SURVEY OF RADIATION PROTECTION AMONGST NON-RADIOLOGY STAFF WORKING IN FLUOROSCOPY-GUIDED OPERATING THEATRES AT PUBLIC HEALTH INSTITUTIONS IN THE ETHEKWINI DISTRICT OF KWAZULU-NATAL

A dissertation submitted in fulfilment of the requirements for the Degree of Master of Health Sciences in Radiography in the Faculty of Health Sciences, Durban University of Technology

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JULY 2019

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Declaration of originality

I do hereby declare that this dissertation is my own original work and has not been submitted for a degree at any other university. All the sources used in the work have been acknowledged and referenced in accordance with the Durban University of Technology requirements.

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Dedication

I dedicate this dissertation to my precious daughter, Fadeke Aderibigbe, and to my dear brother, Michael Tatenda Hundah. Fadeke, your birth has brought light into my life. My brother Michael, finding you after many years of searching has filled that void in our lives and confirms that truly the Lord lives!

Acknowledgements

I would like to express my sincere gratitude to the following individuals and institutions for their input into this study;

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- Prof. T. Puckree for her expertise and guidance as co-supervisor;
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- All of the respondents who took part in this study.

Above all to the Lord Almighty for this opportunity!

Abstract

Background

Although fluoroscopy facilitates the performance of less invasive surgical techniques and therefore an increase in its use outside the radiology department, it carries with it the burden of radiation exposure. Several studies on radiation exposure during fluoroscopy-guided surgical procedures have been conducted in South Africa, but no known knowledge, attitude and practices (KAP) study has been conducted on radiation protection. Together with inadequate radiation protection practices among non-radiology theatre staff, the dearth of reported research on this subject has created the need for this study. This study therefore aimed to determine the KAP relating to non-radiology staff during fluoroscopy-guided operating procedures at public health institutions in the eThekwini district of KwaZulu-Natal. The relationships between KAP, demographic factors and intentions to implement radiation protection practices were related to the theory of planned behaviour.

Methodology

Ethical approval and gatekeeper permissions were obtained from the relevant stakeholders. A quantitative cross-sectional survey was adopted to collect data from non-radiology staff in fluoroscopy-guided operating theatres at eThekwini district public health institutions. Random stratified sampling was used to obtain a sample of 179 participants. A validated questionnaire was administered over 12 weeks. Respondents signed a consent form prior to participating and no names were provided on the questionnaire for purposes of confidentiality. Data were analysed using descriptive and inferential statistical tests such as the Chi-square test, Fisher's exact test and Spearman's rho correlation coefficient.

Results

The response rate was 54%, the respondents' mean age was 38.46 ± 9.47 years, and the majority (66.7%) were female. The respondents demonstrated moderate radiation-related knowledge (61.22%) and exceptional attitude (98.98%), but poor radiation protection practices (3.06%). The respondents' specialty, profession and hospital where they are working demonstrated a significant association with their KAP scores ($p < 0.05$). There are significant positive correlations between knowledge and attitude ($r = 0.270$, $p = 0.021$), and attitude and intention ($r = 0.348$, $p = 0.008$), and significant negative (inverse) correlations between knowledge and practice ($r = -0.264$, $p = 0.017$), and attitude and practice ($r = -0.280$, $p = 0.014$). There are no significant correlations between knowledge and intention, and intention and practice ($p > 0.05$).

Conclusion

Although the respondents have good knowledge and attitude, their radiation practices are poor. This indicates a need for further radiation protection training and improved awareness of and research into exact levels of radiation exposure and the consequences of such exposure.

Keywords

Radiation protection, operating theatre, fluoroscopy, fluoroscopy-guided procedures

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Abbreviations and acronyms

ALARA	As Low As Reasonably Achievable
DNA	Deoxyribonucleic Acid
DUT	Durban University of Technology
HIV	Human Immunodeficiency Virus
HPCSA	Health Professions Council of South Africa
IAEA	International Atomic Energy Agency
IARC	International Agency for Research on Cancer
ICRP	International Commission on Radiological Protection
IREC	Institutional Research Ethics Committee
KAP	Knowledge, attitude and practices
KZN	KwaZulu-Natal
m	metres
mm	millimetres
sec	seconds
mrem	millirem
mSv	millsievert
SA	South Africa
SARPA	Southern African Radiation Protection Association
TPB	Theory of Planned Behaviour
TLD	Thermoluminiscence dosimeter
UK	United Kingdom
USA	United States of America
WHO	World Health Organization

Glossary of terms

C-arm

C-shaped x-ray device that is used during fluoroscopy procedures in the operating room (Ziehm Imaging n.d: 1).

Gray

One gray (Gy) is equivalent to 100 rad (Radiation Emergency Medical Management 2019).

Fluoroscopy

Radiological modality that utilises continuous x-ray beam to allow real-time imaging of body organs (World Health Organisation 2018)

Fluoroscopy-guided procedures

Interventional or surgical procedures that utilise x-rays to obtain real-time images of the patient’s internal organs and devices (Medical Imaging and Technology Alliance 2015).

Lead apron

A shield made of lead and rubber that is used to protect the user from excessive ionising radiation during x-ray procedures (Mosby’s Medical Dictionary 2009).

Operating theatres

A hospital room dedicated for surgical procedures (Segen’s Medical Dictionary 2012).

Radiation protection

Protocols and guidelines that are incorporated to protect individuals from ionising radiation (Nuclear Energy Agency 1994).

Rem

One rem is equivalent to 0.01 sievert (Sv) (Radiation Emergency Medical Management 2019).

Ten-day rule

A radiation protection guideline for female patients of childbearing age that states that ‘whenever possible, one should confine the radiological examination of the lower abdomen and pelvis to the ten-day interval following the onset of menstruation’ (Segen’s Medical Dictionary 2012).

Chapter One

Introduction

1.1 Background to the study

The invention of X-rays in 1895 was a remarkable breakthrough in medicine, with modalities such as fluoroscopy expanding their use beyond the radiology department and becoming a golden tool during surgical procedures (British Library n.d.; International Commission on Radiological Protection (ICRP) 2011: 10). Through the use of ionising radiation, fluoroscopy allows surgical procedures to be performed less invasively, hence reducing mortality (ICRP 2011: 10). Despite the usefulness of fluoroscopy, protection from radiation exposure – regardless of dose levels – is of importance in departments utilising X-ray photons, because over a period of time radiation exposure can cause biological effects in the human body (Moore and Heeckt 2011: 2). Therefore the burden of occupational radiation exposure has to be addressed.

The Radiation Control Directorate of the South African Department of Health has established radiation protection policies related to fluoroscopy (Health Professions Council of South Africa (HPCSA) 2014/15: 9) but the International Atomic Energy Agency (IAEA) (n.d.) still raises concerns relating to the compliance of non-radiology staff as they lack proper radiation training. The ICRP (2011: 2) reiterates that in most countries both the radiation monitoring boards and hospital radiation teams often focus on staff in the radiology department and neglect protection of the non-radiology fluoroscopy-utilising staff. Abu Shab (2005: 5-6) reported negligence amongst this staff and questioned their knowledge, attitude and practices (KAP) regarding radiation protection. Khan *et al.* (2010: 1) and Palacia *et al.* (2014: 228) also revealed in their studies in the United Kingdom (UK) that most surgical trainees are lacking in essential radiation protection knowledge and adherence.

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Wambani *et al.* (2014) argued that no studies have scrutinised the fluoroscopy theatre staff's compliance with the recommended radiation protection measures in South Africa. This study hence aimed to address this gap in the South African research and literature to assess this dimension in radiation protection in the eThekwini district of KwaZulu-Natal (KZN). The study's outcome could be used by the relevant departments as baseline information for decision making relating to in-service training that will impact on occupational radiation exposure strategies. It can also be used to influence policy regarding compliance with radiation protection measures during fluoroscopy.

1.2 Research problem

The problem that this research is focusing on is the absence of baseline information for decision making relating to radiation protection in-service training. The consequences of not finding a solution to this problem would be unidentified staff radiation protection awareness levels. Moore and Heeckt (2011: 2) emphasise that the use of fluoroscopy in non-radiology surgical departments raises concern over the staffs' radiation protection awareness, as unmonitored prolonged exposure to ionising radiation can result in serious biological effects. Khan *et al.* (2010: 1) and Palacia *et al.* (2014: 228) indicate that although the National Health Boards have radiation protection guidelines and policies, negligence has been reported and research reveals a lack of essential radiation knowledge, adherence and safe practice amongst surgical staff in several countries.

Abu Shab's (2005: 5-6) study reported improper radiation protection practices amongst non-radiology fluoroscopy-guided theatre staff at public health institutions in the eThekwini district of KZN. Wambani *et al.'s* (2014) report indicated unavailability of fluoroscopy research in South Africa investigating the radiation awareness of such staff, and hence calls for a radiation awareness study to be conducted amongst non-radiology staff.

1.3 Aim

The aim of this quantitative study is to determine the Knowledge, Attitude and Practice (KAP) of non-radiology staff in fluoroscopy-guided operating theatres at public health institutions in the eThekwini district of KZN as associated with the concepts related to the theory of planned behaviour (TPB), in order to obtain evidence-based baseline information that could be used to enhance social and behavioural change.

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1.4 Objectives

The study had the following objectives:

1) To determine KAP in radiation protection amongst non-radiology staff in fluoroscopy-guided operating theatres at public health institutions in the eThekwini district of KZN through administration of a KAP survey.
2) To establish the correlation or relationships between the staff's radiation protection KAP, demographic factors and intention to implement radiation protection practices.

1.5 Significance of the study

This study's outcome could be used to improve radiation protection practices, resulting in possible reduced occupational and patient radiation exposure in the relevant KZN healthcare community. Furthermore, this study will address the gap in the literature indicated by Wambani *et al.* (2014): that there is no known fluoroscopy research in South Africa investigating non-radiology staff's radiation awareness. It could also impact policy change with regard to monitoring and evaluation for compliance with protection guidelines.

1.6 Delimitations

This study was generalised to non-radiology staff working in fluoroscopy-guided operating theatres at public health institutions in the eThekwini district of KZN.

1.7 Research study outline

This dissertation comprises six (6) chapters, which are briefly described below.

Chapter one: Introduction

This chapter provides an account of the background to the study, and a description of the research problem, the aim, objectives, significance of the study and its delimitations.

Chapter two: Literature review

This chapter provides a detailed analysis of the relevant literature outlining the current discourse on radiation awareness and the theoretical framework of the research.

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Chapter three: Methodology

A detailed account of the research paradigm, design, methodology, sampling procedure, data collection process, ethical considerations and data analysis methods is provided.

Chapter four: Results

This chapter presents the results of the study by displaying the data that were collected and analysed.

Chapter five: Discussion

This chapter provides a discussion of the results and trends presented by the collected data with reference to available literature.

Chapter six: Conclusions, limitations and recommendations

A conclusion stating the response to the research aims and objectives is given. Recommendations based on the findings which emerged and the limitations of the study are also clarified.

1.8 Assumptions

The following assumptions were applicable to the current study:

- The sample was representative of the population under study. This was achieved by the researcher conducting a thorough population identification study and a statistician calculating the sample size (Appendix H: Sample size calculation by statistician).

- The respondents provided honest and truthful responses. This was ensured by preserving anonymity and confidentiality by not including respondents' names on the questionnaires. The respondents also had the right to withdraw from the study without any ramifications (Simon 2011: 1).

- The cross-sectional survey design was the appropriate tool to address the research problem and achieve the stated objectives. As indicated by Simon (2011: 1), a pilot study was conducted to assess the ability of the survey questionnaire to achieve the set objectives.

- Reality is objective and was separated from the researcher. According to Robert (1998) this is applicable to studies with a positivist paradigmatic background.

- The current study can be replicated and generalised. To ensure this, a pilot study was conducted to assess reliability and validity (Biddix 2009).

Chapter Two
Literature review

2.1 Introduction

This chapter presents a critical account of information in the literature that relates to radiation protection in non-radiology fluoroscopy-guided operating theatres. The historical context of radiation protection, and the theoretical framework based on the theory of planned behaviour and its concepts are presented. Literature was accessed through related textbooks from the Durban University of Technology (DUT) library and electronically through online journals, ebooks, conference paper publications and dissertations.

Several radiation protection knowledge attitude and practice (KAP) surveys have been conducted amongst non-radiology staff internationally (Moore and Heeckt 2011: 1; Khan *et al.* 2010: 1; Palacia *et al.* 2014: 228), but there are no known KAP studies conducted in South Africa (Wambani *et al.* 2014). The studies that were conducted internationally indicated poor radiation awareness (Khan *et al*. 2010: 1; Palacia *et al*. 2014: 228; Rosario *et al.* 2015; Tunçer *et al*. 2017) and present the need for such KAP surveys to be conducted in South Africa in order to establish radiation protection baseline data.

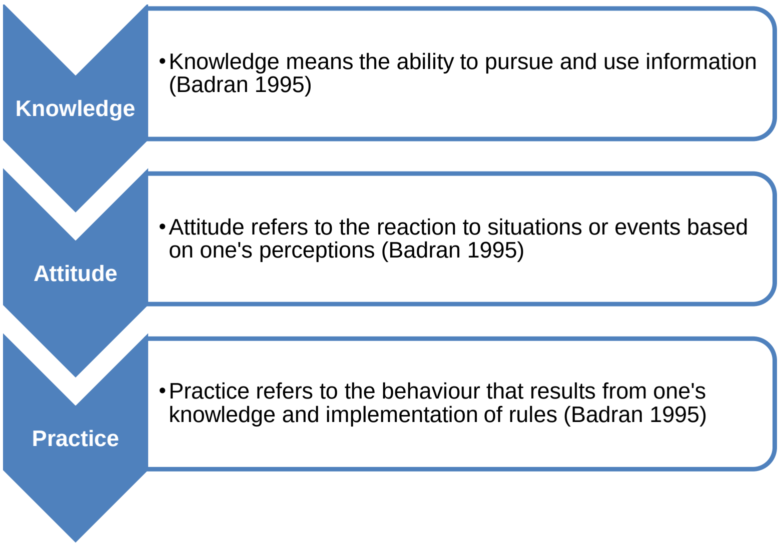
2.2 Historical context

The invention of X-rays in 1895 was a remarkable breakthrough in medicine, leading to modalities like fluoroscopy, which makes use of X-rays to produce real-time still images of a patient's body for use in diagnostic and interventional procedures (British Library n.d.; Medical Imaging and Technology Alliance 2015). Since the invention of fluoroscopy its use has expanded beyond the radiology department to other non-radiology departments such as orthopaedics, gastrointestinal and cardiovascular, that use fluoroscopy-guided surgical procedures because of its ability to allow surgical procedures to be performed less invasively (ICRP 2011: 10). Like any other ionising radiation modality fluoroscopy introduces a radiation risk requiring strict radiation protection practices to be implemented or considered (International Atomic Energy Agency (IAEA) 2013). This risk was only discovered in the early 1900s after several cases of acute radiation-induced injury and the death of one of the early research scientists (Sherer *et al.* 2014: 64). In the following years several societies and organisations such as the IAEA were formed internationally to study the destructive effects of X-rays and ways to minimise them (Sherer *et al.* 2014: 64). This formed the foundation for radiation protection awareness.

Based on the radiation studies conducted over the years an international system of radiation protection was built for use in all departments utilising ionising radiation (Nuclear Energy Agency 2000: 7). In the present day almost every country has a National Radiation Control Board and radiation safety teams at hospital level (IAEA 2013). In South Africa the South African Radiation Protection Coordinating Body was formed in 1997 and the Department of Health includes the Directorate: Radiation Control (South African Radiation Protection Association 2013). There has, however, been anecdotal evidence of poor radiation protection monitoring in fluoroscopy-utilising non-radiology departments (Abu Shab 2005: 5-6). This study intends to explore this gap.

2.3 KAP surveys

Emerging as a public health research method in the 1930s, the KAP survey is a representative study of a specific population to collect information on what is known, believed and done in relation to a particular topic (Eckman 2014: 5; World Health Organization (WHO) 2008: 6) (Figure 2.1). Having been used by several healthcare researchers, it has proven to be a useful tool in identifying and explaining trends or levels of KAP towards a particular phenomenon (Eckman 2014: 18). Results from KAP surveys enable an efficient process of awareness creation tailored according to the community needs (Kaliyaperumal 2004: 7). According to the WHO (2008: 6) KAP surveys are conducted for exploration, testing of hypotheses or establishing baselines. The KAP survey under discussion seeks to establish a baseline level of radiation protection KAP amongst non-radiology surgical staff working in eThekwini district public health institutions in KZN.



- Knowledge means the ability to pursue and use information (Badran 1995)
- Attitude refers to the reaction to situations or events based on one's perceptions (Badran 1995)
- Practice refers to the behaviour that results from one's knowledge and implementation of rules (Badran 1995)

Adapted from Chien-Yun *et al.* (2012: 74).

Figure 2.1: Meanings of the components of KAP.

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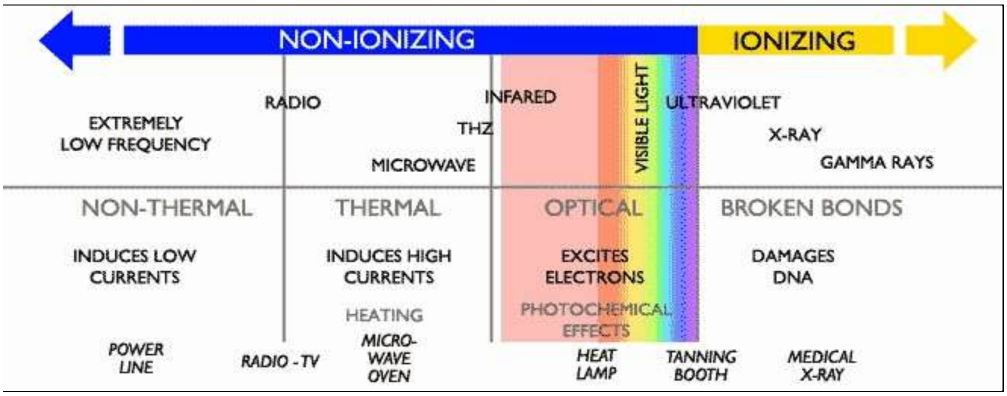
According to the KAP constructs an individual’s knowledge about a phenomenon directly influences their attitude and practice or behaviour towards that phenomenon (WHO 2012: 21). Hence this research study aims to assess the correlations between the KAP relating to the radiation protection phenomenon.

2.4.1 Radiation

The National Cancer Institute (2018) and Canadian Nuclear Safety Commission (2012: 1) define radiation as energy transmitted in the form of electromagnetic waves or subatomic particles. The different frequencies and wavelengths of the electromagnetic waves make up the electromagnetic spectrum, as shown in Figure 2.2.



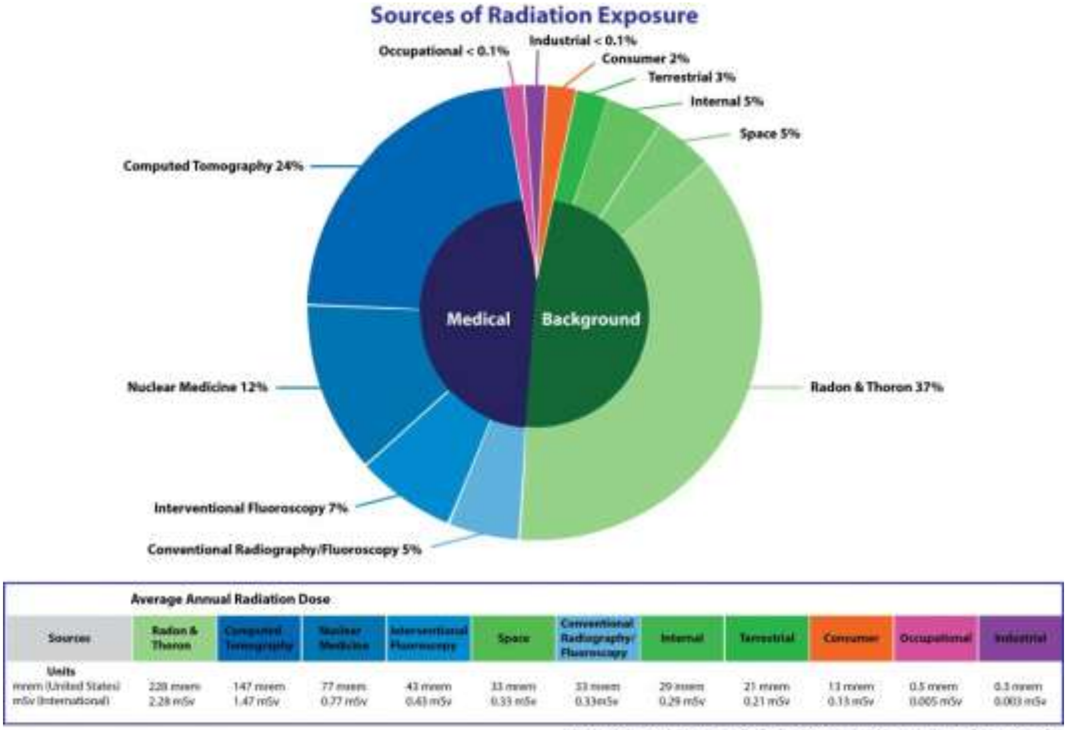
Adapted from Flores-McLaughlin *et al*. (2017).

Figure 2.2: The electromagnetic spectrum.

Miller-Keane (2003) indicated that ionising radiation contains enough energy to eject electrons from molecules, producing excessive free charge which is capable of inducing cellular damage in the body organs. The ionising radiation category comprises X-rays, gamma rays, alpha particles and beta particles (Canadian Nuclear Safety Commission 2012: 32). On the other hand, Flores-McLaughlin *et al*. (2017) identify non-ionising radiation as electromagnetic radiation that does not possess enough energy to replace atoms or molecules directly, resulting in no cellular damage. Non-ionising radiation includes ultraviolet radiation, visible light, infrared rays, microwaves, radiofrequency and extremely low-frequency radiation (Sheetz 2015).

2.4.2 Sources of ionising radiation

The United Nations Scientific Committee on the Effects of Atomic Radiation (2008: 223) and the Washington State Department of Health (2002: 2-3) agree that all human beings cannot escape the exposure to background ionising radiation from natural sources such as cosmic rays, terrestrial radiation and natural radioactivity in the body and man-made sources such as medical radiation, nuclear power and consumer products. Figure 2.3 illustrates a detailed analysis of radiation exposure sources.



Average Annual Radiation Dose

Sources	Radon & Thoron	Computed Tomography	Nuclear Medicine	Interventional Fluoroscopy	Space	Conventional Radiography/ Fluoroscopy	Internal	Terrestrial	Consumer	Occupational	Industrial
Units mrem (United States) mSv (International)	228 mrem 2.28 mSv	147 mrem 1.47 mSv	77 mrem 0.77 mSv	43 mrem 0.43 mSv	33 mrem 0.33 mSv	33 mrem 0.33mSv	29 mrem 0.29 mSv	21 mrem 0.21 mSv	13 mrem 0.13 mSv	0.5 mrem 0.005 mSv	0.3 mrem 0.003 mSv

(Source: National Council on Radiation Protection & Measurements, Report No. 160)

Adapted from National Council on Radiation Protection & Measurements (2015).

Figure 2.3: Sources of radiation exposure.

As indicated in Figure 2.3, interventional fluoroscopy, the modality under study, contributes about 7% of the total radiation received annually (United States Environmental Protection Agency 2017). Occupational exposure constitutes less than 1% of radiation sources (United States Environmental Protection Agency 2017), with a need for radiation protection to be implemented effectively to keep this at a minimum.

2.5 Effects of radiation

Regardless of associated dose levels, radiation protection is of vast importance in all departments involving the use of ionising radiation, as the low cumulative doses can be carcinogenic, affecting the skin, eyes, gonads and blood cells over time (Cecen *et al.* 2015). The level of radiation exposure determines the degree of cellular damage, as documented by Imaizumi *et al.* (2006: 1019) in a study conducted amongst atomic bomb survivors of Hiroshima and Nagasaki.

Imaizumi *et al.* (2006: 1019) concluded that the incidence and prevalence of thyroid cancer increased according to the level of radiation exposure. According to the IAEA (2013) radiation effects can be either deterministic or stochastic.

2.5.1 Deterministic effects

Deterministic effects, also known as non-stochastic effects, are defined by the Radiation Health Unit (2007: 1) as radiation effects that occur when the threshold radiation dose is exceeded. Royal (2015: 586) explains that below this threshold effects will not occur, as many cells need to be affected. Royal (2015: 586) and the Radiation Health Unit (2007: 1) agree that the severity of deterministic effects is directly proportional to the radiation dose. The ICRP (1990) discovered that if a radiation dose to the eye lens is maintained below the annual dose of 150 mSv, cataracts are unlikely to occur during a 50-year working period. Examples of deterministic effects include cataracts, infertility, haematological deficiencies, foetal death, skin erythema and dementia (Royal 2015: 586; Radiation Health Unit 2007; United States National Research Council, 2006: 393). Table 2.1 indicates the annual dose limits for preventing deterministic effects.

Table 2.1: Threshold for deterministic effects (Sv)

	Effects	One single absorption (Sv)	Prolonged absorption (SV-year)
Testis	Permanent infertility	3.5 – 6.0	2
Ovary	Permanent infertility	2.5 – 6.0	>0.2
Lens of the eye	Milky or lens cataract	0.5 – 2.0	>0.1
		5.0	>0.15
Bone marrow	Blood-forming deficiency	0.5	>0.4

Adapted from ICRP 1990.

The ICRP (2000) further presented the estimated time of onset of deterministic effects to the eye lens and skin, as indicated in Table 2.2.

Table 2.2: Potential clinical effects of radiation exposure to the skin and eye lens

Effects	Threshold dose (Gy)	Time of onset
SKIN**:**		
Early transient erythema	2	2-24 hours
Main erythema reaction	6	~1.5 weeks
Temporary epilation	3	~3 weeks
Permanent epilation	7	~3 weeks
Dermal necrosis	>12	>52 weeks
EYE:		
Lens opacity (detectable)	>1-2	>5 years
Lens / cataract (debilitating)	>5	>5 years

Adapted from ICRP 1990.

2.5.2 Stochastic effects

According to the ICRP (2007: 33) the probability but not the severity of stochastic effects is determined by dose. The United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) (2015: 7) argues that to date no marker linking a cancer or hereditary disease in an individual to ionising radiation exposure, irrespective of dose, has been found. UNSCEAR (2015: 7) further argues that even if it is found, it will not be able to indicate whether the source was natural or artificial radiation. Therefore only the frequency of a stochastic effect in a population can be linked to exposure to ionising radiation, as studied in the irradiated populations of Hiroshima and Nagasaki (United States National Research Council 2006: 394; Imaizumu *et al*. 2006). The United States National Research Council (2006: 394), Radiation Health Unit (2007) and ICRP (2007: 33) consider cancer and hereditary diseases as examples of stochastic effects of radiation.

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2.6 Fluoroscopy outside the radiology department

Defined as an imaging technique that uses X-rays to obtain real-time moving images of the interior of an object, fluoroscopy allows continuous imaging of internal structures and immediate serial image capturing (Mosby's Medical Dictionary 2017). According to Panchbhavi (2018) the use of fluoroscopy has expanded to real-time imaging during discography, urological surgery (particularly retrograde pyelography), liver biopsy, lumbar puncture and various cardiology procedures, such as percutaneous coronary interventions. The use of fluoroscopy outside the radiology department is increasing each day due to the ability of fluoroscopy to allow surgical procedures to be completed less invasively, hence reducing morbidity, risk of infection, mortality, costs and patients' hospital stay (ICRP 2011; National Cancer Institute 2005a: 1). However, the National Cancer Institute (2005a: 1) argues that this has introduced a public health concern resulting from increased radiation exposure to patients and healthcare staff, as most of these departments do not have adequate radiation protection training.

Comment [L7]: there are two references for National Cancer Institute 2005 - please indicare which is 2005a and which is 2015b on the reference list and in the text. Find all in the text and mark either 2005a or 2005b (if you are referring to both put (National Cancer Institute 2005a, 2005b)

2.7 Radiation doses

Royal (2015: 586) noted that radiation effects are dependent on different doses such as skin dose, organ dose and effective dose. To avoid exposure to detrimental radiation dose levels international and national radiation organisations have set in place annual dose limits that should not be exceeded (IAEA 2013). Furthermore, these dose limits should be included in the radiation protection policies of all departments utilising ionising radiation (IAEA 2013). In most countries both the radiation monitoring boards and hospital radiation teams often focus on the radiology department, hence neglecting non-radiology fluoroscopy-utilising departments (ICRP 2011: 2); this increases the chances of these non-radiology departments not being aware of the dose limits.

In South Africa the National Nuclear Regulator (2018) has set the annual worker dose limit at 20 mSv with reference to evidence from the Japanese bomb blast survivors and other groups exposed to radiation. The South African Department of Health Directorate: Radiation Control (2015) set its annual radiation dose limits in accordance with those set by the ICRP, as indicated in Table 2.3 below.

Table 2.3: Dose limits for radiation workers and the public

Application	Occupational	Public
Effective dose	20 mSv per annum, not more than 100 mSv over a period of 5 years (not more than 50 mSv in any one year)	1 mSv per annum
Annual equivalent dose to:		
Lens of the eye	20 mSv	1 mSv
Skin	500 mSv	50 mSv
Hands and feet	500 mSv	……..

Adapted from SA Department of Health Directorate: Radiation Control (2015).

The scatter radiation emitted from the patient and radiation leakage from the X-ray tube are responsible for the biological effects in the operating theatre personnel and are considered occupational exposure (Hartzis *et al*. 2012: 41). Several studies have been conducted internationally to ensure that health workers working in fluoroscopy-guided operating theatres do not receive radiation doses above the set dose limits (Rhea, Rogers and Riehl 2015; Cecen *et al.* 2015: 297; Van der Merwe 2012; Moore and Heeckt 2011: 2; Ho *et al*. 2007: 455; Lynskey III *et al*. 2013: 1549). The studies were conducted for the different professional categories (surgical and non-surgical) and different body parts such as the thyroid, eye, chest and pelvic area (Rhea, Rogers and Riehl 2015; Cecen *et al.* 2015: 297; Van der Merwe 2012; Moore and Heeckt 2011: 2; Ho *et al*. 2007: 455; Lynskey III *et al*. 2013: 1549).

According to Rhea, Rogers and Riehl (2015) several studies have indicated equivalent and effective doses to be significantly low for personnel, specifically anaesthetists working at a distance of 1.5 m from the C-arm. However, the surgeons are noted to receive higher radiation doses as they are close to the patient and the C-arm (Rhea, Rogers and Riehl 2015). Results from a study conducted by Cecen *et al.* (2015: 297) indicated 90.5 mrem measured at the foot of the table and 68.17 mrem at the head of the table. Radiation doses dropped significantly with an increase in the distance from the table in either direction (Cecen *et al.* 2015: 299). Van der Merwe (2012) conducted similar studies on an orthopaedic surgeon, gastroenterologist and neurosurgeon in the Free State, South Africa. The highest radiation doses were noted for the neurosurgeon mostly with the X-ray tube above the theatre table (65.68 mSv) as opposed to when it was below the X-ray table (0.84 mSv) (Van der Merwe 2012). Furthermore, Van der Merwe (2012) concluded that radiation doses with the X-ray tube above the theatre table during back pain procedures exceeded the occupational annual dose limit of 500 mSv to the hands, raising the need for proper C-arm positioning techniques to reduce radiation dose, as indicated by the HPCSA (2014/15: 9).

According to Moore and Heeckt (2011: 2) the radiation exposure estimate for pelvic fluoroscopy with a regular C-arm is 4.0 rad/min and that for fluoroscopy with a mini C-arm is 0.12 – 0.4 rad/min. This is quite high compared to radiation exposure estimates for a chest radiograph, which is 0.025 rad (Moore and Heeckt 2011: 2). Doses recorded in a study on vascular surgeons in China report ranges of 0.13 to 0.27 mSv to the body, 0.10 to 0.33 mSv to the eye and 0.29 to 1.84 mSv to the hands (Ho *et al*. 2007: 455). Generalising the results from several studies indicates that the hands receive higher amounts of radiation dose than eye lens, as documented in theory (Ho *et al*. 2007: 455; Lynskey III *et al*. 2013: 1549). Lynskey III *et al*. (2013: 1549) indicate that the threshold effect of radiation on the ocular lens is not correct as the organ is probably more sensitive to radiation than is perceived. In theory, the thyroid is considered to be very sensitive but low radiation doses are recorded for it in comparison to the hands, as indicated by Ho *et al*. (2007: 455), Van der Merwe (2012) and Abu Shab (2005).

