86.6% of respondents held a bachelor's degree, with very few holding postgraduate qualifications. While this indicates the majority of respondents are well educated, the low proportion of postgraduates may limit a deeper understanding of radiation protection. This reflects systemic constraints: postgraduate

opportunities in Ethiopia and across Sub-Saharan Africa remain scarce, restricting advanced clinical competencies and safety practices (Sisiku, Hewwit-Tyler & Akudejedu 2025:6).

These demographic profiles align with a study conducted in a similar setting (Mulat, Tsehaye, Akalu, Kebede & Abate 2023:2), which also reported a male-dominant, early to mid-career workforce. Overall, the findings suggest that while the workforce is relatively educated and experienced, systemic gaps in post-graduate education opportunities across the country may limit the translation of knowledge into consistent safe practice.

5.3 PROFESSIONAL BACKGROUND OF RESPONDENTS

Respondents were drawn from four federal referral hospitals, two of which are academic hospitals. These variations may influence access to training, supervision, and safety practices across hospitals. The study findings show that the work experience distribution among most respondents had between 6 and 10 years of professional experience, with a total of 35.3% respondents having more than 10 years of experience, and 17.1% have less than 5 years of experience. These findings differ from a study by Lodamo (2021:18), where 56.5% of respondents had less than five years of experience, suggesting a younger workforce in that context. In the current study, more than two-thirds of respondents had more than five years of experience, indicating that the departments are staffed with a relatively seasoned workforce and would typically engage in safety practices. However, their years of experience did not necessarily translate into optimal safety practice. In contrast, Fiagbedzi et al (2022:150) reported better compliance with radiation safety among radiographers with less experience. These findings highlight that professional experience alone does not guarantee adherence to safety practices. It should be coupled with continuous education and institutional reinforcement.

Regarding formal training on radiation protection, 76.8% reported having received formal training, while 23.2% had not. These findings are different from similar studies in Ethiopia, by Alemayehu et al (2023:7), where 65.66% respondents reported not receiving formal on-job radiation safety training. And a study by Lodamo (2021:18) also reported that only 37.1% of respondents had such formal training. These findings suggest that access to radiation protection and safety training varies significantly among healthcare facilities in Ethiopia, depending on resources, leadership and regulatory enforcement. However, without standardised continuous training, those who received the initial training may fail to sustain safe practice.

Taken together, the findings revealed that most respondents have received formal training and have considerable experience; however, the absence of standardised continuous training limits its effectiveness, highlighting the need for regular and standardised training on radiation protection and safety across Ethiopia's healthcare system.

5.4 DISCUSSION IN LINE WITH THE RESEARCH OBJECTIVES AND LITERATURE.

This section discusses the study findings in relation to the research objectives and compares them with existing literature.

5.4.1 Objective 1: To assess the knowledge of medical imaging professionals regarding radiation protection and safety measures.

The knowledge section consisted of 12 items and was interpreted based on four subscales. Nine questions were correctly answered by a significant number of respondents, indicating the majority have a good knowledge of radiation protection principles and safety measures. However, several notable gaps emerged across specific domains.

5.4.1.1. Paediatric safety and patient-centred protection practice.

Children are the most vulnerable group when it comes to radiation, as their bodies are more susceptible to long-term side effects even from small doses of radiation; therefore, extra caution is necessary (Granata, Sofia, Francavilla, Kardos, Kasznia-Brown, Nievelstein, Olteanu, Owens, Salerno, Sorantin & Apine 2025:386). Therefore, imaging professionals' knowledge of radiation parameters and safety protocols is crucial in safeguarding children from unnecessary radiation exposure. The results from this subscale showed a mixed level of awareness among medical imaging professionals. Respondents demonstrated a moderately high understanding of how to protect radiosensitive organs in paediatric patients during imaging procedures; however, the inconsistency observed may suggest that knowledge is not fully integrated with clinical reasoning. A study conducted in Sri Lanka reported a high knowledge score on items concerning paediatric imaging parameters and radiation protection (Satharasinghe, Niroshan & Jeyasugiththan 2023:537). In contrast, Moolman et al (2020:119) reported that 57.4% of respondents were unsure of the exposure values of a paediatric chest X-ray. Similarly, a study conducted in Saudi Arabia and Australia revealed that 38% and 35% of respondents, respectively, were uncertain whether paediatric patients are more radiosensitive than adults (Alsleem 2019:235). These variations across studies are not random. In Ethiopia, they likely reflect limited exposure in paediatric protocols, the

absence of training across facilities, and most importantly, the absence of national standardised guidelines on radiation safety practices for vulnerable populations.

Correct positioning is essential for diagnostic image quality and dose optimization. Despite the clinical importance of accurate positioning in radiological imaging for image quality, diagnostic accuracy and radiation safety, the knowledge gap among respondents regarding positioning is concerning and may be reflected in practice. According to Salimi, Shiri, Akavanallaf, Mansouri, Arabi and Zaidi (2023:3249), an average 10mm error in 60% of clinical cases of patient mis-centering was reported during CT examinations. This is in line with a study by Sukupova, Vedlich and Jiru (2016:105) who reported a high prevalence of mis-centering (470 out of 473 cases). In clinical practice, this may lead to poor image quality and increase unnecessary radiation dose to the patient. In Ethiopia referral hospitals, heavy workload often pushes imaging staff to prioritise efficiency over accuracy, leading to suboptimal positioning. The combination of knowledge deficit and environmental pressure is further concerning as it undermines radiation safety practice and compromises patient safety.

Similarly, knowledge of optimal shielding use was limited. Such a gap requires careful attention, considering the benefit of optimal shielding use in minimizing unnecessary radiation exposure, particularly in paediatric patients. This finding contrasts with a study by Teferi, Tequabo and Bedane (2017:3), conducted in a similar setting, which reported that 80.6% of respondents demonstrated good knowledge of optimal use of shielding gear during imaging; however, the majority did not consistently use the gear, regardless of its availability in their respective departments. Similarly, Maina et al (2020:636) also observed reluctance among imaging professionals to consistently use shielding equipment, aligning with findings from Lewis et al (2022:56), where respondents were aware of radiation protection and safety measures. Yet, their compliance, particularly in providing shielding, was a matter of personal choice. The findings from these studies highlight that health behaviours are shaped by more than knowledge alone. Workplace culture, individual attitude, resource availability and institutional safety regulation all contribute to selective compliance. In high workload environments, shielding is often deprioritised in favour of efficiency. Overall, the findings from this subscale necessitate the need for in-house training and establishing stricter radiation protection and safety protocols in imaging departments.

5.4.1.2 Radiation protection principles and technical knowledge

The results from this subscale showed that medical imaging professionals have a strong understanding of radiation protection principles and safety measures. Most respondents correctly answered the four items: effective ways to reduce patient dose, dose optimization, factors influencing patient dose, and the aim of radiation protection in a healthcare setting. The study findings were consistent with a study by Fiagbedzi et al (2022:150), which reported high awareness of radiation protection among respondents. Such awareness is important for achieving an equilibrium between patient safety and image quality. However, other studies contradict this pattern. For example, a study by El Kherrat et al (2024: 483) reported that 29.2% of the staff were unaware of basic principles of radiation protection and 74% did not understand radiation protection objectives, aligning with a study where imaging professionals' knowledge of technical parameters and their impact on image quality and patient dose was low (Mahmoudi et al 2019:46). These contradictions across studies may reflect differences in training systems, institutional emphasis and regulatory oversight, suggesting that knowledge levels are also shaped by systemic factors. Overall, the findings show a strong theoretical knowledge among respondents. This is fundamental, as these concepts are the backbone of radiation safety principles. However, knowledge alone is insufficient unless it is consistently translated into safe practice.

5.4.1.3 Operational and regulatory knowledge.

The findings related to items in this subscale showed mixed results. For an occupational radiation worker who has declared pregnancy, the equivalent fetal dose should not exceed 1mSv during at least the remainder of the pregnancy by the International Commission on Radiological Protection (ICRP: 2007). Knowing this limit ensures compliance with safety protocols, minimizes radiation exposure, and promotes responsible safety practice. However, two-thirds of respondents incorrectly identified this recommended maximum permissible dose limit declared for pregnant imaging professionals. This is similar to Gebremedhin's study (2022:59), which also found that limited awareness among imaging professionals regarding occupational dose, with only 39% of respondents able to correctly identify them. In Ethiopia, this limited knowledge reflects a weak emphasis on regulatory frameworks, particularly in the vulnerable population, raising concerns about both patients' and staff's safety.

In contrast, in the current study, about 67% of respondents correctly identified the national annual dose limit for occupational exposure according to Ethiopian Radiation Protection

Authority (ERPA) regulations. Although most are aware of the country's national guidelines, the remaining one-third of incorrect responses could undermine regulatory compliance and compromise radiation safety.

Proper collimation during imaging helps focus the radiation beam on the area of interest, improving image quality and reducing unnecessary radiation by limiting scattered beams, particularly during mobile radiography. Knowledge score regarding this was fairly strong. Respondents were able to identify how to reduce scatter radiation to personnel, demonstrating a sound understanding of radiation safety parameters. However, studies have shown that this may not have been the case in practice, particularly relating to collimation. Imaging professionals tend to increase the area of collimation to avoid cutting the anatomical part. A study in Australia reported that collimation was poorly undertaken during the range of examinations (Ball, McKerrow & Murphy 2023:24). This aligns with a study by Karami and Zabihzadeh (2017:104), where all examined radiographic images showed a large collimation contributing to avoidable radiation to patients. Addressing this gap requires not only further investigation into the actual practice but also necessitates targeted training on general regulatory safety rules to embed proper technique into routine imaging.

