Availability and Utilisation of Radiation Protection and Safety Measures by Medical Imaging Technologists in Rwandan Hospitals

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Declaration

I, Patrick Muiga Maina, Student Number 200617350, hereby declare that the dissertation entitled, "**Availability and Utilization of Radiation Protection and Safety Measures by Medical Imaging Technologists in Rwandan Hospitals**", which is herewith submitted to the University of Johannesburg in compliance with the requirements for the Master's degree, is my authentic and original work, unless clearly indicated otherwise, and in such instances, full reference to the source has been acknowledged, and has not been submitted to any other university. I understand and accept that the copies submitted for examination are the property of the University.

Signed on this ……13th …........... day of December, 2019

………………………
Patrick Muiga Maina

Dedication

The heights I have reached are by God's grace. I could not have done it on my own.

I dedicate this study to:

i. My lovely wife, Nancy Michere; handsome sons, James and Jack; and beautiful daughter, Hilda, for their tolerance and patience. During the course of this study, much valuable time was taken away from them.

ii. My parents who have always been a source of encouragement, especially my dad, who has always encouraged me not to settle for less.

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Abstract

Medical imaging technologists (MITs) are taught and use techniques and protective devices to keep radiation to a minimum, to themselves, patients and the environment, through but not limited to shielding, employing appropriate distances, optimum radiographic exposures, and use of techniques such as good communication, immobilization, beam limitation, justification for radiation exposure and quality control programmes.

Following the enactment of the new law relating to radiation protection in 2018, it was relevant to interrogate the current state of radiology departments to establish whether they are equipped for implementation of the new regulations. The aim of this study therefore, was to assess the availability and utilization of radiation and safety measures by medical imaging technologists in Rwandan Hospitals.

A quantitative non-experimental descriptive method study design was used and data was collected by means of a questionnaire which was developed by the researcher using studies conducted in other jurisdictions and adapted to suit the local context to achieve the aim and target all the MITs in the public hospitals. One hundred and sixteen (116) representing 96.67% of expected participants from public hospitals participated in the study. The participants came from 44 (91.67%) of the total of 48 public hospitals.

The study found that radiation safety measures were not adequately implemented as 40.87% of MITs did not have radiation-measuring devices, with 29% of those having the devices, not receiving results consistently. Lead rubber aprons were mostly available for 99.13%, however, 59% of participants had never checked their integrity. A Pigg-o-stat was the least available at 0.86%. 36.8% of MITs blamed neglect by administrators as a reason for non-availability of the radiation equipment. Participants mostly used lead rubber aprons (93.04%) and lead equivalent barriers (83.62%).

There was a lack of adequate radiation safety equipment while quality management, use of exposure charts and use of immobilizing devices as techniques for radiation safety were not implemented. It was evident that education and experience did not influence the radiation safety practice. Barriers to radiation safety were negligence, lack of equipment and difficulty in using some of the equipment. There is a need for a concerted effort between RURA, the Ministry of Health, training institutions and hospital managements to improve the culture of radiation safety.

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List of abbreviations

AQD	Acceptable quality dose
B.Sc.MIT	Bachelor of Science in Medical Imaging Technology
CPD	Continuous Professional Development
DRLs	Dose reference levels
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
IR	Image receptor
kVp	Kilo Voltage peak
M.Sc.MIT	Master of Science in Medical Imaging Technology
mAs	Milliampere seconds
MITs	Medical Imaging Technologists
MoH	Ministry of Health
PPDs	Personnel protective devices
RAHPC	Rwanda Allied Health Professions Council
RURA	Rwanda Utilities Regulatory Authority
UNSCEAR	United Nations Scientific Committee on the Effects of Atomic Radiation

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CHAPTER ONE

INTRODUCTION

1.1 Background

The importance of radiation protection to the patient, occupational exposure to staff and the exposure to the public cannot be overemphasised. The International Atomic Energy Agency (IAEA), based on the International Commission for Radiological Protection (ICRP) recommendations and findings of United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), develops international basic safety standards that are supposed to be implemented by individual countries at national level (IAEA safety standards series No. SSG – 46). In line with this, Rwanda has legislated a new law governing radiation protection (Rwanda Law Nº 59/2017 of 24/1/2018).

The three cardinal principles of radiation protection are shielding, time and distance. Knowledge and understanding of the three factors or lack thereof influences the radiographer's attitude towards the use of radiation safety measures (Mojiri and Moghimbeigi 2011:2-5).

Patients benefit directly from the use of medical radiation. It is, however, important that radiation is only limited to the area of interest with dose optimization. According to International Basic Safety Standards (BSS), there should be controlled access to the radiology examination rooms, especially when equipment is in use, this being for the safety of the public (IAEA safety standards series, ISSN 1020 – 525X; No. GSR part 3). BSS states monitoring of the publics' exposure in areas surrounding the radiology establishment should also be considered. Requirement 20 of the same BSS requires the establishment and enforcement of monitoring and recording of occupational exposure (IAEA safety standards series No. SSG – 46; IAEA safety standards series, ISSN 1020 – 525X; No. GSR part 3).

The benefits and hazardous nature of diagnostic ionizing radiation have been known since the early 20th century, leading to the development of ways to optimize radiation protection for the benefit of staff and patients (Statkiewicz-Sherer, Visconti, Ritenour, and Haynes 2014:2-3). It is critically important to note that patient exposure also influences occupational exposure, this being radiation exposure to staff working in the x-ray department. Therefore, prudency in the control of exposure by any means delivered to the patient is crucial and has the additional benefit of lowering occupational exposure (Statkiewicz-Sherer *et. al.,* 2014:310).

Prior to the new legislation (Rwanda Law Nº 59/2017 of 24/1/2018), the use of radiation and monitoring of staff was not regulated in Rwanda. Article 5 subsection three permits the regulatory authority to inspect, monitor and assess ionising radiation related activities. Requirements of the law in article 15 state that there should be periodic medical assessment of employees by employers and it permits the regulatory authority to take measures should it find the working environment detrimental to the health of any employee. Article 17 further requires/obligates establishments licensed with equipment that produce ionising radiation to ensure that exposure of persons to ionising radiations is kept as low as possible and does not exceed dose limits prescribed in the regulation. Employees should also be provided with protective equipment and their safety guaranteed by the employer as per article 20.

1.2 Problem Statement

The Medical Imaging Sciences programme to train medical imaging technologists to perform radiographic procedures in Rwanda was started in 1998 (University of Rwanda database), which was four years after the 1994 genocide against the Tutsi. This was of great importance due to the role medical imaging technologists play in the health care delivery process, as they were non-existent at the time. Although producing these images uses ionising radiation, there has never been a mechanism to monitor how radiation protection measures are implemented for the benefit of staff, patients and the public in Rwanda. When proper monitoring and safe guards are not put in place there is bound to be public health burden to state due to possible radiation induced illnesses, short and long term.

The recent law Nº 59/2017 of 24/1/2018 governing radiation protection was promulgated and gazetted in 2018. This law states, in broader terms, regulation of ionising radiation and expectations of radiation protection through a regulatory framework. It has not been implemented as yet, thus it was relevant to interrogate the current state of radiology departments that use radiation for medical purposes and to establish whether they are equipped for implementation of the new regulations with specific reference to radiation safety measures.

1.3 Research Question

The research question arising from the problem statement is, “What resources are available to medical imaging technologists in order to apply radiation safety measures to protect self, patient and the environment?”

1.4 Research Aims and Objectives

1.4.1 Aim

The aim of this study was to assess the availability and utilization of radiation and safety measures by medical imaging technologists in Rwandan Hospitals.

1.4.2 Objectives

1. To identify the radiation safety measures available and the level of usage by medical imaging technologists in their relevant hospitals.
2. To determine whether education has any effect on the utilization of radiation safety measures.
3. To determine barriers that prevent medical imaging technologists from implementing the required radiation safety measures.

1.5 Rationale

In Rwanda there has never been documentation as to the availability and condition of radiation safety measures to limit radiation to the areas of interest during radiographic and radiological examinations. It also has not been established whether radiographers at all times protect patients from unnecessary radiation during examinations. Spot-checks in a few facilities made by the researcher showed poor x-ray room designs that pose a risk to the public. In the researcher’s experience, there was a lack of/or limited monitoring of staff and when, for example, thermo-luminescent dosimeters were available, the dosimeters were sent abroad for analysis which took a long time for results to be made available to the MITs. A centre recently established by the IAEA in Rwanda for reading the thermos-luminescent dosimeters is yet to be fully operational.

Eze, Irurhe, Njoku, Olowu and Abonyi*.,* (2013:386-391) observed that there was poor radiation protection practice even with the knowledge of radiation protection and how to protect staff and patients from risks. This was further confirmed in an additional study carried out in northern Nigeria, which recommended periodic in-service training and monitoring of radiation safety in view of the poor radiation protection practices (Awosan, Ibrahim, Saidu, Ma'aji, Danfulani, Yunusa, and Ige, 2016:LC7-LC12). Ngoye, Motto, and Muhogora, (2015:s23-s30) in a study conducted in Tanzania reported limited quality control of imaging equipment, which led to sub-optimal imaging, thus resulting in repeat examinations and unnecessary radiation. Considering that Rwanda is a developing country in Africa, in a low resourced setting and the gazetting of the new law relating to radiation protection in Rwanda in 2018, research similar to that done by Eze *et.al*, (2013:386-391) could be of value to the Rwanda Utility Regulatory Agency (RURA). This study was therefore, aimed at assessing the availability and utilization of radiation safety measures by medical imaging technologists in Rwandan Hospitals in view of the new legislation law n° 59/2017 of 24/1/2018 governing radiation protection.

Radiation safety measures in the context of this study were protective items such as lead rubber aprons and protective glass shielding. Mechanisms to minimise ionizing radiation to patients and elimination of the same to the medical imaging technologists and the public are: effective communication; immobilization of the patient; appropriate technical exposure factors; collimation; quality control programmes; air-gap technique and unnecessary radiological procedures.

1.6 Operational Definitions

Safety measures	Effective measures employed by medical imaging technologists to protect patients, personnel and the general public from unnecessary radiation (Statkiewicz-Sherer *et. al.,* 2014:2).
Unnecessary radiation	Radiation exposure that does not benefit a person in terms of diagnostic information obtained for the clinical management of medical needs or any radiation exposure that does not enhance the quality of the study (Statkiewicz-Sherer *et. al.,* 2014:2&3).
Education	Having knowledge about something.
Educational age	Years since graduation (Shabani, Hasanzadeh, Emandi, Mirmohammadkhani, Bitarafan-Rajabi, Abedelahi and Ziari, 2018:142)
Exposure factors	milliamperage (mA); kilovoltage (kVp); and milliseconds (s).
Image Receptors	The combination of cassette, intensifying screens and film, recording an image through use of light as a result of radiation striking the intensifying screens (Fauber 2000:136).
Beam Limitation	Decrease in the size of the projected radiation field also referred to as beam restriction or collimation (Fauber 2009:136).

Immobilization	Rendering the patient incapable of moving with consent (Ng and Doyle 2019:181).
Restraint	Use of physical force to stop the movement without consent (Ng and Doyle 2019:181).
Radiographic Projection	The path taken by an x-ray beam as it passes through the body (Medical dictionary).
Regulation of radiation	Enforcement of determined radiation protection standards for the protection of the general public, patients and occupational exposed personnel (Statkiewicz-Sherer *et. al.,* 2014:209).

1.7 The Research Outline

The research is reported as follows:

1.7.1 Chapter 1 – Introduction

Chapter one comprises of the background to the study, problem statement, research question, research aims and objectives and rationale of the study. This chapter also includes definitions of key terminology and the abbreviations of some of the terms used.

1.7.2 Chapter 2 – Literature Review

The chapter contains reviewed literature pertaining to radiation safety measures.

1.7.3 Chapter 3 – Research Methodology

This chapter gives a detailed description of the research methodology, the research tool, the research design and the ethical consideration.

1.7.4 Chapter 4 – Data Analysis

Chapter four presents comprehensive analysis of the data collected and describes the process that was followed to analyse the data collected.

1.7.5 Chapter 5 – Discussion of the Results

Chapter five discusses the study findings in conjunction with the reviewed literature.

1.7.6 Chapter 6 – Conclusion and Recommendations.

The final chapter contains the conclusion and the recommendations.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

According to Maggio, Sewell and Artino (2016: 297-303), for the researcher to design a robust study that leads to effectively communicating study results and the importance thereof, the literature review becomes an important element in the research process. Relevant literature relating to this study in various aspects is therefore analysed to set the basis of what is ideal and what is happening in other jurisdictions. This will eventually enable the researcher to compare the situation in Rwanda in line with data presented in order to identify the gaps taking into account the requirement of Rwanda's new legislation, law Nº 59/2017 of 24/1/2018 regulating the use of radiation.

Literature reviewed focuses on three main aspects:

1. Discussion of the use of radiation protection and safety measures to protect the patient, staff and public.
2. The effect on whether education has any effect on the utilization of radiation protection and safety measures.
3. The barriers that prevent medical imaging technologists from implementing the required radiation protection and safety measures.

Medical imaging technologists and radiographers are used synonymously throughout the review, depending on the author and setting where various studies were done.

2.2 Radiation Protection and Safety Measures

The medical imaging technologist has the primary responsibility to ensure that radiation safety is applied during radiological procedures. There are a number of ways to keep radiation protection of the patient in check, these being effective communication; immobilization/restraint; protective shielding; technical exposure factors; processing of images; quality control programmes; the air gap technique; reject analysis; unnecessary radiologic procedures; beam limitation, use of high-speed image receptors, modifying radiographic projections and beam filtration (Statkiewicz-Sherer *et. al.,* 2014:2; 268-280; Selman 2000:412-413). All these cannot be used in isolation as they are interdependent and usage or lack thereof will influence the occupational exposure and exposure to the public.

2.2.1 Effective Communication

Most patients referred for radiological examinations receive limited or no information at all on the procedures they are about to undergo (Ukkola, Oikarinen, Henner, Haapea, and Tervonen. 2017:e114-e119). Therefore, when the patients lack information about the examinations, they are likely not to understand instructions, which may lead to less desired images followed by the necessity of repeat radiographic examinations, hence more radiation dose to the patient (Statkiewicz-Sherer *et. al.*, 2014:268). In a study done in Vermont, USA as reported by Evans, Bodmer, Edwards, Levins, Meara, Ruhotina, and Carney (2015:13-15) respondents indicated that they would prefer to receive information from their healthcare professionals.

In addition to information on the radiographic procedure, information on the possible risk associated with imaging examinations should be known. In another study conducted in four major Jordanian hospitals by Alhasan, Abdelrahman, Alewaidat and Khader (2015:45-49), it transpired that more than half the patients who came to imaging rooms received little information regarding radiation when they underwent imaging examinations. Therefore, most of the patients are not aware of the possible risks that are associated with the use of ionizing radiation. Alhasan *et. al.,* (2015:45-49)*,* further suggested that when patients are aware of risks associated with radiation, unnecessary exposure from medical examinations could be minimized. They found in their study that there was a strong correlation between providing patient radiation information upon examination and the patient's radiation awareness question scores.

2.2.2 Immobilization and Restraint

Immobilisation requires consent and non-use of overpowering physical force while restraint employs overpowering physical force and normally consent is not sought. However, it must be noted that although both focus on avoiding unnecessary radiation, caution should be exercised with restraint as in some instances it is not successful and still results in more than one exposure being taken, thereby not serving the purpose of radiation protection (Ng and Doyle (2019:179-187).

Proper immobilization or restraint of the body and the specific body part is required where voluntary motion is likely, the following being examples thereof:

a. Pigg- o- stat for paediatric chest imaging, otherwise known also as baby fix;
b. Radiolucent compression straps with stretching ability placed over the belly or thighs, are extremely useful with restless and excited young and older children; and

c. Sandbags and wedge sponges are indispensable in supporting and achieving symmetry of the examined part and to prevent movement of the arms and legs when presented with an uncooperative patient (Statkiewicz-Sherer *et. al*., (2014:270), Klavs (2016:81-86).

Immobilisation techniques are used to avoid excessive patient exposure by reducing repeat exposure and the reduction of occupational exposure received by medical imaging technologists (Rostamzadeh, Farzizadeh and Fatehi 2015:200-208). Klavs (2016:81-86) agreed with Rostamzadeh *et. al.,* (2015) and state that immobilization instruments as applicable should be regularly checked to ensure their proper function. In another study done in five hospitals with the highest concentration of radiographers in the Lagos Metropolis, Nigeria, a significant number of respondents (75%) indicated the use of immobilisers as indispensable in radiation protection (Eze *et al.,* 2013:386-391).

2.2.3 Protective Shielding

This takes the form of structural protective barriers, lead and concrete and accessory protective devices normally with lead-impregnated vinyl that includes aprons, gloves, thyroid shields and protective eyeglasses, all of which should be of appropriate thickness (Statkiewicz-Sherer *et. al*., 2014: 314-315).

A study conducted in Iran radiology departments of Kermanshah, lead glass was equipped in 62.5% of the radiography rooms, with only 50% of the rooms installed with lead safe doors, as a result it should be noted that in radiography rooms where there are no safe lead lined doors, there is potentially an increased dose acquired by medical imaging technologists, patients and attendants (Rostamzadeh *et. al,* 2015:200-208). Additionally, Rostamzadeh *et al,* (2015:200-208) believe the use of radiography rooms should be prohibited and imaging process deemed unacceptable in instances where there is no lead equivalent glass when the control panel is located outside the room. In terms of protective clothing, a study by Sharma, Singh, Goel and Satani (2016:2207-2210) done in Agra City, India, found that lead rubber aprons and thyroid shields could be the most commonly used protection devices while lead rubber gloves and protective eyeglasses had limited use by radiographers. In the same study by Sharma *et. al.,* it was indicated that a dosimeter was never or rarely used by the majority (66%) of radiographers. The study also suggested that less than 60% of radiographers made use of the wall shield during radiographic exposures. This is further supported by Rostamzadeh e*t. al.,* (2015:200-208) in a study done in radiology departments of Kermanshah University of Medical Sciences, Iran. It was also found that lead rubber aprons, gonad shields and thyroids shields were the most available compared to lead glass goggles and lead rubber gloves.

Availability, however, does not translate to usage. Doolan, Brennan, Rainford, and Healy, (2004:15-21) in a separate study, discovered that patients were having up to five exposures of the pelvis without any protective shields being used even though there are radiosensitive reproductive organs associated with the pelvis. Practical effectiveness of gonadal shielding, especially for female patients according to Warlow, Walker-Birch and Cosson, (2014:178-182) is questionable and suggests abandonment altogether as it has the potential of repeat exposures due to location, but they also add that it is not in doubt for males as it significantly reduces dose. Similarly, in Lithuania, Valuckiene, Jurenas and Cibulskaite (2016:695-708) found that among the possible protective x-ray barriers, only the lead rubber apron was used at all times. It was also noted that abdominal pelvic shielding of the patient was the least used at 12.9% despite its significance in radiation protection by way of reducing exposure, especially for male patients. Another interesting finding by Heo, Chun, kang, Lee, Jang and Park (2016:1-6) revealed to the contrary that among different health workers that are exposed to radiation, the rate of wearing a protective lead rubber apron by radiologic technologists was an average of 50.3%.

2.2.4 Technical Exposure Factors

Radiographic exposure parameters are selected based on patient thickness, tissue composition and pathology (Ching, Robinson and McEntee 2014:176-190). To produce images with consistent quality that do not require repeats, it is imperative to have standardized selection of exposure factors. This can be achieved by the medical imaging technologists developing an exposure technique chart after having worked with certain equipment. Exposure technique charts are established for the average patient and it is not in any way envisaged to replace critical thinking skills of exposure adjustments by the medical imaging technologist depending on the circumstances of a particular patient.

In a radiology department each x-ray unit should have an exposure technique chart for that specific unit due to inherent factors (Fauber, 2009:256-258). A study by Korir, Wambani and Ochieng, (2010:127-133) conducted at Kenyatta National Hospital in Nairobi, attributed difficulty in approximating exposure factors from observed patient size and non - formulating an exposure chart to a significant increase. They noted that films were rejected due to over exposure when intensifying screen speed was changed. Another study in Ghana, reported that missing exposure charts and documented protocols contributed to inappropriate and inconsistent kVp setting with consequences of unnecessary exposure to the patients (Ofori, Antwi, Scutt and Ward, 2012:160-171)

In line with the above, a study was conducted in Canada on dose optimization strategies for efficacy as spelled out by the As Low As Reasonably Achievable (ALARA) principle. Using a digital detector, the objective was to examine usefulness of the dose optimization by increasing tube voltage and decreasing tube current – exposure time strategy. Images of the pelvis, skull and hand were done using phantoms with standard kVp, +20kVp and +30kVp; practitioners were then randomly given the images to evaluate the perceived aesthetic and diagnostic quality of the digital radiographs. The practitioners rated images acquired by standard exposure factors as significant according to diagnostic quality. However, increasing exposure by 20kVp also presented images of diagnostic quality and were, seen by the practitioners as an effective strategy to reduce radiation dose while still acquiring images of diagnostic quality as lower mAs would be applied (Lorusso, Fitzgeorge, Lorusso, Lorusso and Mrt 2015:162-173).

In optimizing screen film imaging, the IAEA publication suggests that the film is a self-regulating system (IAEA – TECDOC – 1667, 2012:2) that gives immediate feedback (figure 2.1) regarding a radiation dose applied (Figure 2.1). The publication aims to provide a satisfactory image, using only a certain range of radiation levels. Too low a radiation level does not record useful detail while in too high a radiation level, overexposure of the film occurs. It is further noted that failure to use a certain range of radiation for a particular screen/film combination will occasionally require a repeat examination or the quality will be insufficient for diagnosis, thereby missing important radiographic features (IAEA – TECDOC – 1667, 2012:2).

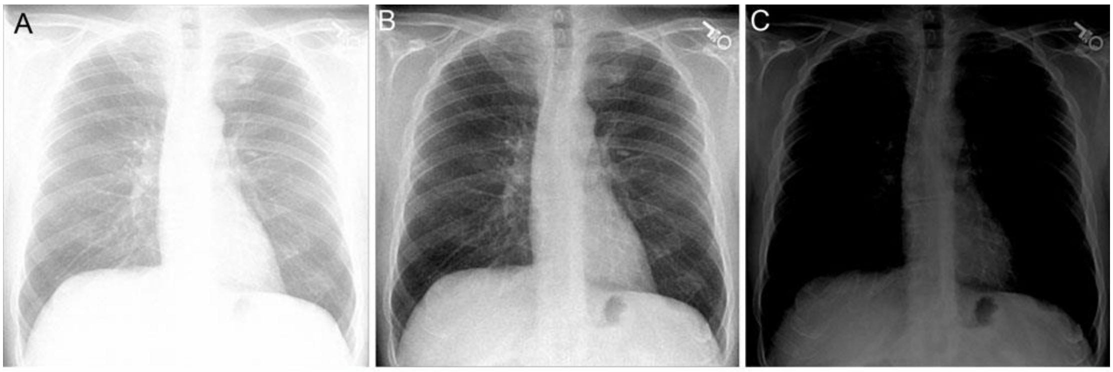

Figure 2.1 Responses of a screen-film detector with a fixed radiographic speed. (A) Underexposure, (B) correct exposure and (C) overexposure (Seibert and Morin 2011:576).

