KNOWLEDGE AND PRACTICES OF RADIOGRAPHERS REGARDING INFECTION CONTROL IN RADIOLOGY DEPARTMENTS IN MALAWI

By

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DECLARATION:

In accordance with Rule G4.6.3, I hereby declare that the above-mentioned treatise/dissertation/thesis is my own work and that it has not previously been submitted for assessment to another University or for another qualification.

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DEDICATION

I dedicate this dissertation to my late father:

Glad Nyirenda

May your soul rest in peace. You always taught me and reminded me of the importance of education. Your words of encouragement have made me whom I am today.

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ABSTRACT

Infection control is an essential cornerstone of clinical care at all healthcare settings. The changing pattern of infections emphasises the need for all healthcare workers, including radiographers, to implement and strictly adhere to standard infection control precautions (SICP) that will protect both patients and healthcare workers from healthcare associated infections (HAIs). However, implementing SICP can be difficult, especially if radiographers do not have adequate knowledge, and skilled practices, in infection control. As a practicing radiographer and a health educator, the researcher observed that there were discrepancies regarding implementation of SICP by radiographers in Malawi. No study has been conducted to explore and describe the knowledge and practices of radiographers regarding infection control in radiology departments in Malawi. There are also no infection control guidelines. These gaps led to this study being conducted.

The aim of the study was to explore, and describe, knowledge and practices of radiographers regarding infection control in radiology departments in government referral hospitals in Malawi in order to develop a draft guideline for infection control to facilitate sound knowledge and practices of radiographers regarding infection control in these departments.

The study took place in four government referral hospitals and followed a quantitative, exploratory, and descriptive design that was contextual in nature. The study was conducted in two phases. In the first one a self-administered questionnaire was used to explore and describe the knowledge and practices of radiographers regarding infection control in government referral hospitals in Malawi. The second one included the development of a draft guideline for infection control in order to facilitate sound knowledge and practices of radiographers regarding infection control in government referral hospitals in Malawi.

In phase one, the research population consisted of 80 permanently employed radiographers. A census sampling method was used to select 62 respondents. The data were collected by means of a self-administered questionnaire that was developed based on a literature review. Some questions were adapted from an existing questionnaire. The questionnaire consisted of questions and statements. It had four parts: demographic information (Part A), knowledge regarding infection control (Part B), practices regarding infection control (Part C), and additional relevant information (Part D). Descriptive and inferential statistics, with the help of a statistician, were used to analyse the data.

The results of the study revealed that radiographers had average knowledge and practice in terms of infection control. The results revealed a significant association between age and knowledge ($P<0.05$).

In phase two, a draft guideline was developed. The guideline’s content is based on 20 gaps identified in phase one of the study, as well as literature. The draft guideline consists of seven sets of recommendations: hand hygiene, personal hygiene, personal protective equipment (PPE), safe handling of sharps and sharp containers, decontamination and cleaning, housekeeping, and routine infection control practices.

Reliability and validity were ensured. Ethical considerations were considered throughout the study. Respect for persons, beneficence and justice were adhered to.

The study is the first in the field of radiography in Malawi. Results of this study should contribute to the body of knowledge of radiography practice. The results are to be used to inform practicing radiographers, heads of departments, the Ministry of Health and Population, and other health practitioners about the current practices and knowledge of radiographers in government referral hospitals in Malawi. The draft guideline should facilitate sound knowledge and practices regarding infection control among practicing radiographers in these departments. Recommendations include further development and implementation of the draft guideline, and radiography education and development of further research on infection control in the radiography profession, specifically in the African context.

Keywords: guideline, healthcare associated infections, infection control, knowledge, practices, radiographer, radiology, Malawi.