Significant discrepancies were also observed for the average hand dose per minute among different surgeons (Ho *et al*. 2007: 457), raising the issue of radiation dose received by different body parts being dependent on an individual's radiation protection practices. Ho *et al*. (2007: 457) point out that the surgeons measuring the highest hand doses were not moving their hands to outside the X-ray field during exposures. This could possibly be the reason for the high hand doses noted by Van der Merwe (2012). The approximate surgeon radiation dose per procedure with a 0.5 mm lead apron worn for an orthopaedic hip procedure of 25 sec screening time is 5 µSv/procedure, 21 µSv for an orthopaedic spine procedure and 250 µSv for kyphoplasty (IAEA n.d.). In South Africa a dosimetry study conducted at King Edward VIII Hospital in Durban revealed an overall mean radiation of 0.22 mSv to the hands, 0.20 mSv to the thyroid gland and 0.010 mSv to the whole body, with average operating and screening times of 77 minutes and 3.26 minutes respectively during 96 internal fixations of the lower limbs (Abu Shab 2005). These results correlate with those of Van der Merwe's (2012) study, measuring 1.87 mSv at the thyroid, 0.34 mSv at the umbilical region under the lead apron and 5.98 mSv outside the lead apron.

The radiation doses associated with fluoroscopy-guided procedures can be high enough to cause skin injuries and perhaps cancer in later years, justifying the need to implement radiation protection guidelines in the operating theatre (IAEA 2013).

2.8 Radiation protection implementation

The use of fluoroscopy in surgical procedures provides significant benefit to the patient but high occupational exposure to the staff as they are in close proximity to the patient during exposure (Le Heron *et. al.* 2010). Panchbhavi (2018) also point out that the prolonged radiation exposure time involved with some of these complicated surgical procedures poses a greater risk to the staff, with the possibility of exceeding the recommended annual dose limits as indicated by Van der Merwe (2012). Therefore every non-radiology department utilising fluoroscopy needs to have adequate radiation protection measures in place (Panchbhavi 2018).

Establishing the foundation for occupational radiation protection, the ICRP (2007: 103; 88-89) identified the three basic principles of radiation protection as justification, optimisation and dose limitation. Le Heron *et al.* (2010) and the

National Cancer Institute (2005a:1) agree that in practice application of optimisation and dose limitation principles are arguably the most important. Table 2.4 outlines the strategies that can be implemented to achieve optimisation and dose limitation.

Table 2.4: Strategies to manage radiation dose to patients and operators

IMMEDIATE	LONG TERM
OPTIMISE DOSE TO PATIENT	
Use proper radiological technique: • Maximise distance between X-ray tube and patient • Minimise distance between patient and image receptor • Limit use of electronic magnification **Control fluoroscopy time:** • Limit use to necessary evaluation of moving structures • Employ last-image-hold to review findings **Control images:** • Limit acquisition to essential diagnostic and documentation purposes **Reduce dose:** • Reduce field size (collimate) and minimise field overlap • Use pulsed fluoroscopy and low frame rate	Include medical physicists in decisions: • Machine selection and maintenance Incorporate dose-reduction technologies and dose-measurement devices in equipment Establish a facility quality improvement programme that includes an appropriate X-ray equipment quality assurance programme, overseen by a medical physicist, which includes equipment evaluation/inspection at appropriate intervals
MINIMISE DOSE TO OPERATORS AND STAFF	
Keep hands out of the beam **Use moveable shields** **Maintain awareness of body position relative to the X-ray beam:** • Horizontal X-ray beam – operator and staff should stand on the side of the image receptor. • Vertical X-ray beam – the image receptor should be above the table **Wear adequate protection** • Protective well-fitted lead apron • Leaded glasses	Improve ergonomics of operators and staff: • Train operators and staff in ergonomically good positioning when using fluoroscopy equipment; periodically assess their practice • Identify and provide the ergonomically best personal protective gear for operators and staff • Urge manufacturers to develop ergonomically improved personal protective gear • Recommend research to improve ergonomics for personal protective gear

Adapted from the National Cancer Institute (2005a: 3).

Comment [L8]: 2005a or 2005b?

According to the HPCSA (2014/15: 9) the Radiation Control division of the South African Department of Health has strict fluoroscopy radiation protection guidelines and rules. The guidelines emphasise that the C-arm equipment should be operated by a licensed radiographer or radiologist only (HPCSA 2014/15: 9). The other rules include recording and filing of screening times as well as use of pulsed fluoroscopy instead of continuous so as to lower both screening time and radiation dose (HPCSA 2014/15: 9). The principle of 'As Low As Reasonably Achievable' (ALARA) assists in reducing the stochastic risks to an absolute minimum and can be implemented by keeping exposure times as short as possible (Panchbhavi 2018). Furthermore, Le Heron *et al.* (2010) stress the need to provide staff with adequate radiation protection education and training as applicable to specific situations.

A number of academics have investigated the use of the distance rule as a radiation protection measure, as several healthcare staff complain that lead aprons are heavy to wear considering how long the theatre screening cases can be (Rhea, Rogers and Riehl 2015). A systematic review conducted by Rhea, Rogers and Riehl (2015) for studies conducted between January 1980 and May 2015 concluded that there is either no radiation dose at all or a very negligible amount recorded at 1.5 m from the C-arm during orthopaedic surgery. Rhea, Rogers and Riehl (2015) therefore concluded that there is no need to wear a lead apron for staff working beyond 1.5 m from the C-arm during orthopaedic theatre screening. However, Cecen *et al*. (2015) argue that although low doses were also recorded in their study, there is still a need to wear lead aprons as accumulative radiation exposure regardless of dose levels can have a carcinogenic effect on skin, eyes and gonads over the long term.

Anecdotal evidence suggests that the abovementioned radiation protection principles are just theory-based as there are reportedly inadequate radiation protection practices such as non-usage of lead aprons and operation of the C-arm by any other personnel in the operating theatre (Sherer *et al.* 2014: 64).

2.9 Radiation protection amongst non-radiology staff

KAP surveys on radiation knowledge have been conducted in several countries, with most of them studying the radiology staff (Lynskey III *et al*. 2013: 1549). Other radiation KAP surveys have been conducted on non-radiology doctors in Brazil and intensive care nurses in Iran (Madrigano *et al*. 2014, Dianati *et al.* 2014). The majority of the participants in these studies indicated poor radiation awareness (Madrigano *et al*. 2014; Dianati *et al.* 2014).

A number of studies have specifically investigated fluoroscopy-utilising departments, with orthopaedics being the most frequently targeted group because fluoroscopy is considered indispensable during orthopaedic surgery (Moore and Heeckt 2011: 1; Khan *et al*. 2010: 1; Palacia *et al*. 2014: 228; Rosario *et al*. 2015). In the UK studies revealed that most surgical trainees lack the essential radiation protection knowledge concerning adherence to rules and regulations and safe practice (Khan *et al*. 2010: 1; Palacia *et al*. 2014: 228). A KAP survey conducted amongst orthopaedic surgical trainees in the Philippines also showed poor radiation protection knowledge and practices (Rosario *et al.* 2015). Royal (2015: 586) and the National Cancer Institute (2005a: 1) agree that despite the increasing use of radiation in medicine, most professionals lack knowledge about the significance and effects of radiation exposure. A recent survey conducted amongst orthopaedic surgeons in Turkey revealed inadequate knowledge of the risks of fluoroscopy and radiation protection (Tunçer *et al*. 2017).

Comment [L9]: a or b?

Other studies have investigated the radiation KAP amongst theatre nursing staff in Sao Paulo State, Brazil and Nigeria (Querido and Poveda 2014; Luntsi *et al*. 2016). A descriptive cross-sectional survey questionnaire distributed amongst nurses in Maiduguri Metropolis, Nigeria gathered different results from the norm, revealing that the nurses in that region had good knowledge of ionising radiation but below average attitude towards radiation protection (Luntsi *et al*. 2016). Luntsi *et* al. (2016) reasoned that the good knowledge results were attributed to the staff having high professional qualifications but poor misconceptions about radiation, hence the poor attitude towards radiation

Comment [L10]: pls check spelling

protection. Lastly, interviews conducted by Querido and Poveda (2014) in selected medical institutions in Sao Paulo State, Brazil indicated poor implementation of radiation protection guidelines by the nursing staff.

Several fluoroscopy-based studies have been conducted in South Africa with most of them investigating the radiation doses received by either the patient or the operating surgeon (Van der Merwe 2012; Nyathi *et al.* 2009). However, no KAP studies have been conducted to deduce the compliance of the theatre staff with the recommended radiation protection measures (Wambani *et al*. 2014). This KAP survey sought to address this gap in the South African literature and to provide evidence-based baseline information that could be used to enhance social and behavioural radiation protection change amongst the non-radiology surgical staff, as described in the methodology chapter that follows.

2.10 Theoretical framework

Theories have been used for decades to help explain and change various human behaviours. They have proved to be useful in establishing links between health behaviours and beliefs in health education studies (National Cancer Institute. 2005b: 5). The relationships between radiation protection attitude and practices of the staff will be related to the Theory of Planned Behaviour (TPB), because it has proven to explore the relationships between health behaviour, beliefs, attitudes and intentions (National Cancer Institute. 2005b: 16). This has been indicated in weight control studies and KAP studies on HIV/AIDS prevention and condom use in several locations (Montanaro 2011: 4; Taylor *et al.* 2007: 8). Being an explanatory health behaviour theory, it can be used as a road map to aid in identifying needs, problems and barriers (National Cancer Institute. 2005b: 5; WHO 2012: 19) in the radiation protection practice amongst the staff being studied.

In 1985 Icek Ajzen formulated the TPB from the theory of reasoned action by adding the perceived behavioural control aspect (Ajzen 1985; University of Twente 2012). This was after establishing that behaviour cannot be 100%

voluntary and under control (University of Twente 2012). According to the TPB the best predictor of behaviour is intention (WHO 2012: 28). Ajzen (1993: 49) was convinced that behavioural intention is influenced by a person's attitude toward performing the behaviour, by the degree of perceived behavioural control and by beliefs about whether individuals who are important to the person approve or disapprove of the behaviour.

In this case, the likelihood of the staff wearing radiation protective clothing and applying other necessary radiation protection measures is predicted by their intention to practise radiation protection. The intention to practise radiation protection is in turn influenced by their attitude towards radiation protection, their perceived ability to control occupational radiation exposure levels, and how their colleagues and management perceive radiation protection practice. The staff's attitude towards radiation protection practice can either be positive or negative, depending on their belief regarding the outcome of its practice. Believing that radiation protection practice prevents radiation-induced cancer instils a positive attitude in the individual, increasing their chances of probably incorporating radiation protection in their daily practice. Increased radiation protection awareness amongst the staff encourages its implementation in daily practice, as they perceive that the management and colleagues highly approve of this behaviour. Table 2.5 explains the concepts associated with the TPB and its application to the current study.

Table 2.5: Concepts of the TPB

Concept	Definition	Measurement approach	Application to the current study
1. **Behavioural intention**	Perceived likelihood of performing behaviour	Are you likely to (perform the behaviour)?	Is the staff likely to wear protective clothing and apply necessary radiation protection measures?
2. **Attitude**	Personal evaluation of the behaviour	Do you see (the behaviour) as good, neutral or bad?	What is the staff's perception about radiation protection practice?
3. **Subjective norm**	Beliefs about whether key people approve or disapprove of the behaviour; motivation to behave in a way that gains their approval	Do you agree or disagree that most people approve of/disapprove (of the behaviour)?	Do the hospital authorities and colleagues approve or disapprove of the radiation protection measures?
4. **Perceived Behavioural Control**	Belief that one has, and can exercise, control over performing the behaviour	Do you believe (performing the behaviour) is up to you, or not up to you?	Does the staff believe that they can control their occupational radiation exposure by practising radiation protection?

Adapted from WHO (2012: 29) and National Cancer Institute (2005b: 17).

2.11 Summary

A detailed analysis of the available literature relating to radiation protection in non-radiology departments has been presented. The current discourse leading to the need to carry out this study has also been presented. The following chapter outlines how data were collected to address the study's objectives.

Chapter Three

Methodology

3.1 Introduction

This chapter describes the research paradigm, design, approach, sampling techniques and theoretical framework used in this study. The data analysis techniques and ways of ensuring validity and reliability of the study are also presented.

3.2 Research paradigm

O'Brien and Collins (2003) define paradigms as complex sets of fundamental beliefs that are used to define people's general perspective of the world. Creswell (2014: 35) refers to them as "worldviews" that express the philosophical assumptions about the world and the nature of research that the researcher incorporates into a study. According to Polit and Beck (2017: 9) research paradigms are differentiated according to the believed nature of reality, known as ontology, and the relationship between the researcher and the phenomenon being studied, referred to as epistemology.

Based on the nature of the research problem and the aim to obtain statistical numerical data that could be generalised to the non-radiology staff, this research study adopted a positivist paradigmatic position. According to Dash (2005) in the early 19th century the French philosopher August Comte emphasised observation and reason as means of understanding human behaviour, forming the base of positivism. The Robert Wood Johnson Foundation (2008) notes that a positivist paradigm is founded on realistic ontology, representational epistemology and quantitative methodology. Wisker (2008: 67) and Polit and Beck (2017: 9) explain that positivists hold on to the assumption that the world is knowable and that through research reality can be known.

Polit and Beck (2017: 9) and Dudovskiy (2018) further point out that positivist paradigms often involve the use of existing theory to develop hypotheses that are tested to generate quantitative data from large representative samples. This was applicable to the current study as two null hypotheses had to be tested through collection of data from a sample of 179 respondents. Wisker (2008: 68-9) concludes that although studies that adopt the positivist worldview are characterised by low validity scores, the reliability is high and the research findings are generalisable to the study population. As indicated by Robert (1998), implementation of the positivist paradigm allowed the three variables (knowledge, attitude and practice) to be researched and described objectively without the researcher interfering with the phenomena being studied and hence minimising bias.

3.3 Research approach

As indicated by Creswell (2014: 31, 49), the choice of research approach in this study was influenced by the paradigmatic positioning of the study, the research design, and research questions as well as the data collection and analysis techniques. Creswell (2014: 36) highlighted that positivism assumptions hold true more for quantitative research than qualitative research. The Robert Wood Johnson Foundation (2008) supported that by indicating that positivist approaches rely heavily on experimental and manipulative methods and hence quantitative methods are used.

The quantitative approach, as defined by Regoniel (2015), is a research method that quantifies variables for the basis of making generalisations about a phenomenon. Considering the nature of this study, which intended to quantify the variables (KAP), establish their correlations in relation to the TPB and statistically generalise the findings to the non-radiology staff, the quantitative approach was found best suited to address the set objectives. The deductive quantitative methodology with a few open-ended descriptive questions allowed the researcher to grasp the point of view of the respondents. The answers to the few open-ended research questions were analysed qualitatively.

3.4 Research design

Research design is defined by Labaree (2009) as a plan implemented to address research problems in a study. An analytical cross-sectional survey design was adopted for this study as it allowed the researcher to study all of the three variables, knowledge, attitude and practices, at the same time. The research design provided data about frequencies and percentages on a large scale without interfering with the subjects, as indicated by the Institute for Work and Health (2015). The International Agency for Research on Cancer (1999) adds that cross-sectional surveys are also useful in assessing practices, attitudes and knowledge of a population in relation to a particular health event, making it the ideal design for this study. The Institute for Work and Health (2015) indicates that cross-sectional studies can be conducted over a shorter period of time compared to longitudinal studies. Furthermore, cross-sectional surveys allow correlations between variables and differences between subgroups in the population to be examined (Visser *et al.* 2013: 404). This was essential in order to meet the second objective of this study.

However, the Institute for Work and Health (2015) argues that cross-sectional studies may not provide enough information about cause-and-effect relationships in a study as they are conducted at a single moment in time. Therefore, the causes of the KAP results were not revealed as they were not the objectives of this study. Visser *et al.* (2013: 225) also argue that for survey methods, sampling errors and validity can limit the accuracy of the results obtained. For the current research, external validity was ensured by utilising the stratified random sampling technique to obtain a heterogeneous sample that was representative of the population and by piloting the questionnaire to test face validity.

3.5 Study population

According to Polit and Beck (2017: 56) the study population refers to all the individuals or objects with common defining characteristics under study. The population in this study was the non-radiology healthcare staff working in fluoroscopy-guided operating theatres at the following public health institutions in eThekwini district of KZN: King Edward VIII Hospital, King Dinuzulu Hospital, Addington Hospital, Prince Mshiyeni Memorial Hospital, Inkosi Albert Luthuli Central Hospital and R.K. Khan Hospital.

The population size was 332 which comprised 213 doctors and 119 theatre nurses. The doctors' category constituted consultants, registrars and medical officers. Refer to Appendix I: Study population and sample size, for each hospital's population size. The researcher identified the population by enquiring about the staff statistics with the relevant departments. Registrar statistics were obtained from King Edward VIII Hospital Human Resources department. The inclusion and exclusion criteria were as follows:

Inclusion criteria:

- Health professionals working in fluoroscopy-guided surgical theatres;
- Surgeons, theatre nurses and anaesthetists; and
- Both males and females, all races.

Exclusion criteria:

- Radiology staff allocated to the operating theatres; and
- Administration staff and cleaners. These were excluded as they do not enter the theatre rooms during operating (surgical) procedures.

3.6 Sampling

Defined as a process of selecting elements of a population for inclusion in a research investigation, some types of sampling increase the study's validity and reliability (O'leary 2017: 203). O'leary (2017: 203) adds on that this allows the results of the sample to be generalised to the population under study. Taking into consideration the importance of a heterogeneous sample, the stratified random sampling technique was utilised. For the current study the population was firstly categorised into two strata according to their professions. The nurses' strata and doctors' strata were made up of 119 and 213 people respectively. Respondents from these two strata were then randomly selected for each hospital, as outlined in Appendix H. Randomly selecting respondents gives each individual an equal chance of being chosen (Creswell 2014: 204). Based on the accepted margin error of 5%, a confidence level of 95% and response distribution of 50%, the sample size was 179 which comprised 115 doctors and 64 nurses.

3.7 Research setting

The researcher personally delivered the questionnaires to all of the departments at the six selected hospitals to ensure a higher response rate and also to allow respondents to ask questions (Polit and Beck 2017: 280). The self-administered questionnaires and informed consent forms with information sheets were distributed during the departmental or category meetings. Oliver (2010: 84) addresses the need for data to be collected in as naturalistic a setting as possible. Davies and Logan (2012: 15) add that it aids in avoiding interference by confounding variables such as the presence of the researcher. The researcher therefore allowed the respondents to complete the questionnaire individually and in their own space. After completion the researcher personally collected the questionnaires.

3.8 Research instrument

The research instrument refers to the tool used to collect data in a research study (Polit and Beck 2017: 175). Considering the positivistic worldview and the deductive quantitative methodology positioning of this study, a modified questionnaire proved to be the suitable data collection instrument (Wisker 2008: 187). Polit and Beck (2012: 275) noted that questionnaires make a golden tool for cross-sectional surveys as they can be used to obtain data from a large population size, involving less time and expense and with no interviewer bias. Brink, Van der Walt and Van Rensburg (2012: 153) add that due to the anonymity involved with the administration of questionnaires, participants tend to provide honest responses (which is one of the assumptions of this study). However, Brink, Van der Walt and Van Rensburg (2012: 153) argue that although questionnaires prove to be easier to test for reliability and validity, the response rates are usually very low. Wisker (2008: 187) explains that this is usually due to potential respondents' stereotyped view of questionnaires as being long and boring. To address this issue the researcher prepared a 6-page questionnaire covering all of the objectives under investigation. Polit and Beck (2017: 276) further argue that questionnaires do not allow the researcher to clarify any questions that respondents may find difficult to understand. A pilot study was therefore performed to test the face validity of the distributed questionnaire. However, no major corrections were made as only minor spelling and typing errors were noted.

The self-administered questionnaire (Appendix J) comprised 53 questions categorised into six sections investigating the biographical and demographical data, knowledge of radiation protection, attitude towards radiation protection, intention to practise radiation protection, and practice of radiation protection amongst the non-radiology surgical staff. The quantitative closed questions included marked semantic differential scales and five-point Likert scales.

3.9 Validity and reliability

Validity and reliability were taken into account throughout the entire research process to ensure that accurate data to address the set research questions were obtained. The researcher utilised the stratified random sampling technique to obtain a representative sample of the population under study. Trochim (2006) indicates that this improves external validity.

3.9.1 Reliability

Phelan and Wren (2006) define reliability as the degree to which a data collection tool produces stable and consistent results. Fullerton (1993) goes on to emphasise that a replicable measuring instrument should demonstrate the least degree of measurement error. Reliability of the questionnaire was ensured by stating the questions in simple English for easy understanding by the respondents, as this has a direct impact on the outcome (Mathers, Fox and Hunn 2009: 24). The questionnaire also included more than five questions to measure each of the three variables knowledge, attitude and practice. Furthermore, the internal consistency method was adopted by making use of Cronbach's alpha statistic to ensure repeatability of the questionnaire (Trochim 2006). The constructs of the study were clearly defined to minimise random error to 5%.

3.9.2 Validity

Heale and Twycross (2015) define validity as the extent to which a concept is accurately measured in a quantitative study. The instrument that was utilised managed to measure and determine the KAP relating to non-radiology staff in fluoroscopy-guided operating theatres at public health institutions in the eThekwini district of KZN, as intended. Defined by Heale and Twycross (2015) as a measure to ensure that the instrument is representative of the content associated with the variable under investigation, content validity was implemented through face validity. In accordance with Fullerton (1993), who states that content validity is determined logically rather than statistically, and Biddix's (2009) recommendations, the questionnaire was piloted amongst experts in the non-radiology fluoroscopy- utilising operating theatre departments. The experts were asked to review the questionnaire to ensure that it would determine radiation protection KAP levels. The respondents did not participate in the final data collection.

A separate suggestion sheet, Appendix K, was attached for comments on any changes that would benefit the study. The experts gave positive feedback and overall agreement that the questionnaire was ideal to determine radiation protection KAP amongst these staff members. Only spelling and typing errors were noted.

3.10 Ethical considerations

Emerging during the World War II research ethics has become a fundamental part of every research study involving human subjects, in order to protect their rights and dignity (Wisker 2008: 86). Several ethical themes were taken into consideration during this research study to warrant compliance with the ethical requirements of medical research.

In accordance with the Declaration of Helsinki General Principles number 23 and 35 (World Medical Association 2013: 2-3), ethical clearance was obtained from the IREC before conducting the study. Following IREC approval (Appendix F) the research proposal was registered on the National Health Research database in order to formally receive gatekeeper permission from the Department of Health (Appendix A). Further permission was granted by the CEOs of the six hospitals (Appendix B), and the Health District Manager (Appendix G) as well as the Hospital Heads of Departments (Appendix C). To incorporate the British Sociological Association Ethical Principle number 28 (British Sociological Association 2006: 4) and the Declaration of Helsinki General Principle number 26 (World Medical Association 2013: 3), the respondents gave written consent (Appendix E) to participate in the study after reading the attached letter of information (Appendix D). The letter of information explained the aims of the study and the data collection procedure to be utilised. It further elaborated to the potential respondents that participating in the study was voluntary and did not include any risks or benefits, and that they had the right to withdraw from the study at any point.

Privacy and confidentiality of the respondents were addressed in accordance with the Declaration of Helsinki, General Principle number 24 (World Medical Association 2013: 2) by ensuring anonymity of the respondents. To anonymise the study no respondent names were required, and instead numbers were used to identify them. Anonymity of the respondents, a cornerstone of research ethics (Oliver 2010: 77), was observed to ensure objectivity amongst the respondents and hence provision of honest responses, as indicated by Oliver (2010: 77): “the anonymity frees them to express their true feelings’’. For this study only the researcher, supervisor and statistician had access to the confidential primary data, which will be stored in a secure place by the researcher for 5 years, after which they will be shredded. Electronic documents will be stored in a password-protected computer and hard drive for 5 years, after which they will be transferred to an external electronic media device. This is in accordance with the British Sociological Association Ethical Principle number 46 (British Sociological Association 2006: 6), which further illustrates in Ethical Principle number five (British Sociological Association 2006:1) the importance of presenting the study outcomes accurately and truthfully, as ensured in this research study by the preceding measures. Lastly, the respondents will have access to this study's outcomes (World Medical Association 2013: 3) through DUT's online research database portal.

Comment [L11]: number?

3.11 Data collection

After ethical issues had been ensured and gatekeeper permissions had been granted, data were collected over 12 weeks, as summarised in Figure 3.1.

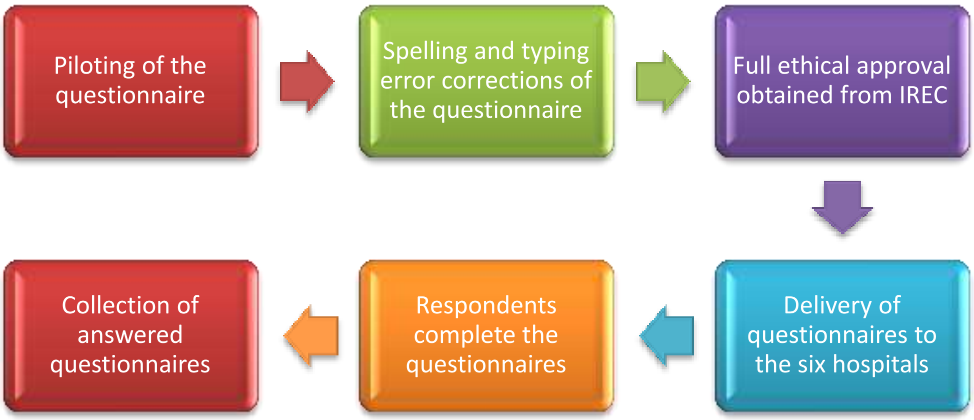

Figure 3.1: Data collection process.

As illustrated in Figure 3.1, the questionnaire was piloted in January 2018 to help the researcher identify any unforeseen challenges, and to test the feasibility of the study and the ability of the questionnaire to provide answers to the research questions. Noted spelling errors were corrected and the questionnaire was submitted for ethical approval. After full ethical approval and gatekeeper permissions were obtained, as explained earlier, the self-administered questionnaire was delivered to the six hospitals and collected by the researcher after 12 weeks.

3.12 Data analysis

The Organisation for Economic Co-operation and Development (2013) and Business dictionary (2018) define data analysis as a process of evaluating, describing and illustrating raw data using analytical and logical reasoning to draw conclusions about findings as well as to add value to the statistical output. The type of statistical analysis implemented in the current study was determined by the data generated by each question. Muller (2013) mentions that the data analysis technique and questionnaire design used determine the type of research question or hypotheses that can be addressed. For the current study, the following were applicable:

- Parametric and non-parametric statistics were utilised.
- Categorical data on biographical items, including age and gender, were presented as frequency tables and graphs and analysed using descriptive statistical techniques. These included bar graphs, pie charts, and calculation of mean, mode, median and range of scores.
- The parametric test ANOVA (analysis of one-way variance) was used to compare the groups: surgeons, registrars, medical officers and nurses (Smith 2013: 2).
- Considering that the sample size was less than 1000, bivariate correlations between variables were tested through use of Fisher's exact test (McDonald 2014). The correlation coefficient was set at -1.0 to +1.0. Cross-tabulations were performed to determine significant relationships between variables. The level of significance used was $p < 0.05$.
- Inferential statistics were used to draw conclusions about the population from which the sample was taken. Inferences within a stratum and comparisons across strata were made using the computer software SPSS version 25.0.

- The qualitative data obtained from the open-ended descriptive questions were coded, themed under categories and presented in tables and figures.

3.13 Theoretical framework

The relationships between the radiation protection KAP of the staff were related to the TPB, as explained earlier in chapter two. The four concepts associated with the TPB were tested in this study through various questions in three categories of the questionnaire. Table 3.1 explains the concepts associated with the TPB and how they were tested in the current study.

Table 3.1: Concepts of the TPB

Concept	Definition	Measurement approach	Application to the current study
Behavioural intention	Perceived likelihood of performing behaviour	Are you likely to (perform the behaviour)?	This concept was tested through questions in Sections C and D investigating how likely the staff are to make use of protective wear, to plan as well as to put in an effort to make use of the protective wear
Attitude	Personal evaluation of the behaviour	Do you see (the behaviour) as good, neutral or bad?	This was addressed in Section C which measured the respondents' perceptions and attitudes towards radiation protection practice
Subjective norm	Beliefs about whether key people approve or disapprove of the behaviour; motivation to behave in a way that gains their approval	Do you agree or disagree that most people approve of/disapprove (of the behaviour)?	Respondents were asked in Questions B23, B22, E48 and F52 if their departments have radiation safety policies in place, as these determine if the management approves radiation safety regulations
Perceived behavioural control	Belief that one has, and can exercise, control over performing the behaviour	Do you believe (performing the behaviour) is up to you, or not up to you?	Respondents were investigated as to their radiation protection practices and their perceived outcomes in Questions C27, C28 and C29

Adapted from WHO (2012: 29) and National Cancer Institute (2005b: 17).

3.14 Summary

An account of the data collection process has been presented. Justifications for the choice of methodology, research tool and associated data collection measures have also been outlined. The proceeding chapter presents the outcome from this data collection process.

Chapter Four

Results

4.1 Introduction

This chapter presents the statistical data obtained from the questionnaires distributed amongst non-radiology staff working in fluoroscopy-guided operating theatres in the eThekwini district of KZN. The study intended to determine this staff's KAP towards radiation protection and the correlation between KAP, intention to practise and demographic factors.

The questionnaire was the primary data collection tool. The data collected from the responses were analysed using SPSS version 25.0. The results will present the descriptive statistics in the form of graphs, cross-tabulations and other figures for the quantitative data that were collected. Inferential techniques included use of Pearson's correlation test, the Chi-square test and Fisher's exact test, which are interpreted using the p-values. The level of significance was set at $p < 0.05$.

4.2 Response rate

In total 179 questionnaires were distributed and 98 were returned, resulting in a 54.7% response rate. All of the returned questionnaires were usable for data analysis although some of the participants did not respond to a few questions. For these questions $n < 98$ as indicated in the proceeding sections.

4.3 The research instrument

The questionnaire consisted of 53 items, with a level of measurement at a nominal or an ordinal level. The questionnaire was divided into six sections which measured various themes as follows:

- Section A: Biographical data
- Section B: Knowledge of radiation protection

- Section C: Attitude towards radiation protection
- Section D: Intention to practise radiation protection
- Section E: Practice of radiation protection
- Section F: General.

4.4 Reliability statistics

Reliability and validity constitute the two most significant aspects of a measurement's accuracy (Hopkins 2000). Reliability is computed by repeatedly measuring the same phenomenon in the same sample (Hopkins 2000). The internal consistency method was adopted by making use of Cronbach's alpha statistic to ensure repeatability of the questionnaire (Trochim 2006). A reliability coefficient of 0.60 or higher is considered as 'acceptable' for a newly developed construct (Loewenthal 2004).

The information below reflects the Cronbach's alpha score for all of the items (Sections B to E) that constituted the questionnaire.

Section B (Questions 11 - 23)

Reliability statistics

Cronbach's Alpha	N of Items
0.607	13

Section C (Questions 30 - 34)

Reliability statistics

Cronbach's Alpha	N of Items
0.603	5

Section D (Questions 37 – 39)

Reliability statistics

Cronbach's Alpha	N of Items
0.886	3

Section E (Questions 40 - 49)

Reliability statistics

Cronbach's Alpha	N of Items
0.611	10

The reliability scores for all sections exceed the recommended Cronbach's alpha value. This indicated a degree of acceptable, consistent scoring for these sections of the research.

To determine whether the scoring patterns per statement were significantly different per option, a Chi-square test was done. The null hypothesis claims that similar numbers of respondents score similarly across each option for each statement (one statement at a time) (Helmenstine 2017). The alternate hypothesis states that there is a significant difference between the levels of agreement and disagreement (Helmenstine 2017).

The results are presented according to the six sections mentioned earlier.

4.5 Section A: Biographical data

This section summarises the biographical characteristics of the respondents. Table 4.1 illustrates the overall age distribution by gender.