5.4.1.4 Radiation monitoring and equipment safety.

Routine inspection is a cornerstone of radiation safety, ensuring that protective equipment remains effective. However, the most critical gap was observed in this subscale. The results showed notable gaps in knowledge in equipment inspection and dosimetry use. Only 12% of respondents could identify the recommended frequency for checking and maintaining radiation protection equipment. This is very worrying as it suggests that imaging professionals may view routine checks as non-essential rather than a key safety practice. Research has indicated that radiation protection gear is often overlooked in practice. Fiagbedzi et al (2022:150) found that, despite having good awareness of safety procedures, respondents largely neglected radiation protective equipment, such as lead aprons, gloves, and thyroid collars. This aligns with a study by Lewis et al (2022:389), where imaging professionals demonstrated good knowledge of radiation protection but showed poor compliance with shielding protocols. In Ethiopia, addressing this gap requires embedding equipment inspection and shielding protocols into institutional safety culture. This can be done through practice-based training, monitoring and establishing staff accountability mechanisms to safeguard both patients and staff.

The moderate understanding of factors affecting dosimeter performance highlights a systemic issue. Proper use and understanding of the factors that influence the accuracy and functionality of the dosimeter is essential, as incorrect usage can alter its readings and compromise occupational safety. A significant number of respondents still lack essential knowledge about what can influence the accuracy and operation of dosimeter readings, contributing to inaccurate cumulative exposure readings. This aligns with findings from a study by Partap, Raghunanan, White and Seepaul (2019:3), who found that only 27% of respondents knew how to correctly position their dosimeter badge, and 32% understood that environmental factors, such as sunlight, can modify the dosimeter reading. In Ethiopia context, this may be related to a lack of knowledge, an irregular monitoring system, and limited feedback on dosimeter readings. The results from this subscale necessitated introducing a regular in-service training, hiring a quality assurance officer to oversee and maintain mandatory equipment logs and enforcing personal monitoring safety rules, thereby fostering a culture of radiation safety within radiology departments, as noted by Prajapati, Kumar, Boora and Sah (2022:195).

Overall, while the findings revealed that respondents demonstrate a solid foundational understanding of radiation protection, attitudes and workplace norms influence how knowledge is valued and implemented. It is also crucial to consider whether this knowledge translates into real-time practice, as some studies have noted a gap between knowledge and practice (Gebremedhin 2022:58; Lewis et al 2022:56). The following section examines respondents' attitudes towards radiation safety.

5.4.2 Objective 2: To investigate the attitudes of medical imaging professionals towards radiation protection and safety in their daily practices.

Positive attitudes are often considered a prerequisite for safe health behaviour. The findings from the attitude section indicate that most respondents held a positive attitude towards radiation protection and safety practices. This is important because attitude shapes motivation in safety practice. Cultivating a positive attitude in healthcare requires reinforcement through relevant, practical training. Frane and Bitterman (2020) emphasised that as medical imaging technology advances, imaging professionals are expected to continually update their knowledge and maintain safe practice. Similarly, Alavi, Dabbagh, Abbasi and Mehrdad (2017:5) reported that positive attitudes do not always develop automatically; they require continuous training. Their study found that most respondents held a poor attitude despite receiving in-service training on radiation protection. However, previous in-service training failures might be related to the content

of the training. This suggests that while regular training on radiation safety is essential, the quality of the content, its relevance and the mode of delivery must be carefully examined to ensure meaningful improvement in imaging staff knowledge, attitudes and safety practices. In the Ethiopian context, this indicates that existing training on radiation protection may be theoretically adequate but practically insufficient, limiting its impact on safety behaviour. Therefore, training design should be strengthened and aligned with the realities of the clinical setting to ensure that a positive attitude translates into safe practice.

Safety and quality care are inseparable in any healthcare practice. In this study, the majority of respondents expressed that strict adherence to radiation safety practices improves the overall quality of patient care and that departmental safety culture influences staff commitment to radiation safety. This consensus aligns with the World Health Organization (2024:2), which highlights that a radiation safety culture is defined by the attitudes, behaviours, and actions of stakeholders towards radiation safety. A robust safety culture addresses the safety of patients, staff, and the public and is closely linked to high-quality healthcare. Thus, respondents' consensus indicates not only a foundational awareness but also a professional commitment to integrating radiation safety practices as a core element of patient-centred care. It also highlights the importance of institutional safety culture in encouraging staff adherence to radiation safety protocols. However, in resource-constrained settings such as Ethiopia, the translation of this depends on strong institutional enforcement, strong supervision and consistent regulatory monitoring.

Routine safety checks of radiation protective equipment are essential to ensure their suitability and performance in attenuating radiation exposure and preventing unnecessary occupational risk (Mohd Ridzwan et al 2019: e02478). Research shows that when safety checks are not regularly conducted, staff confidence in protective equipment declines. A study by Goula et al (2021:12) reported staff refusal to wear protective gear due to a lack of routine checks for damage (such as cracks in lead aprons and gloves) and improper storage conditions, with some thrown on the floor and others stacked carelessly. While 83% of respondents in the current study expressed a positive attitude and broad agreement on the need for regular safety checks and equipment maintenance for effective radiation protection, results from the knowledge section reveal notable uncertainty about the recommended frequency of equipment checks and maintenance. This discrepancy highlights that while respondents have a positive attitude, limited procedural awareness of safety checks may hinder translation of these attitudes into safe

practice. This gap is also linked to contextual factors. For example, in Ethiopia, training often only focuses on general radiation protection without adequately covering quality assurance procedures, leaving staff supportive in principle but unclear in practice. Therefore, these findings necessitate the need for context-specific and practice-oriented training that reflects the realities of clinical environments.

Despite these positive attitudes, an important contradiction emerged. A considerable proportion of respondents perceived that providing shielding for each patient was time-consuming, and that efficiency in completing imaging exams may outweigh safety concerns. These responses reflect a system-level tension between productivity and safety. In high patient-load environments, such as referral tertiary hospitals in Ethiopia, imaging staff may prioritise efficiency over radiation safety due to staff shortages and high workloads. A similar trend was reported in a study by Lewis et al (2022:390), where some respondents considered radiation protection a waste of time, and others reported prioritising completing examinations over safety practices due to workplace impediments, such as workload and resource constraints. This poor attitude significantly influences their behaviour towards the use of radiation protective equipment, resulting in inconsistency in their radiation protection practices, as also noted by Mohd Ridzwan et al (2019:6). The poor attitudes related to safety practice in the current study also contradict the respondents' own positive responses on knowledge section, that strict adherence to radiation safety practices enhances the overall quality of patient care, suggesting a knowledge - practice gap mediated by environmental constraints. These findings reflect that the observed inconsistency is beyond individual issues but a structural challenge, such as poor departmental safety culture and regulatory reinforcement within the Ethiopian healthcare system.

The ALARA principles are fundamental elements in radiation protection and safety practices; however, beyond the theoretical basis, their practical application still needs to be examined. The study findings show that most respondents believed that the ALARA principles are applicable in their routine work. Despite this theoretical acceptance, a considerable proportion perceived safety practices benefiting only patients, and one-third considered discussing radiation hazards and safety measures with patients a waste of time. These views contradict the core idea of the ALARA principles, which emphasise not only the optimisation, justification, and minimisation of radiation exposure but also fostering a culture of radiation safety. Research has shown that imaging staff often fail to provide adequate information about radiation hazards and doses to their patients. This is

frequently due to the assumptions about prior communication by the referring doctor or to avoid causing unnecessary concern. Such practices deprive patients of the right to make informed decisions (Ukkola, Kyngäs, Henner & Oikarinen 2020: e117; Reitan & Sanderud 2020:86). In Ethiopia, such attitudes may stem from time pressure, a lack of communication training and limited departmental emphasis on patient-centred care.

Finally, regarding the role of dosimeters in routine practice, findings indicated that one in four respondents undervalued their value in radiation safety practices. This may reflect a limited understanding of occupational dose monitoring, weak enforcement of dose monitoring and a lack of feedback after dosimeter readings. This aligns with the study by Mohd Ridzwan, Bhoo-Pathy, Wee and Isahak (2021:947), who reported a lack of adherence among imaging staff due to poor attitudes towards personal dosimetry. Personal dosimeters are often viewed solely as dose-recording devices; however, they also serve as a reminder for imaging staff to evaluate their safety practices and are closely linked to the ALARA principles. The knowledge section revealed a low-moderate level of awareness about dosimeters among respondents. This gap between knowledge, attitude, and behaviour may limit the effective implementation of the radiation safety principles.

Overall, the findings from this section highlight a general positive attitude among respondents but also reveal inconsistencies between belief and behaviour. This contradiction is likely driven by contextual pressures such as workload, staff shortage, weak regulatory enforcement and unavailability of resources. This underscores that improving radiation protection practices requires more than adequate knowledge and a positive attitude; it demands systemic intervention that addresses structural barriers within the healthcare environment.

4.3 Objective 3: To assess the current practices of medical imaging professionals in implementing radiation protection measures during routine procedures.

The findings from the practice section revealed significant gaps in the practical application of radiation protection and safety measures among medical imaging professionals. Radiation and occupational safety protocols are fundamental in ensuring standard radiation safety practices for patients, staff, and the public. During imaging examinations or procedures that involve radiation, all recommended safety protocols must be followed by the imaging professionals. However, in the current study, only half of the respondents consistently adhered to standard safety protocols, and less than half consistently provided radiation protection gear to their patients. This inconsistency suggests that

safety compliance is not fully embedded in routine work, which may contribute to unnecessary radiation exposure for patients. Similar findings have been reported by Abuzaid et al (2019:452), where imaging staff adherence to radiation protection protocols was unsatisfactory, particularly in the consistent utilisation of protective gear. Despite respondents' adequate knowledge and positive attitudes, there is a gap in practice. This gap shows that translation of knowledge and attitudes into routine behaviours is not automatic but rather influenced by contextual factors such as workload, resource availability and regulatory enforcement.