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ABBREVIATIONS

BBV	Blood borne virus
CPD	Continuous professional development
CT	Computed tomography
DRC	Departmental Research Committee
ECDPC	European Centre for Disease Prevention and Control
FPGSC	Faculty Postgraduate Studies Committee
HAIs	Healthcare associated infections
HCPC	Health and Care Professional Council
HDU	Highly dependence unit
HPCSA	Health Professions Council of South Africa
ICU	Intensive care unit
IPAC	Infection prevention control committees
MRI	Magnetic resonance imaging
NHSRC	National Health Sciences Research Council
NMMU	Nelson Mandela Metropolitan University
PPE	Personal protective equipment
SICP	Standard infection control precautions
SSI	Surgical site infections
TCPS	Tri – Council Policy Statement
USA	United States of America
VBA	Visual Basic for Applications
WHO	World Health Organization

CHAPTER ONE

OVERVIEW OF THE STUDY

1.1 INTRODUCTION AND BACKGROUND

Infection control is a discipline concerned with controlling the spread of healthcare associated infections (HAIs) acquired by patients while receiving care within a healthcare setting (Boyle & Strudwick, 2010:298). Infection control is acknowledged universally as a solid, and essential basis, towards patient safety; it supports the reduction of HAIs and their consequences (Zsuzsanna, 2010:6). HAIs are caused by pathogenic microorganisms which can be detected in air, water and on surfaces (United Kingdom. National Health Services Professionals Handbook, 2010:23). The modes of spread of HAIs include: direct, indirect and airborne contacts. Some of the most common HAIs that occur within healthcare settings include respiratory infections, urinary tract infections, blood infections, and wound infections following surgical interventions (Infection Control Certification, 2013:1). Adherence to standard infection control precautions (SICP) by radiographers is critical in combating these infections. Radiographers therefore need to have adequate knowledge and practices on infection control if they are to contain the magnitude of HAIs.

According to the World Health Organization (WHO) (2009:6), HAIs are among the major causes of death and prolonged hospital stays worldwide. In 2011, the WHO reported that they HAIs accounted for 16 million days of hospital stay and 33,000 attributable deaths, with a total estimated cost of approximately 8.96 billion dollars (114.38 billion South African Rand or 7000 billion Malawi kwacha) annually throughout Europe (WHO, 2011:20). A study done in the United States of America (USA) revealed that the direct hospital – related financial burden of HAIs was estimated to be between 25 and 31.5 billion dollars (327.75 and 412.965 billion South African Rand or 18,113.5 and 22,823.01 billion Malawi kwacha) per year (Kilgore, Ghosh, Beavers, Wong, Hymel & Brossette, 2008:102). According to a meta-analysis study by Allegranzi, Nejad, Combescure, Graafmans, Attar, Donaldson and Pittet (2011:231), developing countries in Africa have high rates of HAIs with an incidence of 7.4 infections per 100 patients. The overall prevalence of HAIs in Africa ranged from 2.5% to 14.5%, which is twice as high as the European prevalence of 7.1%, as reported by European Centre for Disease Prevention and Control (ECDPC) in 2008 (Nejad, Allegranzi, Syed, Ellis, & Pittet, 2011:761). The increased global magnitude of HAIs continues to escalate the costs associated with infection control.

According to Friedman, Borg, Allegranzi, Brenner, Bruce and Callery (2011:372), the economic consequences of HAIs include: hospitalisation costs, intervention costs, outpatient and community care costs, and patient costs/outcomes. Some of these costs are as a result of prolonged hospital stays and increased resistance of microorganisms to antimicrobials, which is associated with an increase costs of medication (Kenya. Ministry of Public Health and Sanitation & Ministry of Medical Services, 2010:2). The cost associated with HAIs can only be reduced if all healthcare workers, including radiographers, value the importance of infection control.

Practice of infection control by healthcare workers is paramount. It helps patients to recover quicker, therefore improving their well-being (Infection Control Certification, 2013:3). Adherence to infection control practices improves health outcomes because it helps control morbidity and mortality, decreases healthcare costs, and avoids possible litigation that could arise from HAIs. Infection control is also essential for the safety of families, healthcare workers, and the community at large. Above all, the primary objective of infection control is to control the spread of HAIs in healthcare settings; thereby assisting healthcare workers in the provision of quality healthcare, which is important for the development of any nation (Kenya. Ministries of Public Health and Sanitation & Ministry of Medical Services, 2010:2). However, infection control can only be viewed as an important tool or activity if all healthcare workers, including radiographers, adhere to SICP.