Digital radiography on the other hand, according to Seibert and Morin (2011:573-581), due to a wide exposure latitude, a variable speed class of operation and image post processing capabilities, provides consistent image appearances even with underexposure and overexposed images (figure 2.2) and therefore making it almost possible to determine correct radiographic techniques and patient exposure by image appearance. However, as seen in figure 2.2, underexposure could be recognized by noisy appearance, but with no indication of overexposure, which the authors say has the potential to harm the patient by virtue of overexposure.

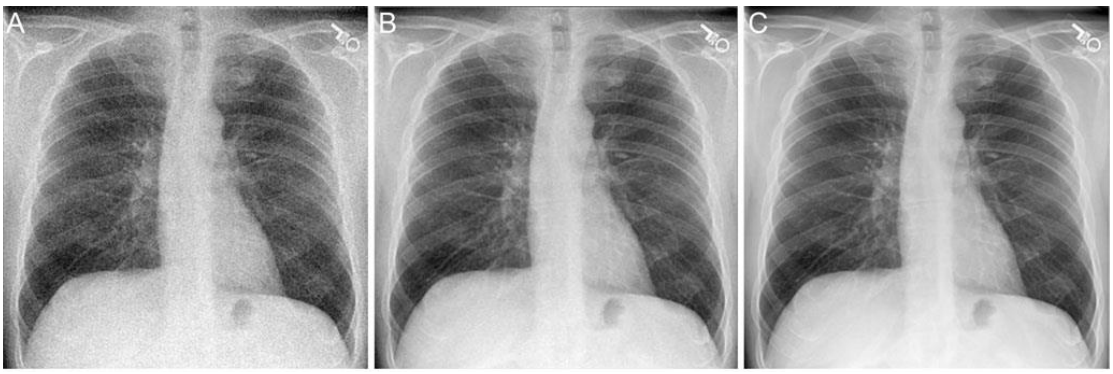

Figure 2.2 Response of a digital detector to exposure intensity variation.

(A) Underexposure, (B) correct exposure and (C) overexposure (Seibert and Morin 2011:576).

2.2.5 Processing of Images

According to Statkiewicz-Sherer *et. al*., (2014:278) the importance of optimal processing assured by careful maintenance of the processor cannot be overemphasized as this avoids repeat examinations ensuring lesser dose to patients. IAEA on the other hand underscores that film processing plays an important role in guaranteeing that medical exposures result in an acceptable diagnostic image for facilities that use film to record the image and recommends the following:

a. Automatic film processors should meet appropriate standards.
b. There should be dedicated film processors with extended processing cycles for film-screen based mammography.
c. Processing times should be based on developer temperatures and specially designed tanks for different processing stages should be utilized if manual processing is the one available.
d. Standards for light tightness in the darkroom for film processing should be according to relevant international and national standards and equipped with safe-light compatible with the film being used.

Similarly, the same IAEA safety standards state that for facilities that read from a printed digital image, printing plays a similar role for ensuring that medical exposures deliver results in a diagnostic image and state that resolution of the printer should be the same as the resolution of the detector in order not to compromise the quality of the final image (IAEA safety standards series No. SSG – 46).

2.2.6 Quality Control Programme

The importance of a quality control programme (QC) is essential for the optimum operation of a radiology department. As a result of a lack of such a programme, consequences may arise such as: high patient dose; unnecessary patient dose; high radiation to workers and increased operation costs, all leading to poor radiological services (Ngoye *et. al.,* 2015:s23-s30). The same authors, further attributed the lack of the implementation of a quality control programme to: non- existence of test tools, radiographers lacking initiative, hospital managers not having radiation awareness and lack of enforcement by regulatory bodies.

In a study conducted in some Nigerian hospitals, lack of quality control was identified as one of the major contributors of inadequate collimation, thereby leading to potentially unnecessary radiation to patients undergoing radiographic examinations (Okeji, Anakwue and Agwuna 2010: 31-33). Separately, Dimas, Ibeanu, I, Zakari and Mustapha (2017:323-331) in Katsina state, Nigeria, noted that all the equipment evaluated presented acceptable quality control results, however, recommended sustained routine periodic tests so that faults are identified when they occur, thus preventing unnecessary repeat exposures, which lead to an increase in radiation doses to both patients and staff. In support of a QC programme a study by Eze *et. al.,* (2013:386-391) conducted in Lagos, Nigeria reported that the majority of radiographers (85%) from five hospitals considered quality control/assurance as an essential part of radiation protection.

2.2.7 Reject Analysis

Acharya, Pai, and Acharya, (2015:392) defined repeat rate as the proportion of rejected films in relation to the total number of films exposed. According to Acharya *et. al.,* (2015:392), repeat film analysis helps reduce radiation exposure to patients and the cost of examination and further suggest there should be a change in teaching techniques in order to achieve greater improvements in repeat rates. Joseph, Mohammed, Samuel, Abubakar, and Goni, (2015:21-27) recommend that a reject/repeat analysis programme should be done on a quarterly basis. An experimental study carried out by Clark and Hogg (2003:127-137) in the United Kingdom on reject/repeat analysis showed exposure factors as the single highest contributor to repeat examinations with the pelvic, knee and ankle examination having 37%, 44%, and 35% respectively. Statkiewicz-Sherer *et. al.,* (2014:276) recommend the use of standardized technique charts for uniform selection of exposure factors for each x-ray unit and postulate that it is even more important with the advent of digital radiography due to its ability to record intensities with a wide latitude. In addition, Seibert and Morin (2011:573-581) indicate in light of over exposure, manufacturers of digital systems have come up with ways of indicating levels of incident exposure by calculating exposure index, which they note are diverse and confusing (figure 2.3).

Table 1 Manufacturer and exposure index parameters used for digital radiography systems

Manufacturer	Exposure indicator name	Symbol	Units	Exposure dependence, X	Detector calibration condition
Fujifilm	S value	S	Unitless	200/S ∝ X (mR)	80 kVp, 3 mm Al "total filtration" S=200 @ 1 mR
Carestream	Exposure index	EI	Mbels	EI+300=2X	80 kVp, 1.0 mm Al+0.5 mm Cu; EI=2000 @ 1 mR
Agfa	Log of median of histogram	lgM	Bels	lgM+0.3=2X	400 speed class, 75 kVp+1.5 mm Cu; lgM=1.96 @ 2.5 μGy
Konica	Sensitivity number	S	Unitless	For QR=k, 200/S ∝ X(mR)	QR=200, 80 kVp, S=200 @ 1 mR
Canon	Reached exposure value	REX	Unitless	Brightness=c_1, Contrast=c_2, REX ∝ X^1	Brightness=16 Contrast=10 REX≈106 @ 1 mR[1]
Canon	EXP	EXP	Unitless	EXP ∝ X	80 kVp, 26 mm Al, HVL=8.2 mm Al, DFEI=1.5 EXP=2000 @ 1 mR
GE	Uncompensated detector exposure	UDExp	μGy air kerma	UDExp ∝ X (μGy)	80 kVp, standard filtration, no grid
GE	Compensated detector exposure	CDExp	μGy air kerma	CDExp ∝ X (μGy)	Not available
GE	Detector exposure index	DEI	Unitless	DEI ≈ratio of actual exposure to expected exposure scaled by technique and system parameters. Expected exposure values can be edited by user as preferences.	Not available
Swissray	Dose indicator	DI	Unitless	Not available	Not available
Imaging Dynamics	Accutech	F#	Unitless	$2^{f\#}=X(mR)/X_{tgt}(mR)$	80 kVp+1 mm Cu
Philips	Exposure index	EI	Unitless	1000/X (μGy)	RQA5, 70 kV, + 21 mm Al, HVL=7.1 mm Al
Siemens	Exposure index	EXI	μGy air kerma	X(μGy)=EI/100	RQA5, 70 kV+0.6 mm Cu, HVL=6.8 mm Al
Alara CR	Exposure indicator value	EIV	Mbels	EIV+300=2X	1 mR at RQA5, 70 kV, + 21 mm Al, HVL=7.1 mm Al = > EIV=2000
iCRco	Exposure index	None	Unitless	Exposure index ∝ log[X (mR)]	1 mR @ 80 kVp+1.5 mm Cu => 0

Figure 2.3 Manufacturer and exposure index parameter used for digital systems

(Seibert and Morin 2011:578).

However, the recommended indicators (figure 2.4) from these indices are supposed to guide the medical imaging technologists on determining the appropriateness of the radiographic technique for the patient being imaged.

	Overexposure	**Underexposure**	**Adult: Nongrid and Grid**	**Distal Extremities Nongrid**
Kodak	>2500	<1600 tabletop; <1800 Bucky	1800–2100	2200–2400
Agfa	>2.9	<2.1	2.1–2.3	2.4–2.6
Fuji/Philips/Konica Minolta	<100	>250 tabletop; >400 Bucky	200–300	75–125

Figure 2.4 Recommended exposure indices
(Carter and Vealé 2010: 88).

In a similar study, although on computer radiography (CR), conducted in the United States of America (USA), in a university hospital (UH) and a large community hospital (CH), 288, 000 computer radiography records were analysed for reject analysis. For both institutions, the skull/facial bones, shoulder, hip, spine, in-department chest and pelvis were the most common frequently occurring examination types with a reject rate of 8% or higher. The most prevalent reasons being a combination of positioning errors and anatomy cut off, which accounted for 45% of all rejects at CH and 56% at UH. Improper exposure was 14% at CH and 13% at UH; motion 11% at CH; and 7% at UH with smaller percentages for other reasons (Foos, Sehnert, Reiner, Siegel, Segal, and Waldman 2009: 89-98).

2.2.8 Unnecessary Radiologic Procedures

No procedure is supposed to be carried out unless it is justified since justification is a fundamental principle of radiation protection (Vom, & Williams, 2017:212-219). The medical imaging technologists are the apparent gatekeepers between the patient and unjustified ionising radiation and should be able to inform the radiologist or referring clinician if referrals are deemed unjustified (Vom and Williams, 2017:212-219). The medical imaging technologists, however, are not the first contact with the patient and receive an already prescribed procedure by the referring clinician that they cannot change, unless it is discussed with the referring clinician. Kada (2017:599-605) explains that patients would be at a greater risk of unnecessary radiological procedures if the prescriber of ionizing imaging examination has a poor knowledge of radiation protection. In such circumstances it would also be extremely difficult to educate the patients of potential dangers, thereby aiding their decision-making. Contrary to this Eze *et. al.,* (2013:386-391) found in five hospitals in Nigeria with the highest concentration of radiographers that despite their excellent knowledge of justification and optimisation, this did not translate into adequate radiation protection.

In support of not carrying out unnecessary radiologic procedures the International Commission for Radiological Procedures (ICRP) recommendations (which form the basis for national and international standards of radiological protection) for unjustifiable examinations are those required “before employment, for health insurance, or for legal purposes undertaken without reference to clinical indication”. Exemptions are when such a procedure is “expected to provide useful information on the health of the individual or in support of important criminal investigations” (ICRP publication 103. Ann. ICRP 2007; 37(2-4)).

According to Sobiecka, Bekiesińska-Figatowska, Rutkowska, Latos and Walecki (2016:325-330); and Vom and William (2017:212-219), some examinations are requested without a justification of why they are needed; this is because of limited or no clinical details from the referring clinician. For instance, when there is limited or no clinical detail, a wrong examination such as computerised tomography scans would be requested and done where plain radiography would have been adequate. Radiographers have also been accused of not consistently performing justification as they obey unquestioningly and would not question or challenge unethical practice even when clearly discernible.

2.2.9 Beam Limitation

With larger areas covered by the x-ray beam, there will be a larger amount of scatter radiation produced and therefore the primary beam should always be confined to the area of diagnostic interest (Munro, Ostensen and Ingolfsdottir 2004:23). However, very tight beam limitation to the area of interest would result in numerous repeats (Zetterberg and Espeland 2011:566-569). In support of this a study conducted in Iran by Karami, Zabihzadeh, Gilavand and Shams, (2016:1637-1642) identified poor beam limitation as the greatest source of unnecessary radiation to patients in diagnostic radiology with only 15.5% of all the radiographs they evaluated having been satisfactorily collimated. Karami *et. al.,* (2016:1637-1642) further observed that apart from increased patient exposure, image quality deteriorates with unnecessary large collimation due to primary and scatter radiation. The advantages of accurate beam collimation according to Killewich, Falls, Mastracci and Brown, 20011(9s-14s) is that collimation reduces radiation exposure with an additional advantage of improved sharpness. Radiographers ultimately control the limitation of the x-ray beam to areas of interest, however, Stollfuss, Schneider and Krüger-Stollfuss (2015:118-122) conclude that a radiographer's dedication and awareness are the only identifiable factors influencing the collimation. This is consistent with Karami and Zabihzadeh's (2017:101-106) findings that the common reasons cited by radiographers for using larger collimation is the fear of cutting off the area of diagnostic interest, so it is thought it is better to use a larger collimation.

Surprisingly and of interest, in Australia, a phantom -based study to investigate the impact of x-ray beam collimation on radiation dose to the lenses of the eye and thyroid along with the effect on image quality in facial bone radiography, suggest that the use of automatic exposure chambers as opposed to fixed exposure could actually reduce radiation dose to lenses of the eyes with bigger collimation compared to strict collimation, although strict collimation would still deliver better image quality.

In spite of that, the authors say radiographic skill is of considerable importance in order to accurately collimate along with detailed knowledge of surface anatomy otherwise crucial anatomical structures could be excluded leading to repeats and therefore, beating the purpose of radiation protection. (Powys, Robinson, Kench, Ryan, and Brennan 2012: e497-e505).

2.2.10 Use of High Speed Image Receptors

For conventional radiography, intensifying screens enhance the effect of x-ray radiation allowing for reduction of exposure, therefore the higher the speed of the screens the lower the patient doses. It should be further noted, that for digital imaging the speed of the image receptor, that is the photostimulable phosphor plate, requires twice as much mAs compared to a 400 speed intensifying screen (Fauber 2009:184 & 195). In agreement Carter and Vealé (2010: 2010: 74 & 75), say construction of film and screen in terms of size and layers of crystals determines the speed in conventional radiography, but it is not the case for computed radiography as speed depends on emitted light or reflection of the amount of photostimulable luminescence according to the width and intensity of the laser beam as it scans the imaging plate which results in a comparative speed equivalent to a 200 speed film/screen system. The authors therefore advise caution should be exercised when converting to a CR system from a film/screen system to adjust technical factors appropriately. A case in point is that a change to CR from film/screen system would require doubling the mAs.

Additionally, Carter and Vealé (2010: 82 & 83) note there are majorly standard and high-resolution plates with comparative speeds of 200 and 100 respectively. High resolution is slower and would require additional exposure. For standard plates there are recommended exposures that determine the sensitivity or speed (figure 2.5).

	Kodak	Agfa	Fuji/Philips/Konica Minolta
Symbol	EI	lgM	S
Exposure factors	1 mR at 80 kVp	20 μGy at 75 kVp	1 mR at 80 kVp
Filtration	Al/Cu	Cu	Al
Sensitivity value	2000	2.6	200
Relative sensitivity x = exposure	+300 = 2x –300 = ½ x	+0.3 = 2x –0.3 = ½ x	½ S = 2x 2x S = ½ x

Figure 2.5 Receptor exposures for determining Imaging Plate sensitivity

(Carter and Vealé 2010: 88).

Martin, 2007:e18 advise that the choice of speed of screen film combination is very critical as it influences the image quality and the radiation dose received by the patient. In agreement with Martin (2007), Korir *et. al.,* (2010:127-133) in a study conducted at Kenyatta National Hospital, Nairobi noticed a low kVp and reduced mAs after screens were changed from 200 to 400 film/screen speed combination indicating patient dose optimization.

2.2.11 Modifying the Radiographic Projection

Projection variations for the abdomen, lumbar spine and pelvis have a significant effect on the effective dose and reduction of radiation risk. A posterior anterior projection for the abdomen, lumbar spine and pelvis results in a lower effective dose than anterior posterior It is, however, appreciated that this is not always possible. A left anterior oblique projection of a lumbar spine gives a lower effective dose compared to a right posterior oblique projection, as is right anterior oblique projection as compared to left posterior oblique. A reason for this is that sensitive organs are located further from the radiation source and in some instance shielded by structures such as bones of the pelvis and lumbar spine (Chaparian, Kanani and Baghbanian, 2014:32-39).

2.2.12 Beam Filtration

Beam filtration is an important factor in the reduction of radiation dose with improvement of image quality (Costa, Nova, and Canevaro 2009:379-387). Filtration removes soft x-rays that end up absorbed by the patient's skin and other organs, thus increasing the radiation risks without contributing to the image. This effect is measured/checked by a half value layer that at 2.3mm of aluminium should at-least reduce the x-ray beam to half at 80kVp (Dimas *et. al.,* 2017:323-331). The increase of patient entrance surface dose is significantly increased by 20-50keV photons that should be filtered out as the beam exits the x-ray tube. Aluminium or copper is normally used, however, copper is much more efficient in eliminating lower energy photons as 0.2mm of copper is considered to be equivalent to 10mm of aluminium (Martin 2007:e38). A further study conducted by Butler and Brennan (2009:15-23) in Ireland demonstrated added filtration significantly reduced radiation dose without any change of image quality.

2.3 Effect of Education on Radiation Safety

Mojiri and Moghimbeigi (2011: 1-5) from a study in India say knowledge and education on radiation safety is an aspect that has strong direct effects in technical protection against health hazards associated with radiation exposures. The researchers found that radiographers have limited or no information on lead rubber gloves and lead equivalent goggles with sufficient information on lead rubber aprons, thyroid shield, wall shield and radiation signs (Mojiri, Moghimbeigi 2011:1-5). A similar study by Awason *et al.,* (2016: lc07-lc12) in a different setting in Northern

Nigeria indicated that although 78.2% of participants were aware of personnel protective devices (PPDs) that should be worn to reduce exposure to ionizing radiation, only 52.7% had good knowledge of various personnel protective devices with only about half the participants knowing about PPDs such as lead equivalent goggles (51.8%), lead rubber gloves (51.8%), thyroid shields (43.6%) and gonadal shields (46.4%).

In a study in Oman it was found that there was no significant difference between radiation protection knowledge and educational age (time since graduation). The radiation protection practice score for radiographers with an educational age of greater than 15 years was significantly higher compared with those having lesser or equal to15 years. Advancement in age and a longer employment period was also seen to have played a significant role in making radiation safety practice better, given that the radiological technologists acquired experience on radiation safety with practice. This therefore lead to a further suggestion that younger radiological technologists and recently trained radiographers will need formal continuous training due to their insufficient knowledge of radiation effects (Shabani *et al.,* 2018:141-147).

A study conducted in Italy where 780 radiographers participated, a different trend emerged as, 12.1% indicated that they attended courses to update their radiation protection regularly, 56.4% rarely attended any training and 31.5% never took part in such courses. However, 90% stated that they had adequate knowledge of radiation protection. Radiographers who had fewer years of experience were found to have a higher level of knowledge than the experienced radiographers. (Paolicchi, Miniati, Bastiani, Faggioni, Ciaramella, Creonti, Sottocornola, Dianisi and Caramella

2016:233-242). Paolicchi *et. al.,* (2016:233-242) further suggest the lack of basic radiation protection awareness is unacceptable for radiographers as it is the core of the profession, however, they reported that 95% of participants had an awareness of the need to communicate to the patient the possible risks related to radiation exposure.

Interestingly in Nepal, diploma graduates, BScMIT graduates, MScMIT graduates, diploma students and BScMIT students had no difficulties in answering most of the radiation protection questions, even though it was revealed that the academic course mostly addressed imaging procedures, techniques and interpretation skills. Nonetheless, adequate lessons for radiography students in radiation protection and revision of curriculum to include radiation protection, safety methods, radiobiology and risky issues were recommended as mandatory (Maharjan 2017).

2.3.1 Lack of Educational and Training Programmes Including Continuous Professional Development (life- long learning)

Knowledge, attitude and practice has an impact on radiation protection and taking safety measures as revealed in a study conducted in Iran, where it transpired there was insufficient knowledge on radiation protection and adherence to radiation protection practice. Further to the findings, overcoming misconceptions and changing attitudes towards radiation was found to be challenging (Alavi, Dabbagh, Abbasi and Mehrdad 2016:727-734). Similarly, Hayre, Blackman, Carlton and Eyden (2018:e13-e18) in their study noted that not all radiographers offered protection to patients on similar examinations, particularly on the use of lead rubber aprons. The authors believe these inconsistencies in applying protection measures could be due to cultural myths, about beliefs of radiation risk and acting on instincts or what has been heard from senior colleagues without regard to literature of evidence based research.

With reference to the level of education and knowledge in Agri, Turkey, the knowledge of associate degree graduates, who were radiology technicians, was found to be significantly higher than that of high school and undergraduate graduates (Senemtaşi Ünal, Gelis and Baykan 2018:111-115). However, in Iran Shabani *et. al.,* (2018:141-147) did not find any significant difference between knowledge of radiation protection and the level of education among radiographers and this was thought to be due to continuous training courses. Further, in areas where there were policies requiring the staff to attend radiation protection courses and limiting their working shifts, it was found that radiographers tended to have significant knowledge on radiation protection.

Another study done in Iran governmental referral hospitals affiliated to the Tehran University of Medical Sciences, reported that higher job satisfaction, higher levels of education and being married were interrelated with a more positive attitude towards self-protection among radiation workers (Alavi *et al.,* 2016:727-734).

2.4 Barriers Preventing MITs from Implementing the Required Radiation Protection and Safety Measures

The following are the identified barriers: unjustified diagnostic procedures, insufficient optimization actions; lack of diagnostic reference levels; lack of educational and training programmes including continuous professional development (lifelong learning); lack of radiation protection culture and team work; lack of effective regulation in radiation protection; lack of proper use of radiation protection measures and tools; limitations /difficulties to audit procedures' exposure; and the quality control of the equipment (Vano, Jimenez, Ramirez, Zarzuela, Larcher, Gallego, and Del Rosario Perez 2018:109-120).