Patient-centred communication regarding their concerns about radiation also emerged as an area that requires attention. At times, communicating radiation information can be difficult because the public may not fully understand the extent of the radiation dose they are about to receive. This unfamiliarity necessitates addressing patients' concerns with confidence and empathy so that they can make informed decisions about their diagnosis and treatment (Wieder 2019:4). In the present study, less than half of the respondents addressed patients' concerns about radiation risks. This is similar to a study that found imaging staff occasionally struggle to communicate with patients regarding radiation risks. Such procedural compliance gaps have been linked to insufficient awareness of risk communication (Reitan & Sanderud 2020: 87). The observed gap in the current study may be related to time constraints and a lack of training focused on patient risk communication. Addressing this gap is highly important in respecting informed decision-making and easing the anxiety associated with radiation exposure.

Pregnant patients should be part of the decision-making process following a clear discussion of the risks and benefits of a particular imaging procedure involving radiation. When a pregnant patient undergoes a radiographic examination, justification for the examination should be evaluated. Then, the procedure must be optimized before proceeding with imaging (Abushouk, Sanei Taheri, Pooransari, Mirbaha, Rouhipour, & Baratloo:2017:4). However, only 58.6% of respondents consistently inquired about the possibility of pregnancy before imaging examinations. This inconsistency not only poses a clinical risk for the fetus but also raises an ethical concern about informed consent and patient safety. This gap is also related to a lack of training in risk communication and weak departmental emphasis on patient-centred care, particularly on vulnerable populations. In Ethiopia, high workload and staff shortage may further discourage thorough patient screening.

Regarding occupational safety, findings from both the knowledge and attitude sections revealed a notable gap in personal dosimeter compliance. Consistent with this, only half of the respondents reported regularly wearing their dosimeter. This gap suggests that compliance is influenced by workplace norms and enforcement practices rather than awareness alone. A similar pattern was reported in other studies. A study in Ghana reported that imaging staff frequently neglected to wear their dosimeter badges during working hours (Botwe, Antwi, Adesi, Anim-Sampong, Dennis, Sarkodie & Opoku 2015:6). Similarly, Mohd Ridzwan et al (2021:951) highlighted a deliberate non-compliance among imaging staff due to normative social influences in their workplace. In Ethiopia, limited feedback on reading and weak departmental enforcement likely explain the gap in every domain. Such non-compliance directly contradicts the International Atomic Energy Agency (IAEA) safety standard requirement that stipulates all occupationally exposed radiation workers are required to wear a radiation monitoring device (IAEA:2014).

Proper shielding is a key practice in protecting individuals from unnecessary radiation exposure. Regarding shielding practices, although a lead apron was widely used by most respondents, there was low usage of other gear, such as lead gloves, lead glasses, radiation glasses, and gonad shields. This selective compliance suggests that respondents prioritise what is commonly used in their environment or only use the comfortable ones to speed up workflow, rather than adopting a systemic approach to safety. A study in Portugal found a similar trend where healthcare workers reported higher compliance with lead apron and thyroid shield but underutilised lead glasses and gloves due to availability and discomfort (Antunes-Raposo, França, Lima, Mendonça-Galaio & Sacadura-Leite 2022:247). Furthermore, Quality control and assurance practices also showed significant gaps, with nearly 45.1% of study respondents never conducting such assessment of shielding equipment. Some reported relying on visual inspection, and a few admitted not knowing how to do the assessment. This lack of standard assessment protocol poses a radiation risk as imaging professionals may be unaware of the effectiveness of the gear, which could be attributed to a lack of departmental protocol, proper training, and quality assurance practices. Without routine systemic quality assurance, the effectiveness of protective equipment cannot be guaranteed, leaving patients and imaging staff vulnerable to increased occupational exposure.

Repeat exposure in diagnostic imaging requires careful management due to the cumulative nature of radiation dose. Minimising repeated radiation exposure, therefore, requires a multifaceted approach. Key strategies include adhering to radiation safety

principles, integration of dose-tracking software into routine work, optimizing radiographic techniques and protocols, and patient education, which are crucial measures of radiation safety and improving diagnostic outcomes (Almotairi, Almutairi, Almutairi, Al Otaibi, Almutairi & Ishaq 2024: 3698). The findings of the current study are consistent with these recommendations. Respondents emphasised the importance of implementing measures such as fundamental radiation safety principles of time, distance, and shielding, optimizing exposure settings, protocol modifications, and verifying patient identity and exam details. However, the low response rates regarding dose tracking and the limited adoption of alternative imaging modalities are concerning because repeat exposure increases cumulative risk that cannot be mitigated by basic safety principles alone. In Ethiopia context, this gap likely signifies contextual barriers such as the unavailability of alternate imaging modalities and the absence of integrated dose-tracking software.

Overall, the findings from this section demonstrate that practice is less shaped by individual knowledge and attitudes and more by system-level factors. Inadequate pregnancy screening, poor equipment inspection, and weak adherence to ALARA principles reflect the influence of workload pressure, weak departmental regulation, staff shortages, and limited resources in radiation safety practices. These contextual constraints explain why imaging professionals who are knowledgeable and positively inclined to radiation safety still fail to implement consistent radiation safety practices. The uncovered inconsistencies in safety practices underscore the need for strengthened departmental protocols, regular staff training and cultivating a robust safety culture within imaging departments, which are vital in bridging this Knowledge- practice gap.

5.4.4 Objective 4: To identify and analyse the health perceptions and environmental barriers that influence imaging professionals' compliance with radiation protection and safety practices.

This section explored respondents' health perceptions and workplace barriers using the Health Belief Model (HBM). HBM constructs were applied to understand respondents' health behaviours related to radiation protection, safety measures, and environmental barriers that influence their safety practices.

5.4.4.1Perceived susceptibility and severity

Perceived susceptibility and severity are fundamental determinants of health-related behaviours, shaping individuals' motivation and decisions regarding preventative health actions. Individuals who view themselves as vulnerable and recognize a health threat are more likely to adopt protective measures. The study findings showed that more than half

of the respondents believed they were likely to face radiation-related health issues due to occupational exposure, and about three-quarters acknowledged the potential health threat linked to their profession. This heightened risk perception encourages protective behaviours; however, this was not reflected in actual practice. This is similar to a study by Khamtuikrua and Suksompong (2020:3,4), where 63.1% of respondents perceived occupational radiation exposure as hazardous, and almost 97% were aware of the harmful effects on their health. However, adherence to radiation protective gear remained low, indicating a disconnection between awareness and behaviour. This challenges the idea that perceived susceptibility and severity alone are enough to motivate imaging staff to follow radiation safety protocols. Instead, competing workplace demands overrode perceived susceptibility and severity. In such context, awareness and a positive attitude towards radiation safety do not automatically translate into behaviours.

5.4.4.2Perceived benefits and self-efficacy

A strong consensus among respondents was evident regarding the benefits of radiation protection and safety measures, indicating recognition of their importance in fostering a strong radiation safety culture within the imaging department. This aligns with a study in which two-thirds of respondents reported a positive perception of creating a safe work environment and recognized their role in ensuring radiation safety (Shubayr, Muawwadhah, Shami, Jassas, Tawhari, Oraybi, Madkhali, Aldosari, & Alashban 2024:34). Although most respondents acknowledged the benefits of engaging in safety practice, the actual safety practice was subpar. A similar finding was reported in a study in South Africa, where staff perceived radiation safety practices as a collective duty. However, they often struggled to balance providing patient-centered care with adhering to essential safety precautions. Sometimes, prioritizing clinical procedures over patient safety, they choose to perform interventional procedures without protective gear (Rose, Uebel & Rae 2018:8). In the current study, the tension between professional commitment and systemic barriers hinders imaging staff's consistent safety practices.

Confidence in executing safety practices is also a critical factor in engaging in health prevention behaviours. In this study, most respondents demonstrated high self-efficacy, reporting confidence in their ability to implement radiation safety measures. This contrasts with a study by Karami et al (2017:118), which observed sub-optimal safety practices among imaging staff due to a lack of knowledge or skills in properly positioning the gonad shield, stemming from fear of obscuring the anatomy of interest in female patients. The findings from perceived benefits and self-efficacy suggest that respondents are confident

and are aware of the benefits of engaging in safety practices and believe in their ability to perform them. However, findings from the attitude section revealed inconsistence on the application of safety principles, indicating a discrepancy between respondents' attitudes and their actual behaviours. This further shows that structural constraints continue to undermine the translation of confidence into behaviour.

5.4.4.3Perceived barriers

Departmental safety culture and systemic limitations were identified as key perceived barriers among respondents, including high workload, resource constraints, insufficient training on radiation protection, poor institutional safety culture, patient non-cooperation, a general lack of awareness of the importance of radiation protection among staff members, and difficulties in enforcing compliance among staff members. These findings align with two studies from South Africa by Lewis et al (2023:213; 2022:390), where 57.9% of imaging staff agreed that working in an environment that promotes safety culture improves their safety practices. However, their safety practice remained suboptimal due to workplace challenges, including limited resources, inadequate training, high workload, lack of managerial support, and staffing shortages, which were reported to contribute to poor compliance with safety practices among staff. These findings highlight that these barriers stem from systemic limitations rather than individual behaviours, indicating non-compliance was not solely due to a lack of awareness but also due to system-level deficiencies. In the study context, high workload, poor regulatory oversight and resource constraints explain why practices remain inconsistent.

5.4.4.4 Environmental factors

Findings from the enabling environment closely mirrored respondents' perceptions of workplace barriers, suggesting that this was not merely behavioural but rooted in an actual systemic issue within their work environment. Respondents frequently cited challenges such as limited access to continuous education and training, a poor radiation safety culture, insufficient resources, a high workload, insufficient regulatory guidance and the absence of regular access to safety audits or inspections, revealing institutional and policy gaps. These systemic barriers hinder both compliance and accountability. These findings are similar to a study from Eswatini, where the absence of a regulatory body contributed to radiographers' non-compliance with safety practices (Shungube & Khoza 2024:9). Similarly, a survey by Geletu et al (2017:4) in Ethiopia reported that behavioural and legislative gaps contributed to an increased risk of radiation exposure among imaging staff. The study also further emphasised the need for strong legislative

and organisational support to establish a safe imaging environment. The consistency between perceived barriers and enabling environment underscores the critical need for systemic reform, such as strengthening legislative frameworks, establishing robust regulatory oversight, improving staffing and workload distribution and continuous professional development. At the same time, individual commitment remains essential for fostering a culture of radiation safety across imaging departments within the country.