Table 4.1: Age distribution by gender

Gender	N	Mean	Std. Deviation	Minimum	Maximum
Female	64	37.89	9.52	23.00	64.00
Male	33	39.58	9.44	26.00	68.00
Total	97	38.46	9.47	23.00	68.00

Overall, the ratio of males to females is approximately 1:2 (33.7%: 66.3%) (Table 4.1). One respondent refused to disclose the age therefore only 97 respondents were considered for this question. The average age of the male respondents was 39.58 ± 9.44 years, whilst that for females was 37.89 ± 9.52

years. There was no significant difference between the gender by age (p = 0.409). However, there were significantly more female respondents than male respondents (p = 0.001).

Table 4.2: Hospitals where respondents are working

	Frequency (n)	Percent (%)
King Edward VIII Hospital	19	19.6
King Dinizulu V Hospital	6	6.2
R.K Khan Hospital	16	16.5
Prince Mshiyeni Hospital	22	22.7
Addington Hospital	7	7.2
Inkhosi Albert Luthuli Central Hospital	27	27.8
Total	**97**	**100.0**

Table 4.2 indicates the hospitals at which the respondents are working. One respondent indicated more than one hospital, resulting in only 97 respondents being considered for this question. Most of the respondents, (n = 27, 27.8%) are working at Inkosi Albert Luthuli Central Hospital whilst the least number of respondents (n = 6, 6.2%) are working at King Dinizulu V Hospital. There was a significant difference in the sample composition according to the hospitals at which they are working (p = 0.001).

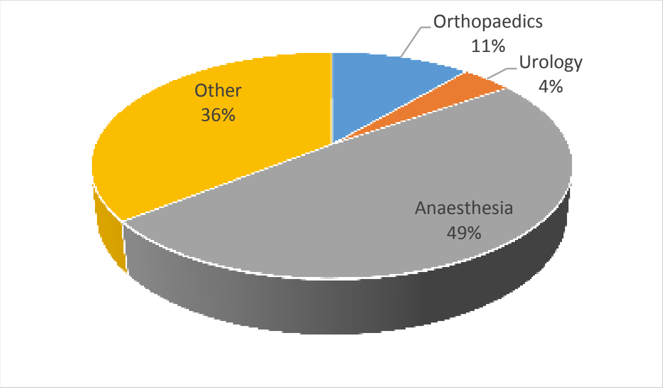

Figure 4.1: Area of speciality.

Figure 4.1 indicates the areas of speciality that respondents hold. Approximately half of the respondents are based in the anaesthetics speciality (49.0%) with a little more than a third being 'Other' (35.7%). The category 'other' was constituted of paediatrics, all-rounders (nurses who rotate through all the departments), operating theatre, general surgery and paediatrics surgery specialists. There was a significant difference in the sample composition by specialisation (p < 0.001).

There were almost similar numbers of respondents with diplomas (n = 32, 34%) and degrees (n = 36, 38%). Only one (n = 1, 1.1%) respondent possessed a PhD qualification whilst 11% and 16% had a certificate or masters qualification respectively.

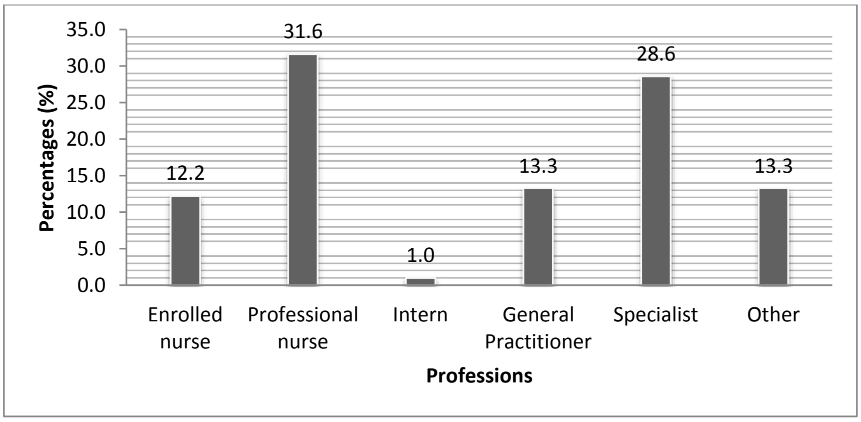

Figure 4.2: Distribution by profession.

Figure 4.2 illustrates the professions of the respondents. The majority of the respondents (43.8%) were nurses (professional and enrolled) and the least number were intern doctors (n = 1, 1%). The professionals categorised as 'Other', constituting (13.3%) of the respondents, included registrars and clinical technologists. Specialists included orthopaedic surgeons, paediatric surgeons, urologists and anaesthetists. There is a significant difference in the sample composition by profession (p < 0.001).

Table 4.3: Years of experience in the speciality area

Profession	N	Mean	Std Deviation	Minimum	Maximum	Range
Enrolled nurse	12	6.8333	7.99811	1.00	20.00	19.00
Professional nurse	31	13.0968	8.17865	1.00	34.00	33.00
Intern	1	2.0000	.	2.00	2.00	0.00
General practitioner	13	7.6154	9.23344	1.00	37.00	36.00
Specialist	27	10.3704	7.13684	1.00	30.00	29.00
Other	13	7.1538	3.43623	3.00	14.00	11.00
Total	**97**	**9.9175**	**7.81514**	**1.00**	**37.00**	**36.00**

Table 4.3 indicates the number of years of experience in these speciality areas. The professional nurses had the highest mean years of experience (13.1 +/-8.2 years). The most experienced respondent was a general practitioner with 37 years of experience in the speciality area. There is a significant difference in the sample structure by years of experience in their speciality areas ($p = 0.001$).

Significantly more respondents (82.7%) work in theatre more than three days per week, whilst 6.1% and 11.2% work three days per week and less than three days per week respectively ($p < 0.001$). Table 4.4 outlines how often the respondents use fluoroscopy (screening) during surgical procedures per week.

Table 4.4: How often respondents use fluoroscopy (screening) during surgical procedures per week

	Frequency (n)	Percentage (%)
For 0 cases	2	2.0
For 1-3 procedures	41	41.8
For 4-7 procedures	38	38.8
For 8-10 procedures	9	9.2
For more than 10 cases per week	8	8.2
Total	98	100.0

The majority of the respondents (n=41, 41.8%) use fluoroscopy during 1-3 surgical procedures per week (Table 4.4). There is a significant difference as there are more respondents with less than 8 procedures ($p < 0.001$).

4.6 Section analysis

This section that follows analyses the scoring patterns of the respondents per variable per section. The results to closed-ended questions are first presented using summarised percentages for the variables that constitute each section. Results are then further analysed according to the importance of the statements. For ease of interpretation of closed-ended statements the responses 'Strongly Disagree' and 'Disagree' are considered as 'Disagree' whilst 'Agree' and 'Strongly Agree' are considered as 'Agree' for discussion and scoring purposes only. Responses to open-ended questions were summarised and categorised into themes. The themes are presented as frequencies in tables and graphs at the end of each subsection. Responses to closed-ended questions were scored for each respondent. A correct answer was scored a point (1) whilst zero (0) was allocated for an incorrect answer. Table 4.5 outlines the respondents' scoring on the KAP questions.

Table 4.5: Respondents' scoring on KAP statements

	N	Mean score	Maximum	Minimum	Percentage pass (%)
Intention	98	2.97	3	0	98.98
Knowledge	98	7.20	12	3	61.22
Attitude	98	6.33	9	3	98.98
Practice	98	1.16	8	0	3.06

Respondents scored exceptionally well for statements on intention (98.98%) and attitude towards radiation protection (98.98%). However, the respondents performed poorly (3.06%) in the section 'practice of radiation protection' (Table 4.5).

4.7 Section B: Knowledge of radiation protection

This section presents results related to knowledge of radiation protection (Questions B11 to B23). The section was further categorised into three parts, namely; radiation physics (Questions B12 and B17), radiation biology (Questions B11, B13–B16); and radiation protection protocols and guidelines

(Questions B18–B23). Table 4.6 presents the responses to open-ended questions in Section B.

Table 4.6: Section B (Knowledge of radiation protection)

		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Chi Square
		P (%)	P (%)	P (%)	P (%)	P (%)	p-value
Radiation is harmful	B11	2.0	0.0	3.1	31.6	63.3	0.000
X-ray beams reflect from room walls	B12	7.1	18.4	39.8	24.5	10.2	0.000
Scattered radiation is as harmful as direct radiation	B13	2.0	14.3	18.4	44.9	20.4	0.000
Radiation causes cancer	B14	2.0	1.0	3.1	36.7	57.1	0.000
A pregnancy test is mandated for all female patients of child-bearing age	B15	3.1	13.3	15.3	39.8	28.6	0.000
I am aware of the deterministic and stochastic effects of radiation	B16	27.6	21.4	26.5	16.3	8.2	0.014
I understand the ALARA principle	B17	48.0	27.6	11.2	9.2	4.1	0.000
I am aware of radiation control policies and guidelines in a South African context	B18	20.4	32.7	18.4	20.4	8.2	0.005
I know about the use of a lead apron	B19	2.0	0.0	3.1	50.0	44.9	0.000
I know about thyroid shielding	B20	2.1	5.2	9.3	46.4	37.1	0.000
I have read about studies regarding safety of radiation exposure of surgical staff	B21	32.7	26.5	8.2	21.4	11.2	0.000
We perform fluoroscopy-guided surgical procedures on pregnant patients in our department	B22	36.1	23.7	28.9	9.3	2.1	0.000
Our department has radiation safety policies specific to pregnant patients	B23	15.3	17.3	33.7	23.5	10.2	0.003

*P represents Percent

Table 4.6 illustrates the distribution of the responses to the closed-ended questions in Section B (knowledge of radiation protection). The following patterns are observed:

- Some statements show (significantly) higher levels of agreement whilst other levels of agreement are lower (but still greater than levels of disagreement).
- Five statements indicate higher levels of disagreement (B16, B17, B18, B21 and B22).
- The significant values (p-values) for all the statements are less than 0.05 (the level of significance), which implies that the distributions were not similar. That is, the differences between the way in which respondents scored (Agree, Neutral, Disagree) in Section B were significant.

4.7.1 Knowledge of radiation biology

All the responses to questions of radiation biology scored $p < 0.001$, except B16: *'I am aware of the deterministic and stochastic effects of radiation',* which has a less significant difference ($p = 0.014$) (Table 4.6). This reflects that a significant proportion of the respondents agreed with statements B11 to B15, demonstrating high scores for knowledge of radiation biology.

Table 4.7: Reasons for answers to 'radiation is harmful'

Reason	**Frequency n (%)**
Causes cancer	56 (57.1%)
Body organ damage	16 (16.3%)
DNA damage	3 (3.1%)
Infertility	13 (13.3%)
Dependant on causing factors	2 (2.0%)
Affects foetus	3 (3.1%)
Cumulative effect	3 (3.1%)

As indicated in Table 4.7, the majority of the respondents (n=56, 57.1%) reasoned that radiation is harmful because it causes cancer.

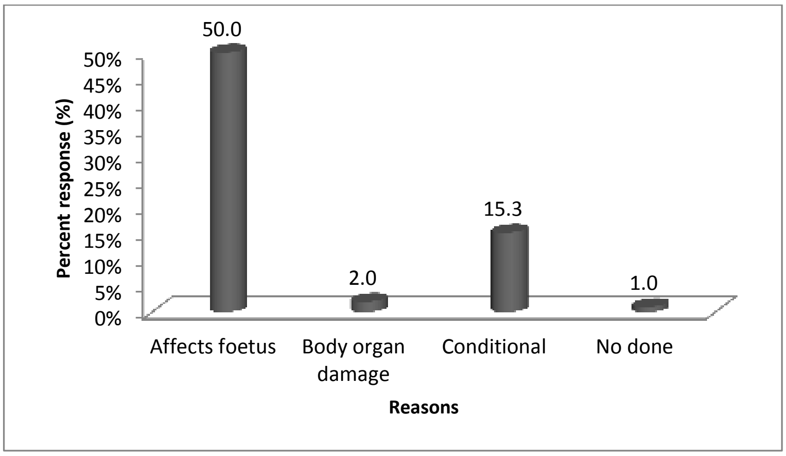

Figure 4.3: Reasons for responses to 'A pregnancy test is mandatory for all female patients of child-bearing age'.

As indicated in Figure 4.3, the majority of the respondents (50%) reasoned that a pregnancy test is mandatory because radiation affects the foetus.

Of the 10 respondents who responded to B16, only (n=2, 2%) of the respondents stated that deterministic effects have a threshold and stochastic effects do not have a threshold.

4.7.2 Knowledge of radiation physics

Questions B12 and B17 tested knowledge of radiation physics. As illustrated by Table 4.6, Question B12 had the highest number of neutral responses (n=39, 39.8%) and more than a third (34.7%) of the participants agreed that X-ray beams reflect from room walls ($p < 0.001$). The majority of the respondents (75.6%) significantly disagreed that they understand the ALARA principle. The majority of the participants (n=10, 10.2%) who responded to B17 stated that ALARA stands for As Low As Reasonably Achievable and only one respondent (n = 1, 1.0%) stated As Low As Reasonably Acceptable.

4.7.3 Knowledge of radiation protection protocols and guidelines

Overall Question B19 and B20 had significantly high percentages of Agree responses, 94.9% and 83.5% respectively (p < 0.001) (Table 4.6). Slightly more than half of the participants (53.1%) are not aware of radiation control protocols and guidelines in the South African context (p = 0.005). This value (significant difference) was less than the other five questions in this category. Question B23 had a unique response pattern. Almost similar numbers of respondents either disagreed (n=32, 32.6%), agreed (n=33, 33.7%) or were neutral (n=33, 33.7%) towards the statement *'Our department has radiation safety protocols specific to pregnant patients'*, hence the less significant difference as compared to the other questions in this category (p = 0.003) (Table 4.6).

The responses to the open-ended questions on radiation protection protocols and guidelines indicated that of the 14 participants who responded to Question B23, the majority (n=6, 6.1%) stated abdominal shielding as the radiation safety policy in their respective departments. Similar number of respondents (n = 4, 4.1%) mentioned lead aprons and risk-benefit analysis whilst only one respondent (n = 1, 1.0%) indicated that a pregnancy test is a radiation safety protocol. Only 2 (2.0%) of the respondents stated the ALARA principle.

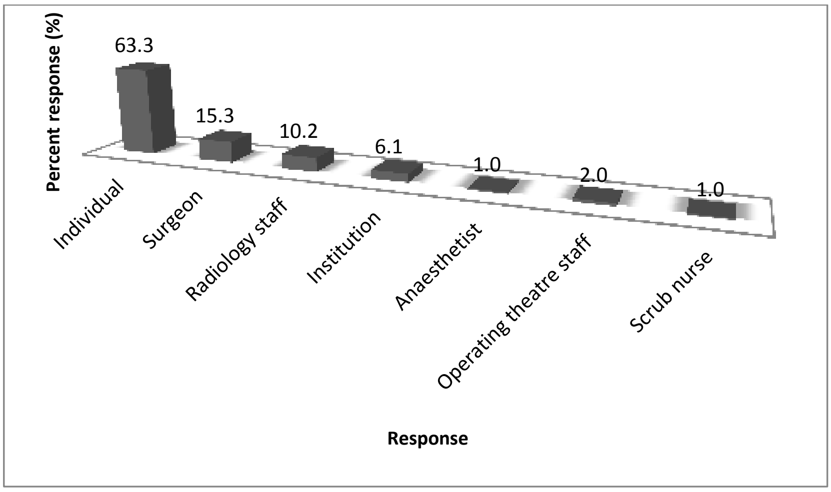

Figure 4.4: Responses to 'Who decides to shield?'.

As indicated in Figure 4.4, the majority of the respondents (63.3%) consider that during fluoroscopy-guided procedures an individual is responsible for deciding whether to shield or not.

Of the 6 respondents who responded to Question B24, only (n=1, 1.0%) respondent stated 20 mSv as the maximum annual dose.

Table 4.8: Responses to 'Who is more at risk from the radiation source during a fluoroscopy-guided surgical procedure?'

Who is more at radiation risk	Frequency n (%)
Patient	50 (51.0)
Surgeon	36 (36.7)
Radiology staff	3 (3.1)
Scrub nurse	21 (21.4)
Anaesthetics team	5 (5.1)
Operating theatre staff	19 (19.4)

Table 4.8 indicates that slightly more than half of the respondents (n=50, 51.0%) stated that the patient is more at risk from the radiation source during fluoroscopy-guided surgical procedures. The majority of the respondents (36.7%) further reasoned that patients are more at risk from radiation during fluoroscopy-guided surgical procedures (Table 4.8) because they are proximal to the radiation source. Some of the respondents reasoned that the patients are more at risk because they are not lead shielded (4.1%) and there are multiple exposures during fluoroscopy-guided procedures (1.0%).

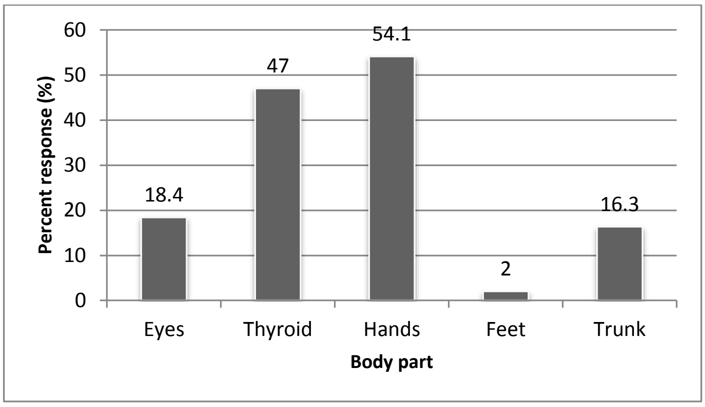

Figure 4.5: Body area most exposed to radiation.

Figure 4.5 illustrates that slightly more than half of the respondents (54.1%) perceive the hands to be the body part that receives the highest dose during surgical procedures.

The majority of the respondents (n=46, 47.0%) mentioned that the stated body area (Figure 4.5) received the most radiation because it is not lead shielded whilst some of the respondents reasoned that the body area is radiation sensitive (n = 10, 10.2%) or that the body area is proximal to the x-ray beam (n = 20, 20.4%). Similar number of respondents (n = 1, 1.0%) stated ‘damages cells’, ‘depends on radiation dose’ and large surface area’.

4.8 Section C: Attitude towards radiation protection

This section presents the results for the questions that determined the respondents’ attitude towards radiation protection.

4.8.1 Questions C27 to C29

The weighted means for the ranked data for Questions C27 to C29 were more towards the positive ranking (likely or extremely important), indicating that the respondents are likely to:

- Reduce both the patients' and operating theatre staff's exposure to harmful radiation by using radiation protection best practices in the operating theatre (6.49 +/-0.78) ($p < 0.001$).
- Use best radiation protection practices in the operating theatre, so that they can be a positive role model to other operating theatre staff (6.56 +/-0.65) ($p < 0.001$).

A statistically significant fraction of the respondents considers reducing exposure to radiation as extremely important (6.65 +/-0.65) ($p < 0.001$).

4.8.2 Questions C30 to C34

Table 4.9 presents the responses to the closed-ended questions C30 to C34.

Table 4.9: Responses to Questions C30 to C34

		Strongly Disagree	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**	**Chi Square**
		P (%)	P (%)	P (%)	P (%)	P (%)	p-value
Radiation exposure should be monitored in every hospital to prevent related disease	C30	1.0	0.0	2.0	29.6	67.3	0.000
Radiation exposures are monitored in your surgical ward	C31	38.1	18.6	36.1	5.2	2.1	0.000
Gonadal shield should be provided to children during procedures involving radiation exposure	C32	0.0	2.0	21,4	43.9	32.7	0.000
Occupational radiation exposure should continue to be monitored after childbearing age	C33	0.0	1.0	12,2	41.8	44.9	0.000
While requesting multiple radiological studies for the critically ill patients, I take into consideration the cumulative radiation dose of these studies by weighing up the pros and cons	C34	4.6	13.8	32.2	28.7	20.7	0.000

*P represents Percent

There was a significant difference between agree and disagree responses for the statements C30 to C34 ($p < 0.001$) (Table 4.9). A significant number of the respondents agreed to the implementation of various radiation protection measures such as the monitoring of radiation exposures in every hospital (96.9%) and provision of a gonadal shield to children during procedures involving radiation exposure (76.6%). The majority of the respondents (n=31, 31.6%) reasoned that a gonadal shield should be provided to children during procedures involving radiation exposure in order to prevent radiation effects to the gonads and only four respondents (4.1%) indicated that they do not apply gonad shielding. Similar number of respondents (n = 1, 1.0%) mentioned ‘radiation protection of the thyroid gland’, ‘radiation dose dependent’ and ‘not only children’ as reasons why a gonadal shield should be provided to children during procedures involving radiation exposure.

The majority of the respondents (n=26, 26.5%) reasoned that occupational radiation exposure should continue to be monitored after childbearing age to prevent cumulative radiation effects, whilst a similar number of respondents stated ‘to prevent infertility (n = 1, 1.0%) and ‘dose dependent’ (n = 1, 1.0%). Almost a quarter of the respondents (n= 20, 20.4%) mentioned that it should be monitored to prevent cancer. However, more than half of the respondents (n=55, 56.1%) disagree that radiation exposures are monitored in their surgical wards. Of the 19 participants who responded to Question C31 ‘Please explain how they are monitored’, 17 or 17.3% stated that radiation exposure is not monitored due to unavailability of radiation monitoring devices. The other respondents (n=2, 2.0%) mentioned that radiation exposure is monitored in their surgical wards by use of protective wear. Question C34 was only applicable to individuals who are qualified to request radiological studies, comprising doctors and specialists. Almost half of the respondents (49.4%) agree that they take cumulative radiation dose into consideration when requesting multiple radiological studies for critically ill patients.

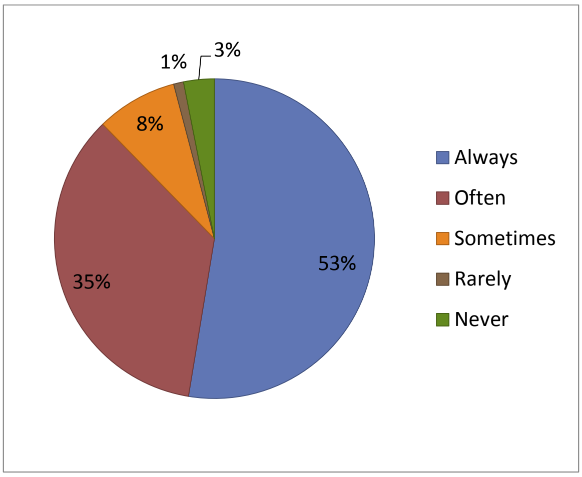

Figure 4.6: How often the respondents wear lead aprons.

Figure 4.6 presents the results to Question C35. A significant proportion of the respondents either always (53.0%) or often (35.0%) wear a lead apron during fluoroscopy-guided surgical procedures ($p < 0.001$).

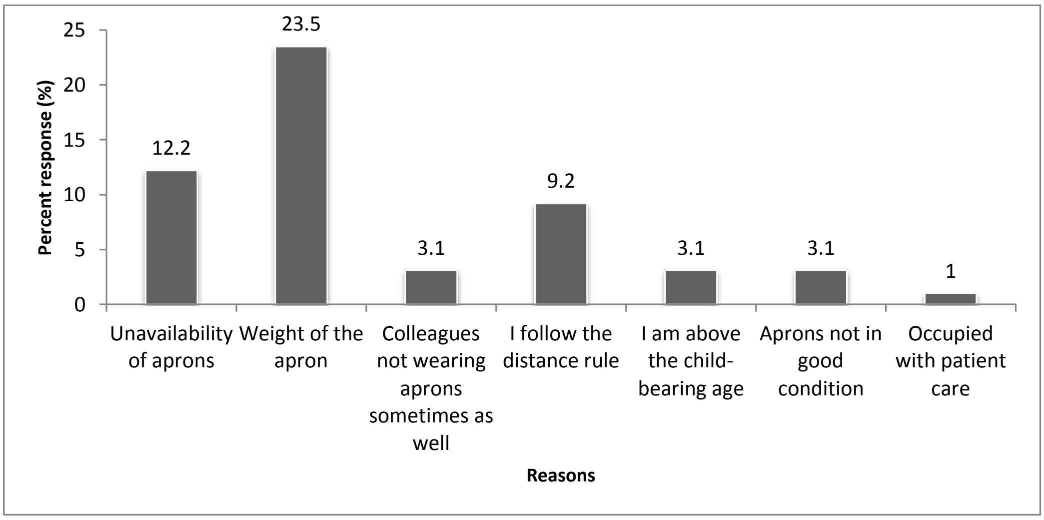

Figure 4.7: Reasons for not wearing a lead apron during fluoroscopy-guided surgical procedures

Figure 4.7 illustrates the distribution of the reasons why some of the respondents do not wear lead aprons during fluoroscopy-guided surgical procedures. Almost a quarter of the respondents (23.5%) do not wear lead aprons during fluoroscopy-guided surgical procedures because of the weight of the aprons.

4.9 Section D: Intention to practise radiation protection

This section presents the results for questions addressing the respondents' intention to practise radiation protection.

The weighted mean values for the ranked data for Questions D37 to D39 were more towards the positive ranking 'likely' for all statements, indicating that the respondents are more likely to:

- plan to use best radiation protection practices in the operating theatre (6.52 +/- 0.89, $p < 0.001$);
- make an effort to use best radiation protection practices in the operating theatre (6.56 +/- 0.85, $p < 0.001$); and
- intend to use best radiation protection practices in the operating theatre (6.52 +/- 1.02, $p < 0.001$).

Comment [r12]: is this table necessary in view of information provided in ullets

4.10 Section E: Practice of radiation protection

This section presented the results for questions addressing the practice of radiation protection amongst the respondents. Table 4.10 presents the responses and significant difference (p-values) for Questions E40 to E48. Responses to Question E49 are presented separately as a different Likert scale measure was utilised.

Table 4.10: Responses to Questions E40 to E48

		Always	Usually	Sometimes	Rarely	Never	Chi Square
		P (%)	P (%)	P (%)	P (%)	P (%)	p-value
I wear a lead apron during surgical procedures involving use of fluoroscopy	E40	66.3	24.5	4.1	4.1	1.0	0.000
I use thyroid shielding during surgical procedures involving use of fluoroscopy	E41	5.1	13.3	9.2	16.3	56.1	0.000
I wear radiation goggles during surgical procedures involving use of fluoroscopy	E42	2.0	0.0	1.0	6.1	90.8	0.000
I wear a radiation-monitoring device (TLD) during surgical procedures involving use of fluoroscopy	E43	10.3	2.1	0.0	2.1	85.6	0.000
I wear or use other radiation protection devices during surgical procedures involving use of fluoroscopy	E44	6.2	2.1	10.3	4.1	77.3	0.000
Radiation protection equipment (i.e. lead aprons, lead gloves, thyroid shielding) is available	E45	14.3	28.6	35.7	12.2	9.2	0.000
I ask for a pregnancy test in female patients of child-bearing age.	E46	8.7	10.9	19.6	10.9	50.0	0.000
I provide gonadal shielding to children during procedures involving radiation exposure	E47	2.1	9.3	11.3	8.2	69.1	0.000
Our department records exposures for fluoroscopy	E48	17.3	3.1	10.2	13.3	56.1	0.000

*P represents Percent

As indicated in Table 4.10, there was a statistically significant difference across the responses for all of the statements E40 to E48 ($p < 0.001$). Almost two-thirds of the participants (n=65, 66.3%) always wear a lead apron during surgical procedures involving use of fluoroscopy but the majority of the respondents never use other radiation protection devices such as thyroid shielding (n=55, 56.1%), radiation-monitoring device (thermoluminescent dosimeter (TLD)) (n=83, 85.6%) or radiation goggles (n=89, 90.8%). The majority of the respondents never implement patient-related radiation protection practices such as asking for a pregnancy test for female patients of child-bearing age (n-46, 50.0%) or providing gonadal shielding to children during procedures involving radiation exposure (n=67, 69.1%).

Table 4.11: Reasons for not using protective wear during surgical procedures involving use of fluoroscopy

Reason	Frequency n (%)
Distance rule	4 (4.1)
Not available	63 (64.3)
Unavailability of goggles	12 (12.2)
Unavailability of lead gloves	2 (2.0)
Unavailability of radiation-monitoring devices	12 (12.2)
Unavailability of thyroid shields	6 (6.1)

Table 4.11 outlines the reasons why respondents do not wear some of the protective wear during fluoroscopy-guided surgical procedures. More than half of the respondents (n=63, 64.3%) do not use protective wear during fluoroscopy-guided surgical procedures because it is not available.

The majority of the respondents (n=9, 9.2%) indicated that fluoroscopy exposures are recorded by the radiographer. Similar number of respondents (n = 1, 1.0%) stated that it is recorded on the arm and that it is recorded by the nurse whilst n = 4 (4.1%) mentioned that the exposures are recorded on paper. The majority of the respondents (n=10, 10.2%) indicated that fluoroscopy exposures are documented on paper whilst a similar number (n =2, 2.0%) stated that it is documented on the system and that it is documented by the radiology department.

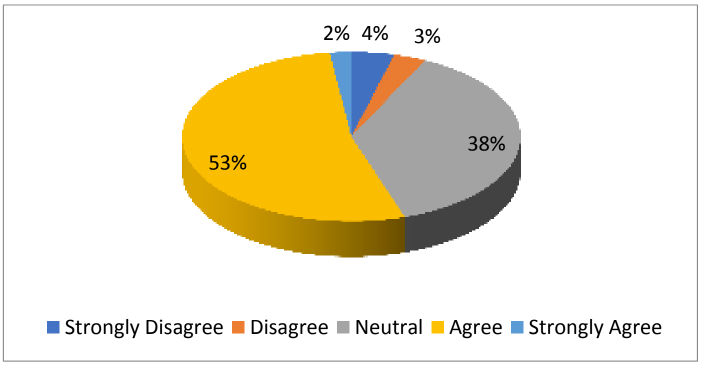

Figure 4.8: Responses to the statement 'I need more training on radiation protection'.

Almost all the respondents (91%) agreed that they need more training on radiation protection (Figure 4.8). (The five responses were combined to become agree, neutral and disagree, as mentioned earlier in this chapter).

Exactly half of the respondents (n=49, 50.0%) indicated that they need more training on radiation protection because they lack radiation protection knowledge. The least number of respondents (n = 2, 2.0%) stated that there is no need for training and 5.1% and 12.2 indicated that they require more training to improve on radiation awareness and that they lack radiation protection knowledge respectively.

4.1 Section F: General questions

This section presents the responses to open-ended general questions on radiation protection. A significant number of respondents (n=93, 94.9%) mentioned that a lead apron is used for radiation protection, whilst some respondents (n=11, 11.2%) consider that the lead apron is specifically used for gonad protection. Table 4.12 outlines the reasons given by the participants to the question 'Why is radiation exposure to the thyroid gland harmful?'.

Table 4.12: Reason why radiation exposure to the thyroid gland is harmful

Reason	Frequency n (%)
Causes cancer	65 (66.3)
Thyroid dysfunction	29 (29.6)
Thyroid gland abrasion	1 (1.0)
Thyrotoxicosis	1 (1.0)
More radiation sensitive	4 (4.1)

As indicated in Table 4.12, the majority of the respondents (n=65, 66.3%) consider radiation exposure to the thyroid gland to be harmful because it causes cancer.

Table 4.13: Patient-related radiation protection protocols

Patient-related radiation protection protocol	Frequency n (%)
ALARA	5 (5.1)
Risk-benefit analysis	9 (9.2)
Protective wear	9 (9.2)
Pregnancy test	7 (7.1)
Shielding of pregnant patients	6 (6.1)

The majority of the respondents either indicated that they do not know any patient-related radiation protection protocols (44.9%) or that there are no radiation protocols in their respective departments (19.4%). A few participants stated patient-related radiation protection protocols that are presented in Table 4.13. Similar numbers of respondents gave risk-benefit analysis (n=9, 9.2%) and protective wear (n=9, 9.2%) as patient-related radiation protection protocols. The participants were also asked to state personnel-related radiation protection protocols, which are presented in Table 4.14.