2.4.1 Insufficient Optimization Actions and Lack of Diagnostic Reference Levels (DRLs)

Martin and Vano (2018:E1-E4) define DRL as the "form of dose investigation level against which hospitals can compare patient radiation dose data for diagnostic and interventional procedures at their hospital". They indicate DRLs help in identifying facilities that require protection optimization and sights. Europe has managed to maintain reasonable radiation levels for diagnostic procedures in their 20 years of implementation of DRLs. A commentary by Rehani (2015 n.p.), however, cautions blanket use of DRLs as these were created with the average patient in mind usually at 70kg body weight, which is counterproductive for patients with a higher body build as they need higher doses than prescribed by DRLs for acceptable image quality. The author further cites other challenges as lacking the means of proving dose figures appropriate for larger patients that many countries using DRLs developed without taking into consideration technological changes. The current need, according to Rehani (2015 n.p.), is optimization for an individual patient while the DRLs were not developed for that purpose. Another need is for the optimization of the patient at hand while the DRLs reflect on facility and outcomes from retrospective analysis and assumption of acceptable image quality rather than confirming and documenting optimization.

Rehani 2015 n.p. therefore, proposes a new approach of acceptable quality dose (AQD) where every facility should determine average dose values that produce images of clinically acceptable quality for individual examinations classified in weight groups of 10kg body weight for adults with 5kg for children. The emphasis for AQD is from facility to national. AQD could also be used to compare rooms in the same facility, hospitals or countries and in detecting circumstances where optimization is needed. AQD is useful in identifying suboptimal images, finding out why these occur and using this as a learning experience. This approach covers all three parameters of dose; image quality and patient's body build with image quality taking precedence and dose second.

2.4.2 Lack of Radiation Protection Culture and Teamwork

When an organisation has a good radiation safety culture, it manifests in employees preventing harm to one another when they strive to adopt safe behaviour. The following features are key to a strong safety culture; safety taken as a personal responsibility by everybody, commitment to safety demonstrated by leaders, organisational spread of trust, safety first reflected in decision making, questioning potentially unsafe acts and decisions that come even from the seniors, freely reporting and admission of problems and errors and not allocating blame, embracing learning in the organisation, involvement of the employer in improving safety and performance, constantly examining the safety and good operational performance (Cole, Hallard, Broughton, Coates, Croft, Davies, Devine, Lewis, Marsden, Marsh, McGreary, Riley, Rogers, Rycraft and Shaw 2014:469-484).

The foregoing is also supported by Ploussi and Efstathopoulos (2016:142) with the review of importance of radiation protection culture where they allude culture to be a "combination of attitudes, beliefs, practices and rules among professionals, staff and patient regarding radiation protection". Their review acknowledges improvement of the radiation protection culture as the challenge, as opposed to building one. To create one, however, they indicate continuing education, stakeholder's effective communication at various ranks together with implementation of a quality assurance programme as key. The resultant benefits therefore, are reduction of the radiation doses, enhancement of radiation risk awareness, minimized unsafe practices and improvement of the quality of a radiation programme.

According to Rostamzadeh *et. al.,* 2015:200-208 limited attention given to radiation protection principles as a measure of radiation protection is attributed to the recklessness and negligence of departmental structures, Radiographers' disregard for radiation protection principles, and hospital managers' insufficient knowledge. How this is handled to rectify the challenge however, determines the success. Larson, Kruskal Krecke and Donnelly (2015; 35:1677-1693) postulate that people's first response when they are accused of incompetence and negligence is defensiveness but this could be turned around through inspiration and coaching in the right environment for improved performance. The authors further advise that an organization culture that fosters healthy teamwork, with elements such as humility, cooperation, patience and willingness to accept feedback tends to experience fewer adverse patient events.

2.4.3 Lack of Effective Regulation in Radiation Protection

Countries are required, through legislation, to have national regulatory mechanisms on radiation protection. The international atomic energy agency (IAEA) offers support through missions that strengthen and enhance member states' regulatory framework to comply with safety measures and this is done through technical support, more especially at infancy stages (Mroz, Reber, Suman, Shadad, Hailu and Mansoux for IAEA).

In Korea regulation of radiation is controlled by two separate acts; the medical services act for diagnostic radiation and the nuclear safety act for therapeutic radiation and nuclear medicine, both supervised by different entities. However, it is interesting to note, they do not focus on patient safety (Do 2016:S6-9).

2.4.4 Lack of Proper Use of Radiation Protection Measures and Tools

A study conducted in Iran, Kermanshah radiology departments estimated accessibility of radiation protection devices to radiographers was at 56.8%. Regarding safety of radiographers, only 71.7% of radiographers used film badges in practice against 81.3% of those who stated that they used them. Furthermore, according to official records, 43.8% of radiographers had medical check-ups, however, only 54.2% claimed that they performed these periodic check-ups. Although 60.4% of radiographers also indicated participation in annual training courses, official records reported a rate of 41.7%. In practice, radiation protection shields for patients were used by only 19.2% for whom it was necessary, but 54.2% of radiographers claimed to be using them. Where immobilization of a patient was necessary, only 51.7% of patients were immobilized via mechanical support against 71.7% stated by radiographers. Additionally, the ten-day rule was applied at 41.7% contrary to the level of 66.7% reported by radiographers. (Rostamzadeh *et. al.,* 2015: 200-2008). It would appear that what was implemented in practice and what was stated as having being done, differed substantially.

2.4.5 Limitation/difficulties to Audit Procedures Exposure and the Quality Control of the Equipment

Consequences of not having a quality control programme according to Ngoye *et. al.,* (2015:s23-s30) are: high patient dose as performance of equipment is not effectively used, unnecessary patient dose due to substandard imaging equipment that gives non-diagnostic images that require repeating, high occupational radiation dose as defective equipment leads to high scattered radiation and high exposure output. An increased cost for use of additional resources becomes inevitable and there are poor radiological services with patients getting delayed diagnosis and losing time with eventual poor imaging service.

Collective dose of radiation to the population can be minimized through clinical audits, which in this case is systematic evaluation of procedures and processes that seek to improve radiation protection. These are compared against standards of good practice and typically would involve an on-site visit collectively done by a radiologist, a medical physicist and a radiographer (Holmberg, Malone, Rehani, McLean and Czarminski 2010:15-19). According to a statement from the European Society of Radiology (ESR) 2010:21-26 it is compulsory to consider professional input for design and standards chosen for audit and notes that the audit itself requires a sufficient amount of time together with financial resources.

2.5 Summary

The literature has revealed that radiation safety is a subject that generates a lot of concern among individuals, societies and organisations. The International Commission of Radiological Protection (ICRP) has developed recommendations and the International Atomic Energy Agency (IAEA) has set up safety standards that should be implemented. Consequences and possible consequences have been outlined when measures are not adhered to and recommendations have been cited on what should be done to rectify the situation. No similar studies have been carried out in Rwanda and therefore this study aims at assessing the availability and utilization of radiation safety measures in Rwanda.

Chapter three presents the methodology for this study.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter outlines and documents, the research design and methodology applied in this study. The research was aimed at assessing availability and utilization of radiation and safety measures by medical imaging technologists in Rwandan Hospitals. The objectives of the study were as follows:

1. To identify the radiation safety measures available and the level of usage by medical imaging technologists in their relevant hospitals.
2. To determine whether education has any effect on the utilization of radiation safety measures.
3. To identify barriers that prevent medical imaging technologists from implementing the required radiation safety measures.

3.2 Research Design

The research design illustrates a systematic way in which the study will be carried out. The selection thereof takes into account various variables central to the study (Creswell 2009:3, Brink, Van der Walt, and Van Rensburg*,* 2012:96). This study used a quantitative non-experimental descriptive method. Quantitative studies emphasise measurement and analysis of casual relationships, not processes (Denzin and Lincoln, 2005:10). Descriptive designs become suitable where there is no primary purpose of examining relationships (Brink *et. al*., 2012: 112-113).

Data was collected by means of a self-structured questionnaire, based on literature reviewed and the research done by Eze *et al.,* (2013:386-381) in Nigeria; Awosan *et al* (2016:LC7-LC12) in Nigeria and Ngoye *et al.,* (2015:s23-s30) done in Tanzania, which was adapted to suit the Rwandan context.

A questionnaire is an instrument for collecting information and providing structured data without the presence of the researcher (Cohen, Manion, and Morrison, 2011:377). The questionnaire was composed of two sections. Section A contained questions for demographic purposes while Section B contained closed-ended questions, multiple choice questions, a Lickert rating scale question and open-ended questions. Open-ended questions are categorized into themes in the data analysis (Brink *et al.,* 2012:194).

3.3 Research Setting

The research setting included district, provincial and referral hospitals in Rwanda that ordinarily have radiology departments. According to a list obtained from the Ministry of Health's website, the total number of hospitals in these categories is forty-eight, consisting of referral hospitals (8), provincial hospitals (4) and district hospitals (36). The researcher, prior to the study, could not ascertain the total number of medical imaging technologists working across all of the 48 public health facilities with radiology departments, although

i. there was an estimate of 118, according to a study done in 2015 (Rosman, Nshizirungu, Rudakemwa, Moshi, de Dieu Tuyisenge, Uwimana, and Kalisa, 2015) and
ii. data sought from Rwanda Allied Health Professions Council (RAHPC) that licenses medical imaging technologists, indicated there were 204 licensed

medical imaging technologists as of March 2018, and it was appreciated that not all would be practising.

The study was conducted in 44 out of the 48-targeted public facilities in the country, as three district hospitals did not have any medical imaging technologists although they had radiology departments and one district hospital is a specialised mental health facility without a need for a radiology department. The researcher established that there was a total number of 131 MITs in the 44 public hospitals visited and from whom data was collected.

3.4 Sampling

According to Babbie & Mouton (2016:164), sampling is simply who and what will be observed and therefore the researcher has to decide who and what is included through a process of selection. Probability sampling was selected for two reasons; to avoid the researcher's conscious or unconscious bias while selecting the participants and to enable an estimation of sampling error (Babbie & Mouton, 2016:202, Brink *et. al.,* 2012:134).

The entire population was studied directly due to the small number of the target population and the entire geographical area not being very large. Out of the 131 medical imaging technologists in the study in all the district, provincial and referral hospitals, 116 participated and filled in the questionnaire, 7 participated during the pilot study stage, 4 were working in radiotherapy and therefore were excluded from the study, 1 was on study leave, 2 were on a government official mission abroad and 1 was on annual leave.

3.4.1 Inclusion Criteria

In the view of the small number of Medical Imaging Technologists, and in order to have a statistically significant sample all Medical Imaging Technologists working in public diagnostic radiology facilities in Rwandan hospitals regardless of their age, beliefs, disability, gender, nationality or race were included.

3.4.2 Exclusion Criteria

Medical imaging technologists not registered with Rwanda Allied Health Professional Council (RAHPC) and MITs working in a radiotherapy department were excluded from the study.

3.5 Research Procedures, Data Collection and Analysis

Authorisation was granted by the Ministry of Health of Rwanda, which also disbursed the authorisation letter directly to the hospitals and therefore, there was no need for securing permission from individual hospitals. However, the researcher engaged with each hospital's Head Medical Imaging Technologist of the imaging department before disbursement of the questionnaire through email and telephone calls and arranged for an appropriate time for data collection.

The researcher, on arrival at each hospital, first visited hospital administrators to check whether they were in receipt of the authorisation letter from the MoH and eventual onsite authorisation. Thereafter the researcher proceeded to the radiology department where objectives of the study in line with the information sheet and consent form were explained and invited the MITs who had signed for consent to complete the questionnaire. In some instances, where the hospitals acknowledged receipt of the authorisation letter and granted approval prior to arrival, the researcher went directly to the radiology departments without having to pass through administration.

3.5.1 Phase 1:

Prior to data collection, a pilot study was carried out that covered MITs in the three categories of hospitals from which data was to be collected. In total seven MITs participated in the pilot study: one Head MIT and two MITs were selected from a referral hospital, two MITs from a district hospital in Kigali and two from a provincial hospital that was closest to Kigali. The MITs completed and reviewed the questionnaire for any ambiguity that might have existed. Discussion was then held with the selected MITs after completion of the questionnaire, to check whether they had the same understanding of the questions. There were no significant changes and only the following minor changes were incorporated in the amended questionnaire.

1. Question 12, a third column of “do not know” was added as the participants indicated that some items might be available although they were not aware of their availability as they did not know what they were.
2. Question 17, an additional column was included and titled “N/A” as the participants argued that some departments were fully digital and therefore the statement “Image receptor (IR) with high speed are only used” would not apply.

MITs who took part in the pilot did not participate in the main study to avoid the possibility of compromising internal validity (Brink *et al.,* 2012:100).

3.5.2 Phase 2:

Data collection by the researcher was carried out between 18th February and 16th April 2019. The questionnaires (annexure i) in unsealed envelopes were distributed to the MITs across the country in each of the forty-four health facilities by the researcher in person. The researcher then explained the objectives and the purpose of the study in line with the information letter and consent form and invited MITs to complete the questionnaire after signing the consent form. The researcher allowed adequate time for the participants to complete the questionnaire. Just as was the experience with a study conducted by Ngoye *et. al.,* (2015:S25), the face to face approach during this phase accorded he researcher a high response rate from the MITs and an opportunity to clarify the questions and statements where there was a need.

The completed questionnaires were returned in a sealed envelope and placed in a sealed box and collected by the researcher later on the same day. Quality data collection brings accuracy to the research results (Brink *et al.,* 2012:149). The researcher visited some of the facilities more than once, in some cases two to three times in order to cover all the MITs who were not there at the initial visit due to departmental schedules.

3.5.3 Phase 3:

This phase involved the data analysis from the questionnaires. The questionnaires consisted of Sections A and B. Section A was aimed at collecting demographic data from the participants in order to appreciate various characteristics of the participants relevant to the study. The participants' sex, age, highest qualification, category of health facility they work in, licensure status, number of participants in a facility, whether radiation protection and safety was part of training and years worked were part of this section. Section B was composed of closed- and open-ended questions to gather data from the participants regarding number of patients seen in a month, radiation monitoring devices, availability of radiation safety equipment/items and whether they were being utilized and how often lead rubber aprons had been checked for cracks.

Section B, question 17 was designed using a 5-point likert scale where “1” indicates strongly disagreeing and “5” strongly agreeing, with an additional column of what did not apply in the participant’s setting. The statements sought to ascertain from the MITs, their level of agreement with statements on communication with the patient, use of immobilization, exposure factors, reject-repeat analysis, quality control, justification of radiographic procedures, collimation, beam filtration, processor cleaning, modification of radiographic projections and image receptors. Question 18 and 20 required the MITs to indicate whether training and workshops on the use of radiation safety and protection measures and quality control would benefit them.

Question 19 was to check the MITs’ familiarity with radiation protection law while question 21 was open-ended and requested the participants to point out what other concerns they had regarding radiation safety and protection.

Data from the questionnaires were coded with numerical numbers and analysed using StataSE13 using descriptive and inferential statistics. The StataSE 13 was used to present the data in pie charts, tables and performing statistical tests. The Chi square test was done together with Cramer’s V as the frequency tables were larger than two by two. Bar graphs were generated using the Microsoft Excel format. The Microsoft Excel format was also utilized in analysing open-ended questions quantitatively. A report was written based on data analysed from the questionnaires while relating to literature reviewed.

3.6 Validity and Reliability

According to Brink *et. al.*, (2012:171) it is important for the researcher to consider validity and reliability when selecting the instrument to be used for data collection. If either validity or reliability were ignored, the instrument would be of no use as they are critical to each other and validity cannot be expected from an instrument that cannot yield reliable results (Brink *et. al.*, 2012:171). The questionnaires all contained the same questions that were completed by all the participants in all the health facilities, thus increasing reliability of the answers (Creswell, 2005:162). The pilot study was carried out to test the quality of validity and reliability of the questionnaire. The pilot study returned a Cronbach Alpha of .8837, which means the questionnaire was good for data collection.

3.7 Ethics

Approval to conduct the research was sought and granted as follows:

i. Approval was obtained from the Ethics Clearance Committee of the University of Johannesburg - Ethical clearance, No. REC–01–95–2018

ii. Ethical Approval was granted by the Institutional Review Board of College of Medicine and Health Sciences, University of Rwanda - Ethical Approval No. 292/CMHSIRB/2018.

iii. A Collaborative Approval Note was received from the Rwanda Biomedical Centre that manages hospitals on behalf of the Ministry of Health - Collaborative Approval Note No. 2005/RBC/2018.

iv. A Scientific Review Approval Notice was obtained from the National Health Research Committee of Rwanda Ministry of Health - Approval Notice No. NHRC/2019/PROT/006.

v. Authorisation of Research to collect data was obtained from the Ministry of Health which was copied to all district, provincial and referral hospital where data was collected - Authorisation of Research No. 20/775/DGPHFIS/2019.

vi. After explanation of the research to the participants, those who agreed to participate signed an informed consent form before completing the questionnaire.

vii. One of the hospitals had an additional requirement over and above authorisation by the Ministry of Health and granted a further approval notice No. RMH IRB/011/2019.

viii. Cited work was correctly referenced and listed in the bibliography.

3.7.1 Right to Freedom of Choice, Expression and Access to Information

The participant's right to freedom of choice was considered by assuring the participants of their right to decide to withdraw and not to participate in the study at any time without any individual consequences. The information sheet, together with a consent form (Annexure II) was issued to all participants and those willing to participate signed the consent form before a questionnaire was issued. The participants were informed that the results of the study would be available to participants upon request.

3.7.2 Right to Privacy, Confidentiality and Anonymity

The questionnaire used an alphabetical and number coding system post completion and did not bear any names, thus assuring anonymity. In this way it has the additional advantage of not being able to keep track of who has or has not returned the questionnaire (Babbie & Mouton, 2016:523).

The information given by the participant was confidential and only accessible by the researcher and the statistician.

3.8 Summary

By using a questionnaire, a quantitative non-experimental descriptive study was conducted. The research setting for the study targeted 116 MITs from 44 hospitals in the categories of district, provincial and referral that ordinarily have diagnostic imaging facilities. The study included all the MITs that are registered by RAHPC and that are working in public health facilities due to their small number and given that the geographical area is not very expansive. The questionnaire consisted of two sections with both closed- ended and open-ended questions with the aim of establishing the availability and utilization of radiation safety equipment/items and measures. To ensure validity and reliability of the data collection instrument, piloting of the questionnaire was conducted by 7 MITs completing the questionnaire. The Cranbuch Alpha generated a value of .8837, using StataSE 13 software. Additionally, the necessary ethical clearance criteria were followed.

Out of 131 MITs working in the three categories of hospitals, 123 (94%) participated in the study and these were from 44 (92%) hospitals out of the 48 hospitals that were initially targeted.

CHAPTER FOUR

RESULTS

4.1 Introduction

This chapter presents details of findings about radiation safety in Rwandan hospitals. The data was collected by using a questionnaire with Sections A and B that included both close- ended and open- ended questions. Data was analysed using stataSE 13. Variables were numerically coded while the open-ended questions were coded in categories and analysed quantitatively. Data has been presented using tables and figures.

4.2 Demographics

A total of 116 (96.67%) medical imaging technologists participated out of 120 who were expected. Seven (7) were in pilot study while four (4) work in the radiotherapy department therefore could not participate in the study. The participants came from 44 (91.67%) of the total of 48 hospitals comprising of district, provincial and referral hospitals (Table 4.1).

Table 4.1 Participants in the study.

	Total expected	Number participated	Percentage of Participation
MITs	120	116	96.67%
Hospitals	48	44	91.67%

4.2.1 Gender

The majority of the participants were male (87 = 75%) while females were 29 (25%), (Table 4.2).

Table 4.2 Participants according to gender.

Gender	Frequency	Percent
Male	87	75.00%
Female	29	25.00 %
Total	116	100.00%

4.2.2 Age

The majority of the participants (83.62%) were 40 years and below, 43.10% fell in the age bracket of 30-35years. Only 7 (6.03%) of the total participants were above 50 years (Table 4.3).

Table 4.3 Participants according to age.

Age (in years)	Frequency	Per cent	Cumulative
Below 30 years	26	22.41	22.41
30-35 years	50	43.10	65.52
36-40 years	21	18.10	83.62
41-45 years	8	6.90	90.52
46-50 years	4	3.45	93.97
51-55 years	4	3.45	97.41
56-60 years	1	0.86	98.28
Above 60 years	2	1.72	100.00
Total	116	100.00	

4.2.3 Qualification

Participants holding an advanced diploma numbered 101 (87.07%) compared to 15 (12.93%) who held a bachelors qualification (Table 4.4).

Table 4.4 Participants according to qualification.

Highest qualification held	Frequency	Per cent
Advanced diploma (A1)	101	87.07
Bachelors (A0)	15	12.93
Total	116	100.00

4.2.4 Health Facility

Slightly more than half of the participants (61 =52.59%) worked in district hospitals, with 49 (42.24%) in referral hospitals (Table 4.5).

Table 4.5 Participants according to level of health facility.

Level of Health Facility	Frequency	Per cent
District hospital	61	52.59
Provincial hospital	6	5.17
Referral hospital	49	42.24
Total	116	100.00

4.2.5 Gender and Health Facility

Males formed, the majority of MIT’s in district hospitals totalling 46/61 (75.41%) and in referral hospitals 38/49 (77.55%). Six MITs worked in provincial hospitals of which 50%were male and 50% female (Table 4.6). Thus overall males constituted 75% of the MIT’s.

Table 4.6 Participants by different categories of hospitals.

	Level of Health Facility, n (%)				
Gender		District Hospitals	Provincial Hospitals	Referral Hospitals	Total
Male	Number	46	3	38	87
	Row %	52.87	3.45	43.68	100.00
	Column %	75.41	50.00	77.55	
Female	Number	15	3	11	29
	Row %	51.72	10.34	37.93	100.00
	Column %	24.59	50.00	22.45	
Total	Number	61	6	49	116
	Row %	52.59	5.17	42.24	100.00
	Column %	100.00	100.00	100.00	

4.2.6 Registration

Inclusion criteria was only for those registered with RAHPC

Table 4.7 Total of Registered Participants by RAHPC.

Registration with RAHPC	Frequency	Per cent
Registered	116	100.00
Total	116	100.00

4.2.7 Number of MITs by Categories of Hospitals

The majority of the hospitals had 1 MIT and 2 MITs, 34.09% and 31.82% respectively. Hospitals having 8 or more MITs were referral hospitals None of the referral hospitals had 1 or 2 MITs (Table 4.8).

Table 4.8 Number of MITs by categories of hospitals.