5.5 INTERRELATIONSHIP BETWEEN KAP, HEALTH PERCEPTION, AND ENVIRONMENTAL FACTORS TOWARDS RADIATION PROTECTION AND SAFETY AMONG MEDICAL IMAGING STAFF.

The correlation analysis revealed important relationships among the knowledge, attitudes, perceptions, practices and environmental factors. The results showed that knowledge is more moderately associated with attitudes and weakly with perceptions. However, the weak correlation between knowledge and both practice and enabling environment suggests that knowledge alone may not meaningfully translate into safe radiation protection behaviours. This disconnection is widely observed in healthcare settings, particularly in resource-constrained environments. In the context of the current study, the disconnect may be further explained by identified systemic and contextual environmental constraints, such as workload, limited resources, inadequate regulatory guidance and poor departmental radiation safety culture, which may restrict the application of knowledge in routine clinical practices. According to Lewis et al (2022:391), a study in South Africa found that imaging staff members possessed a satisfactory level of knowledge; however, their safety practices were substandard due to organizational constraints and workload. A similar pattern was observed in another study in Ghana, where imaging staff demonstrated high knowledge; however, regarding compliance, around 75% did not regularly use their dosimeters or check protective gear (Fiagbedzi et al 2022:150). These findings emphasise that while knowledge is crucial, it is not the sole factor driving safety practices in the imaging department.

Attitude demonstrated significant positive correlations with practice, knowledge, health behaviours, and environment. This indicates that imaging professionals with positive attitudes are more likely to engage in radiation safety practices, adopt motivated health behaviours, and foster a responsive environment. Furthermore, this pattern confirms that attitude, with the support of an enabling environment, may serve as a driving force for translating knowledge into practice. This aligns with findings by Naji, Alehelali and Abu-

Hadi (2026:6) who reported a significant correlation between attitudes towards radiation protection and adherence to safety practices, suggesting comprehensive compliance when institutional protocols are implemented. Similar correlations were seen across several studies (Park & Yang 2021:9; Abu Awwad, Hill, Lewis & Jimenez 2023:6; El Fahssi, Semghouli, Amaoui, Elkhalladi, Çaoui & Jroundi 2024:194). Collectively, these studies demonstrate that attitudes serve as a bridge and are interconnected with knowledge and behaviours, shaping both behavioural outcomes and workplace safety culture.

In this study, practice was more significantly correlated with attitudes, health behaviours and enabling environments than with knowledge. This suggests that radiation safety behaviour is influenced more by contextual and behavioural determinants than by cognitive awareness alone. A similar pattern was reported in a study in Saudi Arabia, where environmental conditions and perceived benefits were identified as significant predictors of practice (Shubayr 2024: 142). Similarly, another study reported that inadequate resources and environmental constraints discouraged imaging staff from engaging in safety practices (Shungube & Khoza 2024:9). These findings are particularly relevant for the current study, as resource limitation, workload, inadequate staff training, insufficient regulatory guidance within the clinical setting in Ethiopia may significantly affect the ability of medical imaging professionals to consistently implement safety measures.

Health perception, as conceptualised within the Health Belief Model, showed significant and positive correlations with attitudes, environment, and practice, and weak but positive correlations with knowledge. This suggests that imaging professionals' beliefs about susceptibility, severity, benefits, barriers and self-efficacy play an essential role in shaping safety behaviour. Individuals who perceive higher personal risk and greater benefit of protective measures are more likely to engage in safer practices. The finding is in line with a study by Park and Yang (2021:9), who also reported a positive correlation between health beliefs, knowledge, and attitudes towards radiation protection. This positive correlation between health perception and other variables highlights the crucial role of behaviour in influencing safety compliance, both in individual and contextual factors.

In conclusion, the findings demonstrate that attitudes, perceptions, and environmental conditions exert a stronger influence on radiation protection practices than knowledge alone. This explains the contradiction observed in the study findings, where imaging staff demonstrated a generally positive attitude but inconsistency in their safety practices. This

discrepancy may be driven by environmental factors such as workload, limited resources and weak regulation. This suggests that improving radiation protection and safety practices requires more than knowledge transfer. It necessitates the need for multidimensional interventions that address behavioural determinants and strengthen the institutional support system.

5.6 SUMMARY

This chapter discussed the findings of the study, along with the study objectives and the existing literature. The study results revealed that respondents possessed adequate knowledge and a positive attitude towards radiation protection and safety. However, areas including dose optimization, patient positioning, dose limits for pregnant staff, prioritising efficiency over safety and equipment checks and maintenance require further attention. The practice section revealed unsatisfactory safety practices and critical gaps in technical understanding, such as inconsistent use and maintenance of shielding equipment, limited implementation of ALARA principles, and inadequate strategies to reduce repeat exposures. There was overlap of findings between perceived barriers and enabling environment, indicating that health beliefs shape both individual and environmental factors. Overall, the findings highlight that knowledge and attitude alone do not guarantee compliance. The correlation analysis further supports that while knowledge is moderately related to attitude and perceptions, it shows no significant relationship with practice and enabling environment. The next chapter will provide the conclusion and recommendations of the study.

CHAPTER 6

CONCLUSION AND RECOMMENDATIONS

6.1 INTRODUCTION

This chapter presents the conclusion and recommendations based on the study findings. The study aimed to investigate and describe radiation protection and safety practices among medical imaging professionals in Addis Ababa, Ethiopia, and to identify gaps in their understanding, attitude, behaviour, and adherence to safety measures. The chapter summarised key findings, drew conclusions and outlined recommendations for various stakeholders. Additionally, the limitations and strengths of the study are acknowledged and discussed in this chapter.

6.2 SUMMARY OF KEY FINDINGS

The objectives of the study were to evaluate the knowledge, attitude, and practice of radiation protection and safety measures among medical imaging professionals, while also identifying and analysing their health perceptions and barriers to safety compliance.

The results showed that respondents had sufficient knowledge and a positive attitude towards radiation protection and safety. The findings also revealed notable gaps in areas such as patient positioning, awareness of radiation dose limits for pregnant staff, prioritising efficiency over safety, consistent use of shielding equipment, and issues regarding regular equipment checks and maintenance.

The analysis of practice section showed suboptimal radiation protection and safety practices among respondents. The findings uncovered significant gaps in technical understanding and implementation, including inconsistent use and maintenance of shielding equipment, limited application of ALARA principles, and inadequate strategies to reduce repeat exposures.

Findings from the HBM constructs revealed a discrepancy between respondents' actual safety practices and their perceived behaviour. Although imaging professionals perceived their line of work was hazardous, this awareness was not sufficiently translated into protective behaviours. Poor departmental safety culture and systemic limitations were also identified as perceived barriers. There was a clear overlap between perceived barriers and the actual environmental challenges, including high workload, resource limitations, insufficient training, and insufficient regulatory guidance. The correlation

analysis revealed that practice was more significantly correlated with attitudes, health behaviours and enabling environments than with knowledge

6.3 CONCLUSION

Overall, while respondents demonstrated adequate awareness and a positive attitude, the translation of knowledge and intention into practice remains inconsistent. HBM findings revealed that imaging professionals perceive their work as hazardous. However, engaging in safety practices was inadequate. Additionally, environmental and behavioural factors exerted a significant influence on radiation safety practices. The overlap between perceived barriers and the actual environmental challenges underscores the role of the enabling environment in shaping individual beliefs and behaviours. These insights necessitate the need for both individual-level and systemic interventions to improve radiation safety practices among imaging professionals.

6.4 RECOMMENDATIONS

These recommendations prioritised system-level interventions, based on the study findings and respondents' voices. The following recommendations are made.

6.4.1 Recommendation for Healthcare Facilities

- Imaging departments should conduct quarterly in-service practice-based radiation safety training focusing on identified gaps, such as dose limits, patient shielding and positioning, equipment checks, and dosimeter use to strengthen the translation of knowledge to practice.
- Establish and reinforce routine safety audits with accountability mechanisms, including monthly internal audits such as formal dose monitoring and reporting, and integrating Dose Management Software (DMS), to track staff consistency and equipment performance in the departments. Bi-annual external inspections by the Ethiopian Radiation Protection Authority (ERPA)
- Hospital managements should introduce structured workload management strategies, such as a rotation system and staff allocation based on patient loads, to reduce compliance barriers caused by the workload.

6.4.2 Recommendation for policymakers and

- ERPA should establish strong national radiation protection guidelines aligned with ICRP, WHO, and IAEA, with stronger enforcement through unannounced

inspections and audits across healthcare facilities, non-compliance penalties and by making radiation safety training mandatory within the national CPD program and linking it to licence renewal.

6.4.3 Recommendations for higher education institutions

- incorporate international initiatives (Image Gently, Image Wisely, AFROSAFE) into teaching to foster familiarity with international standards and reinforce radiation safety during clinical rotations, requiring students to demonstrate patient shielding, dose optimisation and equipment quality control as part of the assessment.
- Promote collaborative research between higher education institutes and healthcare facilities and expand postgraduate programmes beyond Ultrasound to include specialised medical imaging domains, equipping imaging professionals with skills and strengthening Ethiopia's radiation safety culture.

6.4.4 Recommendation for future research

- Conduct a national-level comparative study across public and private hospitals and regions on how individual beliefs and environmental barriers in radiation safety compliance differ across regions.

6.5 CONTRIBUTION OF THE STUDY

The study provides several important contributions to the understanding of radiation protection and safety practices among imaging professionals.