Table 4.14: Personnel-related radiation protection protocols

Personnel-related radiation protection protocol	Frequency n (%)
ALARA	1 (1.0)
Protective wear	70 (71.4)
No allocation of pregnant employees	2 (2.0)
Maximum distance from radiation	3 (3.1)
Rotation of staff	1 (1.0)
Closing of doors	1 (1.0)
Changing radiation badges	1 (1.0)
Use of X-ray warning signs	1 (1.0)

The majority of the respondents (n=70, 71.4%) indicated that protective wear is a personnel-related radiation protection protocol (Table 4.14).

Table 4.15: Radiation protection-related suggestions and recommendations

Suggestion or recommendation	Frequency n (%)
Further training	40 (40.8)
Provision of protective wear	31 (31.6)
Radiation monitoring	21 (21.4)
Radiation protection guidelines	5 (5.1)
Theatre radiographer allocation	1 (1.0)
Provision of imaging equipment	2 (2.0)

Radiation protection-related suggestions and recommendations stated by the respondents are presented in Table 4.15. The majority of the respondents (n=40, 40.8%) suggested further training on radiation protection in their respective departments.

4.12 Cross-tabulations

This section together with section 4.13 on correlations present results that address the second objective of this study: 'Establish the correlation or relationships between the staff's radiation protection KAP, demographic factors and intentions to implement radiation protection practices'.

A Fisher's exact test was performed to determine whether there was a statistically significant relationship between the variables radiation protection-related KAP and the respondents' demographic factors. A significant result is indicated ($p < 0.05$). The null hypothesis claims that there is no significant relationship between the variables whilst the alternate hypothesis states that there is a significant relationship between the variables (Haldar 2013: 166; Surbhi 2016). Refer to Appendix L for tables outlining the distribution of responses based on demographic factors.

4.12.1 Knowledge of radiation protection versus demographic factors

Table 4.16 outlines the significance values (p-values) for knowledge of radiation protection statements versus demographic factors.

Table 4.16: Significance values (p-values) for knowledge of radiation protection statements versus demographic factors

	Gender	Hospital	Highest qualification level	Speciality	Profession	Frequency in operating theatre	Frequency of fluoroscopy-guided procedures
Radiation is harmful	0.269	0.464	0.002	0.324	0.028	0.650	0.713
Radiation causes cancer	0.976	0.305	0.079	0.007	0.056	0.910	0.358
A pregnancy test is mandated for all female patients of child-bearing age	0.100	0.036	0.322	0.604	0.732	0.459	0.073
I am aware of the deterministic and stochastic effects of radiation	0.514	0.000	0.330	0.049	0.892	0.079	0.069
I understand the ALARA principle	0.010	0.001	0.079	0.003	0.000	0.003	0.582
I am aware of radiation control policies and guidelines in the South African	0.039	0.000	0.004	0.027	0.045	0.176	0.018

context							
I know about the use of a lead apron	0.484	0.045	0.516	0.723	0.510	0.772	0.083
I know about thyroid shielding	0.273	0.306	0.073	0.761	0.401	0.601	0.460
I have read about studies regarding safety of radiation exposure of surgical staff	0.007	0.000	0.056	0.049	0.028	0.005	0.013

*Highlighted values indicate significant values (p < 0.05).

Table 4.16 indicates that there are statistically significant relationships between the respondents' knowledge of radiation protection and the hospital where they are working ($p < 0.05$). There are also significant relationships between the respondents' knowledge of radiation and their area of specialisation ($p < 0.05$) as well as their knowledge of radiation and their profession ($p < 0.05$).

4.12.2 Attitude towards radiation protection versus demographic factors

Table 4.17 outlines the significance values (p-values) for attitude towards radiation protection statements versus demographic factors.

Table 4.17: Significance values (p-values) for attitude towards radiation protection statements versus demographic factors

	Gender	Hospital	Qualification	Speciality	Profession	Frequency in operating theatre	Frequency of fluoroscopy-guided procedures
By using radiation protection best practices in the operating theatre, I will reduce both the patient's and operating theatre staff's exposure to harmful radiation	0.115	0.299	0.450	0.453	0.112	0.770	0.743
Reducing exposure to radiation is….	0.004	0.109	0.318	0.179	0.029	0.760	0.955
By using	0.002	0.179	0.229	0.449	0.031	0.405	0.839

radiation protection best practices in the operating theatre, I can be a positive role model to other operating theatre staff							
Radiation exposure should be monitored in every hospital to prevent related disease	0.292	0.229	0.050	0.856	0.626	0.504	0.819
Gonadal shield should be provided to children during procedures involving radiation exposure	0.034	0.000	0.016	0.209	0.244	0.016	0.122
Occupational radiation exposure should continue to be monitored after child-bearing age	0.612	0.799	0.117	0.788	0.288	0.207	0.370
While requesting multiple radiological studies for the critically ill patients, I take into consideration the cumulative radiation dose of these studies by weighing the pros and cons	0.055	0.003	0.053	0.009	0.017	0.969	0.017

*Highlighted values indicate significance ($p < 0.05$).

There are noticeable significant relationships between the respondents' attitude towards radiation protection and demographic factors, specifically gender ($p < 0.05$) (Table 4.17).

4.12.3 Intention to practise radiation protection versus demographic factors

The significance (p-values) of the respondents' intention to practise radiation protection versus demographic factors is outlined in Table 4.18.

Table 4.18: Significance (p-values) for intention to practise radiation protection statements versus demographic factors

	Gender	Hospital	Qualification	Speciality	Profession	Frequency in operating theatre	Frequency of fluoroscopy-guided procedures
I plan to use radiation protection best practices in the operating theatre	0.757	0.056	0.240	0.934	0.871	1.000	0.760
I will make an effort to use radiation protection best practices in the operating theatre	0.943	0.218	0.526	0.827	0.484	1.000	0.896
I intend to use radiation protection best practices in the operating theatre	0.672	0.238	0.279	0.546	0.328	0.980	0.860

As indicated in Table 4.18, there are no significant relationships between the respondents' intention to practise radiation protection and demographic factors ($p > 0.05$).

4.12.4 Practice of radiation protection versus demographic factors

The significance (p-values) of the respondents' practice of radiation protection and demographic factors is outlined in Table 4.19.

Table 4.19: Significance (p-values) for practice of radiation protection statements versus demographic factors

	Gender	Hospital	Qualification	Speciality	Profession	Frequency in operating theatre	Frequency of fluoroscopy-guided procedures
I wear a lead apron during surgical procedures involving use of fluoroscopy	0.689	0.033	0.060	0.609	0.440	1.000	0.785
I use thyroid shielding during surgical procedures involving use of fluoroscopy	0.057	0.001	0.152	0.109	0.397	0.000	0.131
I wear radiation goggles during surgical procedures involving use of fluoroscopy	0.051	0.626	0.608	0.296	0.284	0.113	0.279
I wear a radiation-monitoring device (TLD) during surgical procedures involving use of fluoroscopy	0.485	0.000	0.290	0.041	0.025	0.757	0.338
I wear or use other radiation protection devices during surgical procedures involving use of fluoroscopy	1.000	0.013	0.653	0.194	0.529	0.475	0.028
I ask for a pregnancy test in female patients of child-bearing age	0.020	0.488	0.039	0.217	0.158	0.045	0.371
Our department records exposures for fluoroscopy	0.120	0.006	0.335	0.024	0.033	0.166	0.405

* Highlighted values indicate significance (p < 0.05).

There is a significant relationship between the respondents’ practice of radiation protection and the hospital in which they are working ($p < 0.05$) (Table 4.19).

4.13 Correlations

Bivariate correlation was also performed on the (ordinal) data. The results are presented in Appendix M: Correlations.
The results indicate the following patterns:

- Positive values indicate a directly proportional relationship between the variables.
- Negative values indicate an inverse relationship between the variables.
- All significant relationships are indicated by a * or **.
- **r-value** indicates the correlation coefficient whilst **p-value** represents the significance value (significant relationship).

For ease of interpretation, the statements in Appendix M were categorised according to the questionnaire outline (Appendix J) into:

- Knowledge of radiation protection (B questions).
- Attitude towards radiation protection (C questions).
- Intention to practise radiation protection (D questions).
- Practice of radiation protection (E questions).

Appendix M was interpreted and summarised as outlined below, to address the second objective of this study.

4.13.1 Knowledge of radiation protection versus attitude towards radiation protection

Table 4.20 outlines the correlating statements from the section ‘Knowledge of radiation protection’ (B) and ‘Attitude towards radiation protection’ (C).

Table 4.20: Correlation values for ‘Knowledge of radiation protection’ (B statements) versus ‘Attitude towards radiation protection’ (C statements)

Radiation is harmful (B11)	**r-value**	**p-value**
By using radiation protection best practices in the operating theatre, I will reduce both the patient’s and operating theatre staff’s exposure to harmful radiation (C27)	0.212	0.036
Gonadal shield should be provided to children during procedures involving radiation exposure (C32)	0.227	0.024
Occupational radiation exposure should continue to be monitored after child-bearing age (C33)	0.230	0.023
Radiation causes cancer (B14)	**r-value**	**p-value**
By using radiation protection best practices in the operating theatre, I will reduce both the patient’s and operating theatre staff’s exposure to harmful radiation (C27)	0.206	0.042
A pregnancy test is mandated for all female patients of child-bearing age (B15)	**r-value**	**p-value**
Reducing exposure to radiation is… (C28)	0.253	0.012
Gonadal shield should be provided to children during procedures involving radiation exposure (C32)	0.501	0.000
While requesting multiple radiological studies for the critically ill patients, I take into consideration the cumulative radiation dose of these studies by weighing up the pros and cons (C34)	0.243	0.023
I am aware of radiation control policies and guidelines in a South African context (B18)	**r-value**	**p-value**
While requesting multiple radiological studies for the critically ill patients, I take into consideration the cumulative radiation dose of these studies by weighing up the pros and cons (C34)	0.402	0.000
I know about the use of a lead apron (B19)	**r-value**	**p-value**
By using radiation protection best practices in the operating theatre, I will reduce both the patient’s and operating theatre staff’s exposure to harmful radiation (C27)	0.214	0.034
Gonadal shield should be provided to children during procedures involving radiation exposure (C32)	0.232	0.022
I know about thyroid shielding (B20)	**r-value**	**p-value**
Gonadal shield should be provided to children during procedures involving radiation exposure (C32)	0.248	0.014

* r-value represents correlation coefficient; p-value represents significance value.

Comment [L13]: Is what?

Table 4.20 illustrates positive r-values and p-values ($p < 0.05$) for all the statements, indicating a directly proportional (positive) relationship between the ‘Knowledge of radiation protection’ statements and ‘Attitude towards radiation protection’ statements. The correlation values for knowledge of radiation protection and attitude towards radiation protection are $r = 0.270$, $p = 0.021$.

4.13.2 Knowledge of radiation protection versus practice of radiation protection

Table 4.21 outlines the correlating statements from the section ‘Knowledge of radiation protection’ (B) and ‘Practice of radiation protection’ (E).

Table 4.21: Correlation values for ‘Knowledge of radiation protection’ (B) versus ‘Practice of radiation protection’ (E) statements

Radiation is harmful (B11)	**r-value**	**p-value**
I use thyroid shielding during surgical procedures involving use of fluoroscopy (E41)	-0.207	0.041
A pregnancy test is mandated for all female patients of child-bearing age (B15)	**r-value**	**p-value**
I wear a radiation-monitoring device (TLD) during surgical procedures involving use of fluoroscopy (E43)	-0.253	0.012
I wear or use other radiation protection devices during surgical procedures involving use of fluoroscopy (E44)	-0.329	0.001
I provide gonadal shielding to children during procedures involving radiation exposure (E47)	-0.208	0.041
I am aware of the deterministic and stochastic effects of radiation (B16)	**r-value**	**p-value**
I wear a radiation-monitoring device (TLD) during surgical procedures involving use of fluoroscopy (E43)	-0.234	0.021
I am aware of radiation control policies and guidelines in a South African context (B18)	**r-value**	**p-value**
I use thyroid shielding during surgical procedures involving use of fluoroscopy (E41)	-0.240	0.017
I wear a radiation-monitoring device (TLD) during surgical procedures involving use of fluoroscopy (E43)	-0.323	0.001
I wear or use other radiation protection devices during surgical procedures involving use of fluoroscopy (E44)	-0.298	0.003

I provide gonadal shielding to children during procedures involving radiation exposure (E47)	-0.347	0.001
I need more training on radiation protection (E49)	-0.321	0.001
I know about the use of a lead apron (B19)	**r-value**	**p-value**
I wear a lead apron during surgical procedures involving use of fluoroscopy (E40)	-0.228	0.024
I know about thyroid shielding (B20)	**r-value**	**p-value**
I wear a lead apron during surgical procedures involving use of fluoroscopy (E40)	-0.227	0.025
I use thyroid shielding during surgical procedures involving use of fluoroscopy (E41)	-0.217	0.033

* r-value represents correlation coefficient; p-value represents significance value.

Negative r-values and p–values ($p < 0.05$) are noted for all the statements, indicating an inverse relationship between the 'Knowledge of radiation protection' statements and 'Practice of radiation protection' statements (Table 4.21). The correlation values for radiation-related knowledge and practice of radiation protection are $r = -0.264$, $p = 0.017$.

4.13.3 Knowledge of radiation protection versus intention to practise radiation protection

As indicated in Appendix M, there are no statistically correlating 'Knowledge of radiation protection' (B) statements and 'Intention to practise radiation protection' (D) statements. None of the values are in the category $p < 0.05$.

4.13.4 Attitude towards radiation protection versus intention to practise radiation protection

Table 4.22 outlines the correlating statements between 'Attitude towards radiation protection' (C) and 'Intention to practise radiation protection' (D).

Table 4.22: Correlation values for ‘Attitude towards radiation protection’ (C) statements versus ‘Intention to practise radiation protection’ (D) statements

By using radiation protection best practices in the operating theatre, I will reduce both the patient’s and operating theatre staff’s exposure to harmful radiation (C27)	**r-value**	**p-value**
I plan to use radiation protection best practices in the operating theatre (D37)	0.277	0.006
I will make an effort to use radiation protection best practices in the operating theatre (D38)	0.267	0.008
I intend to use radiation protection best practices in the operating theatre (D39)	0.426	0.000
Reducing exposure to radiation is… (C28)	**r-value**	**p-value**
I plan to use radiation protection best practices in the operating theatre (D37)	0.233	0.021
I will make an effort to use radiation protection best practices in the operating theatre (D38)	0.301	0.003
I intend to use radiation protection best practices in the operating theatre (D39)	0.375	0.000
By using radiation protection best practices in the operating theatre, I can be a positive role model to other operating theatre staff (C29)	**r-value**	**p-value**
I plan to use radiation protection best practices in the operating theatre (D37)	0.511	0.000
I will make an effort to use radiation protection best practices in the operating theatre (D38)	0.493	0.000
I intend to use radiation protection best practices in the operating theatre (D39)	0.574	0.000
Radiation exposure should be monitored in every hospital to prevent related disease (C30)	**r-value**	**p-value**
I intend to use radiation protection best practices in the operating theatre (D39)	0.215	0.033
Occupational radiation exposure should continue to be monitored after child-bearing age (C33)	**r-value**	**p-value**
I plan to use radiation protection best practices in the operating theatre (D37)	0.252	0.012
I will make an effort to use radiation protection best practices in the operating theatre (D38)	0.252	0.012

* r-value represents correlation coefficient; p-value represents significance value.

Table 4.22 illustrates positive r-values and p-values ($p < 0.05$) for all the statements, indicating a directly proportional (positive) relationship between the ‘Attitude towards radiation protection’ statements and ‘Intention to practise radiation protection' statements. The correlation values for attitude towards radiation protection and intention to implement radiation protection practices are r = 0.348, p = 0.008.

4.13.5 Attitude towards radiation protection versus practice of radiation protection

Table 4.23 outlines the correlating 'Attitude towards radiation protection' (C) statements and 'Practice of radiation protection' (E) statements.

Table 4.23: Correlation values for 'Attitude towards radiation protection' (C) statements versus 'Practice of radiation protection' (E) statements

By using radiation protection best practices in the operating theatre, I will reduce both the patient's and operating theatre staff's exposure to harmful radiation (C27)	**r-value**	**p-value**
I wear a lead apron during surgical procedures involving use of fluoroscopy (E40)	-0.238	0.018
I need more training on radiation protection (E49)	-0.291	0.004
Reducing exposure to radiation is…(C28)	**r-value**	**p-value**
I use thyroid shielding during surgical procedures involving use of fluoroscopy (E41)	-0.211	0.037
Gonadal shield should be provided to children during procedures involving radiation exposure (C32)	**r-value**	**p-value**
I wear a radiation-monitoring device (TLD) during surgical procedures involving use of fluoroscopy (E43)	-0.359	0.000
I wear or use other radiation protection devices during surgical procedures involving use of fluoroscopy (E44)	-0.343	0.001
I provide gonadal shielding to children during procedures involving radiation exposure (E47)	-0.279	0.006
Occupational radiation exposure should continue to be monitored after child-bearing age (C33)	**r-value**	**p-value**
I wear a radiation-monitoring device (TLD) during surgical procedures involving use of fluoroscopy (E43)	-0.248	0.014
I wear or use other radiation protection devices during surgical procedures involving use of fluoroscopy (E44)	-0.204	0.045

While requesting multiple radiological studies for the critically ill patients, I take into consideration the cumulative radiation dose of these studies by weighing up the pros and cons (C34)	**r-value**	**p-value**
I wear a lead apron during surgical procedures involving use of fluoroscopy (E40)	-0.267	0.012
I use thyroid shielding during surgical procedures involving use of fluoroscopy (E41)	-0.398	0.000
I wear or use other radiation protection devices during surgical procedures involving use of fluoroscopy (E44)	-0.260	0.016
I provide gonadal shielding to children during procedures involving radiation exposure (E47)	-0.263	0.015

* r-value represents correlation coefficient; p-value represents significance value.

Negative r-values and p-values ($p < 0.05$) are noted for all the statements, indicating an inverse relationship between the 'Attitude towards radiation protection' statements and 'Practice of radiation protection' statements (Table 4.23). The correlation value for attitude towards radiation protection and practice of radiation protection is $r = -0.280$, $p = 0.014$.

4.13.6 Intention to implement radiation protection practices versus practice of radiation protection

As indicated in Appendix M, there are no statistically correlating 'Intention to practise radiation protection' (D) statements and 'Practice of radiation protection' (E) statements.

4.14 Summary

This chapter has presented the data which emerged from the distributed questionnaire and were analysed. The response rate was 54.7%. The mean age of the respondents was 38.46 ± 9.47 years and participants were predominantly female (66.7%). The majority of the respondents (82.7%) work in the operating theatre more than 3 days a week, and 38.8% of the respondents use fluoroscopy for 4 to 7 surgical procedures per week. The respondents scored moderately (61.22%) on the knowledge questions, exceptionally well (98.98%) on attitude and intention (98.98%), but poorly (3.06%) on the practice questions. The respondents' profession, speciality and the hospital where they are working had a significant effect on their KAP scores ($p < 0.05$). There are statistically significant positive relationships between knowledge and attitude, and attitude and intention, but negative relationships between knowledge and practice, and attitude and practice. There are no statistically significant relationships between the respondents' knowledge and intention, and intention and practice.

Comment [r14]: your results chapter is disproproportionally long. If you remove all repetions and irrelevant statistical tables it will reduce to the normal size. I gave feedback on this previously.

Chapter Five

Discussion

5.1 Introduction

This chapter presents the interpretation of the current study's results and a comparison of these findings to available literature. The response rate and respondents' demographic profiles are discussed. Furthermore, the results are discussed according to this study's objectives as outlined in chapter one.

5.2 Response rate

The response rate is defined by the Cambridge Business English Dictionary (2018) as a percentage of completed surveys divided by the number of copies distributed. This is of significance in research as it impacts on the validity and reliability of the study's outcome (Baruch 1999: 422). Gordon (2002) and Nulty (2008: 306) consider an acceptable response rate to be dependent on the type of study or use of the study's outcome. Furthermore, Gordon (2002) concludes that surveys investigating a population's knowledge or behavioural characteristics are valid with a minimum response rate of 60%. However, Baruch (1999: 422, 432) concluded in an exploratory study that 55.6% was an appropriate response rate, adding that there is no defined numerical value for a reasonable response rate. In the current study a response rate of 54.7% was derived as 98 of the 179 distributed questionnaires were completed.

Radiation KAP surveys performed internationally have obtained various response rates; for example, one conducted in Turkey had a response rate of 64%, while in Hong Kong a rate of 88.17% was recorded and in Nigeria a rate of 82% (Tok *et al.* 2015; Wong *et al.* 2012; Luntsi *et al*. 2016: 3). The current study obtained a response rate which is lower than these studies, but similar to that for a study conducted amongst junior clinicians in Hong Kong (Luk, Leung and Cheng 2010: 191). However, there is a set trend of a low response rate to questionnaires amongst public health institution workers in eThekwini district, as indicated in studies conducted by Ackah (2015: iv) and Gam (2015: 38). Gam's (2015: 38) study obtained a response rate of 42.6%, while in Ackah's (2015: iv) study the rate was 65%. In the current study, most of the staff did not participate as they are always busy and consider questionnaires to be long and boring.

5.3 Demographic profile of the respondents

Despite the gender ratio in South Africa being almost 1:1 (Countrymeters 2018), the majority of the respondents were female (66.3%), with most of them being nurses. The nursing profession is female dominated, as has been demonstrated by the South African Nursing Council (2018: 2). This is in contrast to Luntsi *et al.*'s (2016: 1) study conducted in Nigeria, where the gender ratio of the respondents was almost 1:1, and Saeed *et al.*'s (2018: 300) radiation awareness study, where the majority of participants were male (81%). A large number of the respondents (27.8%) are working at Inkosi Albert Luthuli Central Hospital, which is a specialist referral hospital with various surgical disciplines (Inkosi Albert Luthuli Central Hospital 2018), compared to the other five hospitals.

Comment [L15]: Not on ref list - and we need a proper author's name here

The majority of the respondents (69.2%) have one to ten years of experience in their speciality areas; most specialists eventually leave the public sector for private institutions or practices (Econex 2010: 1). The work experience of the participants in Saeed *et al.*'s (2018: 3) study was higher, ranging from less than a year to 30 years, because the sample comprised physicians from both the private and government sector. Most of the respondents (49%) were from the speciality of Anaesthetics; this is because there are more anaesthetists than any other specialists in the various surgical disciplines, according to statistics gathered by the researcher (Appendix I). The population under study is exposed to occupational radiation exposure on a regular basis as most (82.7%) work in theatre on more than three days a week, with an average of one to three fluoroscopy-guided surgical procedures per week.

Comment [r16]: all numbers below 12 should be written out eg one instead of 1

Comment [r17]:

The preceding section discussed the respondents' scoring on KAP statements in sections B, C, D and E of the questionnaire (Appendix J). The KAP statements addressed the first objective of this study.

5.4 Objective 1: Determine KAP in radiation protection amongst non-radiology staff in fluoroscopy-guided operating theatres at public health institutions in the eThekwini district, KZN

5.4.1 Knowledge

The majority of the respondents (61.22%) have good knowledge of radiation protection (Table 4.5). As stated previously in chapter four, the staff's radiation protection knowledge was categorised according to the following areas: radiation biology, radiation physics, and radiation protocols and guidelines. The respondents were investigated to determine whether they were adequately knowledgeable about the effects of radiation and related issues. Overall they demonstrated a high level of knowledge of radiation biology (89.79%). The respondents were quite aware of the effects of radiation, as demonstrated by the results for Questions B11, B14 and F51 (Table 4.6 and Table 4.12). The participants' 'knowledge' is comparatively high compared to that of non-radiology theatre staff investigated by several academics internationally (Yurt, Çavuşoğlu and Günay 2014: 49; Saeed *et al.* 2018: 48; Khan *et al*. 2010: 1; Palacia *et al*. 2014: 228; Rosario *et al*. 2015). Yurt, Çavuşoğlu and Günay (2014: 49), Saeed *et al.* (2018: 48), Khan *et al*. (2010: 1), Palacia *et al*. (2014: 228) and Rosario *et al*. (2015: 1) concluded that the non-radiology staff are lacking adequate radiation-related knowledge. However, the current results are consistent with those obtained amongst theatre nurses in a survey conducted in Nigeria by Luntsi *et al.* (2016: 2). The majority of the respondents (60.4%) in Luntsi *et al.*'s (2016: 2) study had satisfactory radiation-related knowledge.

Almost all of the respondents (94.9%) in the current study agreed that radiation is harmful and further agreed that it causes cancer (93.8%). These results are high compared to those of Luntsi *et al.*'s (2016: 3) study, where 79.7% of the respondents agreed that radiation is harmful. However, the current results correspond with those of Yurt, Çavuşoğlu and Günay's (2014: 51) study, where 93.5% of the participants considered cancer to be associated with radiation exposure. Kurtul and Kurtul (2018: 104) obtained a similar result, with 93.2% of their respondents indicating that they were aware that cancer can develop secondary to radiation exposure. Sherer *et al.* (2014: 64) noted that radiation-induced injuries were identified as early as the 1900s, and the National Cancer Institute (2015) explains that ionising radiation can cause DNA damage resulting in cancer.

Small numbers of respondents from the current study demonstrated that they are slightly aware of the other effects of radiation by mentioning that it causes body organ damage (16.1%) and DNA damage (3%). However, these values are low compared to those found in Yurt, Çavuşoğlu and Günay's (2014: 51) study, where more than two-thirds (76.1%) of the participants indicated that radiation exposure can cause genetic disorders. Furthermore, 3% of the respondents in the current study reasoned that radiation is harmful because of its cumulative effect, corresponding with the findings of Cecen *et al.* (2015), who confirm that the low cumulative radiation doses can result in cancer of the skin or gonads over time. This also relates to the other common harmful effect indicated by the respondents (12.2%), that of infertility. However, far fewer respondents were knowledgeable about radiation exposure causing infertility than in other studies conducted by Kurtul and Kurtul (2018: 104) and Yurt, Çavuşoğlu and Günay (2014: 51). Kurtul and Kurtul (2018: 104) mentioned that 77.4% of their respondents were aware of infertility as a radiation hazard, with a similar number (79.3%) in Yurt, Çavuşoğlu and Günay's (2014: 51) study. In the current study a few (3% and 1%) of the respondents mentioned 'affects foetus' and 'teratogenicity' respectively, compared to Kurtul and Kurtul's (2018: 104) study where 72.7% of the respondents were aware that radiation exposure can result in development of congenital malformations. It is concluded that very few respondents in the current study are aware of the reasons why radiation is harmful.

Seventy-four per cent of the respondents concluded that radiation to the thyroid gland is harmful as it causes cancer, corresponding to the finding of Sinnott, Ron and Schneider (2010) that radiation contributes significantly to thyroid cancer in radiation-induced individuals. However, although the respondents were knowledgeable about some of the effects of radiation, they could not distinguish between deterministic effects and stochastic effects. This is illustrated by the results for Question B16 (Table 4.6), where only 24.5% of the respondents agreed that they were aware of deterministic and stochastic effects. Of the 27% who responded to Question B16 only 2% managed to provide the correct answer that ‘Deterministic has threshold; stochastic no threshold’. The Radiation Health Unit (2007: 1) indicates that deterministic effects only surface when the threshold radiation dose is exceeded, and Roth, Schweizer and Guckel (1996) state that the stochastic effects have no threshold radiation level. The current results are consistent with those of Chaparian, Moghadam and Mansourian’s (2014: 84) study and Saeed *et al.*’s (2018: 302) findings. According to Chaparian, Moghadam and Mansourian’s (2014: 84) only a few (11.8%–31.9%) of the physicians could differentiate deterministic effects from stochastic effects, whilst only 22.7%–46.6% of the physicians in Saeed *et al.*’s (2018: 302) study could do so.

Of the respondents 65.3% agreed that scattered radiation is as harmful as direct radiation, corresponding with Ansell’s (2009) explanation that scattered radiation is the same radiation but in a different direction as it attenuates in an object. However, a KAP study conducted amongst orthopaedic surgical trainees in the UK yielded different results, with almost half of the respondents (48%) indicating that they do not have knowledge about scatter radiation (Khan *et al.* 2010: 3). Slightly more than two- thirds of the respondents (68.4%) under study indicated in Question B15 (Table 4.6) that they are aware that a pregnancy test is mandatory for all patients of child-bearing age. This result is similar to that of Khan *et al.*’s (2010: 3) KAP study, where 68% of the respondents agreed that a pregnancy test is mandatory for this category of patients.

Abdullahi and Toriman (2015) elaborate that X-rays should be avoided during pregnancy, especially during the early weeks, as they can cause miscarriage, foetal growth retardation and congenital deformities. This makes it mandatory to check for pregnancy before radiation exposure in female patients of child-bearing age (Akintomide and Ikpeme 2014: 243). Exactly half of the respondents in the current study (50%) reasoned that a pregnancy test is mandatory because radiation exposure during pregnancy affects the foetus, whilst 2% indicated that it causes body organ damage, and 15.3% that it is conditional to have a pregnancy test done (Figure 4.3). These results indicate that the percentage of participants who are well informed about the risks of radiation during pregnancy is far less than in the radiation awareness study conducted amongst junior clinicians in Hong Kong (Luk, Leung and Cheng 2010: 191). Almost all of the respondents (98%) in Luk, Leung and Cheng's (2010: 191) study were aware that foetal abnormalities can result from exposure to radiation during pregnancy. A few respondents in the current study further explained that it is only mandatory to do a pregnancy test where there is a possibility of pregnancy, which is whenever an individual of child-bearing age has missed a period (Abdullahi and Toriman (2015). A small number of the respondents (8.7%) in Yurt, Çavuşoğlu and Günay's (2014: 51) study stated that the ten-day rule should be incorporated when attending to patients of child-bearing age. It is therefore concluded that very few participants in the current study are aware of the reasons why a pregnancy test is mandatory for all patients of child-bearing age.

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The current study revealed that slightly more than half of the respondents (53.1%) are not aware of radiation protection protocols, especially the patient-related ones. It is further noted in Question F52 that respondents are not well informed on this matter, as 44.9% indicated that they do not know the protocols and 19.4% mentioned that there were no protocols. Almost one-third (32.6%) indicated that there are no specific protocols for pregnant patients in their departments, while another third (33.7%) gave a neutral answer, indicating that the staff is not aware whether there are radiation protocols or what such protocols say. These results do not support Mullens and Singh's (2014: 8) conclusion that policies and guidelines have to be readily available to staff as part of the radiation safety programme in any radiation-utilising department. In South Africa radiation guidelines and policies are governed by the Hazardous Substances Act of 1973 under Group III substances to ensure safety of the public (Herbst and Fick 2012; ChemSafetyPro 2017). On the positive side, a few of the respondents in the current study (21.3%) mentioned ALARA, pregnancy tests, risk-benefit analysis and shielding of pregnant patients as some of the patient-related protocols (Table 4.13). The radiation guidelines basically ensure that the healthcare worker applies all necessary measures to minimise both patient and staff radiation exposure by implementing the ALARA principle (Panchbhavi 2018). These results are not unique to this study, as Khan *et al*. (2010: 1), Palacia *et al*. (2014: 228) and Tunçer *et al*. (2017) also noted poor knowledge of radiation guidelines and protocols amongst their study populations. More than half of the respondents (71.3%) seem to be well informed about some of the personnel-related protocols, such as use of protective wear, maintaining maximum distance from radiation, rotating staff allocation in theatre, no allocation of pregnant employees, the ALARA principle and use of X-ray warning signs (Table 4.14). This correlates with recommended radiation guidelines and strategies outlined by the National Cancer Institute (2005a: 3) and Panchbhavi (2018).

More than half of the participants (59.8%) responded positively to acknowledge that they do not perform fluoroscopy-guided surgical procedures on pregnant patients (Table 4.6). This demonstrates that the staff have average knowledge of the radiation protection guidelines, although they are not aware that these are the guidelines since they indicate that either they ‘do not know’ or ‘there are no protocols’. These results are similar to those of Yurt, Çavuşoğlu and Günay’s (2014: 49) radiation knowledge and awareness study conducted amongst non-radiology staff utilising radiation in Izmir, Turkey. In that study almost half of the participants (44.6%) indicated that females who might be pregnant should not go through radiological examinations, but 57.6% indicated that such examinations can be performed if justified by the referring physician (Yurt, Çavuşoğlu and Günay’s 2014: 49).