SICP are designed to control HAIs from recognised or unrecognised sources of infection. They are necessary to ensure the safety of patients and healthcare workers, including people who visit a healthcare environment. SICP include: hand hygiene, personal protective equipment (PPE), occupational exposure management including sharps, safe care of linen, including uniforms, and safe waste disposal (United Kingdom. National Health Services Professionals Handbook, 2010:1-2).

The most common way in which pathogenic microorganisms are transported, is through hands. Hand hygiene is an important practice in reducing transmission of HAIs during delivery of healthcare. Hand hygiene refers to all processes, including handwashing using soap and water, and hand decontamination using other solutions e.g. alcohol hand rub (United Kingdom. National Health Services Professional Handbook, 2010:3).

Another way to reduce HAIs is the use of PPE. According to the University of Tasmania, Work Health and Safety Policy (2015:6), PPE provides a barrier between a source and an operator. Selection of PPE must be based on assessment of the risk of transmission of infectious agents to a patient. PPE protects the risks of contamination of clothing or skin of healthcare workers or the staff by a patient’s blood, body substances, secretions or excretions. PPE used in healthcare settings includes; gloves, aprons, gowns, face/mouth masks, and eye goggles.

Occupational exposure management, including needle stick (or sharps) injury is one of the elements of SICP, which should be applied in all healthcare settings. Needle stick (or sharps) injuries are one of the most common types of injury to be reported to occupational health services by healthcare workers. Extra care should therefore be taken when handling used needles or sharps to avoid accidental injuries (United Kingdom. National Health Services Professionals Handbook, 2010:17).

Soiled fabric/linen/uniforms, within healthcare settings, can harbour large numbers of potentially pathogenic microorganisms. Appropriate infection control precautions should be taken to ensure that contamination to and from fabric/uniforms does not occur, as this might lead to the transmission of pathogenic microorganisms. Used linen must be safely managed so that it does not become a hazard leading to the spread of potentially pathogenic microorganisms to those receiving healthcare (Lister & Inamdar, 2013:41).

The safe disposal of clinical waste, particularly when it might be contaminated with blood, other potentially infectious body fluids, secretions or excretions, should be adhered to as one of the elements of SICP. It is important for healthcare workers to protect themselves against exposure to blood and body substances during handling of waste. Waste should be contained in an appropriate receptacle, and correct waste disposal would ensure that the risk of transmitting pathogenic microorganisms and potential infection via this route is avoided or minimised (National Health & Medical

Research Council, 2010:89). Standard infection control precautions can only be correctly applied if radiographers understand their roles in infection control. Chapter Two presents a detailed discussion of SICP.

Radiographers' roles in infection control include maintaining a safe practice environment at all times: selecting appropriate hazard control and risk management and infection control precautions, application of reduction or elimination techniques in accordance with the health and safety legislation. Additional roles include the use of correct principles and applications of disinfectants, methods for sterilisation and decontamination, and precautions recommended for dealing with waste and spillage correctly (Health & Care Professional Council Handbook, 2013:18). Chapter Two presents a detailed discussion of the role of radiographers in infection control.

Since radiographers have direct contact with the patients, and other hosts, they are reported as being at a high risk of contracting and spreading infections (Ibeziako & Ibekwe, 2006:250). With the introduction of interventional radiological applications such as opening of intravenous lines, catheterisations performed for gastrointestinal radiological examinations, colonography, cystography, and other special imaging modalities, the tendency for accidental and infectious pathogens are on the increase. Such an increase has been associated with the fact that radiological examinations require direct contact between patients and radiographers (Jayasinghe & Weerakoon, 2014:14). Other radiological procedures that result in direct contact between radiographers and patient include urethrography, hysterosalpingography, and intravenous urography. An important outcome of the introduction of interventional radiology has been an increase in the number of patients seeking radiological services, which has resulted in an increase in the spread of HAIs. According to Rutala and Weber (2008:8), the major risk of all such invasive procedures is the introduction of pathogens that can lead to the spread of HAIs.