Number of staff		District Hospitals	Provincial Hospitals	Referral Hospitals	Total
1	n	13	2	0	15
	Column %	39.39	50.00	0.00	34.09
	Row %	86.67	13.33	0.00	100.00
2	n	13	1	0	14
	Column %	39.39	25.00	0.00	31.82
	Row %	92.86	7.14	0.00	100.00
3	n	5	1	0	6
	Column %	15.15	25.00	0.00	13.64
	Row %	83.33	16.67	0.00	100.00
4	n	1	0	2	3
	Column %	3.03	0.00	28.57	6.82
	Row %	33.33	0.00	66.67	100.00
5	n	1	0	1	2
	Column %	3.03	0.00	14.29	4.55
	Row %	50.00	0.00	50.00	100.00
8	n	0	0	1	1
	Column %	0.00	0.00	14.29	2.27
	Row %	0.00	0.00	100.00	100.00

9	n Column % Row %	0 0.00 0.00	0 0.00 0.00	1 14.29 100.00	1 2.27 100.00
12	n Column % Row %	0 0.00 0.00	0 0.00 0.00	1 14.29 100.00	1 2.27 100.00
16	n Column % Row %	0 0.00 0.00	0 0.00 0.00	1 14.29 100.00	1 2.27 100.00
Total	n Column % Row %	33 100.00 75.00	4 100.00 9.09	7 100.00 15.91	44 100.00 100.00

4.2.8 Training on Radiation Protection and Safety Measures in School

A total of 114 (98.28%) medical imaging technologists responded and almost all, 112 (98.25%) reported to have undergone a curriculum that incorporated radiation protection and safety measures (Table 4.9).

Table 4.9 Participants who had training on radiation safety measures in school.

Radiation protection and safety measures part of curriculum in training	Frequency	Per cent
No	2	1.75
Yes	112	98.25
Total	114	100.00

4.2.9 Number of Years Worked

Among the 115 participants that responded 36 (31.30%) had worked for 10 years or more, 33 (28.70%) 7-9 years, 21 (18.26%) 4-6 years, and 25 (21.74%) had worked for 0-3 years (Table 4.10).

Table 4.10 Participants by number of years worked.

Years worked as medical imaging technologist	Frequency	Per cent	Cumulative
0-3	25	21.74	21.74
4-6	21	18.26	40.00
7-9	33	28.70	68.70
10 and above	36	31.30	100.00
Total	115	100.00	

4.3 Section B:

4.3.1Average Number of Patients

The majority of the participants (62 = 53.45%) stated that their departments receive more than 500 patients in a month. Only 1 (0.86%) participant reported that the department received less than 100 patients in a month (Table 4.11).

Table 4.11 Number of patients seen in a month.

Average number of patients seen in a month	Frequency	Per cent
Less than 100	1	0.86
100-200	17	14.66
200-300	7	6.03
300-400	18	15.52
400-500	11	9.48
Above 500	62	53.45
Total	116	100.00

4.3.2 Radiation Measuring Device

Personal radiation measurement devices had been received by 68 (59.13%) participants while 47 (40.87%) had not been issued with the device (Table 4.12).

Table 4.12 Participants issued with a radiation-measuring device by hospital.

Radiation measuring device by the hospital	Frequency	Per cent
Not issued	47	40.87
Issued	68	59.13
Total	115	100.00

4.3.3 Cross Tabulation: Level of Health Facility and Issuance of Radiation Measuring Device

The majority, 37/47 (78.72%) of MITs that were not issued with a radiation measuring device were in district hospitals, while referral hospitals had the highest number, 40/68 (58.82%), of MITs issued with the device (Table 4.13)

Table 4.13 Issued with radiation measuring device by hospital.

		Issuance of radiation measuring device			
Level of the Health Facility		Not issued	Issued	Not answered	Total
District hospital	n	37	23	1	61
	Within row %	60.66	37.70	1.64	100.00
	Within column %	78.72	33.82	100.00	52.59
Provincial hospital	n	1	5	0	6
	Within row %	16.67	83.33	0.00	100.00
	Within column %	2.13	7.35	0.00	5.17
Referral hospital	n	9	40	0	49
	Within row %	18.37	81.63	0.00	100.00
	Within column %	19.15	58.82	0.00	42.24
Total	n	47	68	1	116
	Within row %	40.52	58.62	0.86	100.00
	Within column %	100.00	100.00	100.00	100.00

Figure 4.1 indicates that out of the total participants who had been issued with personal radiation measurement devices, 20 (29%) received results inconsistently, 23 (34%) MIT's received results after three months and 2 (3%) received monthly reports. A further 11 (16%) never received reading results, 11 (16%) had newly issued devices and 1 (2%) did not answer the question.

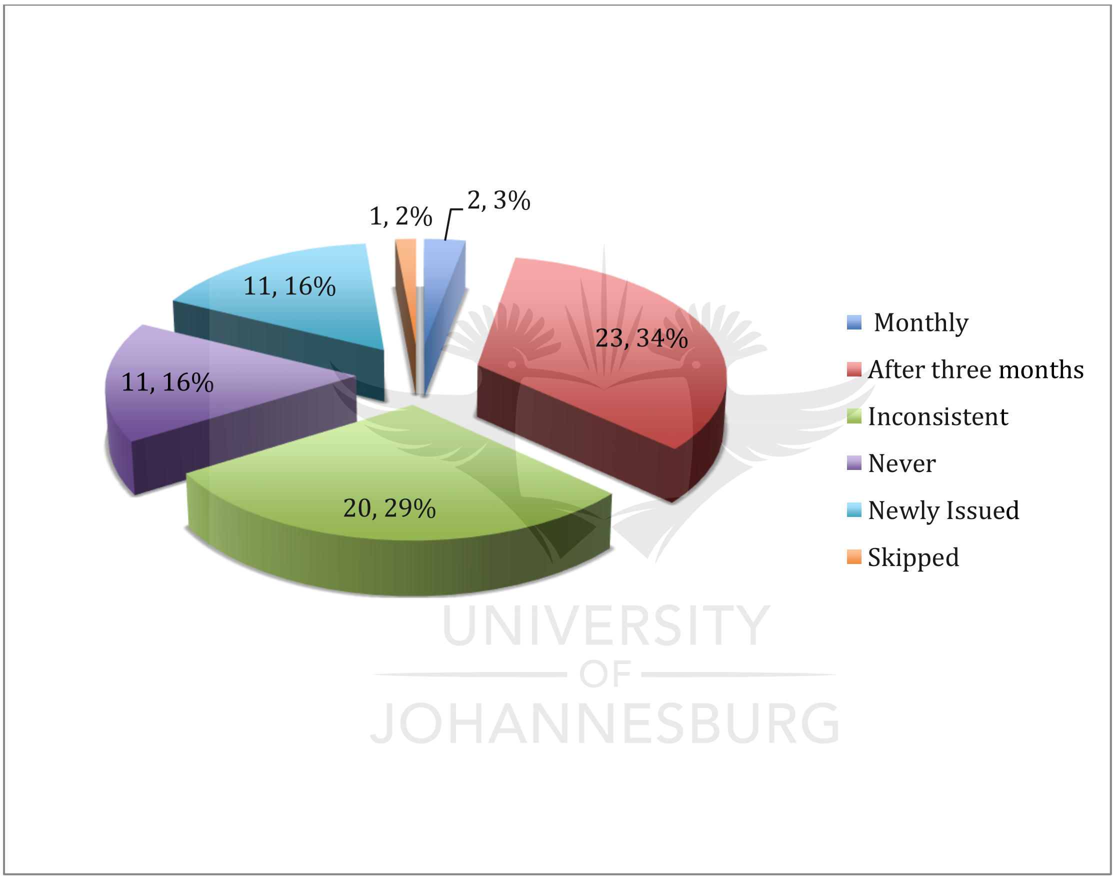

Figure 4. 1 Frequency of receiving results for MITs with radiation measuring device.

Figure 4.2 shows lead rubber apron and lead equivalent barriers are the most available (99.13% and 97.41% respectively). Wedge sponges and sand bags are the least available (6.90% and 9.48% respectively), while pigg-o-stat immobilization was non-existent (0.86%).

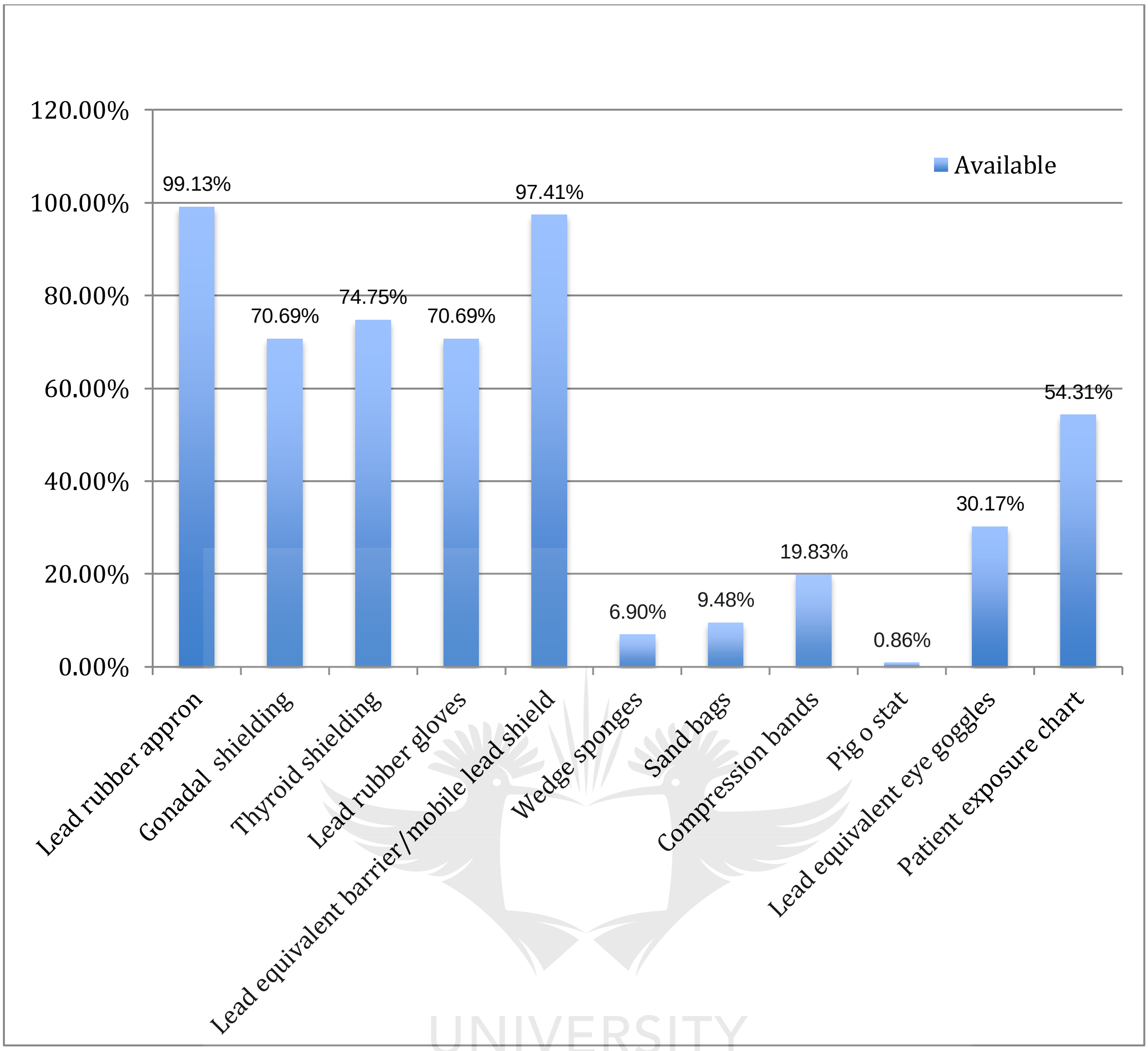

Figure 4. 2 Availability of radiation safety equipment/items.

The following emerged as reasons for non-availability of radiation safety equipment/items:

The following verbatim quotes point to the lack of support from the hospital administration in providing radiation protection and a lack of understanding of the equipment purchases necessary for radiation protection:

a. *"We wrote a memo to the hospital administration but they are not provided/purchase."*
b. *"Even the hospital leader don't care about radiation safety"*

c. *“They are not necessary for us”*

d. *“Wedge sponges, sand bags, compression bands, pigg-o-stat I think we do not advise the hospital to buy it”*

e. *“People responsible in buying them are not aware of their purpose”*

f. *“Some hospital administration staff think that these devices are of no use”*

g. *“Our institution has no capacity to have them due to economic issues unless from the government support”*

h. *“Not available because no request made to administration”*

i. *“Because they are not requested by departmental management to the hospital administration”*

j. *“The items were requested for but tender processes take time in government facilities”*

k. *“Not available to our facility due to, we do not know the need of it”*

l. *“They are not around as it is difficult to find them in market”*

m. *“The existing are old and the hospital has decided to discard them”*

Table 4.14 Reasons for non-availability of the radiation safety equipment/items.

PROPORTION	Count	Per cent
Neglected by administrators	57	36.8%
Not Important	11	7.1%
Lack of awareness by administrators and MITs	21	13.5%
Expensive coupled with bureaucracy	16	10.3%
Negligence by MITs	32	20.6%
Old, dilapidated and lack of outlets to buy	18	11.6%
	155	**100%**

4.3.4 An indication of the Use of the Radiation Safety Equipment and Their Availability

Figure 4.3 shows availability versus usage of radiation safety equipment. Lead rubber aprons and lead equivalent barriers are most regularly used, at 93.04% and 83.62% respectively. Pigg-o-stat is never used.

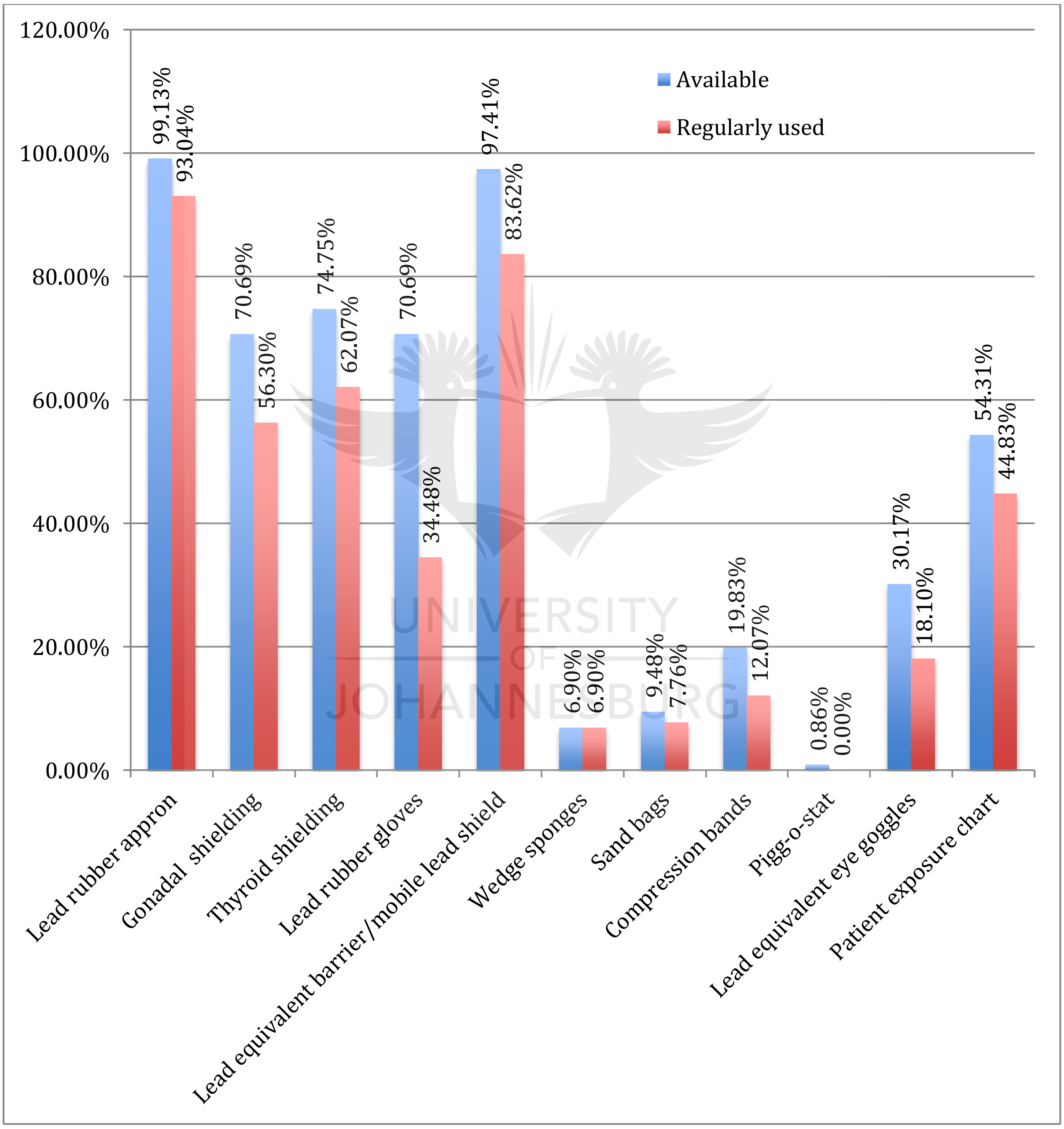

Figure 4. 3 Level of usage of radiation safety equipment/items by MITs.

4.3.5 Measures for Radiation Safety

This section of the questionnaire was designed using a five point Likert scale with an additional column titled "Not applicable" (Table 4.15).

Table 4.15 Measures for radiation safety.

Variable	Freq. (%)
Patients receive clear instructions before radiographic procedures are done	
Strongly disagree	1 (0.86)
Disagree	1 (0.86)
Neutral	6 (5.17)
Agree	47 (40.52)
Strongly agree	61 (52.59)
Total	116 (100.00)
Confirmation as to whether the patient understood the instructions is ensured before an exposure is made	
Strongly disagree	1 (0.87)
Disagree	3 (2.61)
Neutral	21 (18.26)
Agree	56 (48.70)
Strongly agree	34 (29.57)
Total	115 (100.00)
Immobilization devices where applicable are always used	
Strongly disagree	19 (17.12)
Disagree	19 (17.12)
Neutral	9 (8.11)

Agree	18 (16.22)
Strongly agree	16 (14.41)
N/A	30 (27.03)
Total	111 (100.00)
Radiation dose to the patient is top priority in selection of exposure factors	
Strongly disagree	3 (2.59)
Disagree	3 (2.59)
Neutral	8 (6.90)
Agree	21 (18.10)
Strongly agree	81 (69.83)
Total	116 (100.00)
Image quality is top priority in selection of exposure factors	
Strongly disagree	4 (3.45)
Disagree	2 (1.72)
Neutral	3 (2.59)
Agree	30 (25.86)
Strongly agree	77 (66.38)
Total	116 (100.00)
Processor cleaning and maintenance is done at the start of everyday	
Strongly disagree	11 (9.82)
Disagree	14 (12.50)
Neutral	14 (12.50)

Agree	21 (18.75)
Strongly agree	11 (9.82)
N/A	41 (36.61)
Total	112 (100.00)
The department has established reject/repeat analysis programme	
Strongly disagree	34 (29.57)
Disagree	14 (12.17)
Neutral	8 (6.96)
Agree	17 (14.78)
Strongly agree	39 (33.91)
N/A	3 (2.61)
Total	115 (100.00)
The radiographic examination is not done if the request form does not include clinical summary	
Strongly disagree	16 (13.79)
Disagree	15 (12.93)
Neutral	24 (20.69)
Agree	30 (25.86)
Strongly agree	30 (25.86)
N/A	1 (0.86)
Total	116 (100.00)
Clarification is always sought from the referring clinician if there are queries regarding examination(s) requested	
Strongly disagree	3 (2.70)

Disagree	12 (10.81)
Neutral	10 (9.01)
Agree	39 (35.14)
Strongly agree	46 (41.44)
N/A	1 (0.90)
Total	111 (100.00)
The beam is always collimated to only the areas of interest	
Strongly Disagree	3 (2.65)
Disagree	4 (3.54)
Neutral	5 (4.42)
Agree	19 (16.81)
Strongly agree	82 (72.57)
Total	113 (100.00)
X-ray beam filtration is checked annually for all equipment in the department	
Strongly disagree	47 (40.52)
Disagree	14 (12.07)
Neutral	14 (12.07)
Agree	14 (12.07)
Strongly agree	18 (15.52)
N/A	9 (7.76)
Total	116 (100.00)
Radiographic projections requested are modified to minimize radiation doses without having to be told to do so	

Strongly disagree	1 (0.87)
Disagree	4 (3.48)
Neutral	6 (5.22)
Agree	27 (23.48)
Strongly agree	77 (66.96)
Total	115 (100.00)
Only image receptors with high speed are used	
Strongly disagree	8 (7.02)
Disagree	6 (5.26)
Neutral	11 (9.65)
Agree	28 (24.56)
Strongly agree	38 (33.33)
N/A	23 (20.18)
Total	114 (100.00)
Quality control programmes are standard routine practice	
Strongly disagree	28 (24.35)
Disagree	14 (12.17)
Neutral	24 (20.87)
Agree	23 (20.00)
Strongly agree	24 (20.87)
N/A	2 (1.74)
Total	115 (100.00)

Figure 4.4 shows that 68 (59%) of participants have never checked the integrity of the lead rubber apron, 16% are checked annually, 10% every six months, 10% quarterly, 4% biannually and 1% do so on a monthly basis.