- The study findings provide insight into the current situation of radiation protection practice among imaging professionals. It also contributes to the limited body of empirical literature on the field of radiation science in Ethiopia.
- Integrating HBM as a theoretical framework alongside the KAP approach offered a dual perspective. It provided insights into how the constructs interact with systemic barriers in shaping adherence to radiation protection and safety practices.
- The study identified both individual-level and system-level barriers in radiation safety practices. These insights are important as they provide evidence-based recommendations for designing interventions at different levels, based on participant-suggested improvements.
- The study is one of the few focusing on imaging professionals' perspectives, and it can serve as a baseline for future research at the national level. This would be

valuable for hospital administrators, policymakers, and universities seeking to identify and strengthen radiation protection and safety practices in different healthcare settings.

6.6 LIMITATIONS

The study is not without limitations. First, the findings of the study are based on data collected from four public hospitals in Addis Ababa, Ethiopia. Including private hospitals could have brought a balance in terms of views. In addition, including more hospitals from both the private and public sectors could provide an in-depth view and enhance the representativeness of the research findings. Second, the findings from this study may not reflect the reality of regional hospitals where resources, opportunities, and regulatory guidance may significantly differ. Third, self-reported questionnaires may be affected by social desirability and recall bias, common in KAP studies. Finally, the cross-sectional design limits the ability to establish causality; therefore, the findings from correlation analysis only indicate statistical associations between variables. Despite these limitations, the study provides valuable insights into existing gaps in radiation protection practices.

6.7 STRENGTHS OF THE STUDY

The study has several strengths. Firstly, it is among the few to explore occupational health and safety practices from the perspective of medical imaging professionals in Ethiopia. It fills a gap in the literature and lays a foundation for future research. Secondly, the combined use of the KAP and HBM frameworks provides a comprehensive lens on the behavioural and systemic factors influencing radiation safety compliance. Thirdly, the study identified areas needing intervention, offering practical recommendations at the institutional, higher education, and policy levels. Finally, the study incorporated respondents' suggested improvements, ensuring the recommendations are grounded in real-world evidence for targeted interventions.

6.8 CONCLUDING REMARKS

The study set out to investigate and describe radiation protection and safety practices among medical imaging professionals in Addis Ababa, Ethiopia. The results revealed suboptimal radiation safety practices, despite high awareness and a positive attitude. Environmental and behavioural factors further influenced these shortcomings. These findings necessitate standardised radiation safety training, provision and maintenance of

protective equipment, and departmental safety audits to reinforce compliance. By exploring the issue from the imaging professionals' perspective and incorporating their viewpoints, the study provided empirical evidence and informed recommendations. Additionally, strengthening radiation safety practices has crucial clinical and public health implications, including minimizing unnecessary radiation exposure, enhancing patient and staff safety, fostering a sustainable radiation safety culture within healthcare facilities, and improving the overall quality of healthcare services in Ethiopia.

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ANNEXURES

ANNEXURE A: ETHICAL CLEARANCE CERTIFICATE FROM THE DEPARTMENT OF HEALTH STUDIES.

UNISA

COLLEGE OF HUMAN SCIENCES RESEARCH ETHICS REVIEW COMMITTEE

31 July 2024

NHREC Registration # :
Rec-240816-052
CREC Reference # :
20991371_CREC_CHS_2024

Dear Mrs Selam Fasil Ketema

Decision:
Ethics Approval from 31 July 2024 to 30 July 2025

Researcher(s): Name: Mrs. S. F. Ketema
Contact details: 20991371@mylife.unisa.ac.za
Supervisor(s): Name: Dr H. Matakanye
Contact details: matakh@unisa.ac.za

Title: RADIATION PROTECTION AND SAFETY PRACTICES AMONG MEDICAL IMAGING PROFESSIONALS IN ADDIS ABABA, ETHIOPIA.
Degree Purpose: Masters

Thank you for the application for research ethics clearance by the Unisa College of Human Science Ethics Committee. Ethics approval is granted for one year.

The ***low-risk application*** *was reviewed by* College of Human Sciences Research Ethics Committee, in compliance with the Unisa Policy on Research Ethics and the Standard Operating Procedure on Research Ethics Risk Assessment.

The proposed research may now commence with the provisions that:

1. The researcher(s) will ensure that the research project adheres to the values and principles expressed in the UNISA Policy on Research Ethics.
2. Any adverse circumstance arising in the undertaking of the research project that is relevant to the ethicality of the study should be communicated in writing to the College Ethics Review Committee.
3. The researcher(s) will conduct the study according to the methods and procedures set out in the approved application.
4. Any changes that can affect the study-related risks for the research participants, particularly in terms of assurances made with regards to the protection of participants' privacy and the

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Preller Street, Muckleneuk Ridge, City of Tshwane
PO Box 392 UNISA 0003 South Africa
Telephone: +27 12 429 3111 Facsimile: +27 12 429 4150
www.unisa.ac.za

confidentiality of the data, should be reported to the Committee in writing, accompanied by a progress report.

5. The researcher will ensure that the research project adheres to any applicable national legislation, professional codes of conduct, institutional guidelines and scientific standards relevant to the specific field of study. Adherence to the following South African legislation is important, if applicable: Protection of Personal Information Act, no 4 of 2013; Children's act no 38 of 2005 and the National Health Act, no 61 of 2003.
6. Only de-identified research data may be used for secondary research purposes in future on condition that the research objectives are similar to those of the original research. Secondary use of identifiable human research data require additional ethics clearance.
7. No fieldwork activities may continue after the expiry date (30 July 2025). Submission of a completed research ethics progress report will constitute an application for renewal of Ethics Research Committee approval.

Note:

The reference number 20991371_CREC_CHS_2024 should be clearly indicated on all forms of communication with the intended research participants, as well as with the Committee.

Yours sincerely,

Signature:

Prof. KB Khan
CHS Research Ethics Committee Chairperson
Email: khankb@unisa.ac.za
Tel: (012) 429 8210

Signature: PP

Prof ZZ Nkosi
Executive Dean: CHS
E-mail: nkoszz@unisa.ac.za
Tel: 012 429 6758

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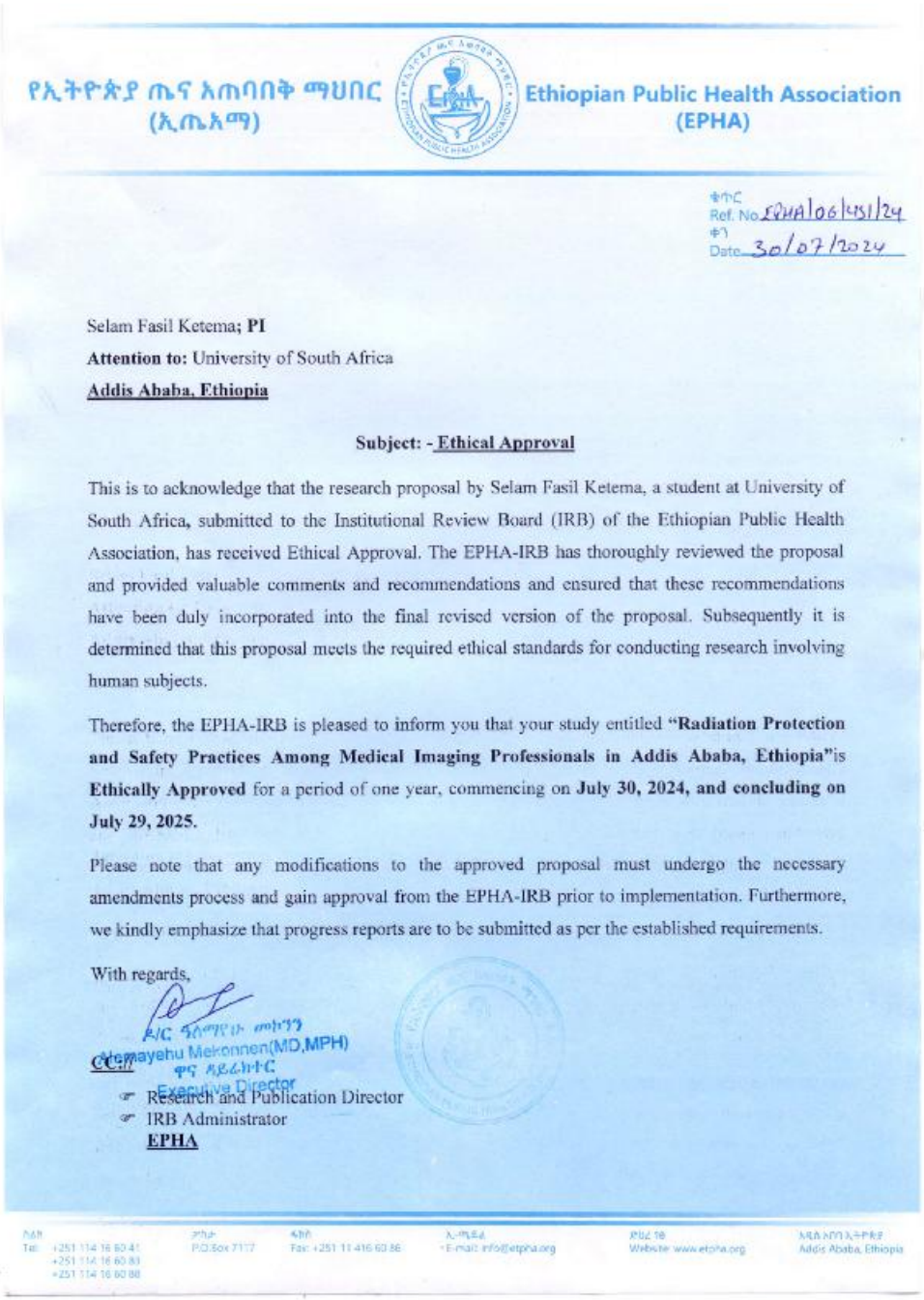
ANNEXURE B: IN-COUNTRY ETHICAL CLEARANCE FROM THE ETHIOPIA PUBLIC HEALTH ASSOCIATION.