Most of the respondents (59.2%) in the current study have not read about studies regarding safety and radiation exposure of surgical staff (Table 4.6). Furthermore, slightly more than two-thirds of the respondents (68.1%) indicated in Question 21 that they have read ‘0’ studies. These figures could be responsible for the number of respondents who demonstrated poor radiation protection knowledge (38.78%). Working in public health operating theatres for more than 3 days per week (82.7%) leaves the staff exhausted and with no time to further their knowledge of issues that are not within their main area of practice. The results of the current study are not unique, as Khan *et al.*’s (2010: 3) study indicated that the majority of their respondents (84%) had not read any literature on radiation safety. This also correlates with a study conducted in Singapore illustrating that the majority of adults prefer watching television or surfing the internet for news and other issues rather than reading academic development documents, unless they are studying (National Library Board 2017).

According to the Department of Labour (1993: 8-10) the Occupational Health and Safety Act stipulates that employers have the responsibility to provide a safe environment, safety wear, policies and guidelines – but the decision to implement these measures rests with the employee. This statement correlates with the results from Question B23i (Figure 4.4), where almost two-thirds of the respondents (63.3%) indicated that it is the individual’s decision to shield. Other common responses to the question ‘Who decides to shield?’ were ‘the surgeon’ (n=14) and ‘radiographer or radiology department’ (n=9). This demonstrates lack of knowledge of radiation protocols in their respective departments, as this is included in the protocols (Meisinger *et al.* 2016: 745). However, the staff’s knowledge of protective wear was outstanding, as 83.5% knew about thyroid shielding and 94.9% knew about lead aprons. This is further evidenced in Question F50 (Section F: General questions) where almost all of the respondents (99%) reported that the use of a lead apron is for gonad protection and radiation protection. These results are similar to those of Khan *et al.* (2010: 3) where 88% of the respondents indicated their awareness of thyroid shielding.

The respondents scored poorly on radiation physics questions (39.79%). This could be attributed to the fact that some of the areas are not included in their academic syllabi (Karolinska Institutet 2017). Another reason could be lack of interest in reading, as illustrated earlier in response to Question 21 (Table 4.6), where 68.1% indicated that they had not read any studies on radiation protection. The respondents whose answers to Question B17 (Table 4.6) were ‘Disagree’ and ‘Neutral’ were considered not to know what the ALARA principle is, and they constituted the majority (86.8%). Only 11.2% of the respondents knew the meaning of the ALARA principle, defining it as ‘As Low As Reasonably Achievable’ or ‘As Low As Reasonably Acceptable’. Both definitions were considered correct. These results are similar to the findings of a study conducted amongst physicians in Yazd Province in Iran, where only 13.9% of the physicians demonstrated knowledge of the ALARA principle (Chaparian, Moghadam and Mansourian’s (2014: 81). These results raise concerns, as knowledge of the ALARA principle is of great importance to all individuals using radiation since they are expected to protect themselves and the patient (Van der Merwe 2012).

Of the respondents who answered Question B24 (n=64), more than half (57.1%) indicated that they do not know what the maximum annual radiation dose is. Where participants did not respond to this question (n=34) it can be reasoned that they did not answer because they also do not know. Only 1% of the respondents gave the correct value of 20 mSv, in accordance with the occupational effective dose limit set by the South African Department of Health Directorate: Radiation Control (2015) of 20 mSv per year. Saeed *et al.* (2018) obtained a slightly higher result, with almost a third of their respondents (31%) stating the correct value of 20 mSv. The current study’s results indicate poor knowledge of radiation protection protocols, as dose limits form part of such protocols of all departments utilising ionising radiation (IAEA 2013).

According to Rhea, Rogers and Riehl (2015) several studies concluded that the surgeons received the highest dose, as they are closest to the patient and the C-arm, whilst the anaesthetists stationed at a distance of 1.5 m from the C-arm received the lowest dose. The results of the current study correspond with this, as almost half of the respondents (49%) consider the patient to be the person who receives the highest radiation dose during fluoroscopy-guided surgical cases, whilst 36.7% mentioned ‘the surgeon’ and 18.4% ‘the operating theatre staff’ (Table 4.8). The majority of the respondents in Khan *et al.*’s (2010: 3) study considered the junior surgical assistant to be the person who receives the highest radiation dose; no explanations were given as the questionnaire constituted only closed-ended questions. Furthermore, most of the respondents (36.8%) in the current study reasoned that proximity to the source of radiation results in high personal dose. These results reflect that the staff are knowledgeable about the principle of distance and shielding with regard to radiation doses. As illustrated in Question C36 (Figure 4.7), some of the respondents (9.2%) use the distance rule as their means of radiation protection based on the principle that increasing the distance from the radiation source significantly reduces the radiation dose (Environment, Health and Safety 2018). However, Cecen *et al.* (2015) concluded in their radiation safety study that this is not academically advised, as low cumulative doses can result in unnoticeable radiation effects over time.

The respondents consider the hands and thyroid gland to be the parts of the body most exposed to radiation, with scores of 54.1% and 46.9% respectively. These results are similar to those of Khan *et al.*’s (2010: 3) study, where 50% of the respondents also considered the hands to be the most sensitive to radiation. However, Lynskey III *et al.* (2013) argue that the eye receives more of radiation dose than perceived. Half of the participants (50%) in studies conducted on interventional radiologists complained of ocular lens changes, indicating that the eye is probably more sensitive to radiation than previously concluded (Lynskey III *et al.* 2013). The majority of the respondents (85.3%) in a study conducted in Turkey supported the belief that the eye is very sensitive (Kurtul and Kurtul 2018: 104). On the contrary, several studies have indicated that the hands receive higher radiation doses than the eye lens (Ho *et al.* 2007: 455; Lynskey III *et al.* 2013: 1549). Ho *et al.* (2007: 455), Van der Merwe (2012) and Abu Shab (2005) concluded their studies with results correlating to those from the current study, noting that the thyroid recorded a lower radiation dose than the hands, as perceived in theory. Most of the respondents (46.9%) reasoned that high doses are recorded for the respective body organs because they are not lead-shielded. However, Ho *et al.* (2007: 455), interprets that high doses were recorded for the hands (0.29–1.84mSv) in their study because most surgeons do not remove their hands from the X-ray field during exposures, thus correlating with the 20.4% of respondents from the current study who reasoned that this was because the organs are proximal to the X-ray beam.

Questions B22, B23, E48 and F52 (Appendix J) intended to address the TPB's concept of 'subjective norm'. According to the current results it can be concluded that the respondents are not aware whether the management approves the implementation of radiation protection in their respective institutions. This is evidenced by slightly more than half of the respondents (53.1%) claiming that either there are no protocols or that they have never been advised about them by the management.

It can be concluded from the preceding results that the participants are aware of most of the personnel-related radiation protection protocols. They are aware that radiation is harmful and that a pregnancy test is mandatory for individuals in the child-bearing age group. However, the respondents do not know the reasons why radiation is harmful and are not aware of patient-related radiation protection protocols. The majority of the participants have not read any radiation-related literature and also demonstrated poor knowledge of the ALARA principle and annual dose limits.

5.4.2 Attitude

Almost all of the respondents (98.98%) scored higher than the set benchmark for the attitude section. Overall the participants demonstrated a significant positive attitude towards radiation protection, which is comparable to the studies of Luntsi *et al*. (2016) and Khan *et al.* (2010: 3). Slightly more than two thirds of the respondents (67.18%) in Luntsi *et al*.'s (2016) study and 77% of the participants in Khan *et al.*'s (2010: 3) study had a positive attitude towards radiation protection. The responses to Questions C27, C28 and C29 were more towards the positive ranking (4–7), implying that the staff's attitude towards reducing radiation doses is positive. It further establishes that the respondents perceive that they have control over their behaviour towards radiation protection. This correlates with the TPB's concept of 'perceived behavioural control', which states that an individual has control over their behaviour (Ajzen 1993: 49). Most of the respondents (86.7%) indicated that they are likely to reduce patients' and staff doses by using best radiation protection practices; 89.8% perceive reducing radiation exposure to be of great importance and believe that they can have a good influence on their colleagues by using best radiation protection practices. Believing that radiation protection practice prevents radiation-induced cancer instils a positive attitude in the individual and increases the chances that they will probably incorporate radiation protection in their daily practice, thus corresponding with the TPB (Ajzen 1993: 49).

The results for questions C30, C32, C33 and C34 (Table 4.9) were 96.9%, 76.6%, 86.7% and 49.4% respectively, indicating that the staff agree on performing tasks to aid radiation protection. This demonstrates a positive attitude towards radiation protection. The 96.9% 'Agree' responses to Question C30 correlate with the IAEA's (2013) indication that radiation doses should be monitored to ensure that annual dose limits are not exceeded, as part of radiation protection policies. These results are similar to those of Khan *et al.* (2010: 3), where 92% of the respondents agreed that radiation doses should be monitored.

The staff under study demonstrated that they are aware of the importance of gonadal shielding in children, evidenced by the 76.6% of 'Agree' responses to Question C32. Some of the respondents (21.4%) are probably not well informed or knowledgeable about the issue, and therefore selected the 'Neutral' response. Only 42.9% of respondents went on to provide reasons to support their response to Question C32. The majority of the respondents reasoned that a gonadal shield should be provided for children to prevent infertility and radiation effects (15.3% and 17.3% respectively). Khan *et al.* (2010: 3) obtained similar results. Almost all of the respondents (94%) indicated that gonadal shielding in children is of vast importance. Shielding gonads during radiation exposure significantly reduces the radiation dose to the reproductive organs and thus minimises chances of sterility and aspermia (Fauber 2016; Ogilvy-Stuart and Shalet 1993: 109). Silva, Silva and Ventura (2010: 1) add that "Considering that ionising radiation effects are cumulative and the gonads are particularly sensitive to these effects … the excess of radiation exposure to the gonads must be avoided".

In the current study the respondents demonstrated a good attitude towards post-menopause radiation dose monitoring, indicated by 86.7% agreeing with it. Furthermore, a quarter of the respondents (25.5%) reasoned that it should be monitored to prevent radiation effects, and a further 20.4% that it should be monitored specifically to prevent cancer. The mentioned reasons can be supported by evidence from a survey conducted amongst radiology technologists of all age groups in the USA (Boice Jr. *et al.* 1992: 587). Boice Jr. *et al.* (1992: 587) noted that 4186 (4%) of the respondents (n=104 629) had various cancers such as skin, thyroid, breast and cervical, while 9% had thyroid conditions (Boice Jr. *et al.* 1992: 587). These statistics justify the need for continuous radiation dose monitoring in ionising radiation-exposed individuals, regardless of age, as indicated by the respondents in the current study.

The 'Neutral' responses given by 32.2% of the respondents to Question C34 could be those of the nurses and other staff who are not legalised to request radiology examinations (HPCSA 2014: 1). The HPCSA (2014: 1) strongly recommends that only a medical practitioner, dentist or other suitably qualified healthcare professional should request medical X-ray examinations. Therefore Question C34 was directed to the doctors and specialists only. Some of the respondents (18.4%) indicated that they do not consider the cumulative radiation dose of the multiple radiological studies that they request for patients. This could be as a result of health professionals underestimating the radiation exposures involved in various radiological procedures, as indicated by some academics in their radiation surveys (Yurt, Çavuşoğlu and Günay 2014: 49; Saeed *et al.* 2018: 48). However, the current value is lower than in Khan *et al*.'s (2010: 3) study, where more than a third of the respondents (40%) indicated that they do not weigh up the pros and cons of radiation when ordering radiological examinations. The low value obtained in the current study could be attributed to the fact that most of the respondents who are doctors (98.1%) are qualified and therefore have more knowledge and experience, compared to the surgical trainees in Khan *et al.*'s (2010) study. One of the respondents in the current study further stated the following: *"one should do this but in practice it is not something we are diligent about considering how busy we are"*. This statement suggests that the staff's attitude towards radiation protection is also influenced by external factors such as workload, as indicated by Portoghese *et al.* (2014: 1), who mentioned that heavy workload of healthcare workers has a negative impact on their patient care quality. However, Mæstad, Torsvik and Aakvik (2010: 686) argue that workload does not usually have a major influence on patient care quality; rather, it is dependent on the quality of training received by the healthcare practitioner.

The majority of the respondents (87.7%) adhere to the set radiation protection protocol of wearing lead aprons, and indicated 'Always' or 'Often' in response to Question C35. Almost half (n=41) went on to indicate that they 'Do not always' wear lead aprons, and the majority of these (31.9%) indicated that they do not always wear a lead apron because of its weight. This correlates with the findings of a study conducted by Kurtul and Kurtul (2018: 104) where the majority of the respondents (80.4% and 61.6%) complained that the protective wear was heavy and uncomfortable, reducing mobility. Lightweight aprons that are lead-free are now available on the market and are recommended for long procedures as opposed to the traditional 5.1 kg (100%) lead aprons (AliMed 2018).

Studies have been conducted to assess the possibility of utilising the distance rule, as most healthcare workers complain about the weight of the aprons (Rhea, Rogers and Riehl 2015; Cecen *et al.* 2015). In the current study 9%

claimed that they follow the distance rule. In a systematic review Rhea, Rogers and Riehl (2015) concluded that there is no need to wear a lead apron when working beyond 1.5 m from the C-arm during orthopaedic theatre screening. However, Cecen *et al.* (2015) argue that despite the doses being significantly lower at beyond 1.5 m, it is advisable to wear a lead apron since the cumulative dose can be carcinogenic. The respondents in the current study also demonstrated a good attitude towards radiation protection by portraying their eagerness to acquire more training. The majority of the respondents (55.1%) agreed that they need further training, correlating with the 3.3% of general practitioners and 66% of specialists who agreed to the same in a study conducted in Yazd Province, Iran (Chaparian, Moghadam and Mansourian's (2014: 81).

Overall the respondents demonstrated a positive attitude towards radiation protection protocols and guidelines. However, a significant number of them have a negative attitude towards lead aprons, perceiving these to be heavy and a cause of backache.

5.4.3 Practice

The respondents' practice of radiation protection was assessed in Section E of the questionnaire (Questions E40 to E49) (Appendix J). The questions were categorised to evaluate 'personnel-related' practices (Questions E40 to E45) and 'patient- related' practices (Questions E46 to E48) (Table 4.10). Questions E40 to E44 investigated the respondents' adherence to the use of radiation protective wear. According to the National Cancer Institute (2005a: 3), as part of radiation protection practice individuals working in radiation-exposed environments are advised to wear radiation protective wear such as lead aprons and goggles at all times. However, the current results under discussion indicated poor practice amongst the staff. Only 3.06% of the respondents scored beyond the set benchmark for the practice of radiation protection (Table 4.5). These results correlate with those obtained in several radiation surveys internationally (Khan *et al*. 2010: 1; Palacia *et al*. 2014: 228; Rosario *et al*. 2015; Tunçer *et al*. 2017).

In the current study lead aprons are always worn by almost two-thirds of the respondents (66.3%) (Table 4.10), which is higher than the 39.7% who did so in the study conducted in Turkey (Kurtul and Kurtul 2018: 104). The majority of the staff (56.1%, 90.8% and 85.6%) never use thyroid shielding, radiation goggles or radiation-monitoring devices (TLDs) respectively (Table 4.10). These results are alarming considering that the majority of the respondents (80.6%) use fluoroscopy for 1 to 3 surgical procedures per week. However, this is not unique to this study, as only 36.6%, 5.2% and 2.9% reportedly use thyroid shield, radiation goggles and lead gloves respectively at various institutions in Turkey (Kurtul and Kurtul 2018: 104). These results also correspond to the findings of a radiation protection attitude and practice survey conducted amongst interventional radiologists (Lynskey III *et al.* 2013). Considering that radiologists are perceived as the experts in the radiology field, one would expect them to completely adhere to the recommended radiation protection practices. However, this is not the reality, as findings from the study demonstrated that the majority of the interventional radiologists only use lead aprons and thyroid shields as they are considered to be the 'standard practice' (Lynskey III *et al.* 2013).

Lynskey III *et al.* (2013) discovered that the radiologists were not wearing the other radiation protective wear due to unavailability or discomfort. This correlates with the findings of the current study, where the majority of the respondents (81.6%) mentioned that they do not wear the recommended radiation goggles, thyroid shields and lead gloves due to unavailability. This is not unique to this study; that conducted in Turkey by Kurtul and Kurtul (2018: 104) also indicated that the majority of respondents (80.4%) do not wear protective wear because it reduces mobility due to its weight and is also uncomfortable to wear (61.6%). Very few respondents (10.3%) wear TLDs as compared to 90.1% in Kurtul and Kurtul's (2018:104) study and 76% in Khan *et al.*'s (2010: 3) study. This could be attributed to the fact that the study conducted in Turkey included radiology and radiation oncology staff, who are known to always have TLDs and to monitor radiation doses, as opposed to non-radiology departments (ICRP 2011: 2; Kiah and Stueve 2012: 38). The low number of respondents wearing TLDs could be due to a shortage of these, as indicated by 76.4% of the participants who pointed out that TLDs are not available.

The participants' responses to their patient-related radiation protection practices were also very poor (Table 4.10). This raises concern as it is the role of the healthcare workers to practise good radiation practices for the benefit of themselves and the patients (Kiah and Stueve 2012: 38). More than half of the respondents (50%, 69.1% and 56.1%) indicated that they 'Never' ask for a pregnancy test, 'Never' provide gonadal shielding to children during procedures and 'Never' record fluoroscopy exposures respectively. Question E46 (Appendix J) was meant for healthcare workers authorised to order radiology procedures, including specialists, medical officers and registrars. Forty-nine doctors responded to the question, and the majority of these (30.6%) indicated that they 'Never' ask for pregnancy tests and only 14.3% 'Always' ask, despite indicating earlier that a pregnancy test is mandatory for women of child-bearing age (68.4%). This is in contrast to the findings of Khan *et al.*'s (2010: 3) study, where 76% of the respondents indicated that they ask for a pregnancy test in female trauma patients of child-bearing age. This demonstrated poor radiation protection practice amongst the doctors in the current study, as it is strongly recommended that a pregnancy test be carried out for female patients of child-bearing age (Abdullahi and Toriman 2015).

Only 9.2% of the respondents indicated that the radiographer is responsible for recording the fluoroscopy measures and 14.2% of the respondents explained that these are documented either on paper or in the system by the radiology department. These results correlate with the Radiation Control division of the South African Department of Health's emphasis on recording and filing of screening times and doses by a licensed radiographer operating the C-arm machine at the end of each procedure (HPCSA 2014/15: 9). Most modern C-arm machines show the screening time and dose records on the display monitor at the end of a screening procedure as this is a prerequisite of all C-arms by most radiation regulating boards (IAEA 2017).

These results conclude that the majority of the respondents wear lead aprons but do not wear radiation-monitoring devices (TLDs), radiation goggles and thyroid shielding due to unavailability. A significant proportion of the doctors and specialists (30.6%) do not ask for a pregnancy test for individuals in the child-bearing age group. Lastly, most of the participants lack knowledge of the recording and documentation of radiation exposures in theatre. The following section discusses the data related to the second objective of this study.

5.5 Objective 2: Establish the correlation or relationships between the staff's radiation protection KAP, demographic factors and intentions to implement radiation protection practices

This section discusses the results from the Chi-square test and Fisher's exact test that were performed to assess the relationship between this study's variables (knowledge, attitude, intention to practise and practice) and the correlations between the variables themselves.

5.5.1 Radiation-related KAP versus demographic data

Correlations between KAP and demographic data were established by cross-tabulations, which indicated that there were statistically significant relationships amongst the respondents' radiation-related KAP and some of the demographic factors (Tables 4.16, 4.17 and 4.19). Overall the respondents' highest level of qualification, frequency of working in the operating theatre as well as the frequency of performing fluoroscopy-guided procedures had no significant influence on their KAP scoring.

The hospital in which the respondent works had a significant impact on their radiation-related KAP ($p < 0.05$) (Table 4.16; Table 4.19), correlating with Moshfegh *et al.*'s (2018: 550) KAP study amongst operating room personnel in Iran. Lower levels of KAP were associated with hospitals in remote areas (Moshfegh *et al.* 2018: 550). In the current study the hospital where a respondent is working had a statistically significant relationship with statements addressing radiation protection policies, guidelines and use of protective wear. The statements ‘I am aware of radiation control policies and guidelines in a South African context’, ‘I use thyroid shielding during surgical procedures involving use of fluoroscopy’ and ‘I wear a radiation monitoring device (TLD) during surgical procedures involving use of fluoroscopy’ all had significance values of $p < 0.001$ with regard to the hospital where the respondent was working. It can therefore be interpreted that low knowledge and practice scores were associated with hospitals lacking radiation protection resources and radiation training.

The respondents’ speciality area had a great impact on their responses to questions on ‘knowledge of radiation protection’. This is evidenced by several knowledge statements scoring $p < 0.05$. The majority of the respondents (55.3%) who did not pass the benchmark score for knowledge are from the Anaesthetics speciality, whilst 41.2% are from the operating theatre (nurses) speciality. Wong *et al.* (2012: e267) established that there was a significant difference between the ‘knowledge’ scores of the clinicians and the radiologists ($p = 0.046$). These results could be attributed to the fact that some specialities do not have radiation studies as part of their syllabi compared to others (Karolinska Institutet 2017).

There is a statistically significant relationship between the respondents’ profession and their knowledge of radiation ($p < 0.05$). Exactly half of the respondents (50%) who did not pass the benchmark score on the knowledge section were nurses. This could be due to the fact that radiation protection is not explored within the course of their educational syllabi, as evidenced by the Karolinska Institutet (2017). Saeed *et al.* (2018: 303) also noted in their study that the orthopaedic surgeons and other general surgeons scored poorly on radiation knowledge-related questions in comparison to other health professionals, establishing that the participants’ profession had an influence on their radiation-related knowledge. However, these results do not relate to Luntsi *et al*.’s (2016) knowledge-attitude study, which revealed that nurses had good knowledge of radiation protection. This discrepancy could be a result of the nurses in Luntsi *et al*.'s (2016) study possessing higher levels of qualification compared to the current study, where the highest qualification for the nurses is a diploma.

The participants' gender did not have a statistically significant influence on their 'knowledge' scores ($p > 0.05$), correlating with Saeed *et al.*'s (2018: 3) radiation awareness study, where the difference between the mean score for males and females was only 1.8%. Furthermore, there is no significant relationship between the participants' radiation protection knowledge and their years of working experience ($p > 0.05$). This statistical result is similar to that obtained in Saeed *et al.*'s (2018: 300) study ($p > 0.8$) as well as that of Wong *et al.* (2012: e267) ($p > 0.05$). It can therefore be concluded that the participants' profession, area of specialisation and the hospital where they are working have a significant influence on their knowledge of radiation protection.

A statistically significant relationship was noted between gender and the attitude of the respondent towards radiation protection ($p < 0.05$). The majority of the respondents (66.32%) who scored higher than the set benchmark for attitude were females; the only respondent ($n = 1$) who did not pass the set benchmark was a male. These results correspond with those in a study conducted to establish the relationship between gender and work-related attitudes in the USA (Selvarajan, Slattery and Stringer 2015: 1919), which concluded that female employees had a more positive work-related attitude than their male counterparts. There are no significant relationships between the participants' attitude towards radiation protection and their highest level of qualification, area of specialisation, profession, frequency of working in operating theatres, frequency of performing fluoroscopy-guided procedures and the hospital at which they are working (Table 4.17). It can therefore be concluded that only the gender of the respondents has a significant influence on their attitude towards radiation protection.

There is also a statistically significant relationship between practice of radiation protection and the hospital where the respondents are working ($p < 0.05$) (Table 4.19). These results correlate with Moshfegh *et al.*'s (2018: 550) findings, where hospitals in remote areas of Iran scored poorly in the KAP survey, as mentioned earlier. Boyd (2013: 128) also obtained similar results in a study conducted to utilise TPB to predict the radiographers' practice of radiation protection in the UK. Boyd (2013: 128) concluded that the facility type had a significant influence on the radiographers' past radiation protection behaviours. The majority of the participants from specified hospitals in the current study indicated that the personal protective wear is not available, perhaps resulting in the low 'practice' scores (Table L21 (Appendix L); Table 4.5). The respondents' gender, highest level of qualification, area of specialisation, profession, frequency of working in operating theatre and frequency of working in the operating theatre had no significance influence of their 'practice' scoring ($p < 0.05$). This concludes that only the hospital where the participants are working has a significant influence on their practice of radiation protection.

5.5.2 Correlations amongst the factors of KAP and intention to implement radiation protection practices

The correlation tests for the current study presented results indicating a directly proportional (positive) correlation between the respondents' knowledge of radiation protection and attitude towards radiation protection ($r = 0.270$, $p = 0.021$) (Table 4.20). This implies that as the respondents acquire more knowledge of radiation protection, their attitude towards radiation protection will also improve. Similar results ($r = 0.466$, $p < 0.01$) were obtained in a KAP survey amongst hepatitis B patients in Quetta, Pakistan (Haq *et al.* 2013). The current results also correspond with the WHO's (2012: 21) statement that according to KAP constructs an individual's knowledge about a phenomenon directly influences their attitude and behaviour towards the phenomenon.

However, contrasting results to this WHO (2012: 21) statement were obtained for the knowledge-practice correlation in the current study. The results concluded that there is an inverse (negative) relationship between the respondents' knowledge of radiation protection and practice of radiation protection (r = -0.264, p = 0.017) (Table 4.21). According to these statistical values, as the respondents improve their knowledge of radiation protection their practice of radiation protection decreases. This is not unique to this study, as alcohol knowledge interventions did not improve the drinking behaviour amongst college students in Southern California (Thadani, Huchting and LaBrie 2009: 31). A KAP study conducted in Nigeria concluded that the staff had poor radiation protection practices despite having adequate radiation-related knowledge (Awosan *et al.* 2016). The current results can be linked to the low scores for practice of radiation protection due to a lack of adequate protective wear. The inverse relationship could be the result of other cause-effect factors which are beyond the scope of the current study. Further studies on this outcome will be of great benefit to the study population.

According to the current study's bivariate correlation results there is no statistically significant correlation between the respondents' knowledge of radiation protection and their intention to practise radiation protection (p > 0.05) (Appendix M). These results are unique to the study. A research study conducted in the USA revealed that increasing parents' knowledge of human papillomavirus was associated with increased intention to have their daughters vaccinated (Mansfield *et al.* 2016: 481). Furthermore, Leshi, Samuel and Ajakaye (2016) concluded that there was a positive correlation between knowledge and intention to breastfeed amongst young female adults in Ibadan, Nigeria. The cause-effect for the current result calls for further research investigation.

The current results indicated a directly proportional (positive) relationship between the respondents' attitude towards radiation protection and their intention to practise radiation protection (r = 0.348, p = 0.008) (Table 4.22). This implies that improving the respondents' attitude towards radiation protection increases their intention to implement recommended radiation protection practices, corresponding with the TPB. These results are similar to Boyd's (2013: 137) findings. According to Boyd (2013: 137) the radiographers' direct and indirect attitudes towards radiation protection predicted their intentions to put best radiation protection measures into practice. The TPB denotes that a person's behavioural intention is directly influenced by their attitude towards the phenomenon (Ajzen 1993: 48). Furthermore, increasing behavioural intention motivates the individual to carry out the behaviour (Ajzen 1993: 49). However, this is contrary to the current study's outcome, which revealed no statistical correlation between the respondents' intention to practise radiation protection and practice of radiation protection (Appendix M). These results also do not correlate to Boyd's (2013: ii) findings, which indicated that the radiographers' intention to practise radiation predicted their past radiation protection behaviours.

Furthermore, this study indicated an inverse relationship between the respondents' attitude towards radiation protection and practice of radiation protection (r = -0.280, p = 0.014) (Table 4.23). This outcome does not correspond with the KAP construct which indicates that an individual's attitude directly influences their behaviour or practice (WHO 2012: 21). The current results also do not correlate with the TPB, which concludes that an individual's attitude determines their intentions and their practice or behaviour towards the phenomenon (Ajzen 1993: 48-9). Several studies revealed a positive correlation between attitude and practice (Khorvash *et al.* 2014: 246, Roelens *et al.* 2016). A positive attitude towards HIV was linked to better basic care provision to HIV patients (Khorvash *et al.* 2014: 246). A study of gynaecologists in Belgium demonstrated that improved attitude towards intimate partner violence (IPV) in pregnant patients resulted in an increase in testing for IPV in their patients (Roelens *et al.* 2016). Boyd (2013: 146) also concluded that the radiologic technologists' attitude towards radiation protection predicted their practice of the recommended radiation protocols. The current results revealing an inverse relationship between attitude and practice could be attributed to cause-effect factors such as the low practice scores which are a result of a shortage of radiation protection resources.

5.4 Summary

The current study has indicated that the respondents have average knowledge of radiation protection (61.22%) and a positive attitude towards radiation protection (98.98%), but very poor practice of radiation protection (3.06%). The respondents' speciality, profession and the hospital where they are working have a significant influence on their KAP scores ($p < 0.05$). There are significant positive correlations between respondents' knowledge and attitude ($r = 0.270$, $p = 0.021$), attitude and intention ($r = 0.348$, $p = 0.008$), perceived behavioural control and intention to practise radiation protection ($r = 0.31$, $p = 0.006$). There are significant negative (inverse) correlations between the respondents' knowledge and practice ($r = -0.264$, $p = 0.017$), and attitude and practice ($r = -0.280$, $p = 0.014$). There are no significant correlations between the respondents' knowledge and intention, or intention and practice ($p > 0.05$).

Chapter Six

Conclusion and recommendations

6.1 Introduction

This chapter presents the conclusion, limitations and recommendations of this study.

6.2 Conclusion

It is clear from this study that the non-radiology staff working in theatres using fluoroscopy-guided operating techniques and procedures in the eThekwini District of KZN have a positive attitude and moderate radiation protection knowledge. However, despite this they do not comply with the recommended radiation protection practices. This could be due to the shortage of resources. The study's outcome indicated that the staff's area of specialisation, profession and hospital where they are working have a significant impact on their knowledge, attitude and practice of radiation protection.

The results showed a positive correlation between knowledge and attitude, and attitude and intention, but a negative (inverse) relationship between knowledge and practice, and attitude and practice. These relationships can be utilised to develop target-oriented interventions to improve the staff's radiation protection behaviours and hence to reduce occupational and patient radiation exposures.

6.3 Limitations

There were a few limitations encountered during this study. Data collection was conducted over 12 weeks. This time could be extended, considering how busy the respondents were. Since the study did not adopt a qualitative research design detailed opinions of individuals were not obtained; however, the quantitative design managed to provide baseline information for further research. The majority of the staff were hesitant to participate in the study as questionnaires were considered to be long and boring.

6.4 Recommendations

Considering the outcomes of this study, the researcher recommends the following:

- Performing in-service training on radiation protection in the investigated departments as a means of increasing the staff's radiation awareness.
- Carrying out workshops as Continuous Professional Development (CPD) on a regular basis. The workshops should be targeted at addressing the topics where the staff demonstrated poor knowledge and negative attitude. These topics include; deterministic effects, stochastic effects, patient-related radiation protection protocols, ALARA principle, annual radiation dose limits and personal protective equipment.
- Putting up educative posters on radiation safety in non-radiology fluoroscopy utilising departments. The posters should be written in simple language that the non-radiology staff can easily understand.
- Inclusion of radiation dose and safety courses in the educational curriculum of various theatre professionals.
- Provision of protective wear (thyroid shielding, radiation goggles) and radiation-monitoring devices (TLDs). The majority of the respondents indicated that they do not wear the recommended protective wear because they are not available.
- Further research on the comparison of radiation protection KAP between private institutions and public health institutions, to assess if poor radiation practices are due to a shortage of resources or other factors.
- Further research on the cause-effect of the obtained negative correlation between knowledge and practice, knowledge and intention to practise, attitude and practice.
- Further studies to evaluate the effect of recommended radiation protection in-service trainings on behavioural change (pre- and post-in-service training).

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Appendix A: Permission letter from KZN Department of health

health
Department:
Health
PROVINCE OF KWAZULU-NATAL

DIRECTORATE:

330 Langalibalele street,
Private Bag X9051 PMB, 3200
Tel: 033 395 2805/3189/3123 Fax: 033 394 3782
Email: hrkm@kznhealth.gov.za
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Health Research & Knowledge Management (HKRM)

Reference: HRKM496/17
KZ_201711_041

13 December 2017

Dear Ms S N Hundah
(DUT)

Subject: Approval of a Research Proposal

1. The research proposal titled **'Survey of radiation protection amongst non-radiology staff working in fluoroscopy-guided operating theatres at public health institutions in the eThekwini district of KwaZulu-Natal'** was reviewed by the KwaZulu-Natal Department of Health (KZN-DoH).