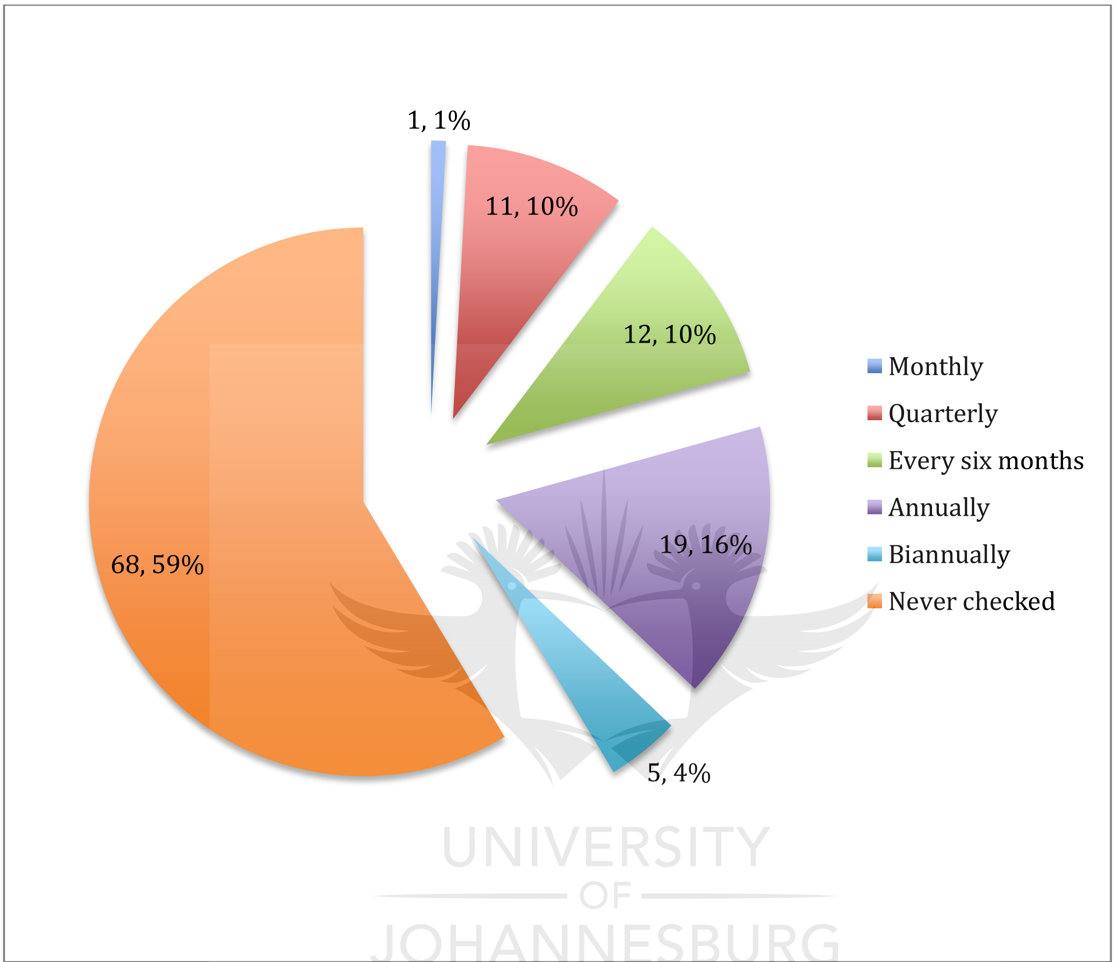

Figure 4. 4 Frequency of check for cracks on lead rubber aprons.

Figure 4.5 illustrates the percentage of participants who were unaware of the various radiation safety equipment /items. The results demonstrated that less than 1% of the participants did not know about lead rubber aprons, gonadal shielding and lead equivalent barrier/mobile lead shields. Pigg-o-stat was not known by 9.48%, while lead rubber gloves, wedge sponges, sand bags, compression bands, lead equivalent eye goggles and patient exposure charts were not know by 1.72%, 6.90%, 2.59%, 2.59%, 2.59% and 2.59% respectively.

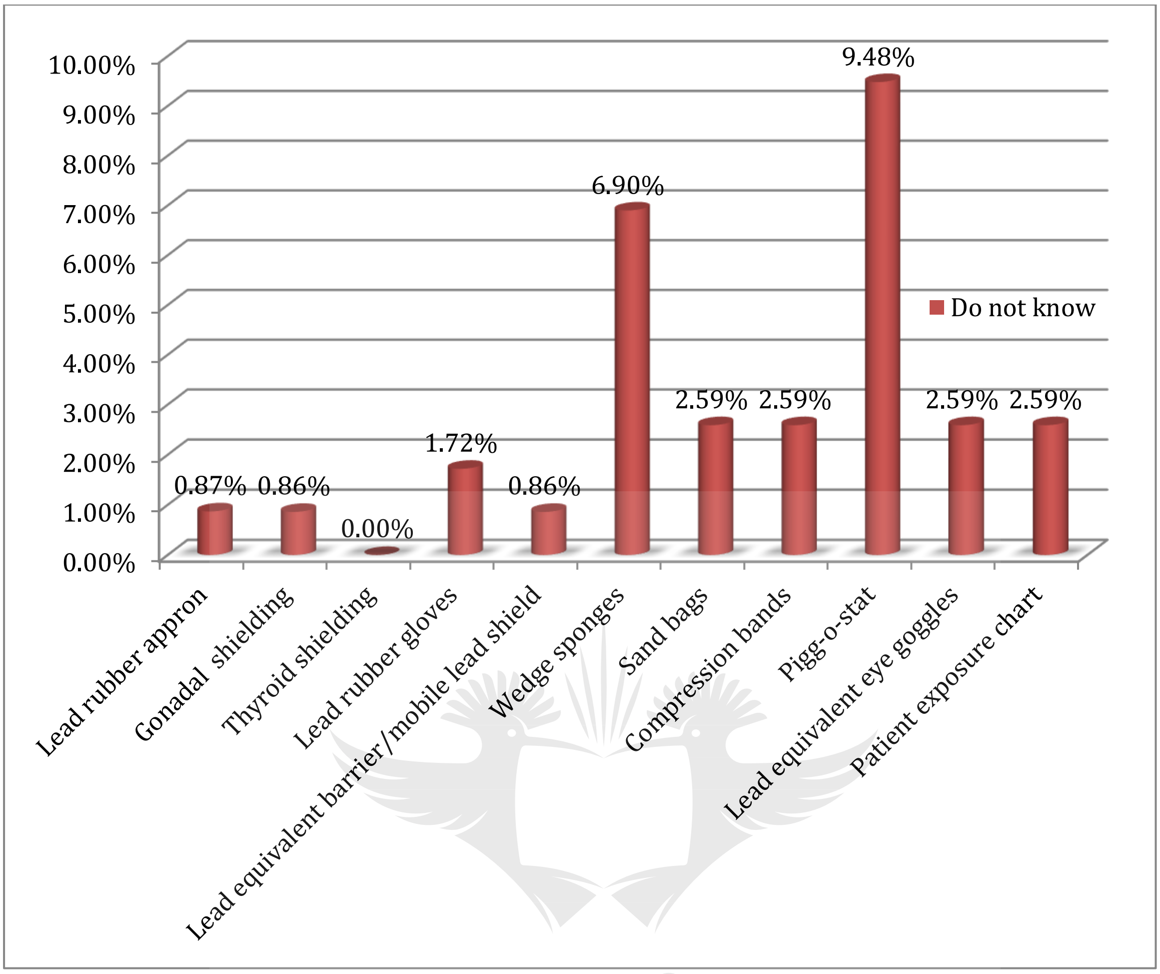

Figure 4. 5 The participants' lack of knowledge of certain radiation safety items.

Figure 4.6 Shows MITs with more than 7 years of work experience regularly used the radiation safety equipment/items slightly more than those with less than 7 years of experience.

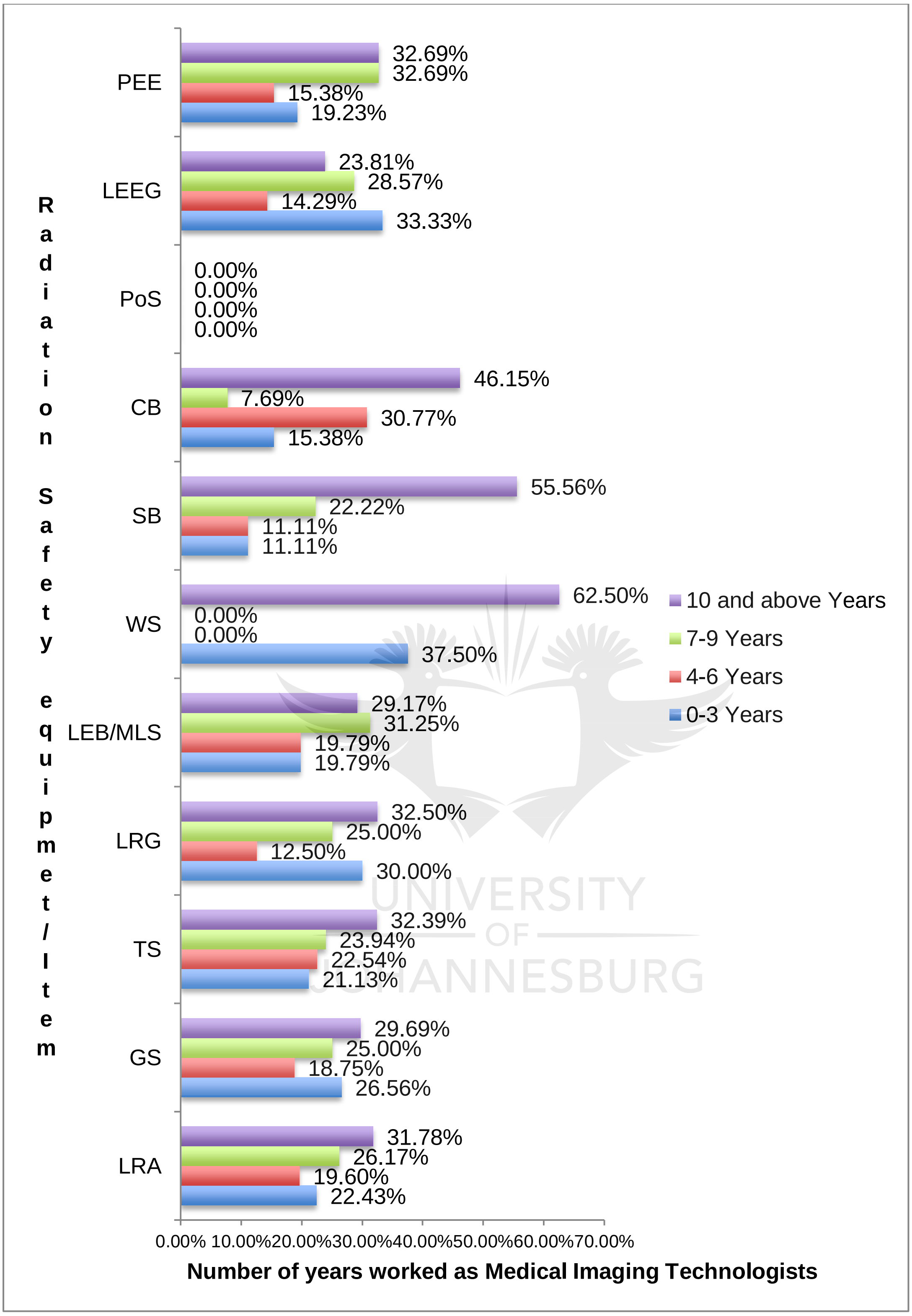

Figure 4.6 Regular usage of radiation safety equipment/item according to years worked as MIT.

*LRA – Lead Rubber Apron, GS – Gonadal Shield, TS – Thyroid Shield, LRG – Lead Rubber Gloves, LEB/MLS – Lead Equivalent Barrier/Mobile Lead Shield, WS –

Wedge Spodges, SB – Sad bags, CB – Compression Band, PoS – Pigg-o-stat, LEEG – Lead Equivalent Eye Goggles, PEE – Patient Exposure Chart

4.3.6 Cross Tabulations

A comparison was drawn between the MITs, based on the number of years worked and their use of specific radiation safety measures. This was necessary in order to check whether there is a relationship between the number of years worked and consideration of radiation safety Techniques. Chi square test results were not significant as the p-values were greater than 0.05 (table 4.16) and Cramer's V showed weak association as it returned a value of below 0.25, except for beam filtration that had moderate association of 0.2693 (table 4.16) However, proportions have been used to draw conclusions that showed that the different variables had no relationship with the length of experience of the MITs (tables 4.17 – 4.30).

Table 4.16 Statistical tests.

	Test results
Patients receive clear instructions before radiographic procedures are done	Chi 2 (12) = 12.1613 P= 0.433
	Cramér's V = 0.1878*
Confirmation of patient understanding of instruction before exposure	Chi 2 (12) = 11.2076 P= 0.511
	Cramér's V = 0.1810*
Use of immobilization devices where applicable	Chi 2 (15) = 6.6233 P= 0.967
	Cramér's V = 0.1417*
Radiation dose to the patient is top priority in selection of exposure factors	Chi 2 (12) = 7.9494 P= 0.789
	Cramér's V = 0.1518*
Image quality is top priority in selection of	Chi 2 (12) = 18.6989 P= 0.096

exposure factors	Cramér's V = 0.2328*
Processor cleaning and maintenance is done at the start of every day	Chi 2 (15) = 9.2802 P= 0.862
	Cramér's V = 0.1669*
Department has established reject/repeat analysis programme	Chi 2 (15) = 8.6316 P= 0.896
	Cramér's V = 0.1589*
Examination not done if the request form does not include clinical summary	Chi 2 (15) = 7.8022 P= 0.931
	Cramér's V = 0.1504*
Clarification always sought if there are queries regarding examination requested	Chi 2 (15) = 11.5100 P= 0.716
	Cramér's V = 0.1868*
Beam is always collimated to only the areas of interest	Chi 2 (12) = 13.4780 P= 0.335
	Cramér's V = 0.2003*
Beam filtration is checked annually for all equipment	Chi 2 (15) = 25.0218 P= 0.050
	Cramér's V = 0.2693**
Modification of projections requested is done to minimize radiation doses	Chi 2 (12) = 15.6294 P= 0.209
	Cramér's V = 0.2138 *
Only image receptors with high speed are used	Chi 2 (15) = 5.6916 P= 0.984
	Cramér's V = 0.1296*
Quality control programmes are standard routine practice	Chi 2 (15) = 20.2147 P= 0.164
	Cramér's V = 0.2431*

* Weak association **Moderate association

Table 4.17 Patients receive clear instructions before radiographic procedures are done.

Number of years worked	Response (n=115)						
		Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Total
0-3	n	0	0	0	10	15	25
	Row %	0.00	0.00	0.00	40.00	60.00	100.00
4-6	n	0	0	2	10	9	21
	Row %	0.00	0.00	9.52	47.62	42.86	100.00
7-9	n	1	0	1	17	14	33
	Row %	3.03	0.00	3.03	51.52	42.42	100.00
10 and above	n	0	1	3	10	22	36
	Row %	0.00	2.78	8.33	27.78	61.11	100.00
Total	n	1	1	6	47	60	115
	Row %	0.87	0.87	5.22	40.87	52.17	100.00

As shown by table 4.17, 60 (52.17%) of all participants considered issue clear instructions to a patient before radiographic procedures are performed.

Table 4.18 Confirmation of patient understanding of instruction before exposure.

Number of years worked	Response (n-114)						
		Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Total
0-3	n	0	0	2	11	11	24
	Row %	0.00	0.00	8.33	45.83	45.83	100.00
4-6	n	0	0	5	11	5	21
	Row %	0.00	0.00	23.81	52.38	23.81	100.00
7-9	n	1	1	8	13	10	33
	Row %	3.03	3.03	24.24	39.39	30.30	100.00
10 and above	n	0	2	6	20	8	36
	Row %	0.00	5.56	16.67	55.56	22.22	100.00
Total	n	1	3	21	55	34	114
	Row %	0.88	2.63	18.42	48.25	29.82	100.00

As depicted by table 4.18, MITs regardless of how long they have worked, find it necessary to confirm patient understanding of an instruction before exposure.

Table 4.19 The use of immobilization devices where applicable.

Number of years worked	Response (n=110)							
		Strongly disagree	Disagree	Neutral	Agree	Strongly agree	N/A	Total
0-3	n	5	4	3	2	3	7	24
	Row%	20.83	16.67	12.50	8.33	12.50	29.17	100.00
4-6	n	4	5	2	3	2	5	21
	Row%	19.05	23.81	9.52	14.29	9.52	23.81	100.00
7-9	n	5	6	3	7	4	8	33
	R%	15.15	18.18	9.09	21.21	12.12	24.24	100.00
10 and above	n	5	4	1	5	7	10	32
	Row%	15.62	12.50	3.12	15.62	21.88	31.25	100.00
Total	n	19	19	9	17	16	30	110
	Row%	17.27	17.27	8.18	15.45	14.55	27.27	100.00

The majority 68 (61.81%) of all MITs strongly disagreed, disagreed or indicated as not applicable the use of immobilization devices. (Table 4.19).

Table 4.20 Radiation dose to the patient is top priority in selection of exposure factors.

Number of years worked	Response (n=115)						
		Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Total
0-3	n	0	1	1	2	21	25
	Row %	0.00	4.00	4.00	8.00	84.00	100.00
4-6	n	0	0	1	4	16	21
	Row %	0.00	0.00	4.76	19.05	76.19	100.00
7-9	n	1	1	4	7	20	33
	Row %	3.03	3.03	12.12	21.21	60.61	100.00
10 and above	n	2	1	2	7	24	36
	Row %	5.56	2.78	5.56	19.44	66.67	100.00
Total	n	3	3	8	20	81	115
	Row %	2.61	2.61	6.96	17.39	70.43	100.00

The results indicated 81/115 (70.43%) strongly agreed that radiation dose to the patient is a top priority when selecting exposure factors (Table 4.20).

Table 4.21 Image quality is top priority in selection of exposure factors.

Number of years worked	Response (n=115)						
		Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Total
0-3	n	0	0	0	8	17	25
	Row %	0.00	0.00	0.00	32.00	68.00	100.00
4-6	n	0	0	2	2	17	21
	Row %	0.00	0.00	9.52	9.52	80.95	100.00
7-9	n	3	1	1	12	16	33
	Row %	9.09	3.03	3.03	36.36	48.48	100.00
10 and above	n	1	1	0	7	27	36
	Row %	2.78	2.78	0.00	19.44	75.00	100.00
Total	n	4	2	3	29	77	115
	Row %	3.48	1.74	2.61	25.22	66.96	100.00

As shown by table 4.21, 106 (92.18%) consider image quality in selection of exposure factors.

Table 4.22 The department has established a reject/repeat analysis programme.

Number of years worked	Response (n=114)							
		Strongly disagree	Disagree	Neutral	Agree	Strongly agree	N/A	Total
0-3	n	4	3	2	4	10	2	25
	Row%	16.00	12.00	8.00	16.00	40.00	8.00	100.00
4-6	n	7	2	1	3	8	0	21
	Row%	33.33	9.52	4.76	14.29	38.10	0.00	100.00
7-9	n	10	3	2	5	12	0	32
	Row%	31.25	9.38	6.25	15.62	37.50	0.00	100.00
10 and above	n	12	6	3	5	9	1	36
	Row%	33.33	16.67	8.33	13.89	25.00	2.78	100.00
Total	n	33	14	8	17	39	3	114
	Row%	28.95	12.28	7.02	14.91	34.21	2.63	100.00

The results indicated 33 (28.95%) strongly disagreed while 39 (34.21%) strongly agreed to having a reject/repeat analysis programme (Table 4.23).

Table 4.23 Processor cleaning and maintenance is done at the start of every day.

Number of years worked	Response (n=111)							
		Strongly disagree	Disagree	Neutral	Agree	Strongly agree	N/A	Total
0-3	n	3	2	3	4	1	10	23
	Row%	13.04	8.70	13.04	17.39	4.35	43.48	100.00
4-6	n	2	3	1	4	3	8	21
	Row%	9.52	14.29	4.76	19.05	14.29	38.10	100.00
7-9	n	4	4	6	3	2	13	32
	Row%	12.50	12.50	18.75	9.38	6.25	40.62	100.00
10 and above	n	2	5	4	9	5	10	35
	Row%	5.71	14.29	11.43	25.71	14.29	28.57	100.00
Total	n	11	14	14	20	11	41	111
	Row%	9.91	12.61	12.61	18.02	9.91	36.94	100.00

Of the 111/116 participants who responded, 80 (72.07%) did not do processor cleaning and maintenance at the start of every day (Table 4.22).

Table 4.24 An examination is not done if the request form does not include a clinical summary.

Number of years worked	**Response (115)**							
		Strongly disagree	Disagree	Neutral	Agree	Strongly agree	N/A	Total
0-3	n	2	3	5	5	9	1	25
	Row%	8.00	12.00	20.00	20.00	36.00	4.00	100.00
4-6	n	2	2	5	6	6	0	21
	Row%	9.52	9.52	23.81	28.57	28.57	0.00	100.00
7-9	n	6	4	7	9	7	0	33
	Row%	18.18	12.12	21.21	27.27	21.21	0.00	100.00
10 and above	n	6	6	7	9	8	0	36
	Row%	16.67	16.67	19.44	25.00	22.22	0.00	100.00
Total	n	16	15	24	29	30	1	115
	Row%	13.91	13.04	20.87	25.22	26.09	0.87	100.00

As depicted by table 4.24, only slightly more than 50% of all the participants considered not doing an examination where the request form did not include a clinical summary.

Table 4.25 Clarification is always sought if there are queries regarding an examination requested.

Number of years worked	Response (n=110)							
		Strongly disagree	Disagree	Neutral	Agree	Strongly agree	N/A	Total
0-3	n	0	3	3	7	10	0	23
	Row%	0.00	13.04	13.04	30.43	43.48	0.00	100.00
4-6	n	0	3	1	11	5	0	20
	Row%	0.00	15.00	5.00	55.00	25.00	0.00	100.00
7-9	n	1	4	3	9	16	0	33
	Row%	3.03	12.12	9.09	27.27	48.48	0.00	100.00
10 and above	n	2	2	3	11	15	1	34
	Row%	5.88	5.88	8.82	32.35	44.12	2.94	100.00
Total	n	3	12	10	38	46	1	110
	Row%	2.73	10.91	9.09	34.55	41. 81	0.91	100.00

As shown by table 4.25, there is no significant difference between the length of service for MITs and whether they seek clarification when there are queries on the examination.

Table 4.26 The beam is always collimated to only the areas of interest.

Number of years worked	Response (n=112)						
		Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Total
0-3	n	1	0	2	6	15	24
	Row %	4.17	0.00	8.33	25.00	62.50	100.00
4-6	n	0	2	1	1	17	21
	Row %	0.00	9.52	4.76	4.76	80.95	100.00
7-9	n	2	1	1	8	20	32
	Row %	6.25	3.12	3.12	25.00	62.50	100.00
10 and above	n	0	1	1	4	29	35
	Row %	0.00	2.86	2.86	11.43	82.86	100.00
Total	n	3	4	5	19	81	112
	Row %	2.68	3.57	4.46	16.96	72.32	100.00

The results in table 4.26 indicate that 82.86% of MITs who had worked longest and 80.95% of MITs with 4-6 years of service strongly agreed to collimate the beam to only the areas of interest.

Table 4.27 The beam filtration for all equipment is checked annually.

Number of years worked	Response (n=115)							
		Strongly disagree	Disagree	Neutral	Agree	Strongly agree	N/A	Total
0-3	n	7	5	1	3	3	6	25
	Row%	28.00	20.00	4.00	12.00	12.00	24.00	100.00
4-6	n	9	2	1	4	4	1	21
	Row%	42.86	9.52	4.76	19.05	19.05	4.76	100.00
7-9	n	19	3	5	2	3	1	33
	Row%	57.58	9.09	15.15	6.06	9.09	3.03	100.00
10 and above	n	11	4	7	5	8	1	36
	Row%	30.56	11.11	19.44	13.89	22.22	2.78	100.0
Total	n	46	14	14	14	18	9	115
	Row%	40.00	12.17	12.17	12.17	15.65	7.83	100.00

The majority, 46 (40%), of the MITs strongly disagreed that beam filtration is checked annually (table 4.27).

Table 4.28 Modification of projections requested is done to minimize radiation doses.