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(ኢጤአማ)

Ethiopian Public Health Association
(EPHA)

ቁጥር
Ref. No EPHA/06/431/24
ቀን
Date 30/07/2024

Selam Fasil Ketema; **PI**

Attention to: University of South Africa

Addis Ababa, Ethiopia

Subject: - Ethical Approval

This is to acknowledge that the research proposal by Selam Fasil Ketema, a student at University of South Africa, submitted to the Institutional Review Board (IRB) of the Ethiopian Public Health Association, has received Ethical Approval. The EPHA-IRB has thoroughly reviewed the proposal and provided valuable comments and recommendations and ensured that these recommendations have been duly incorporated into the final revised version of the proposal. Subsequently it is determined that this proposal meets the required ethical standards for conducting research involving human subjects.

Therefore, the EPHA-IRB is pleased to inform you that your study entitled **"Radiation Protection and Safety Practices Among Medical Imaging Professionals in Addis Ababa, Ethiopia"**is **Ethically Approved** for a period of one year, commencing on **July 30, 2024, and concluding on July 29, 2025.**

Please note that any modifications to the approved proposal must undergo the necessary amendments process and gain approval from the EPHA-IRB prior to implementation. Furthermore, we kindly emphasize that progress reports are to be submitted as per the established requirements.

With regards,

ዶ/ር ዳዲማየሁ መኮንን
Dr. Dimayehu Mekonnen(MD,MPH)
ዋና ዳይሬክተር
Executive Director

CC:/

- Research and Publication Director
- IRB Administrator

EPHA

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አዲስ አበባ ኢትዮጵያ Addis Ababa, Ethiopia

ANNEXURE C: SUPPORT LETTER FROM MINISTER OF HEALTH

ጤና ሚኒስቴር - ኢትዮጵያ
የዜጎች ጤና ለሀገር ብልፅግና !

Ministry of Health - Ethiopia
Healthier Citizens for Prosperous Nation !

ቀን
Date 7. 12 2016
ቀጥር
Ref.No መ, 1/24/45/175

ለ፡ ቅዱስ ጳውሎስ ሚሊኒዬም ሜዲካል ኮሌጅ

ለ፡ አለርት ሆስፒታል

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ከ፡ ፖሊሲ ስትራቴጂ ጥናትና ምርምር መሪ ሥራ አስፈጻሚ

ጉዳዩ ትብብርን ይመለከታል፤

አመልካች ሰላም ፋሲል ከተማ በሳውዝ አፍሪካ ዩኒቨርሲቲ (UNISA) የ MPH ተማሪ ሲትሆን ኢቲካል ክሊራንሳቸውን ጨርሰው የመመረቂያ ጥናታቸውን በእናንተ ሆስፒታል ለማድረግ ፈልገው በቀን 06/12/2016 ዓ.ም ባመለከቱት ማመልከቻ ጠይቀውናል።

ስለዚህ ከሆስፒታላችሁ የሚፈልጉትን መረጃ እንድትተባበሩዋቸው በትህትና እንጠይቃለን።

ከሠላምታ ጋር

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Addis Ababa,Ethiopia

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In Reply Please Refer to Our Ref.No.

E-mail : moh@moh.gov.et
Website : www.moh.gov.et
Ministry of Health,Ethiopia
@FMoHealth

ጤና ሚኒስቴር - ኢትዮጵያ
የዜጎች ጤና ለሀገር ብልፅግና !

Ministry of Health - Ethiopia
Healthier Citizens for Prosperous Nation !

ቀን
Date 7-12 2016
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ለ፡ ቅዱስ ጳውሎስ ሚሊኒዬም ሜዲካል ኮሌጅ

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ጉዳዩ ትብብርን ይመለከታል!

አመልካች ሰላም ፋሲል ከተማ በሳውዝ አፍሪካ ዩኒቨርሲቲ (UNISA) የ MPH ተማሪ ሲትሆን ኢቲካል ኪሊራንሳቸውን ጨርሰው የመመረቂያ ጥናታቸውን በእናንተ ሆስፒታል ሰማድረግ ፈልገው በቀን 06/12/2016 ዓ.ም ባመለከቱት ማመልከቻ ጠይቀውናል።

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Ministry of Health,Ethiopia
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እባክዎን መልስ ሲሰጡ የእኛን ደብዳቤ ቁጥር ይጥቀሱ
In Reply Please Refer to Our Ref.No.

ጤና ሚኒስቴር - ኢትዮጵያ
የዜጎች ጤና ለሀገር ብልፅግና !

Ministry of Health - Ethiopia
Healthier Citizens for Prosperous Nation !

ቀን
Date 7-12 2016
ቁጥር
Ref.No. ጤመ/12 4/45/13

ለ፡ ቅዱስ ጳውሎስ ሚሊኒዬም ሜዲካል ኮሌጅ

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ጉዳዩ ትብብርን ይመለከታል!

አመልካች ሰላም ፋሲል ከተማ በሳውዝ አፍሪካ ዩኒቨርሲቲ (UNISA) የ MPH ተማሪ ሲትሆን ኢቲካል ክሊራንሳቸውን ጨርሰው የመመረቂያ ጥናታቸውን በእናንተ ሆስፒታል ሰማድረግ ፈልገው በቀን 06/12/2016 ዓ.ም ባመለከቱት ማመልከቻ ጠይቀውናል።

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+251 -115-518031
+251 -115-159657
+251 -115-524549
+251 -115-516378
+251 -115-513301

Fax +251-115-519366

1234
Addis Ababa,Ethiopia

E-mail : moh@moh.gov.et
Website : www.moh.gov.et

Ministry of Health,Ethiopia
@FMoHealth

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In Reply Please Refer to Our Ref.No.

ጤና ሚኒስቴር - ኢትዮጵያ
የዜጎች ጤና ለሀገር ብልፅግና !

Ministry of Health - Ethiopia
Healthier Citizens for Prosperous Nation !

ቀን Date 7-12-2016
ቁጥር Ref.No ጤሚ/24/45/173

ለ፡ ቅዱስ ጳውሎስ ሚሊኒዬም ሜዲካል ኮሌጅ

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ጉዳዩ ትብብርን ይመለከታል፤

አመልካች ሰላም ፋሲል ከተማ በሳውዝ አፍሪካ ዩኒቨርሲቲ (UNISA) የ MPH ተማሪ ሲሆን ኢቲካል ኪሊራነሳቸውን ጨርሰው የመመረቂያ ጥናታቸውን በእናንተ ሆስፒታል ለማድረግ ፈልገው በቀን 06/12/2016 ዓ.ም ባመለከቱት ማመልከቻ ጠይቀውናል።

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ከመልካም ጋር

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In Reply Please Refer to Our Ref.No.

ANNEXURE D: SUPPORT LETTER FROM UNISA REGIONAL OFFICE

09 April 2024
UNISA-ET/KA/ST/29/09-04-2024

MINISTRY OF HEALTH
ADDIS ABABA

Dear Madam/Sir,

The University of South Africa (UNISA) extends warm greetings to you and staff members of your esteemed Ministry. By this letter, we want to confirm that Selam Fasil Ketema (student number 20991371) is an MPH student in the Department of Health Studies at UNISA. Currently, she is at the stage of data collection on her Master's research entitled "***Radiation protection and safety practices among medical imaging professionals in Addis Ababa, Ethiopia***".

This is therefore to kindly request your cooperation in assisting the student by giving her in-country ethical clearance that will allow her to collect data from hospitals under your administration. We would like to thank you in advance for all the assistance that you would provide to the student. Attached, please find the provisional ethical clearance that the student received from the main campus.

Sincerely,

Dr. Tsige GebreMeskel Aberra
Director

UNISA-ETHIOPIA CENTER
P.O.BOX:13836
ADDIS ABABA
TEL+251912191483

ANNEXURE E: INFORMATION SHEET AND CONSENT FORM

ANNEXURE: E INFORMATION SHEET AND CONSENT FORM

Research title: RADIATION PROTECTION AND SAFETY PRACTICES AMONG MEDICAL IMAGING PROFESSIONALS IN ADDIS ABABA, ETHIOPIA.

Researcher: Selam F. Ketema

Ethics clearance reference number: (20991371_CREC_CHS_2024)

Research permission reference number: (EPHA/06/45124)

Dear Prospective Participant

I, Selam F. Ketema, am conducting research towards a master's degree in public health at the University of South Africa in collaboration with Dr H. Matakanye, a senior lecturer in the Department of Health Studies. We invite you to participate in a research study that assesses radiation protection and safety practices among medical imaging professionals in Addis Ababa, Ethiopia.

What Is the Purpose of the Study?

By doing this study, we wish to learn more about RTs and radiographers' knowledge, practice, perception, attitude, and environmental barriers toward radiation protection and safety measures and their implementation in the imaging department. This study is expected to collect important information that could improve the public's services and aims to address the need for more literature related to this subject.

Why am I invited to participate?

All radiologic technologists and radiographers working in the diagnostic radiology department in the selected hospitals are invited to participate in this study.

What is the nature of my participation in this study?

We invite you to take part in a survey. You will receive a questionnaire on your understanding of radiation protection and your adherence to safety measures in the imaging room. The completion of the questionnaire is expected to take approximately 15 minutes of your time.

Can I withdraw from this study even after having agreed to participate?

Participating in this study is voluntary, and you are under no obligation to consent to participation. If you do decide to take part, you will be given this information sheet to keep and be asked to sign a written consent form. You are free to withdraw at any time during the data collection phase. The questionnaire will not include questions that identify you as participants, and you will be assigned a code to ensure you remain anonymous. Therefore, it will not be possible to withdraw once you submit the questionnaire.

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Preller Street, Muckleneuk Ridge, City of Tshwane
PO Box 392 UNISA 0003 South Africa
Telephone: +27 12 429 3111 Facsimile: +27 12 429 4150
www.unisa.ac.za

What are the potential benefits of taking part in this study?