Practicing infection control in the radiology department, with the aim of controlling and reducing the spread of infectious diseases, is thus critical (Antwi, Adesi, Gawugah, Opoku, Arthur & Baah, 2015:8). Radiographers need to understand SICP, and actively participate in solutions to reduce the risk to patients, as well as their own personal protection, by complying with these precautions (Sukumar & Yadav, 2012:152). However, compliance with SICP among healthcare workers, which includes radiographers, has been consistently highlighted to be low worldwide (Gammon, Morgan-Samuel & Gould, 2008:158). A systematic review found that compliance with SICP is sub-optimal on an international basis (Gammon *et al*., 2008:165). SICP are paramount to minimising HAIs and high health care costs or burden associated with them (McGaw, Tennant, Harding, Cawich, Crandon, & Walters, 2012:2). Strict adherence by radiographers to SICP may control the risks to HAIs, making it necessary for them to have adequate knowledge and skilled practices about SICP (Phillips & Ker, 2006:518).

1.2 PROBLEM STATEMENT

As a practicing radiographer, and a health educator, the researcher observed that there were discrepancies in terms of the application of SICP by radiographers in radiology departments in government referral hospitals in Malawi. Furthermore, currently there is no national policy or national infection control guideline to be followed when implementing infection control in the radiology departments in Malawi. The researcher observed the following non-adherence practices: failure by radiographers to wash their hands between patients, use of the same gown for a number of patients, and use of the same disposable gloves on several patients. In addition, the researcher observed that most radiographers do not remove jewellery when performing radiological examinations, nor do they clean or disinfect the x-ray couch or chest stand after attending to a patient. Furthermore, the researcher observed that most radiographers did not carry out daily damp dusting of the radiographic equipment as per normal routine radiographic practices in a radiology department. Similar sentiments, in terms of non-adherence to SICP, were expressed in a conversation the researcher had with the principal radiographer at one of the radiology departments. The principal radiographer pointed out that there was poor personal hygiene by some radiographers which included long hair extensions, and long nails, which are assumed to harbour pathogenic microorganisms.

Apart from working in a radiology department, radiographers in Malawi carry out mobile radiography on critically ill patients in intensive care units (ICU), highly dependence units (HDU), and in surgical wards for patients who are on traction, which are all potential sources of pathogenic microorganisms. While working in these areas, radiographers carry x-ray cassettes, grids, lead rubber aprons and anatomical markers. The researcher observed that these items are rarely disinfected or cleaned, posing an infection risk. This observation is similar to what Tugwell and Maddison (2011:17) and Boyle and Strudwick (2010:301) found. Similar practices were observed by the researcher of radiographers in the government referral hospitals' radiology departments in Malawi. This implies that there was poor adherence to SICP. Furthermore, it is unclear what the knowledge of radiographers is regarding infection control. Lack of such knowledge may contribute to poor adherence to SICP in these radiology departments.

Poor adherence to infection control by radiographers could lead to an increase in terms of cost associated with buying equipment or materials necessary for combating HAIs. Such expenditure may negatively affect radiology departments' already limited budgets. This is another reason that radiographers should adhere to SICP. In order to do so requires adequate knowledge on infection control as well as skilled infection control practices. An infection control guideline could assist in facilitating sound knowledge and practices of radiographers regarding infection control.

1.3 RESEARCH QUESTIONS

Based on the identified problems, the researcher aimed to answer two research questions.

- What is the knowledge and practices of radiographers regarding infection control in radiology departments in government referral hospitals in Malawi?
- What information could be included in a draft guideline for infection control in order to facilitate sound knowledge and practices of radiographers regarding infection control in radiology departments in government referral hospitals in Malawi?