Number of years worked	Response (n=114)						
		Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Total
0-3	n	0	1	0	7	17	25
	Row %	0.00	4.00	0.00	28.00	68.00	100.00
4-6	n	0	0	1	3	17	21
	Row %	0.00	0.00	4.76	14.29	80.95	100.00
7-9	n	1	3	1	5	23	33
	Row %	3.03	9.09	3.03	15.15	69.70	100.00
10 and above	n	0	0	4	11	20	35
	Row %	0.00	0.00	11.43	31.43	57.14	100.00
Total	n	1	4	6	26	77	114
	Row %	0.88	3.51	5.26	22.81	67.54	100.00

A large percentage (80.95%) of MITs who had worked for 4 to 6 years strongly agreed that modification of projections requested is done to minimize radiation dose.

Table 4.29 Only use image receptors of high speed.

Number of years worked	Response (n=113)							
		Strongly disagree	Disagree	Neutral	Agree	Strongly agree	N/A	Total
0-3	n	1	1	2	9	8	3	24
	Row%	4.17	4.17	8.33	37.50	33.33	12.50	100.00
4-6	n	2	1	1	5	7	5	21
	Row%	9.52	4.76	4.76	23.81	33.33	23.81	100.00
7-9	n	3	2	4	6	12	6	33
	Row%	9.09	6.06	12.12	18.18	36.36	18.18	100.00
10 and above	n	2	2	4	8	10	9	35
	Row%	5.71	5.71	11.43	22.86	28.57	25.71	100.00
Total	n	8	6	11	28	37	23	113
	Row%	7.08	5.31	9.73	24.78	32.74	20.35	100.00

20.35% did not regard using an image receptor with high speed for radiation safety applicable.

Table 4.30 Quality control programmes are standard routine practice.

Number of years worked	Response (n=114)							
		Strongly disagree	Disagree	Neutral	Agree	Strongly agree	N/A	Total
0-3	n	2	4	5	7	6	1	25
	Row%	8.00	16.00	20.00	28.00	24.00	4.00	100.00
4-6	n	9	2	6	1	2	1	21
	Row%	42.86	9.52	28.57	4.76	9.52	4.76	100.00
7-9	n	9	4	7	9	4	0	33
	Row%	27.27	12.12	21.21	27.27	12.12	0.00	100.00
10 and above	n	8	3	6	6	12	0	35
	Row%	22.86	8.57	17.14	17.14	34.29	0.00	100.00
Total	n	28	13	24	23	24	2	114
	Row%	24.56	11.40	21.05	20.18	21.05	1.75	100.00

As depicted by table 4.30, 42.86% of MITs who had worked for 4 to 6 years, strongly disagreed that a quality control programme was standard routine practice, while only 34.29% of MITs who had worked for 10 years and above strongly agreed it was a standard practice.

4.3.7 Open -Ended Question

Responses regarding why the MITs were not using radiation safety equipment/items:

The following are some of the verbatim statements expressed,

a. *“Because sometimes we don't care for these”*
b. *“Sometimes we do not remember to use it”*

c. *“The department has even the unlicensed worker”*

d. *“Limited number of personnel”*

e. *“Neglected because it is one of wasting time while you have to receive patients”*

f. *“We do not really understand the importance of using them”*

g. *“We don't use them due to the special exams (contrasted) which is not done here in our institution”*

h. *“Because we don't perform hysterosalpinography in our department”*

i. *“We are potentially shielded”*

j. *“Lead equivalent eye goggles are not used because MIT use lead barrier and next of kin do not enter exposure room”*

k. *“We have two x-ray machines, one only has all of those equipment and other not have”*

l. *“Lead rubber apron sometimes the patients refuse saying it is too heavy and they don't have capacity to hold it”*

m. *“Lead rubber gloves, I rarely use the mostly because they are heavy and not flexible to use while doing some procedures”*

n. *“The number of patient is big. As the daily work is for one person, (as the number of staff is little) the protection principally can not be respected well”*

o. *“Because in our department we have only general x-ray that produce low x-ray is not necessary to have all of radiation protection”*

Table 4.31 Reasons given for radiation safety items not being regularly used by MITs.

The MITs' responses that were similar were grouped together into categories each with a heading.

PROPORTION	Count	Per cent
Negligence and lack of awareness	16	18.8%
Time consuming, limited personnel and workload	12	14.1%
Redundant radiation safety equipment	15	17.6%
Feeling of already protected	4	4.7%
Inadequate materials	5	5.9%
Easiness of usage	22	25.9%
Considered not Important	11	12.9%
	85	**100%**

4.3.8 Workshop and Training on Use of Radiation Safety and Measures

Almost all medical imaging technologists, 110 (94.83%) responded that they would benefit from training on radiation safety while 4 (3.45%) do not know whether they would benefit (Table 4.32).

Table 4.32 Workshop and training on use of radiation safety and measures.

	Frequency	Per cent
Would benefit	110	94.83
No benefit	2	1.72
Do not know	4	3.45
Total	116	100.00

4.3.9 Radiation Law

Slightly more than half of medical imaging technologists 65/116 (56.03%) indicated that they were familiar with law governing radiation protection (Table 4.33).

Table 4.33 Familiar with law governing radiation protection.

	Frequency	Per cent
Not familiar	51	43.97
Familiar	65	56.03
Total	116	100.00

4.3.10 Training in Quality Control

Almost all medical imaging technologists, 110 (94.83%) responded that they would benefit from training in a quality control programme while 4 (3.45%) did not know whether they would benefit (Table 4.34).

Table 4.34 Training in quality control programme.

	Frequency	Per cent
Would benefit	110	94.83
No benefit	2	1.72
Do not know	4	3.45
Total	116	100.00

4.3.11 MITs Other Concerns on Radiation Safety

The following are selected verbatim statements in regard to concerns that the MITs had on radiation safety,

a. *"Sometimes we do poor quality image due to lack of some devices for example in children, and this cause repeat which increase radiation to us and our patients"*
b. *"We take severe hours working in radiation field without radiation measuring device which makes us to worry"*
c. *"In order to achieve radiation safety and protection it is better to communicate with the hospital administrators and make them understand about radiation safety and protection"*
d. *"I recommend that all hospitals administration staff get the training on radiation awareness to increase their flexibility on radiographers"*
e. *"The layout of imaging department especially x-ray exposure room is not adequate because it exposes x-rays to surrounding department"*
f. *"It would help us if the number of imaging technologists are increased in department because we work from Monday to Sunday without day off"*
g. *"Pregnant medical imaging technologists are not considered while not even having dosimeters to know how severe is exposure to them and the baby"*
h. *"The hospital leader and clinician especially the general doctors and even other physician need to be trained what x-ray radiation effects, radiation protection measures"*
i. *"There should be serious inspection to all institutions using radiation equipment periodically to check if those equipment are used properly"*
j. *"The board in charge of radiation use should visit areas where ionizing radiations are being used to verify how they practice radiation safety measures"*

Table 4.35 Concerns MITs had regarding radiation safety in their departments.

The MITs' responses received that were similar were grouped together into categories each with a heading.

PROPORTION	Count	Per cent
Radiation safety materials and measures	55	24.7%
Awareness of radiation safety and protection	33	14.8%
Room design and installation	17	7.6%
Personnel	17	7.6%
Staff welfare	30	13.5%
Trainings	26	11.7%
Quality control	27	12.1%
Regulation	18	8.1%
Total	223	100%

CHAPTER FIVE

DISCUSSION

5.1 Introduction

The purpose of the discussion is to explain the meaning of the results (Hess, 2004:1238). This chapter therefore, focuses on the availability and utilization of radiation safety measures by medical imaging technologists in Rwanda as presented in chapter 4. The objectives of the study were:

1. to identify the radiation safety measures available and the level of usage by medical imaging technologists in their relevant hospitals,
2. to determine whether education has any effect on the utilization of radiation safety measures and
3. to determine barriers that prevent medical imaging technologists from implementing the required radiation safety measures.

5.2 Demographics

The research focus was public health facilities that have radiology departments, these being district, provincial and referral hospitals. Forty-four (91.67%) hospitals in these categories according to the results have working radiology departments and 116 (96.67%) MITs from the hospitals participated in the study (Table 4.1). The MoH organogram states that each district hospital should have 5 MITs, each provincial 5 and each referral 5, excluding the teaching referral hospitals. There are only 63 MITs in 32 district hospitals, which form the bulk of the health facilities, suggesting a very significant shortage of MITs.

The results (Table 4.2) show that the greatest proportion 75% (87) of the participants was male compared to 25% (29) females. This finding therefore suggests that MITs working in public health facilities in Rwanda are male dominated.

Among the participants the greatest proportion, 97 (83.62%), are 40 years and below (Table 4.3). This can be explained by the fact that after the 1994 genocide against the Tutsis, there were no MITs in the health system and there was no training programme for radiographers. Medical Imaging Departments were run by people who had on the job training. Training only started in 1998 when an advanced diploma programme was introduced. Therefore, the programme has only been running for 21 years and given that it only admits students who are 18 years and above (UR-MIS curriculum) validates the young workforce. Those over 40 years of age are likely to have undertaken the programme as a mature student or were working or qualified outside of the country.

The majority of the participants 101 (87.07%) had an advanced diploma (Table 4.4). The first Bachelor's programme in Rwanda was only approved in 2013 and training started in September of 2015, leading to the termination of the advanced diploma programme. The first Bachelor degree graduates are expected to graduate in November 2019. The smaller proportion of the participants who had a Bachelor's qualification at the time of this study in the researcher's opinion had obtained their qualification from abroad and mostly in the neighbouring countries.

The findings show the majority of the participants, 61 (52.59%), were attached to district hospitals, 6 (5.17%) in provincial hospitals and 49 (42.24%) in referral hospitals (Table 4.5). District hospitals form the bulk of the health facilities, while referral hospitals are the tertiary facilities.

Regarding distribution of the participants according to gender in the health facilities (Table 4.6), the majority of males, (52.87%) work in district hospitals. In addition, the majority of females (51.72%) work in district hospitals compared to 37.93% in the referral hospitals. Provincial hospitals employ the lowest percentage of both genders at 3.45% of the total male and 10.34% of the total females in all facilities, as these are the fewest number of hospitals among the hospital categories. Although the provincial hospitals had the least number of participants, they were the only facilities with a gender balance of 3 (50%) male and 3(50%) female.

The majority of hospitals in all categories (34.09%) employ only one MIT and therefore it would appear that they are understaffed. A similar number (31.82%) employ two MITs, which could be considered inadequate considering the MoH organogram recommends 5 MIT's per facility and considering that the facilities are supposed to operate 24 hours a day and seven days a week. All the facilities with more than 5 MITs are referral hospitals with none in the district or provincial hospital category. This distribution is inconsistent with the MoH organogram that stipulates a maximum of 5 MITs in district and provincial hospitals.

The majority (98.25%) of the participants reported having training in radiation safety measures, therefore an assumption is made that the curricula incorporated this important aspect. In contrast, Maharjan (2017:n.p.) reported that in Nepal the curriculum lacked radiation safety content and only focused on procedures to produce the images and interpretation skills.

Shabani *et. al.* (2018:141-147) argue that the experience of the MIT and also being older in age could influence better radiation safety practice. In Rwanda, according to the findings of this current study, 60% of the participants have worked for 7 years and above while only 40% have worked for 6 years and below. This indicates that a greater number of all the participants are significantly experienced given the number of years they have worked. According to the findings, however, experience had no significance on the radiation safety practice.

5.3 Availability and Usage of Radiation Safety Measures

The IAEA safety standards for protecting people and the environment require that in order to protect patients and staff from radiation, medical radiological equipment in its entirety should be supplied with suitable radiation safety equipment by the vendors as opposed to being optional extras. The IAEA safety standards further consider it inappropriate for vendors to try and gain sales by trading in radiation protection and safety options of radiological equipment for price reduction, this with a view of convincing administrators of facilities to save financial resources thereby compromising radiation protection and safety. According to the IAEA, control consoles should have a separate structural shielding with visual lead glass to monitor the x-ray room during exposure. If the console is located outside the procedure room, appropriate communication facilities should be provided. Personal protective equipment should be worn in situations where levels of occupational radiation safety cannot be guaranteed by structural shielding such as lead rubber aprons, thyroid shields, lead equivalent eye goggles and lead rubber gloves (IAEA, 2018: 70 and 77).

This study revealed that lead rubber aprons and lead equivalent barriers are predominantly available in all the radiology departments across Rwanda at 99.13% and 97.41% respectively. Similarly, in Lithuania, Valuckiene *et. al.,* (2016:695-708) found only a lead rubber apron was being used at all times, suggesting it was primarily available. For facilities in Rwanda, the finding with regard to lead rubber aprons is not any different from the situation in Lithuania. In a related study conducted in Iran, a lead rubber apron was the most available with lead equivalent barriers being equipped in 62.5% of the radiography rooms. However, the study was done in a single facility with several radiography rooms (Rostamzadeh *et. al.,* 2015:200-208). Other types of radiation safety equipment available according to findings of the Rwanda study were as follows: gonad shield 70.69%; thyroid shield 74.75%; lead rubber gloves 70.69%; wedge sponges 6.90%; sand bags 9.48%; compression bands 19.83%; pigg-o-stat 0.86%; lead equivalent eye goggles 30.17% and patient exposure chart 54.31%.

Participants not issued with a radiation-measuring device by their hospital amount to 40.87% (47), with the majority of these, 37 (78.72%), being in district hospitals.

5.3.1 Reasons on Non-availability of Radiation Safety Equipment/items

Reasons for radiation safety equipment/material not being available in departments or where it was lacking and was sought from MITs through an open-ended question (question 13). There were numerous varied reasons that were cited. They are categorised and are summarised below. Verbatim quotes are indicated as such:

5.3.1.1 Neglect by Administrators

According to 36.8% of the MITs, hospital administrators do not provide radiation safety equipment despite numerous requests: “Because we requested some of them many times in administration, but they didn't give us answer”. This lead to the MITs’ perception that the administrators did not care about radiation safety; “Most of the time the institution don't care any time the x-ray machine is working good and the patients are being received” and “Even the hospital leader don't care about radiation safety”. This could therefore, be attributed to the lack of awareness thereof.

5.3.1.2 Considered Not Important

The MITs do not appreciate the relevance of radiation safety equipment and materials, suggesting an educational gap. Seven per cent (7.1%) of the responses suggested that the radiation safety equipment is not available as it is not important: “They are not necessary for us”. Thus it appears MITs are not bothered if they were available or not: “I have never requested because I think they were not relevant in any department”. Another participant did not find a need to advise for their purchase: “Wedge sponges, sand bags, compression bands, pigg-o-stat I think we do not advise the hospital to buy it”.

5.3.1.3 Lack of Awareness by Administrators and MITs

Unavailability of radiation safety equipment/items due to lack of awareness by administrators and MITs was stated by 13.5% of the participants. When hospital administrators are not aware of radiation safety, it is difficult to have the hospitals prioritize the provision of radiation safety equipment: “Some do not even clearly understand what is all about radiation particularly radiation protection of patient and workers”. As a result, it would appear that the administrators fail to attach value to imaging as long as the patients are being attended to. A situation noted by a participant reads: "Administration has not yet given much value to the service of imaging". The situation becomes complicated when the hospital managers do not even consider involving the MITs as technical staff when equipment is bought for the department: "These tools are not known to those who are supposed to buy equipment for hospital and they don't involve MIT when giving a tender". Therefore, more often than not, radiation safety could be overlooked due to lack of information, as suggested by a participant: "It's because the supplier/or tender committee of equipment in hospital do not have sufficient information about radiation protection".

In some instances, the MITs lack awareness of radiation safety, therefore they would not be in a position to advise on what is required or needed to actualize safety. A response from one MIT read, "Not available to our facility due to, we do not know the need of it". Interestingly, another also stated, "We didn't have enough attention on the importance of these items especially exposure chart, pigg-o-stat, sand bags and wedges sponges".

5.3.1.4 Expensive Equipment Coupled with Bureaucracy

Radiation safety was considered costly and out of reach by 10.3% of the MITs. Responses received include: "May be the reason why it is not here in the facility it is due to its expensive". "Our institution has no capacity to have them due to economic issues unless from the government support". This implies that the cost or expense supersedes radiation safety of people and the environment.

5.3.1.5 Negligence by MITs

MITs (20.6%) cited why their departments lacked radiation safety equipment and material, an example being: "Because they are not requested by departmental management to the hospital administration." Another participant appeared to be comfortable with the status quo of the lack of equipment: “It is how I found the department from my first working day”.

5.3.1.6 Old, Dilapidated and Lack of Outlets to Buy

According to 11.6% of the MITs, old, dilapidated and lack of outlets to buy were the reasons the departments lacked the radiation safety equipment or that what existed became ineffective and got discarded. One of the participants said, “Some of these equipment are old”, while another participant stated that the hospital had discarded them, “The existing are old and the hospital has decided to discard them”.

In the researcher’s experience, radiation safety equipment/items have to be sourced abroad as there are hardly any outlets that stock them locally. MITs considered this as a factor for the departments not having them or why they do not get replaced when the equipment is discarded: “Some equipment is not easily found in the country”. If this radiation safety equipment is not included when radiological equipment is procured, it becomes difficult to get them separately as was stated by one participant: “When the machine come without accessories of radiation protection it is hard to the hospital to find them separately”.

5.3.2 Frequency Check for Effectiveness of a Lead Rubber Apron

According to the IAEA Safety Standards Series No. SSG-46 (2018: 78) integrity and effectiveness of lead rubber aprons could be lost due to damage when mistreated and inappropriately used. Therefore, they should be taken care of and it recommends examining them periodically to check reliability/shielding integrity by the use of fluoroscopy or radiography. The findings in this study revealed 59% of the MITs have never checked the lead rubber aprons in their facility. This then leads to an assumption that the reliability of most of the lead aprons in use across the country cannot be confirmed. It is a possibility that some could have lost their integrity (hence less effectiveness of radiation safety) as, during data collection, the researcher spotted some lead rubber aprons in some facilities were stored folded with some appearing old and physically worn out. There is a need to establish whether this aspect is covered in the curriculum.

5.3.3 Personal Radiation Monitoring

Also, according to the IAEA (2018:81), the personal radiation monitoring period should be between one to three months as specified by regulatory bodies in most states, depending on the risk of the amount of radiation involved, this being one month for image guided interventional procedures and 2-3 months for other examinations with lower doses. Before the legislation of the radiation law in Rwanda, use of personal radiation dosimeters was not enforced. Out of 116 participants who participated in this study, only 68 (58.62%) were issued with radiation dosimeters. Of these 68 with dosimeters, 20 (29%) were not receiving results consistently with 11 (16%) never receiving results. Moreover, 3% of the dosimeters in use were monitored monthly and 34% were monitored after every three months, 16% were newly issued in the last one-month of data collection and therefore were not yet due for monitoring. The newly issued dosimeters were probably due to the introduction of a law regulating the use of radiation in January 2018.

5.3.4 Techniques Employed for Radiation Safety

The various techniques employed for radiation safety such as communication, use of immobilization devices, selection of exposure factors, utilization of exposure charts, collimation, justification of radiological procedures and quality management are not utilised fully, however attention is given to some as discussed below.

5.3.4.1 Communication

The IAEA (2018:95) highlights the importance of good communication in reducing the number of repeat exposures, especially for children. It is, however, equally important for all patients and the IAEA recommends verbal interaction before, during and after the procedure between the MITs and the patient. The findings in Rwanda indicate patients receive clear instructions before the radiographic procedures and the majority of MITs (78.27%) agree or strongly agree to confirm whether the patients understand the instructions they give them before the exposure is made. Only 18.26% indicated that they sometimes confirm whether the patient has understood instructions, which could lead to unnecessary exposure.

5.3.4.2 Immobilizing Devices

IAEA safety standards series No. SSG – 46 (2018:99) requires immobilizing devices to be used if indicated to minimize radiation exposure to the patient, staff and helpers. The IAEA also cautions that restraint of patients should never be done by MITs and where possible not by anybody. Due to the unavailability of some of the restraining devices (Figure 4.2), the majority (61.27%) of MITs do not consider using immobilization devices. During the data collection the researcher noted some of the MITs improvising immobilizing devices with locally available materials, suggesting innovation in low resource settings and in some instances having the helpers restrain the patient.

5.3.4.3 Selection of Exposure Factors and Use of Exposure Chart

According to the findings it can be said that MITs in Rwanda consider both radiation dose and image quality while selecting exposure factors in order to minimize radiation exposure. During the period of data collection, the researcher identified that there are approximately 50% film/screen systems and 50% digital image processing systems operating in the Rwandan hospitals. There are also no dose reference levels derived for Rwanda that the researcher was aware of.

Approximately 44% (figure 4.3) of MITs refer to a patient exposure chart suggesting it is ignored by more than 50%, despite its significance. Fauber (2009:256-258) states specific radiological equipment has inherent factors, therefore making it impossible to use the same exposure factors for different x-ray equipment. Fauber further cautions that a patient exposure chart is not envisaged to replace critical thinking skills of exposure adjustments by MITs depending on the circumstances of a particular patient. Similarly, Eze *et. al.,* (2013:386-399) acknowledge an exposure chart is a necessary radiation safety measure. This being especially important where exposure factors are selected manually as the use of a chart significantly reduces the selection of sub optimal exposures necessitating repeat examinations. Korir *et. al.,* (2010:127-133) are of the opinion that approximating exposure factors from observed patient size and not formulating an exposure chart could increase the rejection of images due to exposure factors as noted in a study in Nairobi.

5.3.4.4 Collimation

Martin (2007:e18) postulates that collimation is an important dose optimization tool for the reduction of patient dose and improvement of image quality. The thoughts of Stollfuss *et. al.,* (2015:118-122), are that the MIT's dedication and awareness are the only identifiable factors influencing collimation. According to the findings a higher number of participants (89.38%) agreed or strongly agreed that the beam is always collimated to the area of interest. It can consequently be said in reference to the findings that collimation as a safety measure and improvement of image quality is used almost all the time. It could thus be concluded there is sufficient dedication and awareness with respect to collimation by MITs in Rwanda; therefore a reduction of unnecessary radiation is achieved.

5.3.4.5 Justification of Radiological Procedures

Most participants (76.58%) agreed or strongly agreed that they always seek clarification from clinicians when they have doubts on the examination requested. Only 51.72% agreed or strongly agreed to not doing the examination if the request form did not include a clinical history. Some of the reasons cited were, some clinicians do not value input from MITs as they believe they know what they want, therefore they portray a "do as I say" attitude. A case in point in one of the facilities is that the MITs indicated some clinicians would send patients without a request form and when they are sent back, the clinician accompanies the patient to the radiology department and instructs the MIT that the clinician is the request form, "Sometimes doctors send the patients without a request form and when we send the patient back, the doctors accompany the patient to x-ray department and say they are the request form". This is consistent with Sobiecka *et. al.,* (2016:325-330) who claim that some examinations are demanded by clinicians without justification when clinicians provide limited or no clinical details. Sobiecka *et. al.,* however, accuse the MITs of obeying and not questioning or challenging this unethical practice even when clearly discernible. The findings of this study in Rwanda could be considered as possible intimidation from the clinicians, despite the fact that as Vom and William, (2017:212-219) advise that it is well within the MITs mandate to inform a radiologist or referring clinician if referrals are not justified, as they are gatekeepers between the patient and unjustified ionising radiation.