The study aims to offer valuable insights into the understanding and implementation of radiation protection and safety practices among radiologic technologists and radiographers. For practitioners in the field, the study may offer insights that contribute to their professional development, potentially leading to enhanced skills, practices, or awareness. The findings and ensuing recommendations aspire to contribute to the enhancement of services provided to the public and the development of policies conducive to ongoing education and training. Furthermore, the study aims to address existing gaps in the literature.

Are there any negative consequences for me if I participate in the research project?

There will be no physical discomfort or risk when participating in the study. If you, however, feel uncomfortable with the questions being posed, you are free to discontinue.

Will the information that I convey to the researcher and my identity be kept confidential?

If you are satisfied with the nature and purpose of the study to be conducted, kindly sign the attached informed consent form. You have the right to insist that your name will not be recorded anywhere and that no one, apart from the researcher and identified members of the research team, will know about your involvement in this research. In addition, your name will not be recorded anywhere, and no one will be able to connect you to the answers you give. Your answers will be given a code number, and you will be referred to in this way in the data, any publications, or other research reporting methods such as conference proceedings.

How will the researcher(s) protect the security of data?

Hard copies of your answers will be stored by the researcher for a minimum period of five years in a locked filing cabinet in a safe place for future research or academic purposes; electronic information will be stored on a password-protected computer. Future use of the stored data will be subject to further research ethics review and approval, if applicable. If necessary, the soft and hard copies of the raw data will be permanently shredded and or erased.

Will I receive payment or any incentives for participating in this study?

While we are unable to provide compensation for your time, your participation plays a crucial role in the success of this study. Your insights are valuable, and we are grateful for your dedication to contributing to the advancement of knowledge in the medical imaging field.

Has the study received ethical approval?

This study has received written approval from the Research Ethics Review Committee of the College of Human Science at the University of South Africa. A copy of the approval letter can be obtained from the researcher if you so wish.

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How will I be informed of the findings/results of the research?

If you would like to be informed of the final research findings or should you require any further information, or want to contact the researcher about any aspect of this study, please contact Selam Ketema at afselena@gmail.com; 20991371@mylife.unisa.ac.za.

Should you have concerns about how the research has been conducted, you may contact Dr Matakanye at matakh@unisa.ac.za or 0124293111. Contact the research ethics chairperson of the University of South Africa, Prof. KB Khan, at khankb@unisa.ac.za 0124296549 if you have any ethical concerns.

Thank you for taking the time to read this information sheet and for participating in this study.

Regards,

Selam ketema

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INFORMED CONSENT FORM

I, _____ (participant name), confirm that the person asking my consent to take part in this research has told me about the nature, procedure, potential benefits, and anticipated inconvenience of participation.

I have read (or had explained to me) and understood the study as explained in the information sheet.

I have had sufficient opportunity to ask questions and am prepared to participate in the study.

I understand that my participation is voluntary and that I am free to withdraw without penalty.

I am aware that the findings of this study will be processed into a research report, journal publications and/or conference proceedings, but that my participation will be kept confidential unless otherwise specified.

I agree to participate in the study.

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

Participant Name & Surname……

Participant Signature……**Date**……

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ANNEXURE F: DATA COLLECTION INSTRUMENT

UNISA university of south africa

Research title: RADIATION PROTECTION AND SAFETY PRACTICES AMONG MEDICAL IMAGING PROFESSIONALS IN ADDIS ABABA, ETHIOPIA

DEMOGRAPHIC INFORMATION

1. Age

2. Gender Female Male

3. Profession Medical Radiology Technologist Radiographer

4. What is your highest level of education in the field of medical Imaging/ radiology?

Diploma

Bachelor's degree

Master's degree

PhD

5. Years of work experience

6. Have you ever received any formal training on radiation protection?

Yes No

7. Have any radiation protection training programs been provided to Imaging professionals at your hospital?

Yes No

8. Were radiation protection and safety measures adequately covered during your tertiary education?

Yes No

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9. Which hospital do you currently work at?

ALERT Comprehensive Hospital

Black Lion Specialised Hospital

St. Paul Specialised Hospital

AaBET Hospital

PRACTICE

Read the statement and indicate your level of agreement.

10. How frequently do you follow recommended safety protocols when operating imaging modalities?

Always

Often

Sometimes

Rarely

Never

11. How frequently do you provide radiation protection equipment for your patients?

Always

Often

Sometimes

Rarely

Never

12. How frequently do you address your patient's concern regarding radiation?

Always

Often

Sometimes

Rarely

Never

13. How frequently do you wear a dosimeter?

Always

Often

Sometimes

Rarely

Never

14. Before performing a radiological examination, how frequently do you ask if your female patient is pregnant?

Always

Often

Sometimes

Rarely

Never

15. What type of radiation shielding equipment do you regularly use in your department? (Select all that apply)

Lead apron

Lead gloves

Gonad shields

Lead glasses

Thyroid collards

Radiation glasses

None

16. What steps do you take to minimize repeat exposures to radiologic examination? (Select all that apply)

I verify patient identity and exam details before starting

I ensure correct positioning and select the right exposure factors

I use collimation to limit the X-ray field

I regularly maintain and calibrate the imaging machine

Providing appropriate shielding for patients

Other:

17. How do you assess the effectiveness of radiation shielding equipment in your department? (select all that apply)

By implementing regular inspections and maintenance

By employing dose measurement and monitoring

By asking my colleagues

I have never done a formal assessment

I do not know

Visual inspection for wear and damage

Other:

18. What methods do you use to minimize radiation exposure to patients, yourself and your colleagues? (select all that apply)

I use personal protective equipment (PPE)

I apply safety measures such as time, distance, and shielding principles

I regularly attend radiation protection and safety training and updates

I use dose monitoring devices

I optimize exposure settings

I modify protocols to minimizes radiation exposure

I have never used all of the above options

Other:

19. How do you manage radiation protection for patients undergoing repeated imaging studies? (select all that apply)

I take a record of the cumulative radiation dose the patient receives.

I will schedule a follow-up exam at intervals to minimize dose accumulation

I do not implement any specific measures; I just repeat the examination.

I will use alternative imaging modalities (e.g., MRI, ultrasound) when possible

I will apply dose reduction techniques and protocols

I do not know

Other:

ATTITUDE

Read the statement and indicate your level of agreement.

20. I believe that regular training in radiation protection is essential for enhancing my radiation safety practices.

Strongly disagree

Disagree

Neutral

Agree

Strongly Agree

21. I believe that strict adherence to radiation safety practices is necessary to improve the overall quality of patient care.

Strongly disagree

Disagree

Neutral

Agree

Strongly agree

22. I believe that routine safety checks and equipment maintenance are necessary for effective radiation protection in my department.

Strongly disagree

Disagree

Neutral

Agree

Strongly agree

23. I believe a departmental radiation safety culture influences the commitment to radiation safety among staff.

Strongly disagree

Disagree

Neutral

Agree

Strongly agree

24. I believe using radiation shielding equipment for every patient is time-consuming.

Strongly disagree

Disagree

Neutral

Agree

Strongly agree

25. The ALARA principles are not applicable in my routine work.

Strongly disagree

Disagree

Neutral

Agree

Strongly agree

26. I believe radiation protection and safety practices only benefit patients.

Strongly disagree

Disagree

Neutral

Agree

Strongly agree

27. In my opinion, informing patients about radiation hazards and safety measures is a waste of time.

Strongly disagree

Disagree

Neutral

Agree

Strongly agree

28. I believe efficiency in completing imaging exams should outweigh concerns about radiation safety.

Strongly disagree

Disagree

Neutral

Agree

Strongly agree

29. I believe using a personal dosimeter does not have any value in my routine work.

Strongly disagree

Disagree

Neutral

Agree

Strongly agree

KNOWLEDGE

30. What is the most effective way to protect radiosensitive organs in paediatric patients during radiographic procedures?

Using a lower X-ray tube voltage (kVp)

Optimizing exposure settings based on patient size and anatomy

Increasing the X-ray tube current (mA)

Positioning the patient closer to the X-ray tube

I do not know

31. Which of the following is the most effective way to reduce patient dose?

Decrease the exposure time

Increase the X-ray beam intensity

Increase the distance between the patient and the X-ray tube

Decrease the distance between the patient and the X-ray tube

I do not know

32. From the International Commission on Radiological Protection (ICRP) recommendation, what is the 1-year maximum permissible dose limit for a declared pregnant radiation worker?

0.1 mSv

1 mSv

11 mSv

20 mSv

I do not know

33. Which of the following actions can best reduce scatter radiation exposure to radiologic technologists/radiographers?

Increasing the kVp (kilovolt peak)

Decreasing the distance from the radiation source.

Using collimation to focus the X-ray beam

Using higher mAs (milliampere-seconds) settings

I do not know

34. Which of the following does not highlight the importance of properly positioning the patient during radiographic procedures?

To reduce radiation exposure to non-target areas

To enhance image sharpness

To increase patient comfort

To minimize repeated examination

I do not know

35. How often should technologists/radiographers check and maintain radiation protection equipment, such as lead aprons and shields?

Daily

Weekly

Monthly

Annually

I do not know

36. Which of the following best describes the concept of "dose optimization"?

X-ray examinations should be prescribed and carried out only when necessary.

The dose delivered during the X-ray examination must be kept as low as reasonably achievable and compatible with the attainment of the required diagnostic examination.

An X-ray examination must include the widest anatomical area so that a single exposure can be possible, to evaluate the minute anatomical details

A radiographic image is optimized when image resolution and contrast are the

I do not know

37. What is the annual dose limit for occupational exposure for radiologic technologists/radiographers according to the Ethiopian Radiation Protection Authority (ERPA) guide?

20 mSv

25 mSv

50 mSv

100 mSv

I do not know

38. Which factor has the greatest impact on the amount of radiation a patient receives during a radiologic procedure?

The type of imaging modality used

The radiologic technologist/radiographer's experience level

The distance between the patient and the radiographer

The exposure settings (kVp, mA, time) used

I do not know

39. What is the main goal of implementing radiation protection measures in healthcare settings?

To enhance the accuracy of dosimeter readings during radiographic procedures.