1.4 RATIONALE OF THE STUDY

In Malawi, the concept of infection control in the radiology departments is not well explored and little is known on the issue. Furthermore, to date, it appears that no study has been conducted to investigate the knowledge and practices of the radiographers regarding infection control in such settings, neither does a guideline for infection control exist. However, a radiographer's compliance to SICP could be critical in controlling the transmission of pathogenic microorganisms. In the interests of patients' safety, it was deemed necessary to conduct this study. The study will be the first to explore and describe of knowledge and practices of radiographers regarding infection control in radiology departments in government referral hospitals in Malawi in order to develop a draft guideline for infection control to facilitate sound knowledge and practices of radiographers regarding infection control in those departments.

The results of this study would inform practicing radiographers, heads of departments, the Ministry of Health and Population, and other health practitioners, about the current practices and knowledge of radiographers in government referral hospitals in Malawi. The draft guideline for infection control could facilitate sound knowledge and practices regarding infection control among practicing radiographers in these departments. This is expected to enable the implementation of SICP: at operational and managerial levels. The results of the study should contribute to the body of knowledge of radiography practice, radiography education and development of further research agenda in the radiography profession, specifically in the African context.

1.5 THE PURPOSE AND OBJECTIVES OF THE STUDY

1.5.1 Purpose of the study

The purpose of the study is to explore and describe the knowledge and practices of radiographers regarding infection control in radiology departments in government referral hospitals in Malawi in order to develop a draft guideline for infection control to facilitate sound knowledge and practices of radiographers regarding infection control.

1.5.2 Research objectives

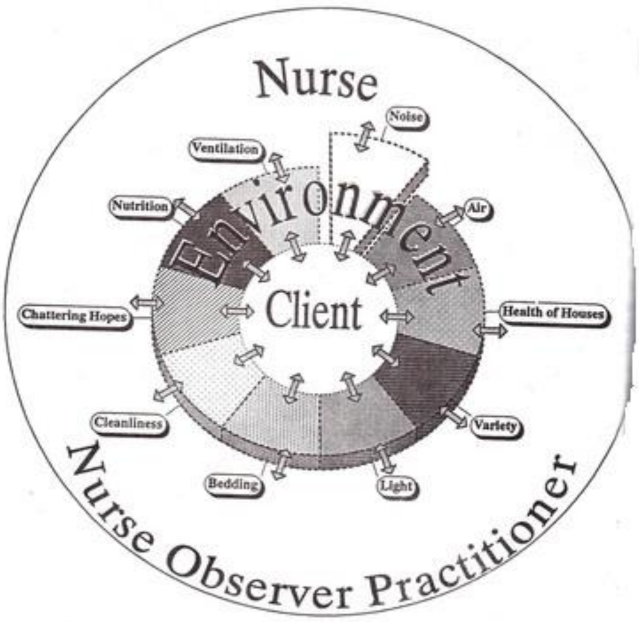
There are two specific objectives in the study.

- To explore, and describe, the knowledge and practices of radiographers regarding infection control in radiology departments in government referral hospitals in Malawi.
- To develop a draft guideline for infection control that could facilitate sound knowledge and practices of radiographers regarding infection control in radiology departments in government referral hospitals in Malawi.

1.6 CONCEPTUAL FRAMEWORK

A conceptual framework refers to the theories, beliefs and prior research findings that guide, or inform, a researcher about his study (Maree, 2016:73). This study was grounded in Florence Nightingale’s environmental theory, which encourages the configurations of environmental settings appropriate for restoration of health (Wayne, 2014:1). According to Lin, Yin and Seto (2011:1), the field of hospital infection control was introduced by Nightingale. Furthermore, no published radiography model or theory, related to infection control and the environment, could be found by the researcher. This study was guided by the work of Florence Nightingale, who was a nurse by profession. Nightingale emphasised that the responsibility of nurses is to put patients in the best position for nature to act on them and allow them to heal (Nightingale, 1969). In the case of this study, a radiographer’s responsibility is to maintain an environment that will prevent patients from obtaining an infection during a radiological procedure. Nightingale attempted to prevent infection during her work in the Crimean War. She introduced many hygienic protocols, some of which remain relevant to this day, not only for nurses but also for radiographers (Nightingale, 1969).