5.3.4.6 Quality Management

MITs, according to the findings, did not appear to consider processor cleaning and maintenance, reject analysis programmes, x-ray beam filtration, speed of image receptors and quality control programmes as contributors to radiation safety (Table 4.15). For instance, some MITs asked the researcher during the data collection whether x-ray filtration and quality control were duties that are within their responsibilities. In limited departments where it is carried out, third parties do it. On processor cleaning, the findings indicate only 36.61% of participants consider processor cleaning and maintenance at the start of every day, possibly because the participants consider this function to be linked to film screen radiography as opposed to digital radiography, despite there being a mixture of both in these facilities.

5.4 Educational Effect of Radiation Safety

According to Mojiri and Moghimbeigi (2011:1-5) in a study done in India, knowledge and education on radiation safety is an aspect that has strong direct effects on technical protection against health hazards associated with radiation exposures. Mojiri and Moghimbeigi (2011:1-5), found that the following percentage of radiographers were not aware of any of the following: 1.4% lead rubber aprons; 32.4% thyroid shield; 21.1% gonad shield; 64.8% lead rubber gloves; 71.8% lead equivalent eye goggles; 33.8% lead equivalent barrier and 19.7% the radiation sign. In comparison, Awason *et. al.,* (2016: lc07-lc12) in Northern Nigeria discovered that only 52.7% of radiographers had good knowledge of various personal protective devices, these being lead equivalent goggles (51.8%), lead rubber gloves (51.8%), thyroid shields (43.6%) and gonadal shields (46.4%). According to the findings (figure 4.5) in Rwanda, however, the scenario is different as participants who indicated not to know about the various PPDs were insignificant (below 7%), with pigg-o-stat not known by nearly 10%. The only consistent finding with the study done in India was the lead rubber apron where in Rwanda only 0.87% of the participants did not know about it. This indicates and leads to the conclusion that the MITs in Rwanda are widely conversant with PPDs.

Shabani *et. al.,* (2018:141-147) reported that radiographers in Oman displayed no significant difference (p=0.400) between radiation protection knowledge and years since graduating (taken as their years of experience), however, the radiation protection practice score for radiographers with an experience greater than 15 years was significantly higher (71.6) compared to those having less or equal to 15 years (58.4). In Turkey, Senemtaşi Ünal *et. al.,* (2018:111-115) had a similar finding in that although occupational experience contributes to the radiation safety factor, it does not influence the radiation safety knowledge level. This is confirmed by a study in Italy where radiographers who had fewer years of experience were found to have a higher level of knowledge of radiation protection than the experienced radiographers, but this, however, did not necessarily mean that radiation safety practice was better (Paolicchi *et. al,* 2016:233-242). Similarly, Kada (2017:599-605) warns of higher radiation risk where there is poor knowledge of radiation protection. Likewise, findings in Rwanda suggest that the number of years practised by an MIT have no effect on the use of the radiation safety equipment despite their adequate knowledge demonstrated by the results. The use of the radiation safety equipment is marginal, mostly at below 50% regardless of number of years worked (figure 4.6).

5.5 Barriers to Radiation Safety

Question 15 was an open-ended question in the questionnaire that sought to ascertain what hindered the MITs from implementing the radiation safety measures available. The participants cited various reasons for none usage of radiation safety measures, which were then grouped into categories mentioned below. Verbatim quotes are indicated as such.

5.5.1 Negligence

In the United Kingdom, Hayre *et al.,* (2018:e13-e18) observed that radiographers in some instances would follow their own beliefs and myths, or word of mouth opinions from colleagues while applying radiation safety measures instead of applying evidence-based research. That, in the researcher's view constituted negligence. For instance, beliefs such as not using a lead rubber apron because dose appears insignificant compared to a CT examination. Some participants cited imaginary/phantom research which alleged that lead rubber aprons trapped ionizing radiation, thereby increasing doses to the patients (Hayre *et, al,.* 2018:e13-e18).

Similarly, 18.8% of the responses from the current study in Rwanda cited "Negligence" as a barrier or actions that suggested negligence or lack of awareness. Findings revealed that MITs sometimes did not care about using or would totally disregard the radiation safety measures even when available for no apparent reason, "Not even used", "Because sometimes we don't care for these" and "Sometimes we do not remember to use it". For instance, one of the participants claimed to have experience, therefore did not need to use equipment: "I have experience", a sign that little relevance is attached to radiation safety. Sometimes it is lack of understanding of its importance: "We do not really understand the importance of using them".

5.5.2 Time Consuming, Limited Personnel and Workload

Radiation safety practice is considered time consuming by 14.1% of the MITs. One of the participants wrote: "Neglected because it is one of wasting time while you have to receive patients", and "When they are so many patients to attend to." As indicated by another participant: "Shortage of time due to a lot of patients". A limited number of staff highlighted: "Limited number of personnel", "The number of patient is big. As the daily work is for one person, (as the number of staff is little) the protection principally cannot be respected well" and "Due to number of patients we have in the department it is not easy to regularly use of protection devices". This could possibly be explained by the fact that most of the departments do not have the required number of staff with the majority of the facilities (65%) having either one or two MITs as shown in Table 4.8.

5.5.3 Inadequate Materials

Radiation safety is not implemented due to unavailability of materials according to 5.9% of the responses received. In some instances, lack of adequate materials for radiation safety was the barrier: "We have two x-ray machines, one only has all of those equipment and other not have" and "Thyroid shield is limited in number (only one)".

5.5.4 Easiness of Usage

Significant responses (25.9%) in regard to why MITs do not use radiation safety equipment even when available cited difficulties in the use of some of the radiation safety materials. For instance, a lead rubber apron is considered heavy and cumbersome: "Lead rubber apron sometimes the patients refuse saying it is too heavy and they don't have capacity to hold it". Lead rubber gloves are too rigid and heavy: "Lead rubber gloves are heavy to use" and "Lead rubber gloves, I rarely use them mostly because they are heavy and not flexible to use while doing some procedures".

Lead equivalent eye goggles are found to be uncomfortable to the wearer: “Eye goggles, I rarely use this because whenever I use it my vision is somehow compromised and putting on them don't make me at ease”, “Equivalent eye goggles we have is not comfortable (it has a poor design)”, “Sometimes wearing them makes me feel uncomfortable (eye goggles) when doing an exam”. In addition, lead rubber gloves could potentially compromise the required sterile environment during interventional procedures. Similarly, Kayan, Yasar, Saygin, Yilmaz, Aktas, Kayan and Çetinkaya (2016:424-427) note the shortcomings while using lead rubber gloves as they limit touch sensitivity and restrict hand movement. Kayan *et. al.,* however, proposed ways of how shortcomings, could be alleviated by the use of regular latex gloves coated with barium sulphate or other contrast media. This is an effective and cheap alternative. A gonad shield is thought to be of poor design and not offering enough protection, “Gonadal shielding that are supplied are not good enough to be used, there are too small with poor design”. Further in agreement with the findings of this current study, Warlow *et al.,* (2014:178-182) also question the design of a gonad shield, especially for female patients, as it can potentially lead to a repeat exposure.

5.6 Other Concerns on Radiation Safety Raised by MITs

The participants in an open-ended question were asked what other concerns they had regarding radiation safety in their facilities. The concerns were categorised based on the responses and are discussed below. Verbatim quotes are indicated as such.

5.6.1 Radiation Safety Materials and Measures

Twenty-five percent (25%) of all the responses on concerns centred on the availability of radiation safety materials and adherence to the radiation safety measures. “Sometimes we do poor quality image due to lack of some devices for example in children, and this cause repeat which increase radiation to us and our patients”. The few materials that are available in hospitals, though inadequate, and according to the responses, are not put to proper use or are too old to be used or destroyed, “Radioprotection tools are there and not enough or old to be used” and “Proper use of some material we have”.

A significant number (40.87%) of staff lack radiation-monitoring devices as confirmed by Table 4.12; “We don't have radiation dosimeters on the department to measure, how much of the radiations we accumulated. So, change is needed”. Additionally, dosimeters of MITs that have them are rarely read: “We have TLDs in our department but they do not help us to know the occupational dose absorbed as there are no reading machine in Rwanda of TLDs.” Therefore, TLD’s lack relevance, as the MITs do not know the results due to the acknowledged (through participants’ verbatim statements) lack of reading facilities in Rwanda. Consequently, the participants’ view is that hospitals assisted by the Ministry of Health should put in place mechanisms to regularly read the dosimeters: “I may suggest that the Ministry of Health may assist especially in measuring and reading our TLDs”, or in the alternative, provide those that give automatic readings after exposure: “It is better to have a dosimeter which is automatically read the dose received after exposure”. One of the participants expressed the need to have collaboration among institutions

“Partnership among concerned institutions for availability of radiation protection tools/equipment and service should be emphasized”.

5.6.2 Awareness of Radiation Safety

A study in Saudi Arabia by Saeed, Al-shaari, Almarzooq, Alsareii, Aljerdah and Al-ayed (2018:2) suggested that a high percentage of physicians lacked awareness regarding radiation protection. In Egypt radiation awareness among physicians and radiologists was reported to be inadequate, potentially increasing radiation risk to patients and other staff working in radiation areas, Algohani, Aldahhasi and Algarni (2018:375). Furmaniak, Kolodziejska and Szopiński, (2016:1-5) in Poland, however, reported dentists and radiographers had insufficient radiation awareness.

In like manner, a lack of awareness of radiation safety and protection in this study was expressed as a concern by 15% of all the responses. Among hospital leaders, participants responded: “Hospital leaders do not understand radiation safety and protection”, “Hospital administration not aware of radiation measuring devices, which makes it hard for radiographers to get them”, “The leaders do not have knowledge about radiation safety” and “The administration doesn't give a priority to the radiation safety”. For clinicians, participants expressed that: “Doctors are not aware what is happening during radiographic procedures”, “Physicians must understand what the Medical Imaging Technologists told them about filling the necessary information regarding the patient on the request form” and “Sensitising doctors for the unnecessary projection reduction”.

“Awareness of radiation protection for people who are not radiographers (dentists, orthopedists)” and “Teach the people, and nurse, workmates how radiation issues work and function”. These programmes were supported by an analysis of a survey done at three of the largest hospitals in Gdańsk, Poland, that showed low levels of awareness of ionizing radiation among nurses, doctors, medical technicians and support staff and recommended systematic education of all healthcare professionals with regard to radiological protection (Szarmach, Piskunowicz, Świętoń, Muc, Mockallo, Dzierżanowski and Szurowska, 2015:57-61). A similar survey conducted among physicians in Italy also supported the need for raising awareness of radiation risks as less than half of the participants indicated having had education on radiation protection and only 23% were interested in acquiring the radiation knowledge (Campanella, Rossi, Giroletti, Micheletti, Buzzi and Villani 2017:1-6).

5.6.3 Room Design and Installation

X-ray rooms are restricted areas and their access should only be for persons undergoing / performing radiographic procedures. They should be big enough with staff protected by means of barriers, but that clearly allows the patient to be observed throughout the x-ray procedure. Furthermore, the x-ray beam should not be directed to any area that is not shielded. Normally all these safety feature provisions should be incorporated during the design stages of facilities (Munro, 2004: 11, IAEA, IAEA Safety Standards Series No. SSG-46: 2018: 55&56). If this recommendation by the IAEA is considered in Rwanda, it is of concern that in the study, eight percent (8%) of the responses referred to shortcomings of room design and installation. A response noted: “The department is not constructed according to the standard.” while another wrote, “The room we are using we don't know if there is lead inside”. Also, “The layout of imaging department especially x-ray exposure room is not adequate because it exposes x-rays to surrounding department”; and “The radiology department is not shielded by lead barrier hence the exposure to staff, patients, families and public". Furthermore, the researcher noted during data collection that some radiology departments are located in congested areas of high occupancy with no radiation warning signs. In one of the facilities the x-ray room had windows behind the room, an area that was also used for laundry. In the same facility there was no lead equivalent barrier inside the room between the x-ray equipment and the control panel.

5.6.4 Personnel

According to the findings of this study (Table 4.8) a significant number (34.09%) of facilities have one staff member that is expected to work throughout the week and all hours of the day that could potentially cause burnout on MITs. One of the participants indicated, "It would help us if the number of imaging technologists are increased in department because we work from Monday to Sunday without day off". "A high number of patients is a limitation to practice every required detail". Also of concern to participants is that the MoH organogram that stipulates personnel numbers is not respected, "The number of workers in department can't be respected as planned on organogram of MoH"

5.6.5 Staff Welfare

According to 14% of responses, welfare of MITs was not appropriately addressed in regard to their safety while at work. "Most of the time the radiographers work many hours a week because their time of working equal to that of health professional and yet they are dealing with radiations", "Medical imaging technologists working hours should be reduced", and "Working hours are too many to practice safety". International Basic Safety Standards by the IAEA, however, do not set limits in terms of time but in dose limits. The BSS 3.111 prohibits use of preferential consideration with respect to working hours as substitutes for measures for protection and safety.

"When there is a pregnant women in department it's better to take that staff where there is no radiation". International BSS require the notified employer of a pregnant female worker to adapt her working conditions. It states that the employer "shall adapt the working conditions in respect of occupational exposure so as to ensure that the embryo or fetus or the breastfed infant is afforded the same broad level of protection as is required for members of the public (BSS: 3.114)."

5.6.6 Quality Control

According to Ngoye *et. al.,* (2015:s25) potentially poor image quality and unnecessary dose to patients result from the lack of a quality control programme, thereby compromising radiation safety. The concerns expressed were the lack of quality control and where it is available, it is not done regularly enough for the assurances of safety. MITs responded as follows: "No check for leakage of radiation is done", "X-ray machine is not checked if it is working properly", "No one ever came to measure the accuracy of our barrier protection", and "Inconsistent quality control programs".

According to the responses, the MITs also feel inadequate in terms of quality control skills, as one participants said, "As staff in imagery field, we really need to be familiar with quality control and safety in radiation." And another mentioned: "Lack of competent personnel of radiological equipment maintenance personnel."

Some facilities have quality control programmes, however, feedback, as cited, is often delayed or not forthcoming to radiology departments: "Checking of equipment is done but feedback delays or never comes". None of the facilities visited had a radiation safety officer who could be instrumental in ensuring quality control standards are adhered to. The MITs responded: “I wish we could have radiation protection officer who would make constant checks on the safety of the radiation control”, and “Radiation protection officer to enforce radiation protection programs in the hospital and department”. Ngoye *et. al.,* reported that a lack of quality control tools in Tanzania had hindered implementation of quality control programmes, a reason also cited in one of the responses: “Quality control equipment needed are not available in the department”.

5.6.7 Regulation

For a long period of time there was no regulation of ionizing radiation in Rwanda, nor has there been formal regulation of staff working as MITs. RAHPC was established by an act of parliament in 2013 to check whether personnel meet the standard to practise and to license them. A law regulating the use of radiation was recently promulgated and puts in place a radiation board to ensure standards are followed, however, only slightly more than half (56.03%) of MITs are familiar with the law as indicated by Table 4.33. Comments with respect to this law were: “The board in charge of radiation use should visit areas where ionizing radiations are being used to verify how they practice radiation safety measures”, “The established law concerning radiation safety and protection should be properly applied”, “Enforcement of radiation protection should be emphasized on by RURA, Compliance by all concerned facilities should be done” and “Regular inspection of every hospital by regulatory board”.

5.6.8 Training

The majority of the responses (94.83%) showed a great desire to have training in radiation safety and quality control programmes. Some participants expressed the following: “We need the training in radiation protection”, “Training on radiation protection and quality control”, “Organize many training on radiation protection and invite all radiographers” and “All institutions that use radiation equipment should organize regular trainings of radiation workers to improve safety use of those equipment”. Another participant on highlighting the need for regular training also noted: “All the radiographers have to be trained many times but many other health care providers and society don't even believe in that there is some measures of radiation protection and safety.” This is consistent with the suggestion of Paolichi *et. al.,* (2016:233-242), Alavi *et. al.,* (2016) and Szarmach *et. al.,* (2015:57-61), that regular training of practising MITs is incredibly important and should be highly considered in order to guarantee patient radiation safety while undergoing medical imaging examinations. This view on enhancement of knowledge by in-service courses is supported also by Asadian and Zarghani, (2018:224) and notes when absent, apart from not acquiring new information, MITs also lose basic knowledge leading to gradual deterioration of performance as they only depend on their experience.

Radiographers also do not work in a vacuum, they are part of the team of health care delivery, and therefore the participants also indicated the need to have hospital managers and other health care professionals trained on radiation safety. One of the responses read, “Not only technologist should be trained on radiation issue, but even hospital managers, so that they provide all needed radiation protection devices”.

5.7 Summary

According to the findings of this research, the radiation safety measures are not adequately addressed in Rwanda. Apart from lead equivalent aprons and lead equivalent barriers, the rest of the personal protective devices (PPDs) to aid in radiation safety were lacking in all categories of hospitals. Lead equivalent aprons, although predominantly available, were not checked for effectiveness for radiation safety and the few that were checked were not done according to the prescribed schedule of IAEA. Personal radiation monitoring is not fully implemented. It appears that Personnel Protective Devices are not available due to neglect, lack of awareness, facilities to read the dosimeters and cost.

Communication, adequate selection of exposure factors, collimation, justification of radiological procedures as techniques for radiation safety are, however, implemented. Quality management, use of exposure charts and use of immobilizing devices are not adequately implemented. Education and experience do not influence radiation safety practice. Barriers to radiation safety were negligence, lack of PPDs and difficulty in using some of the PPDs and available training for MITs and other personnel.

CHAPTER SIX

RECOMMENDATIONS AND CONCLUSION

6.1 Introduction

This chapter presents recommendations based on findings from data analysis and literature reviewed as it pertains to the subject. The recommendations will be submitted to RURA, the Ministry of Health, the University of Rwanda Department of Medical Imaging and Kanombe Military hospital as stakeholders toward improvement of radiation safety. A conclusion is also discussed.

6.2 Recommendations for Radiation Safety

6.2.1 Radiation Safety Equipment

The IAEA requires medical radiological equipment to be, by default, supplied with radiation safety accessories and not as an optional extra or to be purchased separately (IAEA, 2018:61). The findings, however, show that most of the radiology facilities lack basic radiation safety accessories, i.e. wedge sponges, sand bags, compression bags, lead equivalent eye goggles, gonad shields, thyroid shields lead rubber gloves and pigg-o-stats, a scenario which researchers believe is as a result of the radiological equipment being supplied without the devices. RURA, the Ministry of health and hospitals' management should ensure that the tender for future purchases includes all necessary radiation safety equipment together with the radiological equipment in an attempt to mitigate costs and obviate the lack of local outlets for radiation safety equipment.

6.2.2 Awareness and Training

Unawareness of radiation safety may depend on several factors such as: higher learning institution education not addressing or inappropriately addressing the issue of radiation safety, insignificant in-service training coupled with lack of interest; technological complexity and lack of accountability (Paolicchi *et. al.,* 2016:238). Improvement of basic knowledge on radiation and awareness of radiation safety for staff and patient can be checked through regular training courses (Saeed *et. al.,* 2018).

The findings in Rwanda suggest that the lack of adherence to radiation safety is due to the lack of awareness. As a result, radiation safety awareness should be emphasised among MITs; hospital administrators and other medical personnel responsible for prescribing radiological examinations. This could be achieved through hospital based seminars and workshops or centrally organised to reach a larger audience and should involve all stakeholders to be effective. Conducting regular training would boost their awareness, attitude, and performance towards the principles of radiation protection (Asadian and Zarghani 2018:224; Awosan *et. al,* 2016:LC07-LC12).

Moreover, consideration should be given to holding hospital managers accountable in facilities where radiation safety is not adhered to.

In line with findings in Rwanda, the researcher has deduced that there is a need for sensitization campaigns and training among different cadres of staff in health facilities for any meaningful change to occur, and to address the educational gap in radiation safety. The researcher believes hospital management staff who are conversant with radiation safety and its importance would therefore be more willing to facilitate the purchase of radiation safety equipment. If clinicians were more aware of radiation safety measures, they would probably be less likely to disregard the MITs' input and opinion on the importance of a clinical summary, thus avoiding requests for unnecessary projections that do not add clinical value to an investigation.

Rwanda is part of Afrosafe, however, it has not been established whether MITs are aware of the same and how it could be of benefit to them through its education initiative. It is therefore recommended that awareness be created through the Society of Medical Imaging and Radiation in Rwanda (SMIR) that is a professional body for MITs, of its existence and benefits thereof. Rwanda should also consider as a member of a community of nations, to implement the 10 proposed actions issued at an IAEA-organized 2012 international conference held in Bonn, Germany out of which Afrosafe is anchored in order to improve radiation safety.

6.2.3 Quality Control

Equipment can fail when quality control is not implemented or routinely checked, therefore leading to unnecessary doses of radiation and poor image quality, thus compromising radiation safety (Ngoye *et. al.,* s23-s30). In Rwanda the findings reveal that to a greater extent, quality control is not done and where it is done, is normally sanctioned by hospital management. However, the primary objective of management is not radiation safety but facility accreditation. A recommendation is that quality control should be introduced in all facilities as a standard routine and MITs should be trained to carry out the quality control procedures and take ownership of ensuring QC is implemented. Furthermore, a list of responsibilities should be compiled for clarity purposes and to establish duties that fall under MITs and Medical physicists respectively.

6.2.4 Continuous Professional Development

Medical Imaging as a discipline is not stagnant. New information and ways of doing things keep emerging making it exciting and challenging to MITs. As a result, knowledge gained previously becomes obsolete necessitating continuous professional development (CPD) if we are to serve our patients better (European Society of Radiology and European Federation of Radiographer Societies 2019:e26-e38). According to the findings, MITs in Rwanda do not feel adequately equipped with radiation safety skills, explainable by the lack of training in Rwanda once qualified. Therefore, there would be a need for a combined effort among the training institution, regulatory bodies and professional association to come up with tailor-made training modules for in -service MITs.

This study showed that MITs expressed the need to have training in radiation safety and quality control. Introduction of regular CPD training regarding radiation safety should be considered and implemented. The regulatory body, educational institution, professional bodies, Ministry of Health and the hospitals should consider doing this jointly. In the researcher’s opinion, giving radiation safety training with a reward mechanism policy, such as CPD points that contribute towards renewal of practicing licences, could generate interest and get wider coverage. According to Shabani *et. al.* (2018:141-147) instances where there are policies requiring staff to attend radiation protection courses tend to have significant knowledge on radiation protection.