To minimize radiation exposure to both the patient and healthcare staff, reducing the risk of harmful effects.

To ensure the radiologic technologist/radiographer is always protected To reduce the overall duration of radiologic procedures.

I do not know

40. Which of the following factors does not affect the performance of a dosimeter?

Temperature and humidity conditions

Type of radiation being measured

The user's physical health

Calibration and maintenance procedures

I do not know

41. Which of the following actions best optimizes the use of shielding during radiographic procedures?

Ensure lead aprons or shields cover sensitive organs before starting the procedure.

Use a lead barrier or wall to protect the radiologic technologist/ radiographers from scatter radiation during the procedure.

Avoid using shielding near sensitive organs to prevent interference with the

Avoid shielding to reduce procedure time

I do not know

PERCEPTION

Please indicate the extent to which you agree or disagree with the following statements:

42. I am likely to experience health problems due to radiation exposure in my job as a radiologic technologist/radiographer.

Strongly disagree

Disagree

Neutral

Agree

Strongly Agree

43. I am concerned about the potential long-term health consequences of radiation exposure in my profession.

Strongly disagree

Disagree

Neutral

Agree

Strongly agree

44. I believe radiation protective measures (e.g., lead aprons, shielding, selecting the right protocol, and dose optimization) are effective in reducing radiation exposure Mark only one oval.

Strongly disagree

Disagree

Neutral

Agree

Strongly agree

45. A high workload prevents me from consistently following radiation safety measures.

Strongly disagree

Disagree

Neutral

Agree

Strongly agree

46. Resource constraints (staff shortage, old equipment, lack of radiation safety guidelines, protective gear) in my facility hinder effective radiation safety practices.

Strongly disagree

Disagree

Neutral

Agree

Strongly Agree

47. Insufficient training in radiation safety practices prevents me from applying the necessary protective measures.

Strongly disagree

Disagree

Neutral

Neutral

Agree

Strongly agree

49. I am confident in my ability to follow radiation safety measures to reduce unnecessary radiation exposure.

Strongly disagree

Disagree

Neutral

Agree

Strongly agree

ENABLING ENVIRONMENT

Read the statement and indicate your level of agreement.

50. Radiation protection resources (e.g., guidelines, safety manuals, radiation protection equipment) are easily accessible in my workplace.

strongly disagree

Disagree

Neutral

Agree

Strongly agree

51. The radiology department has regular access to safety audits or inspections to assess radiation protection practices.

Strongly disagree

Disagree

Neutral

Agree

Strongly agree

52. The overall safety culture regarding radiation protection in my workplace is positive.

Strongly disagree

Disagree

Neutral

Agree

Strongly Agree

53.My personal dosimeters are taken for measurement regularly.

Mark only one oval.

Strongly disagree

Disagree

Neutral

Agree

Strongly agree

54.I often receive training or updates on radiation safety practices at my workplace.

Strongly disagree

Disagree

Neutral

Agree

Strongly Agree

55.What are the main challenges you face in implementing radiation protection measures in your department? (select all that apply) Check all that apply.

Lack of adequate training for staff

Lack of resources

A general lack of awareness about the importance of radiation protection among staff members.

High workload

Insufficient regulatory guidance

Difficulty in enforcing compliance among staff

Poor patient cooperation
Other:

56. What improvements do you think your imaging department could make to improve radiation protection practices? (select all that apply) *

Implementing regular training sessions on radiation safety for all staff members. Upgrading imaging equipment to newer models with lower radiation exposure.

Increasing the use of protective gear, such as lead aprons and thyroid shields, for patients and staff.

Introducing stricter protocols for minimizing repeat scans and optimising radiation dose.

Enhancing dose monitoring and reporting systems for radiation exposure levels.

Promoting patient education on radiation safety and establishing a multidisciplinary radiation safety team to oversee safety practices, review incident reports, and recommend improvements.

Regularly reviewing and updating radiation protection guidelines in line with the local regulations and international standards.

Other:

ANNEXURE G: CONFIDENTIALITY AGREEMENT

ANNEXURE : G CONFIDENTIALITY AGREEMENT

This agreement is between:

[Mrs. Selam Fasil Ketema, Lead Researcher]

and

[Tewodros Amde, Data collector]

for

research project title: **RADIATION PROTECTION AND SAFETY PRACTICES AMONG MEDICAL IMAGING PROFESSIONALS IN ADDIS ABABA, ETHIOPIA**

I agree to:

1. Keep all the research information shared with me confidential. I will not discuss or share the research information with anyone other than the *Researcher* or others identified by the *Researcher*.
2. Keep all research information secure while it is in my possession.
3. Return all research information to the Researcher when I have completed the research tasks or upon request, whichever is earlier.
4. Destroy all research information regarding this research project that is not returnable to the researcher after consulting with the researcher.
5. Comply with the instructions of the researcher about requirements to physically and/or electronically secure records (including password protection, file/folder encryption, and/or use of secure electronic transfer of records through file sharing, use of virtual private networks, etc.).
6. Not allow any personally identifiable information to which I have access to be accessible from outside (unless specifically instructed otherwise in writing by the Researcher.

Data collector:

Tewodros Amde Hassen

University of South Africa
Preller Street, Muckleneuk Ridge, City of Tshwane
PO Box 392 UNISA 0003 South Africa
Telephone: +27 12 429 3111 Facsimile: +27 12 429 4150
www.unisa.ac.za

---------- ---------- ------8/9/2024------

(Print Name) (Signature) (Date)

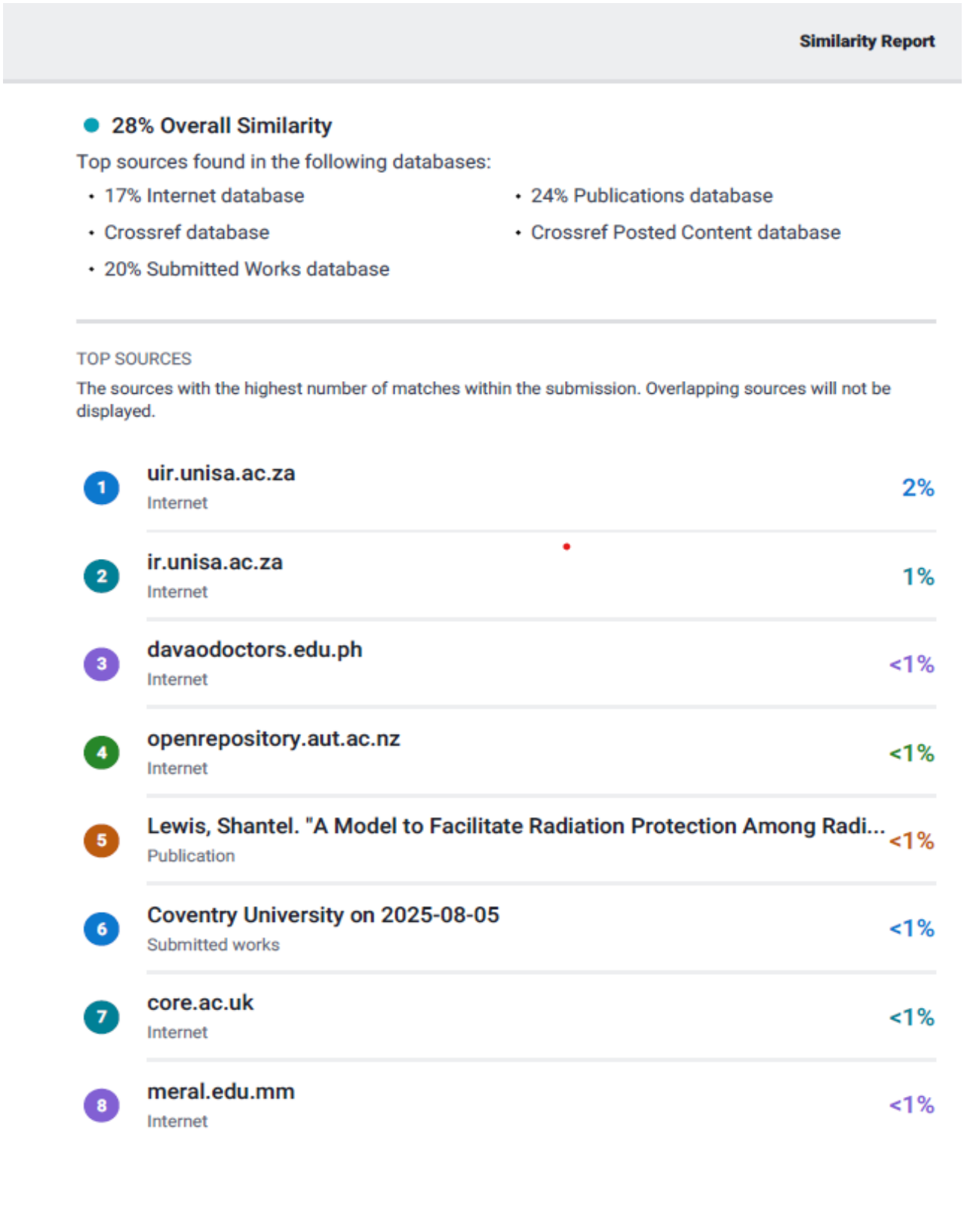
I agree to:

1. Provide detailed directions and instructions on my expectations for maintaining the confidentiality of research information so that the statistician can comply with the above terms.
2. Provide oversight and support to [data collector] in ensuring confidentiality is maintained throughout the data analysis process in accordance with the University of South Africa Policy on the Ethical Conduct of Research Involving Humans.

Researcher:
SELAM FASIL KETEMA
---------- ---------- ----------
08/09/24----------
(Print Name) (Signature) (Date)

University of South Africa
Preller Street, Muckleneuk Ridge, City of Tshwane
PO Box 392 UNISA 0003 South Africa
Telephone: +27 12 429 3111 Facsimile: +27 12 429 4150
www.unisa.ac.za

ANNEXURE H: TURNITIN REPORT



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