According to George (2011:50), Nightingale viewed the manipulation of the physical environment as a major component of care at a health facility including 10 areas: noise, air, health of houses, variety, light, bedding, cleanliness, chattering hopes, nutrition and ventilation as outlined in Florence Nightingale's environmental theory. Figure 1.1 illustrates these areas.



(Gonzalo, 2011)

Figure 1.1: Client and environment in balance

If Figure 1.1 is applied within a radiographic setting, a patient (client) and a radiographer (instead of a nurse), and the major environmental concepts must be in balance. A radiographer can manipulate the environment to compensate for a patient's response to it. The goal of a radiographer is to assist a patient to stay in balance (George, 2011:54). For this study therefore, two areas of the Florence Nightingale's environmental theory were identified as needing to be controlled to prevent HAIs. The two major areas relevant to this research study are health of houses and cleanliness (which is subdivided in cleaniness of the rooms and personal cleanliness). Alligood (2010:100), points out that health of houses attempts to assess the surrounding environment for pure air and cleanliness by removing waste around the area in order to ensure that the environment is clean and has clean air. Cleanliness of rooms attempts to assess a room for dampness and dust or mildew, as such it encourages that rooms should be kept free from dust, dirt and dampness. Personal cleanliness attempts to keep a client dry and clean all the time. Personal cleanliness extends to radiographers, and this requires that radiographers should wash their hands frequently during the day. Personal hygiene attempts to protect oneself and a client from illness. Personal hygiene extends to radiographers as they should take care of themselves and always maintain cleanliness, and groom the external body e.g. taking a daily bath, brushing teeth, etc (George, 2011:52).

In this study, the model is applied by exploring and describing radiographers' knowledge and practices on the following:

- issues to do with a clean environment and waste disposal e.g. disposal of needles after use and on how to take care of the sharp containers before disposal to prevent HAIs (health of houses in Nightingale's model).
- issues to do with whether radiographers clean, disinfect, damp dust and check radiographic equipment for cleanliness prior to using them to prevent HAIs (cleanliness of rooms in Nightingale's model).
- issues to do with the following: use of gloves, handwashing, use of hand rubs, wearing PPE (mask, googles, gloves), covering of cuts/wounds, cutting long fingernails, removal of jewellery during working hours, as well as providing each patient with a clean gown to prevent HAIs (personal cleanliness in Nightingale's model).

Finally, in this study, the researcher develops a draft guideline for infection control in order to facilitate sound knowledge and practices of radiographers regarding infection control in radiology departments in Malawi. The draft guideline is based on data derived from exploring and describing the knowledge and practices of radiographers on the issues of health of houses, cleanliness of rooms and personal cleanliness, as outlined above, as well as existing literature on these issues.

1.7 CONCEPT CLARIFICATION

Clarification of concepts, used in a study, is essential for readers to understand a research project (Creswell, 2013:39). The key terms used in this study are defined and explained so that readers should be able to understand the researcher's intended meaning. For the purpose of this study, the researcher provides conceptual and operational definitions for the concepts presented below.

Guidelines

A guideline exists as recommendations intended to assist providers and recipients of healthcare, and other stakeholders, to make informed decisions (WHO, 2012a:1). A draft guideline is developed in this study which includes written statements expressing procedures or protocols on how implementation of infection control should be conducted in a radiology department.

Healthcare associated infections (HAIs)

HAIs refer to infections associated with healthcare delivery in a hospital or ambulatory setting (Friedman *et al.*, 2011:28). In this study, HAIs are infections one gets upon exposure to infected places where radiological examinations are performed.

Infection control

Infection control refers to processes and activities aimed at identifying and reducing the risks of acquiring and transmitting endemic or epidemic infections among individuals (David & Famurewa, 2010:1). For the purpose of this study, infection control refers to a practice of ensuring that the environment is free from pathogenic microorganisms. Knowledge and practices, regarding infection control, are explored and described in this study. A draft guideline for infection control is developed.