   The proposal is hereby **approved** for research to be undertaken at King Edward VIII, King Dinuzulu, Addington, Prince Mshiyeni Memorial Hospital, Inkosi Albert Luthuli Central & RK Khan Hospitals.

2. You are requested to take note of the following:
   a. Make the necessary arrangement with the identified facilities before commencing with your research project.
   b. Provide an interim progress report and final report (electronic and hard copies) when your research is complete.

3. Your final report must be posted to **HEALTH RESEARCH AND KNOWLEDGE MANAGEMENT, 10-102, PRIVATE BAG X9051, PIETERMARITZBURG, 3200** and e-mail an electronic copy to hrkm@kznhealth.gov.za

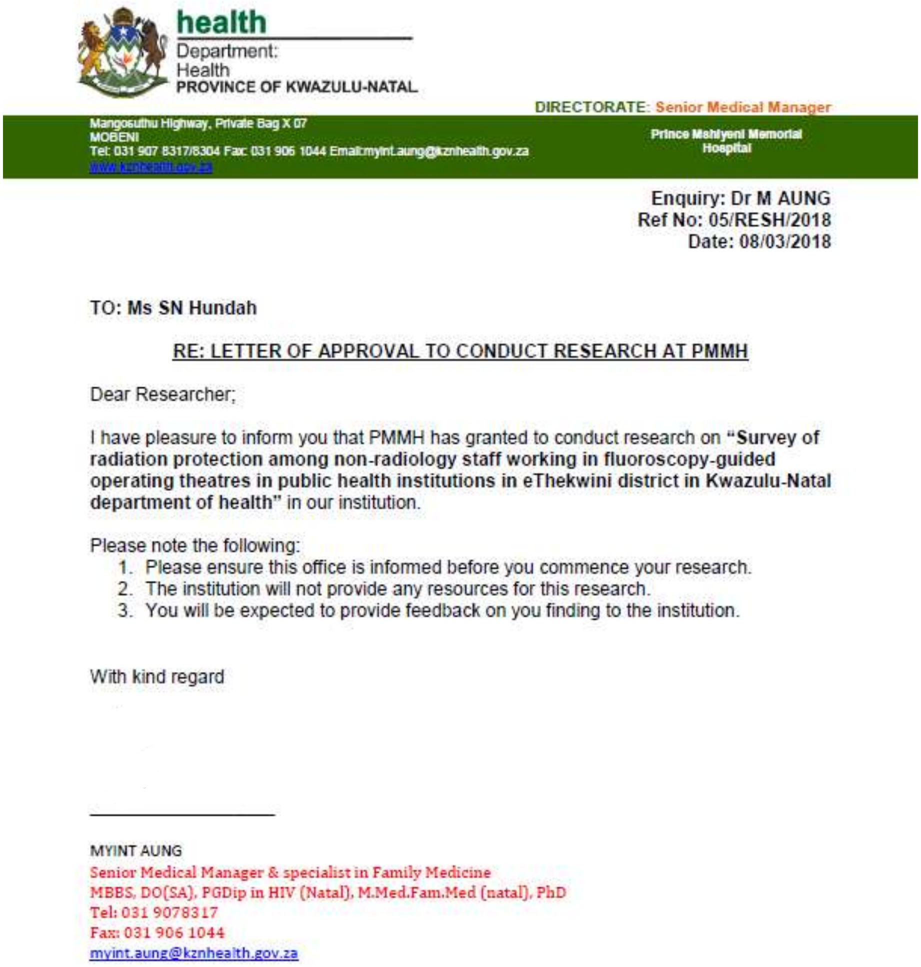
For any additional information please contact Ms G Khumalo on 033-395 3189.

Yours Sincerely

Dr E Lutge
Chairperson, Health Research Committee
Date: 14/12/17

Fighting Disease, Fighting Poverty, Giving Hope

Appendix B: Permission letter from the hospital representatives



health
Department:
Health
PROVINCE OF KWAZULU-NATAL

DIRECTORATE: Senior Medical Manager

Mangosuthu Highway, Private Bag X 07
MOBENI
Tel: 031 907 8317/8304 Fax: 031 906 1044 Email:myint.aung@kznhealth.gov.za
www.kznhealth.gov.za

Prince Mshiyeni Memorial
Hospital

Enquiry: Dr M AUNG
Ref No: 05/RESH/2018
Date: 08/03/2018

TO: **Ms SN Hundah**

RE: LETTER OF APPROVAL TO CONDUCT RESEARCH AT PMMH

Dear Researcher;

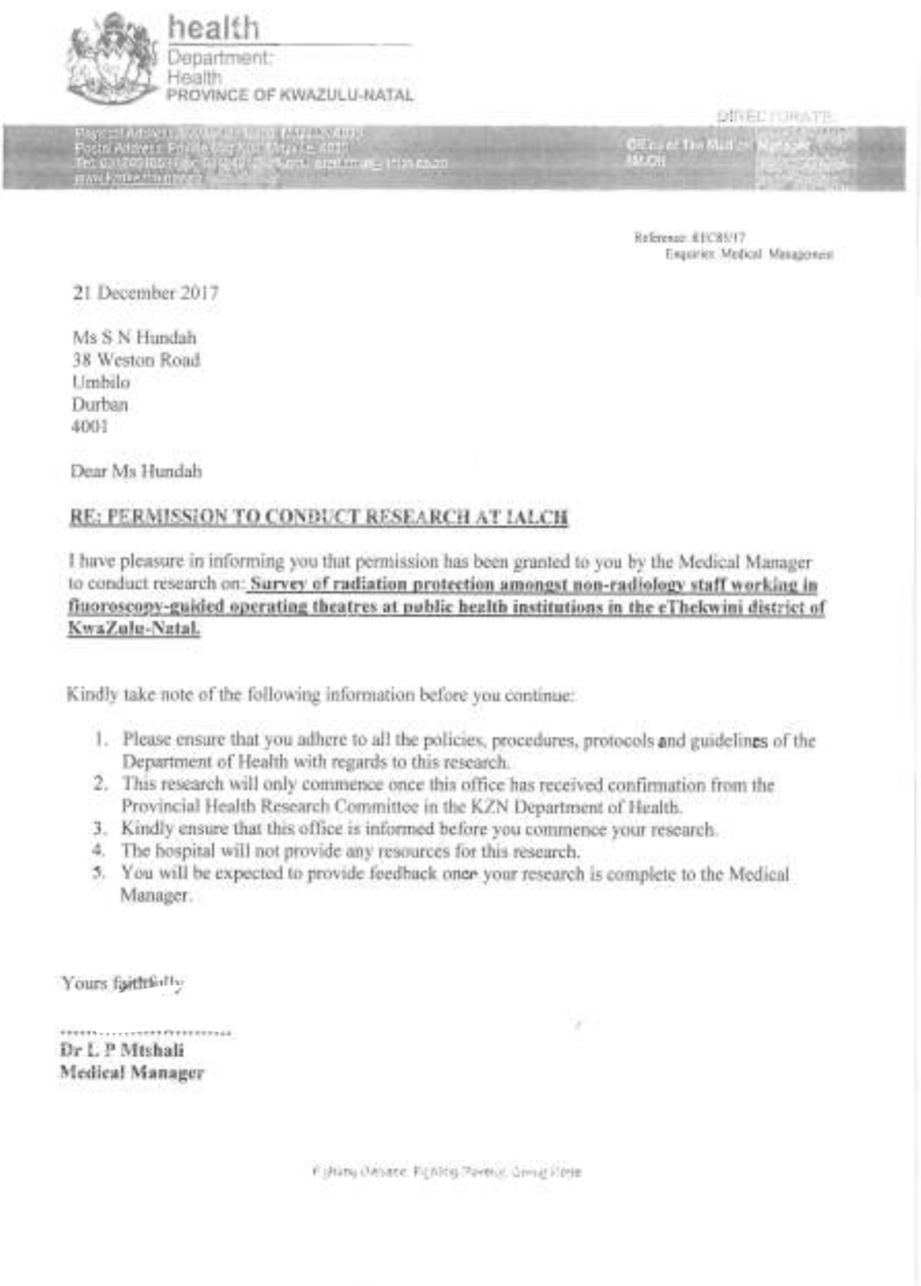
I have pleasure to inform you that PMMH has granted to conduct research on **"Survey of radiation protection among non-radiology staff working in fluoroscopy-guided operating theatres in public health institutions in eThekwini district in Kwazulu-Natal department of health"** in our institution.

Please note the following:

1. Please ensure this office is informed before you commence your research.
2. The institution will not provide any resources for this research.
3. You will be expected to provide feedback on you finding to the institution.

With kind regard

MYINT AUNG
Senior Medical Manager & specialist in Family Medicine
MBBS, DO(SA), PGDip in HIV (Natal), M.Med.Fam.Med (natal), PhD
Tel: 031 9078317
Fax: 031 906 1044
myint.aung@kznhealth.gov.za



health
Department:
Health
PROVINCE OF KWAZULU-NATAL

DIRECTORATE:
Office of The Medical Manager
IALCH

Reference: REC85/17
Enquiries: Medical Management

21 December 2017

Ms S N Hundah
38 Weston Road
Umbilo
Durban
4001

Dear Ms Hundah

RE: PERMISSION TO CONDUCT RESEARCH AT IALCH

I have pleasure in informing you that permission has been granted to you by the Medical Manager to conduct research on: **Survey of radiation protection amongst non-radiology staff working in fluoroscopy-guided operating theatres at public health institutions in the eThekwini district of KwaZulu-Natal.**

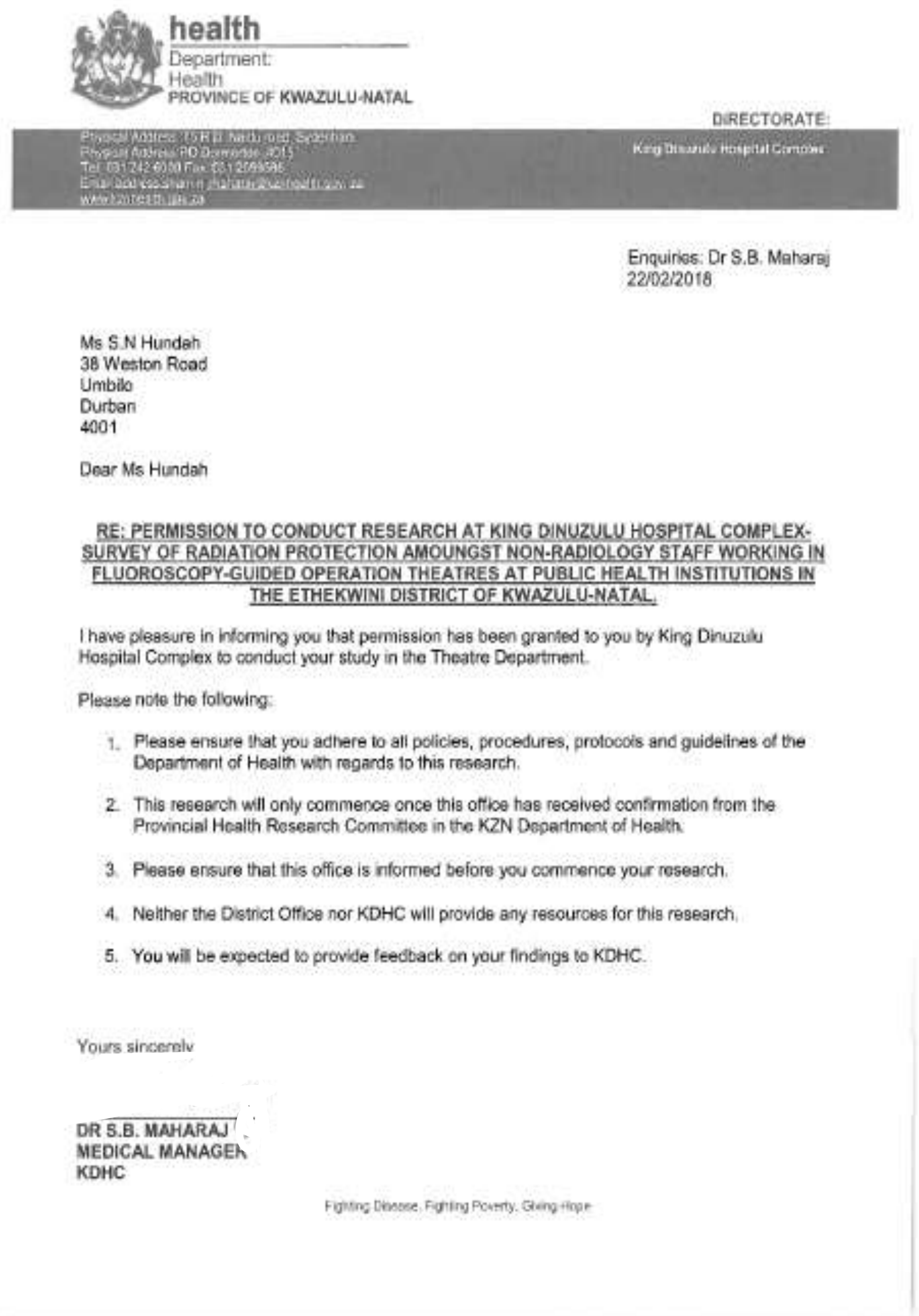
Kindly take note of the following information before you continue:

1. Please ensure that you adhere to all the policies, procedures, protocols and guidelines of the Department of Health with regards to this research.
2. This research will only commence once this office has received confirmation from the Provincial Health Research Committee in the KZN Department of Health.
3. Kindly ensure that this office is informed before you commence your research.
4. The hospital will not provide any resources for this research.
5. You will be expected to provide feedback once your research is complete to the Medical Manager.

Yours faithfully

....
Dr L P Mtshali
Medical Manager

Fighting Disease, Fighting Poverty, Giving Hope



health
Department:
Health
PROVINCE OF KWAZULU-NATAL

DIRECTORATE:
King Dinuzulu Hospital Complex

Enquiries: Dr S.B. Maharaj
22/02/2018

Ms S.N Hundah
38 Weston Road
Umbilo
Durban
4001

Dear Ms Hundah

RE: PERMISSION TO CONDUCT RESEARCH AT KING DINUZULU HOSPITAL COMPLEX- SURVEY OF RADIATION PROTECTION AMOUNGST NON-RADIOLOGY STAFF WORKING IN FLUOROSCOPY-GUIDED OPERATION THEATRES AT PUBLIC HEALTH INSTITUTIONS IN THE ETHEKWINI DISTRICT OF KWAZULU-NATAL.

I have pleasure in informing you that permission has been granted to you by King Dinuzulu Hospital Complex to conduct your study in the Theatre Department.

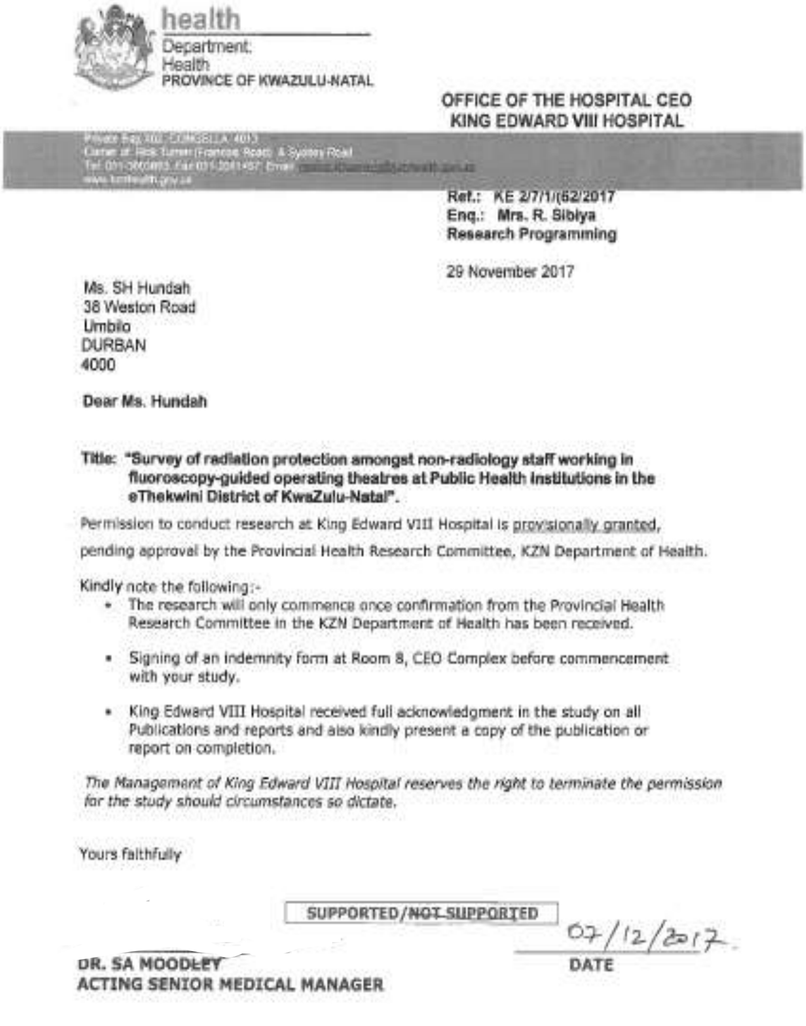
Please note the following:

1. Please ensure that you adhere to all policies, procedures, protocols and guidelines of the Department of Health with regards to this research.
2. This research will only commence once this office has received confirmation from the Provincial Health Research Committee in the KZN Department of Health.
3. Please ensure that this office is informed before you commence your research.
4. Neither the District Office nor KDHC will provide any resources for this research.
5. You will be expected to provide feedback on your findings to KDHC.

Yours sincerely

DR S.B. MAHARAJ
MEDICAL MANAGER
KDHC

Fighting Disease, Fighting Poverty, Giving Hope



health
Department:
Health
PROVINCE OF KWAZULU-NATAL

OFFICE OF THE HOSPITAL CEO
KING EDWARD VIII HOSPITAL

Private Bag X02, CONGELLA, 4013
Corner of Rick Turner (Francois Road) & Sydney Road
Tel 031-3603853, Fax 031-2061457, Email [illegible]
www.kznhealth.gov.za

Ref.: KE 2/7/1/(62/2017
Enq.: Mrs. R. Sibiya
Research Programming

29 November 2017

Ms. SH Hundah
38 Weston Road
Umbilo
DURBAN
4000

Dear Ms. Hundah

Title: "Survey of radiation protection amongst non-radiology staff working in fluoroscopy-guided operating theatres at Public Health Institutions in the eThekwini District of KwaZulu-Natal".

Permission to conduct research at King Edward VIII Hospital is provisionally granted, pending approval by the Provincial Health Research Committee, KZN Department of Health.

Kindly note the following:-

- The research will only commence once confirmation from the Provincial Health Research Committee in the KZN Department of Health has been received.
- Signing of an indemnity form at Room 8, CEO Complex before commencement with your study.
- King Edward VIII Hospital received full acknowledgment in the study on all Publications and reports and also kindly present a copy of the publication or report on completion.

The Management of King Edward VIII Hospital reserves the right to terminate the permission for the study should circumstances so dictate.

Yours faithfully

SUPPORTED/~~NOT SUPPORTED~~

07/12/2017

DR. SA MOODLEY
ACTING SENIOR MEDICAL MANAGER

DATE

health
Department:
Health
PROVINCE OF KWAZULU-NATAL

DIRECTORATE:

Physical Address : R.K. Khan Circle
Physical Address : CHATSWORTH
Tel: [031] 4596001 Fax [031] 4011247 Email:Sharon.gounden@kznhealth.gov.za
www.kznhealth.gov.za

R.K. KHAN HOSPITAL
OFFICE OF THE CEO

ENQUIRIES : DR P.S. SUBBAN

8 December 2017

Ms S.N. Hundah
Student No. 21649783
Durban University of Technology

Dear Madam

RE: PERMISSION TO CONDUCT RESEARCH: SURVEY OF RADIATION PROTECTION NON-RADIOLOGY STAFF WORKING IN FLUOROSCOPY-GUIDED OPERATING THEATRES AT PUBLIC HEALTH INSTITUTIONS IN THE ETHEKWINI DISTRICT OF KWAZULU NATAL

Permission is granted to conduct the study at this institution.

Please note the following:

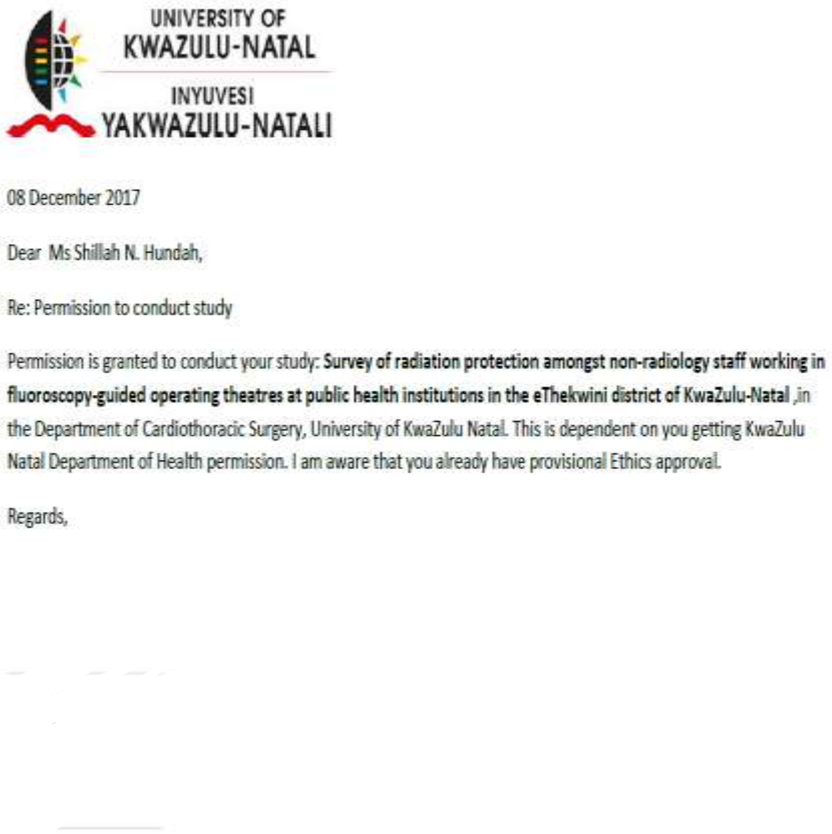
1. Please ensure that you adhere to all the policies, procedures protocols and guidelines of the Institution with regards to this research.
2. Please ensure this office is informed before you commence your research and your University's Ethics approval must be attached.
3. You will be expected to provide feedback on your findings to this institution.
4. You will be liaising with : Mr D. Singh
   ANM – Theatre
   Tel : [031 – 4596035]

Yours faithfully

DR P.S. SUBBAN
CHIEF EXECUTIVE OFFICER

KHAN
HOSPITAL / HOSPITAAL
[illegible]-12-2017
PRIVATE BAG / PRIV[illegible]
CHATS[illegible]

Appendix C: Permission from Head of departments



UNIVERSITY OF
KWAZULU-NATAL
INYUVESI
YAKWAZULU-NATALI

08 December 2017

Dear Ms Shillah N. Hundah,

Re: Permission to conduct study

Permission is granted to conduct your study: **Survey of radiation protection amongst non-radiology staff working in fluoroscopy-guided operating theatres at public health institutions in the eThekwini district of KwaZulu-Natal** ,in the Department of Cardiothoracic Surgery, University of KwaZulu Natal. This is dependent on you getting KwaZulu Natal Department of Health permission. I am aware that you already have provisional Ethics approval.

Regards,

Good Morning
The email request below refers. The proposed research request by Ms Shillah Hundah is supported by the Dept. of Orthopaedic Surgery at IALCH.

-----Original Message-----
From: Karmen Govender
Sent: 05 December 2017 11:35 AM
To: Ismail Goga
Subject: Request for permission to conduct research

-----Original Message-----
From: Shillah Hundah
[mailto:shilz88@gmail.com]
Sent: 05 December 2017 11:07 AM

Technology Masters student intending

Bala Pillay
to me
Hide details

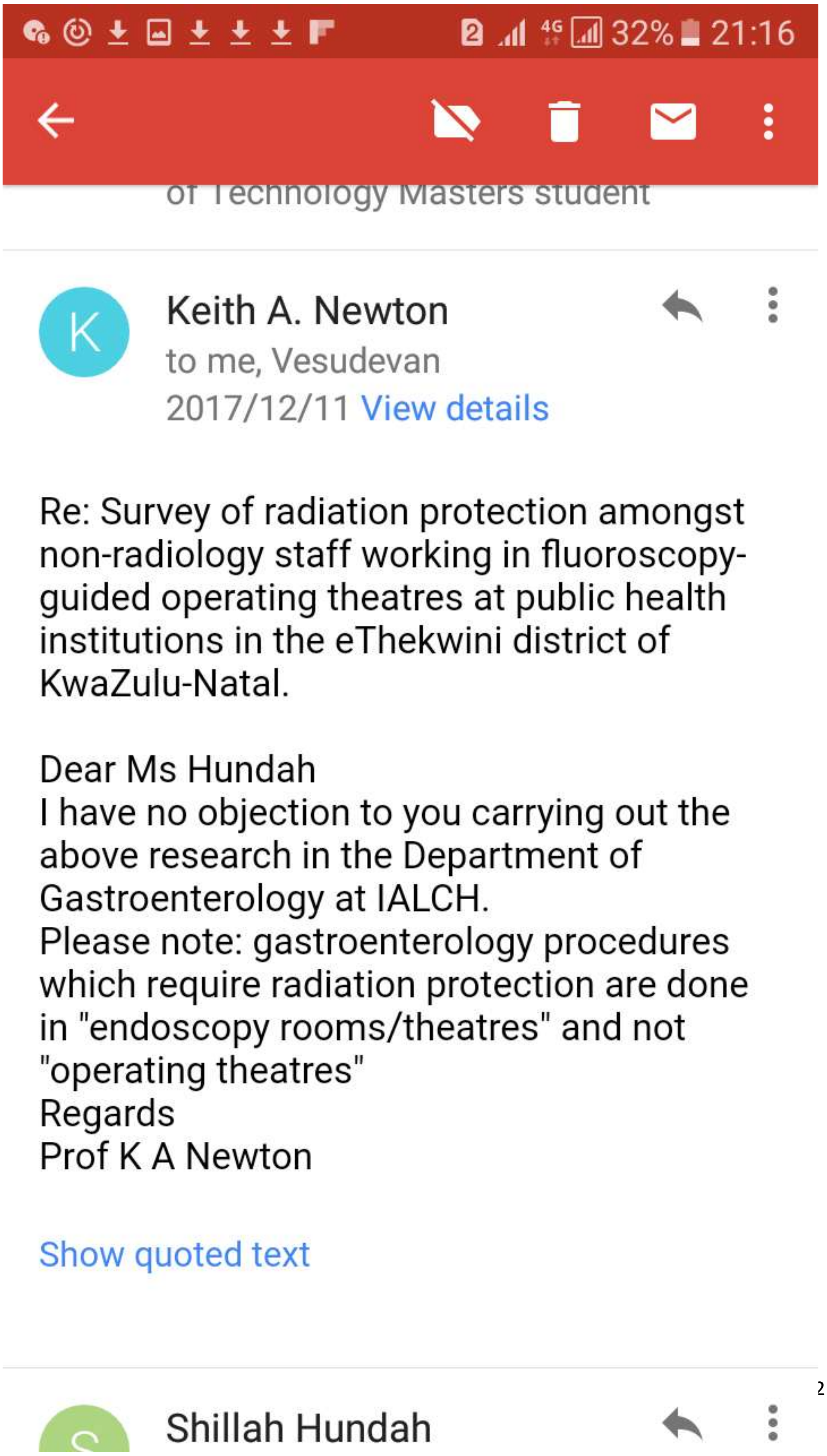
From: Bala Pillay BalaPil@ialch.co.za
To: Shillah Hundah shilz88@gmail.com
Date: 05 Dec 2017, 12:00
View security details

Dear colleague,
Good day ,

Thank you the request relating to your research study. Permission is hereby granted for you to conduct your study as Radiation and its hazards are topical at present from a vascular perspective .
Best wishes and goodluck with your study .

Kind Regards
Dr Bala Pillay (Principal specialist and Head : Department of Vascular /Endovascular surgery)

Show quoted text



of Technology Masters student

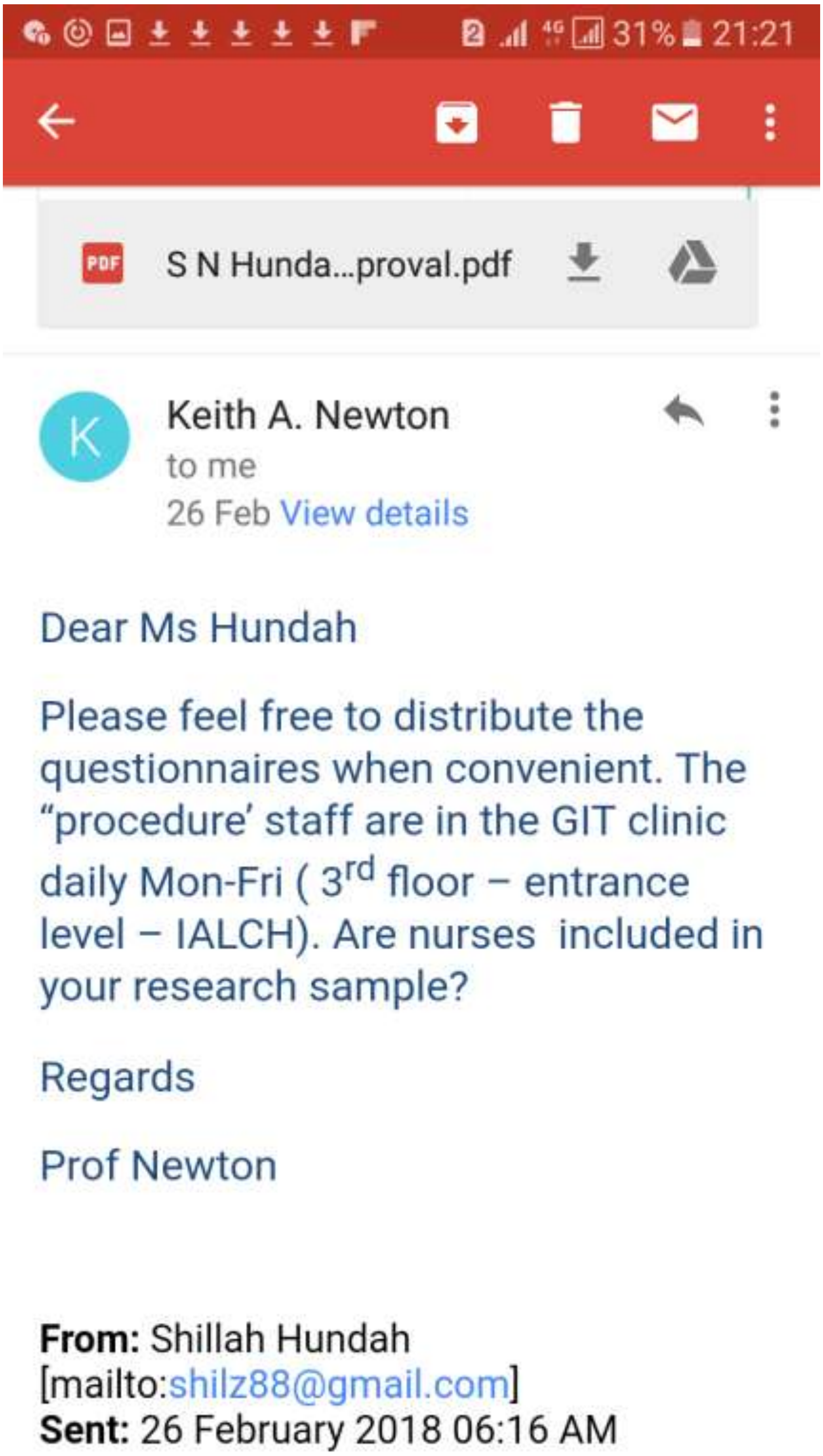
Keith A. Newton
to me, Vesudevan
2017/12/11 View details

Re: Survey of radiation protection amongst non-radiology staff working in fluoroscopy-guided operating theatres at public health institutions in the eThekwini district of KwaZulu-Natal.