6.2.5 Required Number of Staff

The findings of this study showed most departments do not have the required number of staff in line with the available Ministry of Health organogram that stipulates the required number of staff across different categories of health facilities. Consequently, recruitment of additional MITs is desirable to avoid burnout and hence demotivated MITs who may not pay attention to radiation safety. Moreover, it will provide the time and staff to attend radiation safety courses and carry out QC respectively.

6.2.6 Regulation

Information about exposure of staff and confirmation of proper working practices and regulatory compliance is provided or made possible by radiation monitoring and dose assessments (IAEA Safety Standards Series No. SSG-46: 2018). The study revealed the requirement to issue all MITs with dosimeters is not met and there is limited reading and assessment of dosimeters of MITs already in possession of them. MITs and all other occupationally exposed staff should be provided with a radiation dosimeter and the reading needs to be done at regular and consistent intervals. Analysis of the dose result should be done preferably locally at the newly establish centre at the Rwanda standards board by the IAEA and mitigation measures should be carried out, should there be a need to ensure integrity of radiation safety.

The use of staff not trained as MITs to carry out radiological procedures, though rare, was cited in the findings. The researcher therefore, recommends that hospital management should ensure only employees trained and qualified to carry out radiological procedures are employed. The regulatory and professional bodies should regularly check this and develop a means of offering training to unqualified personnel.

There is a requirement for countries to have, through legislation, national regulatory mechanisms on radiation protection (Mroz *et. al.,* for IAEA). Cole *et. al.,* (2014:476) are also of the view that regulators promote radiation safety culture through support and encouragement. Rwanda has already legislated a law to this effect and the findings showed that a significant number of MITs are not aware of the law, however, it is noted that it was recently promulgated and is yet to be fully implemented. Hospital management and MITs should be made aware of the requirement of the law governing radiation safety to ensure compliance of radiation safety as they are the stakeholders. The recommendation is that this could be achieved through seminars and roadshows across the country for the significance of the regulation to be understood.

6.3 Recommendation for Further Research

The researcher recommends a study that will evaluate conformance of room design and installation of equipment to required radiation safety standards, as this was not covered by this study. Also of importance there would be a need for a follow up study after sufficient time of implementation, to check on regulatory compliance, continuous professional development and awareness of radiation protection and safety among the different stakeholders: the hospital administrators, clinicians and other healthcare staff and the public.

6.5 Conclusion

The researcher carried out an assessment of the availability and utilization of radiation safety measures by medical imaging technologists in Rwandan Hospitals. The objectives were met and the results thereof were presented. The focus was on: identifying the radiation safety measures available and the level of usage by medical imaging technologists in their relevant hospitals; determining whether education or knowledge had any effect on the utilization of radiation safety measures and determining barriers that prevent medical imaging technologists from implementing the required radiation safety measures.

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Annexure i: Questionnaire

Annexure I

Questionnaire

Reference Number [ ]

Thank you for accepting to participate in this study. You are kindly requested to answer the following questions with honesty. The aim of the questions is to collect information, which may be very useful in the improvement of radiation safety in radiology departments in Rwandan hospitals. I am available to answer your questions if you have any queries.

Section A:

This section refers to demographic information. Please give accurate answers. Your responses will remain anonymous. Please tick or make a X in the appropriate box as shown below as an example:

Male	Female
	x

1. Gender

Male	Female

2. Age

Below 30 years	
30-35 years	
36-40 years	
41-45 years	
46-50 years	
51-55 years	
56-60 years	
Above 60 years	

3. Highest qualification you hold

Advanced Diploma (A1)	
Bachelors (A0)	
Masters	
Other (Specify)	…………………….

4. In which health facility are you employed?

District hospital	
Provincial Hospital	
Referral Hospital	

5. Are you registered with the Rwanda Allied Health Professional Council (RAHPC)

Yes	
No	

6. How many Medical Imaging Technologists are there in your facility?

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7. Were radiation protection and safety measures part of the curriculum during your training?

Yes	
No	

8. How many years have you worked as a Medical Imaging Technologist?

0-3	4-6	7-9	10 and above

Section B:

9. What is the average number of patients seen in a month in your department?

Less than 100	
100-200	
200-300	
300-400	
400-500	
Above 500	

10. Has the hospital issued you with a radiation-measuring device?

Yes	
No	

11. If you answered **YES** to question 10 above, how often do you get the reading results of your radiation-measuring device?

Monthly	
After three months	
Inconsistent	
Never	
Other (specify)	

12. Indicate the **AVAILABILITY** of the following radiation safety equipment/items listed below that are in your department, by ticking in the appropriate box.

		Available		
		Yes	No	Do not know
1.	Lead rubber Apron			
2.	Gonadal Shielding			
3.	Thyroid Shielding			
4.	Lead rubber gloves			
5.	Lead equivalent Barrier/mobile lead shield			
6.	Wedge sponges			
7.	Sand bags			
8.	Compression bands			
9.	Pigg-o-stat			
10.	Lead equivalent eye goggles			
11.	Patient exposure chart			

13. If your answer is **NO** to any of the options in question 12 above, please give reasons.

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14. Indicate whether the items you responded **YES** to in question 12 above, are in regular use in your department.

	Yes	No

1.	Lead rubber Apron		
2.	Gonadal Shielding		
3.	Thyroid Shielding		
4.	Lead rubber gloves		
5.	Lead equivalent Barrier/mobile lead shield		
6.	Wedge sponges		
7.	Sand bags		
8.	Compression bands		
9.	Pigg-o-stat		
10.	Lead/equivalent eye googles		
11.	Patient exposure chart		

15. If your answer is **NO** to any of the options in question 14 above, please give reasons.

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16. How often are lead rubber aprons in your department checked for cracks?

Monthly	
Quarterly	
Every six month	
Annually	
Biannually	
Never checked	

17. Please indicate the level of agreement with the statements as they pertain to you in your department. Please answer truthfully.

1= Strongly disagree; 2= Disagree; 3= Neutral; 4= Agree; 5=Strongly Agree

	1	2	3	4	5	N/A
Patients receive clear instructions before radiographic procedures are done.						
Confirmation as to whether the patient understood the instructions is ensured before an exposure is made.						
Immobilization devices where applicable are always used.						
Radiation dose to the patient is top priority in the selection of exposure factors.						
Image quality is top priority in the selection of exposure factors.						
Processor cleaning and maintenance is done at the start of every day.						
The department has an established reject/repeat analysis programme.						
The radiographic examination is not done if the request form does not include a clinical summary.						
Clarification is always sought from the referring clinician if there are queries regarding examination(s) requested.						
The beam is always collimated to only the areas of interest.						
X-ray beam filtration is checked for all the equipment in the department annually.						
Radiographic projections requested are modified to minimize radiation doses without having to be told to do so.						
Only image receptors with high speed are used.						
Quality control programmes are standard routine practice.						

18. Do you think you would benefit from a workshop and training on the use of radiation safety and protection measures?

Yes	
No	
Do not know	

19. Are you familiar with the new legislated law governing radiation protection in Rwanda?

Yes	
No	

20. Do you think you would benefit from training in a quality control programme?

Yes	
No	
Do not know	

21. Please indicate what other concerns you may have regarding radiation safety and protection

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Thank you for completing this questionnaire.

Annexure ii: Information Letter and consent form

UNIVERSITY OF JOHANNESBURG

DEPARTMENT OF MEDICAL IMAGING AND RADIATION SCIENCES
RESEARCH STUDY INFORMATION LETTER

Date: 18/03/2019

Good Day

My name is Patrick Maina **I WOULD LIKE TO INVITE YOU TO PARTICIPATE** in a research study on Availability and Utilization of Radiation Safety Measures by Medical Imaging Technologists in Rwandan Hospitals.

Before you decide on whether to participate, I would like to explain to you why the research is being done and what it will involve for you. **I will go through the information letter with you and answer any questions you have.** This should take about 10 to 20 minutes. The study is part of a research project being completed as a requirement for a Master's Degree in Radiography through the University of Johannesburg.

THE PURPOSE OF THIS STUDY is to essess the availability and utilization of radiation Protection safety measures by Medical Imaging Technologists in Rwandan Hospitals in view of the new regulations recently gazetted.

Below, I have compiled a set of questions and answers that I believe will assist you in understanding the relevant details of participation in this research study. Please read through these. If you have any further questions I will be happy to answer them for you.

DO I HAVE TO TAKE PART? No, you don't have to. It is up to you to decide to participate in the study. I will describe the study and go through this information sheet. If you agree to take part, I will then ask you to sign a consent form.

WHAT EXACTLY WILL I BE EXPECTED TO DO IF I AGREE TO PARTICIPATE? You will be asked to complete a questionnaire. Section A contains the demographic while section B contains closed and open-ended questions. Open-ended questions will be categorized into themes during the analysis of the data.

WHAT WILL HAPPEN IF I WANT TO WITHDRAW FROM THE STUDY? If you decide to participate, you are free to withdraw your consent at any time without giving a reason and without any consequences. If you wish to withdraw your consent, you should inform me as soon as possible.

IF I CHOOSE TO PARTICIPATE, WILL THERE BE ANY EXPENSES FOR ME, OR PAYMENT DUE TO ME: You will not be paid to participate in this study and you will not bear any expenses

RISKS INVOLVED IN PARTICIPATION: There are no risks involved in the study. This is due to the fact that as a participant you will only be requested to complete a questionnaire

BENEFITS INVOLVED IN PARTICIPATION: There are no direct benefits to you as a participant from the study.

WILL MY TAKING PART IN THIS STUDY BE ANONYMOUS? Yes. Anonymous means that your personal details will not be recorded anywhere by me. As a result, it will not be possible for me or anyone else to identify your responses once these have been submitted.

WHAT WILL HAPPEN TO THE RESULTS OF THE RESEARCH STUDY? The results will be written into a research report that will be assessed. In some cases, results may also be published in a scientific journal. In either case, you will not be identifiable in any documents, reports or publications. You will be given access to the study results if you would like to see them, by contacting me.

WHO IS ORGANISING AND FUNDING THE STUDY? The study is being organised by me, under the guidance of my research supervisor at the Department of Department of Medical Imaging and Radiation Sciences in the University of Johannesburg. This research has not received any funding as yet.

WHO HAS REVIEWED AND APPROVED THIS STUDY? Before this study was allowed to start, it was reviewed in order to protect your interests. This review was done first by the Department of Department of Medical Imaging and Radiation Sciences, and then secondly by the Faculty of Health Sciences Research Ethics Committee at the University of Johannesburg. In both cases, the study was approved.

WHAT IF THERE IS A PROBLEM? If you have any concerns or complaints about this research study, its procedures or risks and benefits, you should ask me. You should contact me at any time if you feel you have any concerns about being a part of this study. My contact details are:

Patrick Maina
+250788750978
patrickmuiga@gmail.com

You may also contact my research supervisor:
Jeniifer Motto
jennym@uj.ac.za

If you feel that any questions or complaints regarding your participation in this study have not been dealt with adequately, you may contact the Chairperson of the Faculty of Health Sciences Research Ethics Committee at the University of Johannesburg:

Prof. Christopher Stein
Tel: 011 559-6564
Email: cstein@uj.ac.za

Or
Chairperson of the College of medicine and Health Sciences Institutional Review Board at the University of Rwanda:
Chairperson: 0788490522
Deputy Chairperson: 0783340040

FURTHER INFORMATION AND CONTACT DETAILS: Should you wish to have more specific information about this research project information, have any questions, concerns or complaints about this research study, its procedures, risks and benefits, you should communicate with me using any of the contact details given above.

Researcher:

Patrick Maina
patrickmuiga@gmail.com

DEPARTMENT OF MEDICAL IMAGING AND RADIATION SCIENCES
RESEARCH CONSENT FORM

Availability and Utilization of Radiation Protection and Safety Measures by Medical Imaging Technologists in Rwandan Hospitals

Please initial each box below:

☐ I confirm that I have read and understand the information letter dated 18/03/2019 for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily.

☐ I understand that my participation is voluntary and that I am free to withdraw from this study at any time without giving any reason and without any consequences to me.

☐ I agree to take part in the above study.

_____________________ ________________________________ _______________

Name of Participant Signature of Participant Date

_____________________ ________________________________ _______________

Name of Researcher Signature of Researcher Date

Annexure iii: To whom it may concern

FACULTY OF HEALTH SCIENCES

RESEARCH ETHICS COMMITTEE
NHREC Registration no: REC-241112-035

REC-01-95- 2018

27 August 2018

TO WHOM IT MAY CONCERN:

STUDENT: MAINA, PM
STUDENT NUMBER: 200617350

TITLE OF RESEARCH PROJECT: Availability and Utilisation of Radiation Protection and Safety Measures by Medical Imaging Technologists in Rwandan Hospitals

DEPARTMENT OR PROGRAMME: MEDICAL IMAGING AND RADIATION SCIENCES

SUPERVISOR: Ms JA Motto **CO-SUPERVISOR:** Ms L Hazell

The Faculty Research Ethics Committee has scrutinised your research proposal and confirm that it complies with the approved ethical standards of the Faculty of Health Sciences; University of Johannesburg.

The REC would like to extend their best wishes to you with your postgraduate studies.

Yours sincere

Prof C Stein
Chair : Faculty of Health Sciences REC
Tel: 011 559 6564
Email: cstein@uj.ac.za

Annexure iv: Approval Notice

UNIVERSITY OF RWANDA

COLLEGE OF MEDICINE AND HEALTH SCIENCES

CMHS INSTITUTIONAL REVIEW BOARD (IRB)

Kigali, 14th /08/2018

Patrick Muiga Maina
School of Health Sciences, CMHS, UR

Approval Notice: No 292/CMHS IRB/2018

Your Project Title ***"Availability and Utilization of Radiation Protection and Safety Measures by Medical Imaging Technologists in Rwandan Hospitals"*** has been evaluated by CMHS Institutional Review Board.

		Involved in the decision		
			No (Reason)	
Name of Members	**Institute**	Yes	**Absent**	**Withdrawn from the proceeding**
Prof Kato J. Njunwa	UR-CMHS		X	
Prof Jean Bosco Gahutu	UR-CMHS	X		
Dr Brenda Asiimwe-Kateera	UR-CMHS	X		
Prof Ntaganira Joseph	UR-CMHS	X		
Dr Tumusiime K. David	UR-CMHS	X		
Dr Kayonga N. Egide	UR-CMHS	X		
Mr Kanyoni Maurice	UR-CMHS	X		
Prof Munyanshongore Cyprien	UR-CMHS	X		
Mrs Ruzindana Landrine	Kicukiro district		X	
Dr Gishoma Darius	UR-CMHS	X		
Dr Donatilla Mukamana	UR-CMHS	X		
Prof Kyamanywa Patrick	UR-CMHS		X	
Prof Condo Umutesi Jeannine	UR-CMHS		X	
Dr Nyirazinyoye Laetitia	UR-CMHS	X		
Dr Nkeramihigo Emmanuel	UR-CMHS		X	
Sr Maliboli Marie Josee	CHUK	X		
Dr Mudenge Charles	Centre Psycho-Social	X		

After reviewing your protocol during the IRB meeting of where quorum was met and revisions made on the advice of the CMHS IRB submitted on 8th August 2018, **Approval has been granted to your study.**

Please note that approval of the protocol and consent form is valid for **12 months**.

EMAIL: *researchcenter@ur.ac.rw* P.O. Box: 3286, Kigali, Rwanda **WEBSITE: http://cmhs.ur.ac.rw/** ***www.ur.ac.rw***

You are responsible for fulfilling the following requirements:

1. Changes, amendments, and addenda to the protocol or consent form must be submitted to the committee for review and approval, prior to activation of the changes.
2. Only approved consent forms are to be used in the enrolment of participants.
3. All consent forms signed by subjects should be retained on file. The IRB may conduct audits of all study records, and consent documentation may be part of such audits.
4. A continuing review application must be submitted to the IRB in a timely fashion and before expiry of this approval
5. Failure to submit a continuing review application will result in termination of the study
6. Notify the IRB committee once the study is finished

Sincerely,

Date of Approval: The 14th August 2018

Expiration date: The 14th August 2019

Professor Kato J. NJUNWA
Chairperson Institutional Review Board,
College of Medicine and Health Sciences, UR

Cc:

- Principal College of Medicine and Health Sciences, UR
- University Director of Research and Postgraduate Studies, UR

Annexure v: Collaboration Approval Note

RWANDA
BIOMEDICAL
CENTER

A Healthy People. A Wealthy Nation

Kigali, 21/12/2018

Ref: No 2005/RBC/2018

Office of Director General

COLLABORATION APPROVAL NOTE

Dear Chairman of the National Health Research Committee (NHRC),

I, Dr. Jeanine U. Condo, Director General of Rwanda Biomedical Centre confirm that I am aware of the study entitled **"Availability and Utilization of Radiation Protection and Safety Measures by Medical Imaging Technologists in Rwandan Hospitals".**

This study will use a quantitative non-experimental descriptive method to assess the availability and utilization of radiation safety measures by Medical Imaging Technologist in Rwandan Hospitals; in view of the new legislation law no 59/2017 of 24/1/2018 governing radiation protection. The study objectives are to identify the radiation protection and safety measures available and the level of usage by Medical Imaging Technologists in their relevant hospitals; to determine whether education has any effect on the utilization of radiation protection and safety measures and to identify barriers that prevent Medical Imaging Technologists from implementing the required radiation protection and safety measures.

Radiation protection and safety measures in the context of this study are protective items such as lead rubber aprons and protective glass shielding. Mechanisms thereof are effective communication, immobilization of the patient, appropriate technical exposure factors, collimation, quality control programs, air-gap technique and unnecessary radiological procedures employed in minimizing ionizing radiation to patients and elimination of the same to the Medical Imaging Technologist and the public. The study will be conducted in forty-eight (48) health facilities in Rwanda, that have radiology department involving 204 licensed Medical Imaging Technologists from these health facilities.

The study PI is Patrick Muiga Maina from the University of Johannesburg; Master of Technology in Diagnostic Radiography. The study team include Dr Mazarati Jean Baptiste, Ms JA Motto and Mrs L. Hazel. Mr Patrick Muiga Maina is responsible for submitting research findings report to RBC through the Medical Research Center and communicate any challenge faced during the study implementation. Rwanda Biomedical Center is ready to collaborate with the study team to ensure effective implementation.

Sincerely,

RWANDA BIOMEDICAL CENTER

Jeanine U. Condo, MD, PhD
Associate Professor of Public Health
Director General /RBC

www.rbc.gov.rw / Info@rbc.gov.rw / PoBox : 7162 Kigali Rwanda

Annexure vi: Scientific Review Notice

Republic of Rwanda

MINISTRY OF HEALTH

National Health Research Committee
Ref: NHRC/2019/PROT/006

To: **Mr. Patrick Muiga Maina**
Principal Investigator

Scientific Review Approval Notice

With reference to your request for approval of the Research Protocol entitled; "**availability and utilization od radiation Protection and Safety Measures by Medical Imaging Techonolgist in Rwandan Hospital**"; We are pleased to inform you that, following a thorough review and critical analysis of your proposal (**NHRC/2019/PROT/006**), your Research Protocol has been approved by National Health Research Committee.
However,

1) Changes amendments on approach and methodology must be submitted to the NHRC for review and approval to validate the changes.
2) Submission to NHRC of final results is mandatory
3) Failure to fulfill the above requirements will result in termination of study

Once again National Health Research Committee appreciates your interest in research and requests you to submit this proposal to the National Ethics Committee (NEC) and then share a copy of the approval letter from them.

Your final approval reference number is **NHRC/2019/PROT/006.**

Sincerely,

Dr. Parfait UWALIRAYE
Chairperson of NHRC

Date: 23/09/2019

Annexure vii**:** Authorisation of Research

REPUBLIC OF RWANDA

Kigali 13 FEV 2019
N °20/ ...... 775 / DGPHFIS/2019

MINISTRY OF HEALTH
P.O. BOX 84 KIGALI
www.moh.gov.rw

Mr Patrick Muiga Maina
Tel: 0788750978
KIGALI

Dear Patrick,

Re: Authorization of Research

Reference is made to your letter dated 28th /September/2018 requesting Authorization to conduct your research entitled "**Availability and utilization of radiation Protection and safety Measures by Medical Imaging Technologists in Rwanda Hospital**".

Based on Rwanda Notice approval from College of Medicine and Health Sciences No292/CMHSSIRB/2018 of 14th August 2018 and National Health Research Committee Ref :NHRC/2019/PROT/006 dated 23rd January 2019 and Collaborative Note Ref No: N02005/RBC/2018 dated 21st December 2018 from Rwanda Biomedical Center.

I am pleased to inform you that the Ministry of Health has granted authorization to conduct this research and to collect data in Rwanda District, Provincial and Referral Hospitals according protocol and you are requested to share the results with the Ministry of Health and to provide the final report and datasets to the Ministry of Health.

Sincerely,

MINISTERE DE LA SANTE

Dr. Diane GASHUMBA
Minister of Health

Cc:

- **Hon. Minister of State in charge of Primary Health Care**
- **Permanent Secretary/MOH**
- **Director General of Rwanda Biomedical Center (RBC)**
- **Director General of Rwanda Military Hospital**
- **Director General of Butare Teaching Hospital(CHUB**
- **Director General of Kigali Teaching Hospital (CHUK)**
- **Director General of Referral Hospital(All)**
- **Director General of Provincial Hospital(All)**
- **Director General of District Hospital(All)**

Annexure viii: Review Approval Notice (Rwanda Military Hospital)

REPUBLIC OF RWANDA
RWANDA MILITARY HOSPITAL
Website: www.rwandamilitaryhospital.rw
P.O. Box: 3377 Kigali, Tel: (+250)252586420, Hotline: 4060
Email: info@rmh.rw

March 29, 2019 **Ref.: RMH IRB/011/2019**

REVIEW APPROVAL NOTICE

Dear **Patrick Muiga Maina**
University of Johannesburg

Your Research Project: **"Availability and Utilization of Radiation Protection and Safety Measures by Medical Imaging Technologists in Rwandan Hospitals".**

With respect to your application for ethical approval to conduct the above stated study at Rwanda Military Hospital, I am pleased to confirm that the RMH/Institutional Review Board (IRB) has approved your study. This approval lasts for a period of **12 months** from the date of this notice, and after which, you will be required to seek another approval if the study is not yet completed.

You are welcome to seek other support or report any other study related matter to the Research office at Rwanda Military Hospital during the period of approval.

You will be required to **submit the progress report** and any major changes made in the proposal during the implementation stage. In addition, you are required to **present the results** of your study to the RMH/IRB before publication.

Sincerely,

Prof. Alex M. Butera
Colonel
Chairperson Institutional Review Board, RMH