Dear Ms Hundah
I have no objection to you carrying out the above research in the Department of Gastroenterology at IALCH.
Please note: gastroenterology procedures which require radiation protection are done in "endoscopy rooms/theatres" and not "operating theatres"
Regards
Prof K A Newton

Show quoted text

Shillah Hundah



Keith A. Newton

Dear Ms Hundah

Please feel free to distribute the questionnaires when convenient. The “procedure’ staff are in the GIT clinic daily Mon-Fri (3rd floor – entrance level – IALCH). Are nurses included in your research sample?

Regards

Prof Newton

From: Shillah Hundah
[mailto:shilz88@gmail.com]
Sent: 26 February 2018 06:16 AM

Tarr Salim

to me

05 Mar View details

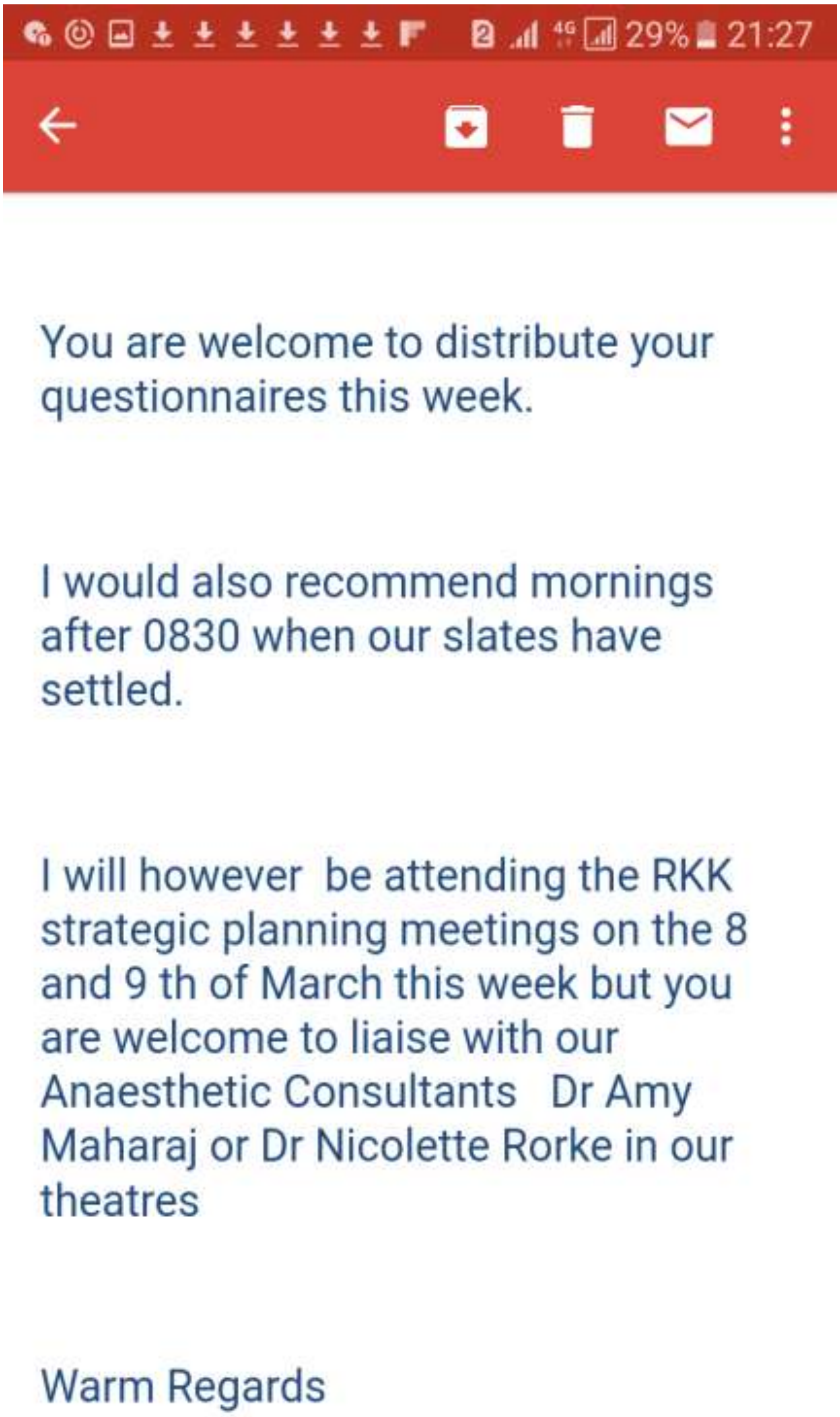
Dear Ms Hundah

The permission from our CEO has been noted

You are welcome to distribute your questionnaires this week.

I would also recommend mornings after 0830 when our slates have settled.

I will however be attending the RKK strategic planning meetings on the 8 and 9 th of March this week but you



You are welcome to distribute your questionnaires this week.

I would also recommend mornings after 0830 when our slates have settled.

I will however be attending the RKK strategic planning meetings on the 8 and 9 th of March this week but you are welcome to liaise with our Anaesthetic Consultants Dr Amy Maharaj or Dr Nicolette Rorke in our theatres

Warm Regards

Ehab Helmy Abdel Goad
to me
Hide details

From: Ehab Helmy Abdel Goad abdelgoad@hotmail.com
To: Shillah Hundah shilz88@gmail.com
Date: 18 Dec 2017, 16:23

Dear Shillah
It will be a pleasure to have you conducting your research in our department.
I will be glad to be of any help to you.
Regards

Dr EH Abdel Goad

MBChB, FRCSireland, FCUrol, MMedSc, FEBU, FICS

health
Department:
Health
PROVINCE OF KWAZULU-NATAL

Inkosi Albert Luthuli Central Hospital
Department of Anaesthetics
Private Bag X 03, Mayville, 4058
800 Bellair Road, Mayville, 4058
Tel.: 031 240 1762/3

30 November 2017

Ms. Shillah Hundah

(Student number: 21649783)

Durban University of Technology

Dear Ms. Hundah

RE: PERMISSION TO CONDUCT RESEARCH IN THE DEPARTMENT OF ANAESTHETICS AT IALCH

With reference to your email of 30 November 2017, on behalf of Dr. Hodgson, Head of IALCH Anaesthesia, we would support your request to conduct a questionnaire survey among members of the IALCH Anaesthesia department:- on the knowledge, attitudes and practices of non-radiology staff towards fluoroscopy use for procedures. We would request that you please share the results of your research with us, as it has particular relevance to anaesthetists, who are being increasing exposed to radiation in theatre, without personal monitoring of radiation levels. Please contact me if you require further assistance. Thank you.

With kind regards

Dr. S Bechan

MBChB DA FCA Cert Crit Care

IALCH HCU Anaesthesia

Appendix D: Information sheet for non-radiology operating theatre staff

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DUT
DURBAN
UNIVERSITY OF
TECHNOLOGY
INSTITUTIONAL
RESEARCH
ETHICS
COMMITTEE

LETTER OF INFORMATION

Title of the Research Study:

Survey of radiation protection amongst non-radiology staff working in fluoroscopy-guided operating theatres at public health institutions in eThekwini district of KwaZulu-Natal.

Principal Investigator/researcher:

Ms S Hundah. BSc (Hons) Diagnostic Radiography

Supervisor:

Mrs S Naidoo. Master of Applied Science (MRT)

Co-supervisor:

Prof. T. Puckree. Ph.D

Brief Introduction and Purpose of the Study:

Since the invention of fluoroscopy, its use has expanded beyond the radiology department to other non-radiology departments such as orthopaedics, gastrointestinal and cardiovascular. It has become a golden tool during surgical procedures because of its ability to allow surgical procedures to be done less invasively hence reducing mortality and medical costs.

Like any other ionizing radiation modality, it comes with a radiation risk. Regardless of the dose levels involved, radiation protection is of great concern as unmonitored prolonged exposure can result in serious biological effects such as cancer. Results from several studies conducted by radiation personnel abroad indicate lack of knowledge and improper radiation protection practices amongst non-radiology surgical staff due to lack of proper training. There has not been conduction of such a study in South Africa.

This study therefore seeks to assess this radiation awareness amongst the non-radiology surgical staff utilizing fluoroscopy in six hospitals in eThekwini district, KwaZulu Natal. The study's outcome can be used by involved departments to decide if there is need for in-service training and improved awareness to avoid unnecessary exposure and radiation-induced biological effects.

Outline of the Procedures:

You will be expected to complete a questionnaire that is related to this research study. The questionnaire will take approximately 30 minutes to be completed. It will occur at a time and place that is convenient for you. The information derived from the questionnaire will be analyzed by the researcher and will be available for your departments as baseline information that could be used. The study's outcome can be used by involved departments to decide if there is need for in-service training and improved awareness to avoid unnecessary exposure and radiation-induced biological effects.

Risks or Discomforts to the Participant:

There are no risks involved in this study.

Benefits:

Findings from the survey reflecting the non-radiology surgical staff's radiation protection knowledge, attitude and practices will be made available to your departments as baseline information that could be used to make strategic decisions such as the need for in-service training interventions. This will benefit the staff towards reduction of unnecessary occupational radiation exposure.

Reason/s why the Participant May Be Withdrawn from the Study:

The participant may withdraw from the study at any time with no explanation to the reasons thereof. There will be no adverse consequences for those individuals who wish to withdraw from the study at any stage.

Remuneration:

There will be no remuneration.

Costs of the Study:

There will be no monetary cost to yourself.

Confidentiality:

All information will be stored safely. All data will only be accessible to the researchers concerned. There will be no invasion of your privacy. Your identity will be kept confidential.

Research-related Injury:

Since this is not a clinical/intervention/or equivalent study a research related injury or adverse reaction to the participant is not expected.

Persons to Contact in the Event of Any Queries:

Please contact Mrs S Hundah 084 347 3139, shilz88@gmail.com or Mrs S Naidoo, 031 373 2875, nalenen@dut.ac.za, or Institutional Research Ethics administrator on 031 373 2900. Complaints can be reported to the Director: Research and Postgraduate Support, Prof S Moyo on 031 373 2577 or moyos@dut.ac.za.

Appendix E: Consent form for non-radiology operating theatre staff.

DUT DURBAN UNIVERSITY OF TECHNOLOGY INSTITUTIONAL RESEARCH ETHICS COMMITTEE

CONSENT FORM

Statement of Agreement to Participate in the Research Study:

- I hereby confirm that I have been informed by the researcher, ____________ (Ms Shillah N. Hundah), about the nature, conduct, benefits and risks of this study - Research Ethics Clearance Number: 85/17.
- I have also received, read and understood the above written information (Participant Letter of Information) regarding the study.
- I am aware that the results of the study, including personal details regarding my sex, age, date of birth, initials and diagnosis will be anonymously processed into a study report.
- In view of the requirements of research, I agree that the data collected during this study can be processed in a computerised system by the researcher.
- I may, at any stage, without prejudice, withdraw my consent and participation in the study.
- I have had sufficient opportunity to ask questions and (of my own free will) declare myself prepared to participate in the study.
- I understand that significant new findings developed during the course of this research which may relate to my participation will be made available to me.

____________________ __________ __________ ________________

Full Name of Participant/ Date Time Signature / Right Thumbprint

I, ______________ (Ms Shillah N. Hundah) herewith confirm that the above participant has been fully informed about the nature, conduct and risks of the above study.

_________________ __________ ___________________

Full Name of Researcher Date Signature

_________________ __________ ___________________

Full Name of Witness (If applicable) Date Signature

Appendix F: IREC Approval

DUT
DURBAN
UNIVERSITY OF
TECHNOLOGY

Institutional Research Ethics Committee
Research and Postgraduate Support Directorate
2nd Floor, Berwyn Court
Gate 1, Steve Biko Campus
Durban University of Technology

P O Box 1334, Durban, South Africa, 4001

Tel: 031 373 2375
Email: lavishad@dut.ac.za
http://www.dut.ac.za/research/institutional_research_ethics

www.dut.ac.za

23 February 2018

IREC Reference Number: **REC 85/17**

Ms S N Hundah
38 Weston Road
Umbilo
Durban
4001

Dear Ms Hundah

Survey of radiation protection amongst non-radiology staff working in fluoroscopy-guided operating theatres at public health institutions in the eThekwini district of KwaZulu-Natal

The Institutional Research Ethics Committee acknowledges receipt of your notification regarding the piloting of your data collection tool.

Kindly ensure that participants used for the pilot study are not part of the main study.

In addition, the IREC acknowledges receipt of your gatekeeper permission letters.

Please note that FULL APPROVAL is granted to your research proposal. You may proceed with data collection.

Any adverse events [serious or minor] which occur in connection with this study and/or which may alter its ethical consideration must be reported to the IREC according to the IREC Standard Operating Procedures (SOP's).

Please note that any deviations from the approved proposal require the approval of the IREC as outlined in the IREC SOP's.

Yours Sincerely,

DUT DURBAN UNIVERSITY OF TECHNOLOGY

Appendix G: Permission letter from eThekwini Health district manager

health
Department:
Health
PROVINCE OF KWAZULU-NATAL

DIRECTORATE: CORPORATE SERVICES

83 King Cetshwayo Highway
Mayville, Durban, 4001
Tel: 031 240 5455 Email: avashri.harrichandparsad@kznhealth.gov.za
www.kznhealth.gov.za

ETHEKWINI HEALTH DISTRICT OFFICE

23 November 2017

Dear Ms S. Hundah

Re: Permission To Conduct Research at eThekwini District Facilities.

This letter serves to confirm that your application to conduct the research study titled: "Survey of radiation protection amongst non-radiology staff working in fluoroscopy-guided operating theatres at public health institutions in the eThekwini district of KwaZulu-Natal " in the eThekwini district at the following health care facilities has been recommended:

1. King Edward VIII Hospital
2. King Dinuzulu Hospital
3. Addington Hospital
4. Prince Mshiyeni Memorial Hospital
5. Inkosi Albert Luthuli Central Hospital
6. R.K Khan Hospital

Kindly upload this letter together with your application as required to the Health Research and Knowledge Unit for the KZN Department of Health for Approval.

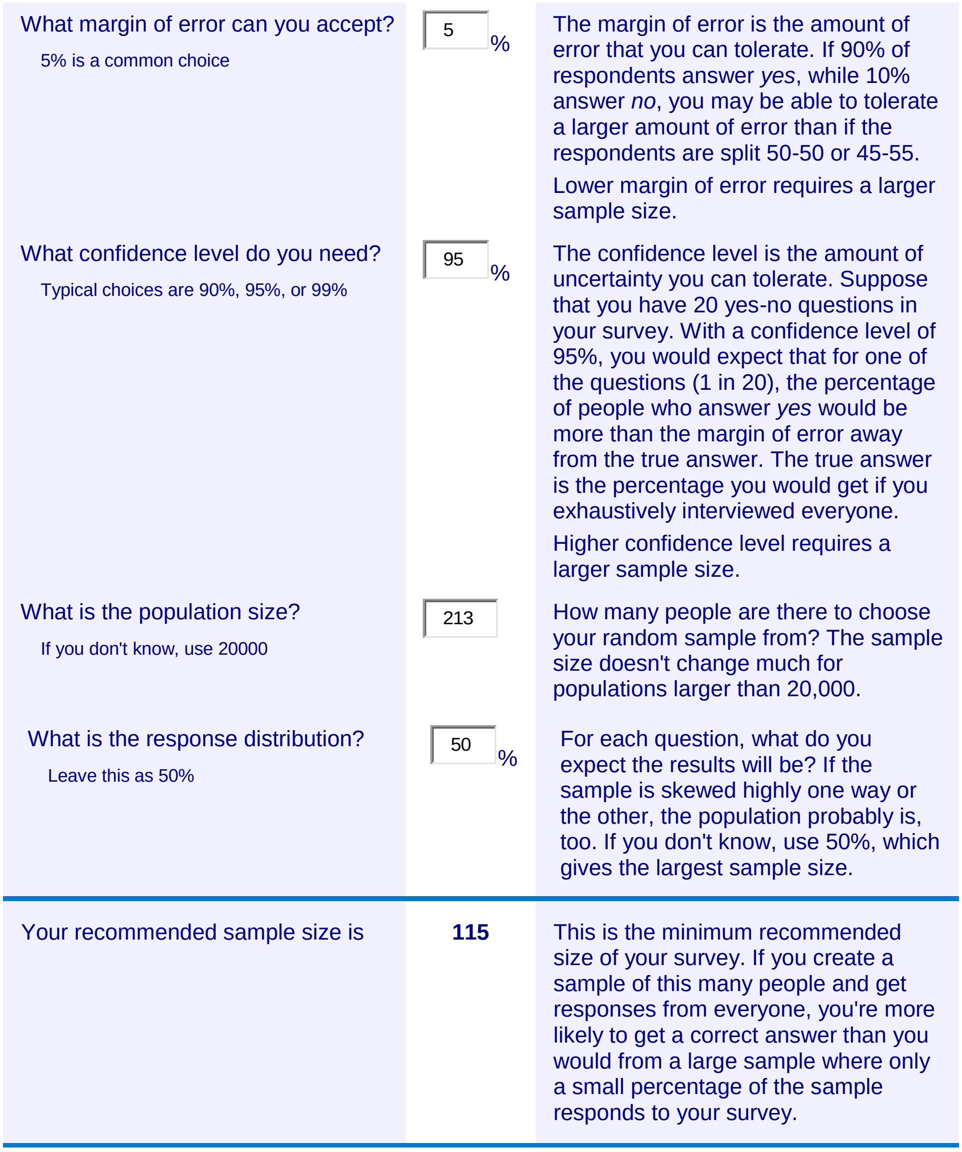
Please also note the following:

1. This research project should only commence after final approval by the KwaZulu-Natal Health Research and Knowledge Unit, and full ethical approval, has been granted,
2. That you adhere to all the policies, procedures, protocols and guidelines of the Department of Health with regards to this research.
3. All research activities must be conducted in a manner that does not interrupt clinical care at the health care facility.
4. Ensure that this office is informed before you commence your research
5. The District Office/Facility will not provide any resources for this research
6. All logistical details must be arranged with the CEO/medical manager /operational manager of the facility.
7. You will be expected to provide feedback on your findings to the District Office/Facility

Yours sincerely

Appendix H: Sample size calculation by statistician

Specialists, Registrars and Doctors

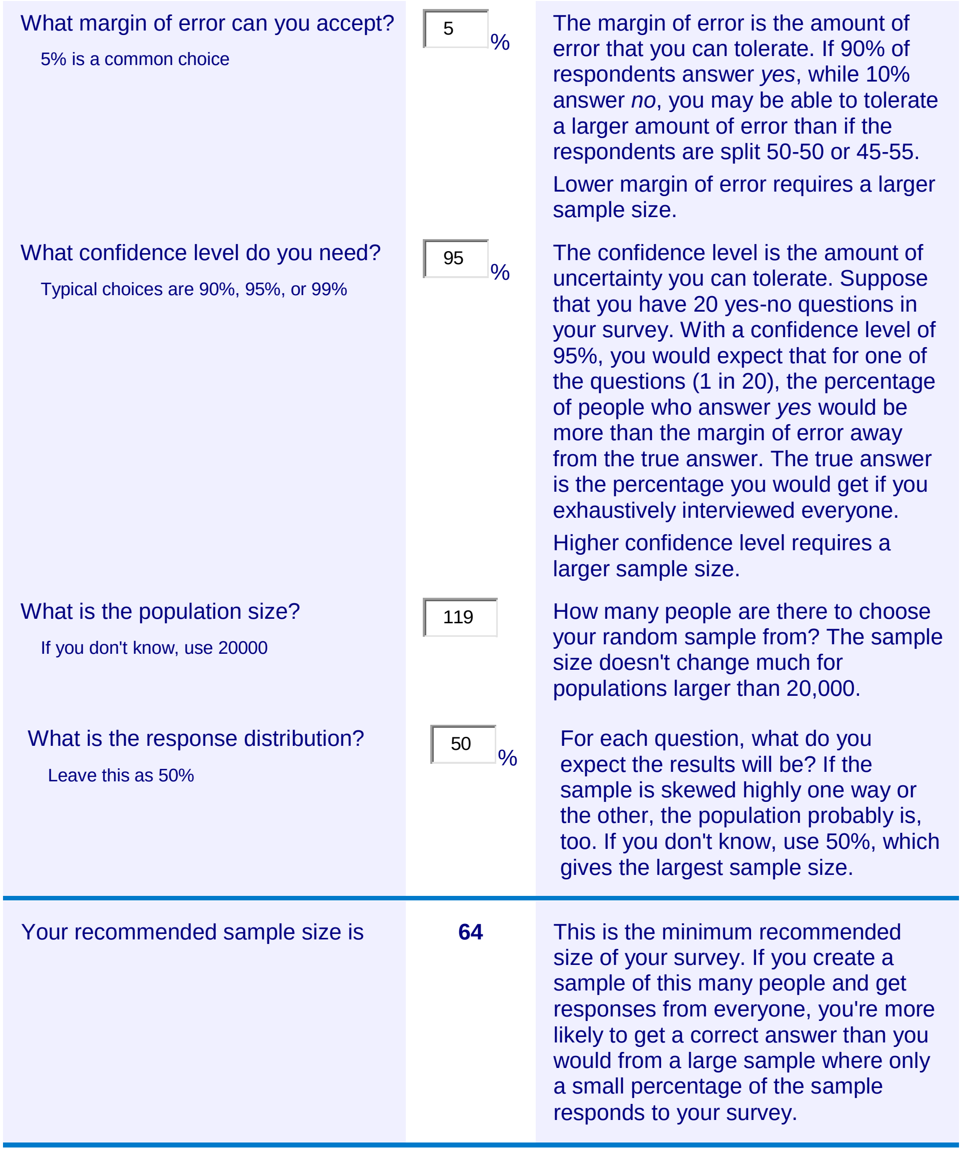


What margin of error can you accept? 5% is a common choice	5 %	The margin of error is the amount of error that you can tolerate. If 90% of respondents answer *yes*, while 10% answer *no*, you may be able to tolerate a larger amount of error than if the respondents are split 50-50 or 45-55. Lower margin of error requires a larger sample size.
What confidence level do you need? Typical choices are 90%, 95%, or 99%	95 %	The confidence level is the amount of uncertainty you can tolerate. Suppose that you have 20 yes-no questions in your survey. With a confidence level of 95%, you would expect that for one of the questions (1 in 20), the percentage of people who answer *yes* would be more than the margin of error away from the true answer. The true answer is the percentage you would get if you exhaustively interviewed everyone. Higher confidence level requires a larger sample size.
What is the population size? If you don't know, use 20000	213	How many people are there to choose your random sample from? The sample size doesn't change much for populations larger than 20,000.
What is the response distribution? Leave this as 50%	50 %	For each question, what do you expect the results will be? If the sample is skewed highly one way or the other, the population probably is, too. If you don't know, use 50%, which gives the largest sample size.
Your recommended sample size is	**115**	This is the minimum recommended size of your survey. If you create a sample of this many people and get responses from everyone, you're more likely to get a correct answer than you would from a large sample where only a small percentage of the sample responds to your survey.

IALCH	KEH	ADH	KDH	PMMH	RKKH	**Total**
38	25	13	13	13	13	**115**

You can proportionally get the numbers within each hospital (and add to get a total)

Surgical nurses



What margin of error can you accept? 5% is a common choice	5 %	The margin of error is the amount of error that you can tolerate. If 90% of respondents answer *yes*, while 10% answer *no*, you may be able to tolerate a larger amount of error than if the respondents are split 50-50 or 45-55. Lower margin of error requires a larger sample size.
What confidence level do you need? Typical choices are 90%, 95%, or 99%	95 %	The confidence level is the amount of uncertainty you can tolerate. Suppose that you have 20 yes-no questions in your survey. With a confidence level of 95%, you would expect that for one of the questions (1 in 20), the percentage of people who answer *yes* would be more than the margin of error away from the true answer. The true answer is the percentage you would get if you exhaustively interviewed everyone. Higher confidence level requires a larger sample size.
What is the population size? If you don't know, use 20000	119	How many people are there to choose your random sample from? The sample size doesn't change much for populations larger than 20,000.
What is the response distribution? Leave this as 50%	50 %	For each question, what do you expect the results will be? If the sample is skewed highly one way or the other, the population probably is, too. If you don't know, use 50%, which gives the largest sample size.
Your recommended sample size is	**64**	This is the minimum recommended size of your survey. If you create a sample of this many people and get responses from everyone, you're more likely to get a correct answer than you would from a large sample where only a small percentage of the sample responds to your survey.

IALCH	KEH	ADH	KDH	PMMH	RKKH	Total
18	9	9	9	9	10	64

You can proportionally get the numbers within each hospital (and add to get a total)

Appendix I: Study population size

Study population size

Specialists, Registrars and Doctors (May 2018)

	IALCH	KEH	ADH	KDH	PMMH	RKKH
Orthopaedics	6	15	8	9	8	7
Paediatric Surgery	7	-	-	-	-	-
Gastro-intestinal	5	-	-	-	-	-
Cardiothoracic surgery	8	-	-	-	-	-
Anaesthetics	20	25	20	20	20	17
Urology	6					
Neurosurgery	9	-	-	-	-	-
Vascular	8	-	-	-	-	-
Neurosurgery	9	-	-	-	-	-
Vascular	8	-	-	-	-	-
TOTAL	**64**	**40**	**28**	**29**	**28**	**24**

Surgical nurses (May 2018)

	IALCH	KEH	ADH	KDH	PMMH	RKKH
Operating theatre nurses	40	15	14	18	17	15

Summary

- Areas with the sign (-) indicate that the hospital does not offer those services using fluoroscopy.
- The current total number of practising doctors is **213**. The doctors comprise of medical officers, registrars and consultants.
- The current total number of surgical (theatre) nurses is **119**.
- The study population size is therefore **332**.

Appendix J: Questionnaire

DURBAN UNIVERSITY OF TECHNOLOGY
Faculty of Health Sciences

Department of Radiography

TOPIC: KAP survey of radiation protection amongst non-radiology staff working in fluoroscopy-guided operating theatres at public health institutions in the eThekwini district of KwaZulu-Natal.

Researcher: Ms S.N Hundah **Supervisor: Mrs S. Naidoo**
Co-supervisor: Prof. T. Puckree

Thank you for agreeing to be part of this research. The purpose of this questionnaire is to identify the percentages of and correlations between radiation protection related knowledge, attitude and practices amongst non-radiology staff in fluoroscopy-guided surgical departments at public health institutions in the eThekwini district, KwaZulu-Natal in order to obtain evidence based baseline information that could be used to enhance social and behavioural change.

Your cooperation in completion of this questionnaire will assist in addressing the gap in South African literature and in my own personal academic development. Information stated in this questionnaire will be kept confidential. Please ensure that you answer all questions honestly to ensure accuracy of data collected.

Please use a tick for the most appropriate answer

SECTION A:

BIOGRAPHICAL AND DEMOGRAPHICAL DATA

A1	Please state your age in years						
A2	Indicate your gender	Female			Male		
A3	Please indicate the hospital in which you are working	King Edward VIII Hospital	King Dinizulu V Hospital	R.K Khan Hospital	Prince Mshiyeni Hospital	Addington Hospital	Inkosi Albert Luthuli Central Hospital

A4	Years of service at this hospital							
A5	Highest level of qualification	Certificate	Diploma	Degree	Masters	PhD	Other, specify…. ……………	
A6	Speciality area	Orthopaedics	Urology	Cardiovascular	Anaesthesia	Gastro-intestinal	Cathlab	Other, specify. ……….. ………..
A7	Profession	Enrolled nurse	Professional nurse	Intern	General Practitioner	Specialist	Other, specify… …………… ……………	
A8	Number of years of experience in this speciality area							
A9	How often do you work in the operating theatre?	Less than 3 days per week	3 days per week	More than 3 days per week				
A10	How often do you use fluoroscopy (screening) during the surgical procedures per week?	For 0 cases	For 1-3 procedures	For 4-7 procedures	For 8-10 procedures	For more than 10 cases per week		

Section B:

Knowledge of radiation protection

		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
B11	Radiation is harmful **State your reason**…………………………………………………………… …………. …………………………………………………………………… …………… …………………………………………………………………… ……………					
B12	X-ray beams reflect from room walls					
B13	Scattered radiation is as harmful as direct radiation					
B14	Radiation causes cancer					
B15	A pregnancy test is mandated for all female patients of child bearing age. **Reason for your answer**………………………………………………					

	…………………………………………………………………… …………………………………………………………………… ………………………					
B16	I am aware of the deterministic and stochastic effects of radiation. **Please state what these are**……………………………………… …………………………………………………………………… …………………………………………………………………… …………………………………………………………………… ………………………………………	☐	☐	☐	☐	☐
B17	I understand the ALARA principle. **Please explain what it is**…………………………………………… …………………………………………………………………… …………………………………………………………………… …………………………	☐	☐	☐	☐	☐
B18	I am aware of Radiation control policies and guidelines in a South African context	☐	☐	☐	☐	☐
B19	I know about the use of a lead apron.	☐	☐	☐	☐	☐
B20	I know about thyroid shielding.	☐	☐	☐	☐	☐
B21	I have read about studies regarding safety of radiation exposure of surgical staff. **Please state how many**……………………………………………	☐	☐	☐	☐	☐
B22	We perform fluoroscopy-guided surgical procedures on pregnant patients in our department.	☐	☐	☐	☐	☐
B23	Our department has radiation safety policies specific to pregnant patients. **Please state the safety policies**………………………………………………………… ………….. …………………………………………………………………… …………………………………………………………………… …………………………………………………………………… ………………………………………	☐	☐	☐	☐	☐
	Who decides whether to shield?					
B24	Please state what the maximum annual dose is in mSv					
B25	Who is more at risk from radiation exposure during a fluoroscopy-guided surgical procedure? **Please state reason/s for your answer in the box to your right hand side**.					
B26	In your opinion, which area of the surgeon's body is most exposed to radiation during fluoroscopy-guided surgical procedures?	Eyes	Thyroid	Hands	Feet	Trunk

Please state reason/s for your answer..........................
....
....
....

SECTION C:

ATTITUDE TOWARDS RADIATION PROTECTION

C27 By using radiation protection best practices in the operating theatre, I will reduce both the patient's and operating theatre staff's exposure to harmful radiation

unlikely 1 2 3 4 5 6 7
likely

C28 Reducing exposure to radiation is

Not very important 1 2 3 4 5 6 7
extremely important

C29 By using radiation protection best practices in the operating theatre, I can be a positive role model to other operating theatre staff

unlikely 1 2 3 4 5 6 7 likely

		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
C30	Radiation exposure should be monitored in every hospital to prevent related disease.	☐	☐	☐	☐	☐
C31	Radiation exposures are monitored in your surgical ward. Please explain how they are monitored..................	☐	☐	☐	☐	☐
C32	Gonadal shield should be provided to children during procedures involving radiation exposure. Please elaborate your	☐	☐	☐	☐	☐

	answer...					
C33	Occupational radiation exposure should continue to be monitored after childbearing age. **Please state your reason**...					
C34	While requesting multiple radiological studies for the critically ill patients, I take into consideration the cumulative radiation dose of these studies by weigh the pros and cons					
C35	How often do you wear a lead apron?	Always	Often	Some times	Rarely	Never
C36	I never / rarely / sometimes wear the lead apron due to **Please circle your answer**			a. Unavailability of aprons b. Weight of the apron c. Colleagues not wearing aprons sometimes as well d. I follow the distance rule e. I am above the child-bearing age f. Other, specify........................		

SECTION D:

INTENTION TO PRACTICE RADIATION PROTECTION

D37	I plan to use radiation protection best practices in the operating theatre								
	unlikely	1	2	3	4	5	6	7	likely
D38	I will make an effort to use radiation protection best practices in the operating theatre								
	unlikely	1	2	3	4	5	6	7	likely

D39	I intend to use radiation protection best practices in the operating theatre								
	unlikely	1	2	3	4	5	6	7	likely

SECTION E:

PRACTICE OF RADIATION PROTECTION

		Always	Usually	Sometimes	Rarely	Never
E40	I wear a **lead apron** during surgical procedures involving use of fluoroscopy	☐	☐	☐	☐	☐
E41	I use **thyroid shielding** during surgical procedures involving use of fluoroscopy.	☐	☐	☐	☐	☐
E42	I wear **radiation goggles** during surgical procedures involving use of fluoroscopy.	☐	☐	☐	☐	☐
E43	I wear a **radiation monitoring device (TLD)** during surgical procedures involving use of fluoroscopy.	☐	☐	☐	☐	☐
E44	I wear or use other radiation protection devices during surgical procedures involving use of fluoroscopy. Please specify them……………………………………………………………… … …………………………………………………………………… …….	☐	☐	☐	☐	☐
	If one or more of your answers to Question E40-E44 is NEVER please state your reason/s……………. …………………………………………………………………… …………………………………………………………………… …………………………………………………………………… …………….	☐	☐	☐	☐	☐
E45	Radiation protection equipment (ie lead aprons, lead gloves, thyroid shielding) is available.	☐	☐	☐	☐	☐
E46	I ask for a pregnancy test in female patients of childbearing age.	☐	☐	☐	☐	☐
E47	I provide gonadal shielding to children during procedures involving radiation exposure.	☐	☐	☐	☐	☐
E48	Our department records exposures for fluoroscopy **How do they record it?**…………………………………… …………………………………………………………………… …………………………………………………………………… …………………………………………………………………… ……………….	☐	☐	☐	☐	☐

	How is it documented?..				
		Strongly disagree	Disagree	Agree	Strongly Agree
E49	I need more training on radiation protection. Please state the reason/s for your answer............				

SECTION F:

GENERAL QUESTIONS

F50 Please explain the purpose of using a **lead apron**

F51 Why is radiation exposure to the **thyroid gland** harmful?

F52 Please state the radiation protection policies and guidelines in your department for; **a) patients**

F53 Are there any **suggestions or recommendations** you have with regard to radiation protection knowledge and practice in your department?

-Thank you for your input and time-

Appendix K: Comments and suggestions towards the questionnaire

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Feedback on questionnaire outline

	Yes	No
1. Was the estimated questionnaire completion time accurate or enough? **Please explain if it was not accurate………………………………………………………………………………………**		
2. Did you encounter any difficult or ambiguous questions? **Please identify them……………………………………………………………………** **………………………………………………………………………………………** **………………………………………………………………………………………** **………………………………………………………………………………………** **………………………………………………………………………………………**		
3. Are there any other challenges that you encountered or any feedback that you would like to communicate with the researcher? **……………………………………………………………………………………………………** **………………………………………………………………………………………** **………………………………………………………………………………………** **………………………………………………………………………………………** **………………………………………………………………………………………** **………………………………………………………………………………………** **………………………………………………………………………………………** **………………………………………………………………………………………**		

Appendix L: Distribution of responses based on demographic factors

a) Knowledge of radiation protection

Table L1: Distribution of responses to 'Knowledge of radiation protection' based on gender

I understand the ALARA principle	Gender		Total
	Female	Male	
Strongly disagree	37 (78.7)	10 (21.3)	47
Disagree	19 (70.4)	8 (29.6)	27
Neutral	4 (36.4)	7 (63.6)	11
Agree	3 (33.3)	6 (66.7)	9
Strongly agree	2 (50.0)	2(50.0)	4
Total	**65 (66.3)**	**33 (33.7)**	**98 (100.0)**
I am aware of radiation control policies and guidelines in a South African context	**Gender**		**Total**
	Female	Male	
Strongly disagree	16 (80.0)	4 (20.0)	20
Disagree	25 (78.1)	7 (21.9)	32
Neutral	8 (44.4)	10 (55.6)	18
Agree	10 (50.0)	10 (50.0)	20
Strongly agree	6 (75.0)	2 (25.0)	8
Total	**65 (66.3)**	**33 (33.7)**	**98 (100.0)**
I have read about studies regarding safety of radiation exposure of surgical staff	**Gender**		**Total**
	Female	Male	
Strongly disagree	26 (81.3)	6 (18.8)	32
Disagree	19 (73.1)	7 (26.9)	26
Neutral	5 (62.5)	3 (37.5)	8
Agree	7 (33.3)	14 (66.7)	21
Strongly agree	8 (72.7)	3 (27.3)	11
Total	**65 (66.3)**	**33 (33.7)**	**98 (100.0)**

Table L2: Distribution of responses to 'Knowledge of radiation protection' based on highest level of qualification

Radiation is harmful	Highest level of qualification					Total
	Certificate	**Diploma**	**Degree**	**Masters**	**PhD**	
Strongly disagree	0 (0.0)	2 (100.0)	0 (0.0)	0 (0.00)	0(0.0)	**2**
Neutral	2 (66.7)	0 (0.0)	1 (33.3)	0 (0.0)	0 (0.0)	**3**
Agree	6 (20.7)	8 (26.7)	13 (44.8)	1 (3.4)	1 (3.4)	**29**
Strongly Agree	2 (3.3)	22 (36.7)	22 (36.7)	14 (23.3)	0 (0.0)	**60**
Total	**10**	**32**	**36**	**15**	**1**	**94 (100.0)**
Scattered radiation is harmful	**Highest level of qualification**					**Total**
	Certificate	**Diploma**	**Degree**	**Masters**	**PhD**	
Strongly disagree	0 (0.0)	1 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)	**1**
Disagree	1 (7.1)	1 (7.1)	10 (71.4)	2 (14.3)	0 (0.0)	**14**
Neutral	2 (11.1)	8 (44.4)	6 (33.3)	2 (11.1)	0 (0.0)	**18**
Agree	6 (14.6)	9 (22.0)	17 (41.5)	8 19.5)	1 (2.4)	**41**
Strongly Agree	1 (5.0)	13 (65.0)	3 (15.0)	3 (15.5)	0 (0.0)	**20**
Total	**10**	**32**	**36**	**15**	**1**	**94 (100.0)**
I am aware of radiation control policies and guidelines in a South African context	**Highest level of qualification**					**Total**
	Certificate	**Diploma**	**Degree**	**Masters**	**PhD**	
Strongly Disagree	3 (15.0)	10 (50.0)	3 (15.0)	4 (20.0)	0 (0.0)	**20**
Disagree	2 (6.3)	11 (34.4)	17 (53.1)	2 (6.3)	0 (0.0)	**32**
Neutral	1 (6.3)	1 (6.3)	10 (62.5)	4 (25.0)	0 (0.0)	**16**
Agree	4 (22.2)	4 (22.2)	5 (27.8)	4 (22.2)	1 (5.6)	**18**
Strongly Agree	0 (0.0)	6 (75.0)	1 (12.5)	1 (12.5)	0 (0.00)	**8**
Total	**10**	**32**	**36**	**15**	**1**	**94**

Table L3: Distribution of responses to 'Knowledge of radiation protection' based on speciality area

X-ray beams reflect from room walls	**Speciality area**				**Total**
	Orthopaedics	**Urology**	**Anaesthesia**	**Other**	
Strongly disagree	1 (14.3)	0 (0.0)	2 (28.6)	4 (57.1)	**7**
Disagree	1 (5.6)	0 (0.0)	9 (50.0)	8 (44.4)	**18**
Neutral	4 (10.3)	0 (0.0)	17 (43.6)	18 (46.2)	**39**
Agree	4 (16.7)	2 (8.3)	16 (66.7)	2 (8.3)	**24**
Strongly Agree	1 10.0)	2 (20.0)	4 (40.0)	3 (30.0)	**10**
Total	**11**	**4**	**48**	**35**	**98 (100.0)**

Scattered radiation is as harmful as direct radiation	**Speciality area**				**Total**
	Orthopaedics	**Urology**	**Anaesthesia**	**Other**	
Strongly disagree	0	0	1	1	**2**
Disagree	3	2	9	0	**14**
Neutral	2	0	11	5	**18**
Agree	4	1	23	16	44
Strongly Agree	2	1	4	13	20
Total	**11**	**4**	**48**	**35**	**98**

Radiation causes cancer	**Speciality area**				**Total**
	Orthopaedics	**Urology**	**Anaesthesia**	**Other**	
Strongly disagree	0	0	0	2	2
Disagree	0	0	1	0	1
Neutral	0	0	2	1	3
Agree	3	2	26	5	36
Strongly Agree	8	2	19	27	56
Total	11	4	48	35	98

I am aware of deterministic and stochastic effects of radiation	**Speciality area**				**Total**
	Orthopaedics	**Urology**	**Anaesthesia**	**Other**	

Strongly disagree	6	0	10	11	27
Disagree	0	1	14	6	21
Neutral	3	3	11	9	26
Agree	2	0	11	3	16
Strongly Agree	0	0	2	6	8
Total	11	4	48	35	98
I understand the ALARA principle	**Speciality area**				**Total**
	Orthopaedics	**Urology**	**Anaesthesia**	**Other**	
Strongly disagree	6	0	17	24	47
Disagree	2	0	18	7	27
Neutral	3	2	4	2	11
Agree	0	1	7	1	9
Strongly Agree	0	1	2	1	4
Total	11	4	48	35	98
I am aware of radiation control policies and guidelines in a South African context	**Speciality area**				**Total**
	Orthopaedics	**Urology**	**Anaesthesia**	**Other**	
Strongly disagree	2	1	6	11	**20**
Disagree	3	0	21	8	**32**
Neutral	1	1	12	4	**18**
Agree	5	2	7	6	**20**
Strongly Agree	0	0	2	6	**8**
Total	**11**	**4**	**48**	**35**	**98**
I have read about studies regarding safety of radiation exposure of surgical staff	**Speciality area**				**Total**
	Orthopaedics	**Urology**	**Anaesthesia**	**Other**	
Strongly disagree	3	1	11	17	**32**
Disagree	2	0	17	7	**26**
Neutral	1	1	6	0	**8**
Agree	4	2	10	5	**21**
Strongly Agree	1	0	4	6	**11**

Total	**11**	**4**	**48**	**35**	**98**

Table L4: Distribution of responses to 'Knowledge of radiation protection' based on profession

Radiation is harmful	**Profession**						**Total**
	Enrolled nurse	**Professional nurse**	**Intern**	**General Practitioner**	**Specialist**	**Other**	
Strongly disagree	1	1	0	0	0	0	**2**
Neutral	1	0	0	0	2	0	**3**
Agree	6	10	0	8	4	3	**31**
Strongly Agree	4	20	1	5	22	10	**62**
Total	**12**	**31**	**1**	**13**	**28**	**13**	**98**
I am aware of radiation control policies and guidelines in a South African context	**Profession**						**Total**
	Enrolled nurse	**Professional nurse**	**Intern**	**General Practitioner**	**Specialist**	**Other**	
Strongly disagree	3	10	0	2	4	1	**20**
Disagree	2	12	1	5	7	5	**32**
Neutral	1	1	0	3	7	6	**18**
Agree	3	5	0	2	10	0	**20**
Strongly Agree	3	3	0	1	0	1	**8**
Total	**12**	**31**	**1**	**13**	**28**	**13**	**98**
I have read about studies regarding safety of radiation exposure of surgical staff	**Profession**						**Total**
	Enrolled nurse	**Professional nurse**	**Intern**	**General Practitioner**	**Specialist**	**Other**	
Strongly Disagree	5	15	0	3	7	2	**32**
Disagree	2	10	0	4	6	4	**26**

Neutral	1	0	1	0	3	3	**8**
Agree	2	2	0	5	10	2	**21**
Strongly Agree	2	4	0	1	2	2	**11**
Total	**12**	**31**	**1**	**13**	**28**	**13**	**98**

Table L5: Distribution of responses to 'Knowledge of radiation protection' based on how often the respondents work in operating theatre

I understand the ALARA principle	**How often respondents work in operating theatre**			**Total**
	Less than 3 days per week	**3 days per week**	**More than 3 days per week**	
Strongly disagree	2	3	42	**47**
Disagree	1	1	25	**27**
Neutral	5	1	5	**11**
Agree	2	0	7	**9**
Strongly Agree	1	1	2	**4**
Total	**11**	**6**	**81**	**98**
I have read about studies regarding safety of radiation exposure of surgical staff	**How often respondents work in operating theatre**			**Total**
	Less than 3 days per week	**3 days per week**	**More than 3 days per week**	
Strongly Disagree	1	3	28	**32**
Disagree	1	2	23	**26**
Neutral	1	1	6	**8**
Agree	8	0	13	**21**
Strongly Agree	0	0	11	**11**
Total	**11**	**6**	**81**	**98**

Table L6: Distribution of responses to 'Knowledge of radiation protection' based on how often the respondents use fluoroscopy per week

I am aware of radiation control	How often respondents use fluoroscopy per week	Total

policies and guidelines in a South African context						
	For 0 cases	**For 1-3 procedures**	**For 4-7 procedures**	**For 8-10 procedures**	**For more than 10 cases per week**	
Strongly Disagree	0	6	10	3	1	**20**
Disagree	0	8	17	2	5	**32**
Neutral	2	9	5	1	1	**18**
Agree	0	10	6	3	1	**20**
Strongly Agree	0	8	0	0	0	**8**
Total	**2**	**41**	**38**	**9**	**8**	**98**

I have read about studies regarding safety of radiation exposure of surgical staff	**How often respondents use fluoroscopy per week**					**Total**
	For 0 cases	**For 1-3 procedures**	**For 4-7 procedures**	**For 8-10 procedures**	**For more than 10 cases per week**	
Strongly Disagree	0	10	14	4	4	**32**
Disagree	1	7	16	0	2	**26**
Neutral	0	5	2	0	1	**8**
Agree	1	10	4	5	1	**21**
Strongly Agree	0	9	2	0	0	**11**
Total	**2**	**41**	**38**	**9**	**8**	**98**

Table L7: Distribution of responses to 'Knowledge of radiation protection' based on the hospital where the respondents are working

A pregnancy test is mandated for all female patients of child bearing age	**Hospital where the respondents are working**						**Total**
	King Edward VIII Hospital	King Dinizulu V Hospital	R.K Khan Hospital	Prince Mshiyeni Hospital	Addington Hospital	Inkosi Albert Luthuli Central Hospital	
Strongly disagree	0	0	0	0	1	2	**3**
Disagree	2	2	0	6	2	1	**13**
Neutral	1	1	0	4	1	8	**15**
Agree	11	2	7	8	2	8	**38**
Strongly Agree	5	1	9	4	1	8	**28**
Total	**19**	**6**	**16**	**22**	**7**	**27**	**97**

I am aware of radiation control policies and guidelines in a South African context	**Hospital where the respondents are working**						**Total**
	King Edward VIII Hospital	King Dinizulu V Hospital	R.K Khan Hospital	Prince Mshiyeni Hospital	Addington Hospital	Inkosi Albert Luthuli Central Hospital	
Strongly disagree	2	0	3	8	3	4	**20**
Disagree	6	0	3	8	2	13	**32**
Neutral	5	2	0	6	0	5	**18**
Agree	6	3	3	0	2	5	**19**
Strongly Agree	0	1	7	0	0	0	**8**
Total	**19**	**6**	**16**	**22**	**7**	**27**	**97**

I have read about studies regarding safety of radiation exposure of surgical staff	**Hospital where the respondents are working**						**Total**
	King Edward VIII Hospital	King Dinizulu V Hospital	R.K Khan Hospital	Prince Mshiyeni Hospital	Addington Hospital	Inkosi Albert Luthuli Central Hospital	
Strongly Disagree	5	1	6	9	2	9	**32**
Disagree	5	0	0	10	0	11	**26**
Neutral	2	1	2	0	0	3	**8**
Agree	7	2	1	2	5	3	**20**
Strongly Agree	0	2	7	1	0	1	**11**
Total	**19**	**6**	**16**	**22**	**7**	**27**	**97**

I know about the use of a lead apron	**Hospital where the respondents are working**						Total
	King Edward VIII Hospital	King Dinizulu V Hospital	R.K Khan Hospital	Prince Mshiyeni Hospital	Addington Hospital	Inkosi Albert Luthuli Central Hospital	
Strongly disagree	0	0	1	1	0	0	**2**
Neutral	0	0	0	1	0	2	**3**
Agree	14	2	4	11	1	16	**48**
Strongly Agree	5	4	11	9	6	9	**44**
Total	**19**	**6**	**16**	**22**	**7**	**27**	**97**

I am aware of deterministic and stochastic effects of radiation	**Hospital where the respondents are working**						**Total**
	King Edward VIII Hospital	King Dinizulu V Hospital	R.K Khan Hospital	Prince Mshiyeni Hospital	Addington Hospital	Inkosi Albert Luthuli Central	

						Hospital	
Strongly disagree	5	0	6	6	3	7	**27**
Disagree	3	2	0	5	2	9	**21**
Neutral	8	0	3	7	1	6	**25**
Agree	3	3	0	4	1	5	**16**
Strongly Agree	0	1	7	0	0	0	**8**
Total	**19**	**6**	**16**	**22**	**7**	**27**	**97**
I understand the ALARA principle	**Hospital where the respondents are working**						**Total**
	King Edward VIII Hospital	King Dinizulu V Hospital	R.K Khan Hospital	Prince Mshiyeni Hospital	Addington Hospital	Inkosi Albert Luthuli Central Hospital	
Strongly Disagree	9	0	14	11	4	9	**47**
Disagree	3	3	2	7	1	11	**27**
Neutral	6	0	0	1	1	2	**10**
Agree	1	1	0	3	1	3	**9**
Strongly Agree	0	2	0	0	0	2	**4**
Total	**19**	**6**	**16**	**22**	**7**	**27**	**97**
We perform fluoroscopy-guided surgical procedures on pregnant patients in our department	**Hospital where the respondents are working**						**Total**
	King Edward VIII Hospital	King Dinizulu V Hospital	R.K Khan Hospital	Prince Mshiyeni Hospital	Addington Hospital	Inkosi Albert Luthuli Central Hospital	
Strongly disagree	7	1	10	6	2	8	**34**
Disagree	6	3	4	2	3	5	**23**
Neutral	4	0	0	9	2	13	**28**
Agree	1	1	2	4	0	1	**9**
Strongly Agree	0	1	0	1	0	0	**2**
Total	**18**	**6**	**16**	**22**	**7**	**27**	**97**
Our department has radiation safety policies specific to pregnant patients	**Hospital where the respondents are working**						**Total**
	King Edward VIII Hospital	King Dinizulu V Hospital	R.K Khan Hospital	Prince Mshiyeni Hospital	Addington Hospital	Inkosi Albert Luthuli Central Hospital	
Strongly Disagree	5	15	0	3	7	2	**32**
Disagree	2	10	0	4	6	4	**26**

Neutral	1	0	1	0	3	3	**8**
Agree	2	2	0	5	10	2	**21**
Strongly Agree	2	4	0	1	2	2	**11**
Total	**12**	**31**	**1**	**13**	**28**	**13**	**98**

b) Attitude towards radiation protection

Table L8: Distribution of responses to 'Attitude towards radiation protection' based on gender

Importance of reducing exposure to radiation	**Gender**		**Total**
	Female	Male	
4.00	1 (50.0)	1 (50.0)	2
5.00	6 (75.0)	2 (25.0)	8
6.00	19 (95.0)	1 (5.0)	20
7.00	39 (57.4)	29 (42.6)	68
Total	65	33	98 (100.0)
By using best radiation protection practices in the operating theatre, I can be a positive role model to other operating theatre staff	**Gender**		**Total**
	Female	Male	
4.00	1 (100.0)	0 (0.00	1
5.00	4 (44.4)	5 (55.6)	9
6.00	27 (90.0)	3 (10.0)	30
7.00	33 (56.9)	25 (43.1)	58
Total	65	33	98 (100.0)
Gonad shield should be provided to children during procedures involving radiation exposure	**Gender**		**Total**
	Female	Male	
Disagree	1 (50.0)	1 (50.0)	2
Neutral	19 (90.5)	2 (9.5)	21
Agree	26 (60.5)	17 (39.5)	43
Strongly agree	19 (59.4)	13 (40.6)	32
Total	65	33	98 (100.0)

Table L9: Distribution of responses to 'Attitude towards radiation protection' based on profession

Importance of reducing exposure to radiation	Profession						Total
	Enrolled nurse	Professional nurse	Intern	General Practitioner	Specialist	Other	
4.00	0	0	0	1	1	0	**2**
5.00	2	4	0	0	2	0	**8**
6.00	4	10	0	4	2	0	**20**
7.00	6	17	1	8	23	13	**68**
Total	12	31	1	13	28	13	**98 (100.0)**
By using best radiation protection practices in the operating theatre, I can be a positive role model to other operating theatre staff	**Profession**						**Total**
	Enrolled nurse	**Professional nurse**	**Intern**	**General Practitioner**	**Specialist**	**Other**	
4.00	0	0	0	1	0	0	**1**
5.00	2	1	0	2	3	1	**9**
6.00	4	17	0	3	4	2	**30**
7.00	6	13	1	7	21	10	**58**
Total	12	31	1	13	28	13	**98 (100.0)**
While requesting multiple	**Profession**						**Total**

radiological studies for the critically ill patients, I take into consideration the cumulative radiation dose of these studies by weighing the pros and cons	**Enrolled nurse**	**Professional nurse**	**Intern**	**General Practitioner**	**Specialist**	**Other**	
Strongly Disagree	0	4	0	0	0	0	**4**
Disagree	0	2	0	4	3	3	**12**
Neutral	4	12	0	4	5	3	**28**
Agree	4	2	1	3	13	2	**25**
Strongly Agree	3	2	0	2	7	4	**18**
Total	11	22	1	13	28	12	**87 (100.0)**

Table L10: Distribution of responses to 'Attitude towards radiation protection' based on qualification

Radiation exposure should be monitored in every hospital to prevent related disease	Highest level of qualification					Total
	Certificate	**Diploma**	**Degree**	**Masters**	**PhD**	
Strongly disagree	0	1	0	0	0	**1**
Neutral	0	0	1	0	0	**1**
Agree	7	5	12	4	0	**28**
Strongly Agree	3	26	23	11	1	**64**
Total	**10**	**32**	**36**	**15**	**1**	**94**

Table L11: Distribution of responses to 'Attitude towards radiation protection' based on how often respondents work in operating theatre

Gonad shield should be provided to children during procedures involving radiation exposure	**How often respondents work in operating theatre**			**Total**
	Less than 3 days per week	**3 days per week**	**More than 3 days per week**	
Disagree	0	0	2	**0**
Neutral	1	0	20	**21**
Agree	8	0	35	**43**
Strongly Agree	2	6	24	32
Total	11	6	81	98

Table L12: Distribution of responses to ‘Attitude towards radiation protection based on speciality area

While requesting multiple radiological studies for critically ill patients, I take into consideration the cumulative radiation dose of these studies by weighing the pros and cons	**Speciality area**				**Total**
	Orthopaedics	**Urology**	**Anaesthesia**	**Other**	
Strongly disagree	0	0	0	4	4
Disagree	0	1	10	1	12
Neutral	2	0	14	12	28
Agree	5	1	15	4	25
Strongly Agree	4	2	8	4	18
Total	11	4	47	25	87

Table L13: Distribution of responses to ‘Attitude towards radiation protection based on how often respondents use fluoroscopy per week

While requesting multiple radiological studies for critically ill patients, I take into consideration the cumulative radiation dose of these studies by weighing the pros and cons	How often respondents use fluoroscopy per week					Total
	For 0 cases	**For 1-3 procedures**	**For 4-7 procedures**	**For 8-10 procedures**	**For more than 10 cases per week**	
Strongly Disagree	0	0	3	0	1	4
Disagree	0	6	3	2	1	12
Neutral	2	6	16	3	1	28
Agree	0	17	5	1	2	25
Strongly Agree	0	9	7	2	0	18
Total	2	38	34	8	5	87

Table L14: Distribution of responses to ‘Attitude towards radiation protection based on the hospital where the respondents are working

Gonad shield should be provided to children during procedures involving radiation exposure	**Hospital where the respondents are working**						**Total**
	King Edward VIII Hospital	King Dinizulu V Hospital	R.K Khan Hospital	Prince Mshiyeni Hospital	Addington Hospital	Inkosi Albert Luthuli Central Hospital	
Disagree	0	1	0	0	1	0	2
Neutral	2	0	0	5	3	11	21
Agree	13	4	5	12	2	7	43
Strongly Agree	4	1	11	5	1	9	31
Total	19	6	16	22	7	27	97
While requesting multiple radiological studies for critically ill patients, I take into consideration the cumulative radiation dose of these studies by weighing the pros and cons	**Hospital where the respondents are working**						**Total**
	King Edward VIII Hospital	King Dinizulu V Hospital	R.K Khan Hospital	Prince Mshiyeni Hospital	Addington Hospital	Inkosi Albert Luthuli Central Hospital	
Strongly disagree	0	0	4	0	0	0	4

Disagree	2	1	0	3	2	3	11
Neutral	6	0	2	13	0	7	28
Agree	6	3	4	2	1	9	25
Strongly Agree	3	1	5	4	1	4	18
Total	17	5	15	22	4	23	86

c) Practice of radiation protection

Table L15: Distribution of responses to ‘Practice of radiation protection’ based on gender

I ask for pregnancy test in female patients of child-bearing age	Gender		Total
	Female	Male	
Always	4 (50.0)	4 (50.)	8
Usually	2 (20.0)	8 (80.0)	10
Sometimes	13 (72.2)	5 (27.8)	18
Rarely	6 (60.0)	4 (40.0)	10
Never	34 (73.9)	12 (26.1)	46
Total	59 (64.1)	33 (35.9)	92 (100.0)

Table L16: Distribution of responses to ‘Practice of radiation protection’ based on qualification

Gonad shield should be provided to children during procedures involving radiation exposure	Highest level of qualification					Total
	Certificate	**Diploma**	**Degree**	**Masters**	**PhD**	
Disagree	1	0	0	1	0	**2**
Neutral	3	12	6	0	0	**21**

Agree	5	9	18	6	1	**39**
Strongly Agree	1	11	12	8	0	**32**
Total	**10**	**32**	**36**	**15**	**1**	**94 (100.0)**
I ask for pregnancy test in female patients of child-bearing age	**Highest level of qualification**					**Total**
	Certificate	**Diploma**	**Degree**	**Masters**	**PhD**	
Strongly disagree	0	1	2	4	1	**8**
Disagree	0	2	5	2	0	**9**
Neutral	3	2	9	4	0	**18**
Agree	0	3	3	1	0	**7**
Strongly Agree	7	19	17	3	0	**46**
Total	**10**	**27**	**36**	**14**	**1**	**88**

Table L17: Distribution of responses to 'Practice of radiation protection' based on profession

I wear radiation monitoring device (TLD) during surgical procedures involving use of fluoroscopy	**Profession**						**Total**
	Enrolled nurse	**Professional nurse**	**Intern**	**General Practitioner**	**Specialist**	**Other**	
Always	4	5	0	1	0	0	**10**
Usually	1	1	0	0	0	0	**2**
Rarely	0	1	0	1	0	0	**2**
Never	7	24	1	11	27	13	**83**
Total	12	31	1	13	27	13	**97 (100.0)**
I provide gonad shielding to children during procedures involving radiation exposure	**Profession**						**Total**
	Enrolled nurse	**Professional nurse**	**Intern**	**General Practitioner**	**Specialist**	**Other**	
Always	0	1	0	1	0	0	**2**

Usually	0	2	0	3	4	0	**9**
Sometimes	4	1	1	2	2	1	**11**
Rarely	0	2	0	1	5	0	**8**
Never	8	24	0	6	17	12	**67**
Total	**12**	**30**	**1**	**13**	**28**	**13**	**97 (100.0)**

Table L18: Distribution of responses to 'Practice of radiation protection' based on how often the respondents work in operating theatre

I use thyroid shielding during surgical procedures involving use of fluoroscopy	**How often respondents work in operating theatre**			**Total**
	Less than 3 days per week	**3 days per week**	**More than 3 days per week**	
Always	1	1	3	**5**
Usually	2	1	10	13
Sometimes	3	3	3	9
Rarely	2	1	13	16
Never	3	0	52	55
Total	11	6	81	98
I ask for pregnancy test in female patients of child-bearing age	How often respondents work in operating theatre			Total
	Less than 3 days per week	**3 days per week**	**More than 3 days per week**	
Always	2	1	5	8
Usually	1	1	8	10
Sometimes	3	2	13	18
Rarely	3	0	7	10
Never	2	1	43	46
Total	11	5	76	92

Table L19: Distribution of responses to 'Practice of radiation protection' based on how often the respondents use fluoroscopy per week

I wear or use other radiation protection devices during surgical procedures involving use of fluoroscopy	How often respondents use fluoroscopy per week					Total
	For 0 cases	**For 1-3 procedures**	**For 4-7 procedures**	**For 8-10 procedures**	**For more than 10 cases per week**	
Always	0	2	1	2	1	6
Usually	0	1	1	0	0	2
Sometimes	2	7	1	0	0	10
Rarely	0	1	2	0	1	4
Never	0	29	33	7	6	75
Total	2	40	38	9	8	97

Table L20: Distribution of responses to 'Practice of radiation protection' based on speciality area

I wear a radiation monitoring device (TLD) during surgical procedures involving use of fluoroscopy	**Speciality area**				**Total**
	Orthopaedics	**Urology**	**Anaesthesia**	**Other**	
Always	1	0	1	8	10
Usually	0	0	0	2	2
Rarely	0	0	1	1	2
Never	10	4	45	24	83
Total	11	4	47	35	97
I provide gonad shielding to children during procures involving radiation exposures	**Speciality area**				**Total**
	Orthopaedics	**Urology**	**Anaesthesia**	**Other**	
Always	0	0	1	1	2
Usually	4	2	3	0	9
Sometimes	0	0	6	5	11

Rarely	0	0	6	2	8
Never	6	2	32	27	67
Total	10	4	48	35	97

Table L21: Distribution of responses to ‘Practice of radiation protection based on the hospital where the respondents are working

I wear a lead apron during surgical procedures involving use of fluoroscopy	**Hospital where the respondents are working**						**Total**
	King Edward VIII Hospital	King Dinizulu V Hospital	R.K Khan Hospital	Prince Mshiyeni Hospital	Addington Hospital	Inkosi Albert Luthuli Central Hospital	
Always	15	4	7	15	4	20	65
Usually	3	0	3	7	3	7	23
Sometimes	1	1	2	0	0	0	4
Rarely	0	1	3	0	0	0	4
Never	0	0	1	0	0	0	1
Total	19	6	16	22	7	27	97
I use thyroid shielding during surgical procedures involving use of fluoroscopy	**Hospital where the respondents are working**						Total
	King Edward VIII Hospital	King Dinizulu V Hospital	R.K Khan Hospital	Prince Mshiyeni Hospital	Addington Hospital	Inkosi Albert Luthuli Central Hospital	
Always	0	1	0	1	0	3	5
Usually	2	0	1	0	0	10	13
Sometimes	3	0	0	2	0	4	9
Rarely	5	1	6	0	1	3	16
Never	9	4	9	19	6	7	54
Total	19	6	16	22	7	27	97
I wear a radiation monitoring device	**Hospital where the respondents are working**						**Total**

(TLD) during surgical procedures involving use of fluoroscopy	King Edward VIII Hospital	King Dinizulu V Hospital	R.K Khan Hospital	Prince Mshiyeni Hospital	Addington Hospital	Inkosi Albert Luthuli Central Hospital	
Always	0	1	9	0	0	0	10
Usually	0	0	2	0	0	0	2
Rarely	0	1	1	0	0	0	2
Never	19	4	4	22	7	26	82
Total	19	6	16	22	7	26	96

I wear or use other radiation protection devices during surgical procedures involving use of fluoroscopy	Hospital where the respondents are working						Total
	King Edward VIII Hospital	King Dinizulu V Hospital	R.K Khan Hospital	Prince Mshiyeni Hospital	Addington Hospital	Inkosi Albert Luthuli Central Hospital	
Always	2	1	0	2	0	1	6
Usually	2	0	0	0	0	0	2
Sometimes	0	0	6	2	0	2	10
Rarely	1	1	2	0	0	0	4
Never	14	4	8	18	7	23	74
Total	19	6	16	22	7	26	96

I provide gonad shielding to children during procedures involving radiation exposure	Hospital where the respondents are working						Total
	King Edward VIII Hospital	King Dinizulu V Hospital	R.K Khan Hospital	Prince Mshiyeni Hospital	Addington Hospital	Inkosi Albert Luthuli Central Hospital	
Always	0	1	1	0	0	0	2
Usually	5	1	0	0	0	2	8
Sometimes	1	0	5	3	0	2	11
Rarely	1	2	2	2	0	1	8
Never	11	2	8	17	7	22	67
Total	18	6	16	22	7	27	96

Appendix M: Correlations