Radiographer

A radiographer is an allied health professional, who is registered with an appropriate professional board, and performs diagnostic examinations on patients using a variety of imaging modalities, including radiography, computed tomography (CT), magnetic resonance imaging (MRI), mammography and cardiovascular interventional technology (Ehrlich & Daly, 2009:438). In this study, a radiographer is a person who performs radiological diagnostic examinations and is involved in infection control. Radiographers are the target population of this study.

Radiology

Radiology refers to an organisation, either independent or within a larger medical facility, specialised for the delivery of medical imaging services e.g. ultrasound, mammography, CT, nuclear medicine, MRI, and fluoroscopy (Mollura & Smith, 2014:7). For the purpose of this study, radiology refers to any environment where a radiographer carries out radiological diagnostic examinations. It may include the radiology department, ICUs, highly dependence units, and surgical wards. Radiology departments, in government referral hospitals in Malawi, are the context in which this study was conducted.

1.8 RESEARCH DESIGN

Research design is a comprehensive plan for data collection in an empirical research project which aims at answering specific research questions or testing specific research hypotheses (Bhattacherjee, 2012:35). A quantitative, explorative and descriptive design that is contextual in nature (Brink, Van der Walt & Van Rensburg, 2012:115) was used for the study. Detailed information regarding the research design is presented in Chapter Three.

1.9 RESEARCH METHODS

Research methods refer to specific activities designed to generate data (Greener, 2008:10). These activities include identification of a population, selecting a sample, collecting and analysing data. The research methods in this study entailed two phases: phase one (questionnaire), and phase two (guideline development). The first phase addresses objective one: to explore and describe the knowledge and practices of radiographers regarding infection control in radiology departments in government referral hospitals in Malawi. The second phase addresses objective two: to develop a draft guideline in order to facilitate sound knowledge and practices of radiographers regarding infection control in radiology departments in government referral hospitals in Malawi.

1.9.1 Phase one: questionnaire

The research population, sampling, data collection instrument, data collection method, pilot study and method of data analysis are explained below.

1.9.1.1 Research population

A population refers to all elements (individuals, objects, events or substances) that meet the sample criteria for inclusion in a study (Burns, Grove & Gray, 2013:703). In this study, population refers to all radiographers who work in the radiology departments in government referral hospitals in Malawi, and are registered with the

Medical Council of Malawi. A detailed description of the research population is provided in Chapter Three.

1.9.1.2 Sampling

Brink *et al*. (2012: 132), define sampling as a researcher's process of selecting a sample from a population in order to obtain information regarding a phenomenon in a way that represents the population of interest. In this study, the researcher had access to the entire research population, hence it was not necessary to use a sampling technique. Instead a census sampling method was used, and is discussed in Chapter Three.

1.9.1.3 Data collection instrument

De Vos, Strydom, Fouche and Delport (2011:186), define a questionnaire as "a document containing questions and or other types of items designed to solicit information appropriate for analysis". In this study, a self-administered questionnaire was used as a data collection instrument for gathering information to determine the knowledge and practices of radiographers regarding infection control in radiology departments in government referral hospitals in Malawi. The researcher developed the questionnaire based on a literature review and an existing questionnaire. The development and content of the self-administered questionnaire are described in Chapter Three.

1.9.1.4 Data collection method

Data collection is the precise, systematic gathering of information relevant to the research purpose or specific objectives, questions or hypothesis of study (Burns & Grove, 2011:52). The data collection method used in the study is discussed in Chapter Three.

1.9.1.5 Pilot study

Babbie and Mouton (2010:200), refer to a pilot study as a small-scale trial run done in preparation for a major study. According to Bhattacherjee (2012:23), a pilot study helps to detect potential problems in a research design and/or instrumentation and to ensure that the measurement instruments to be used in the study will be reliable and valid measures of the constructs of interest. The researcher conducted a pilot study in radiology departments in two government district hospitals in Malawi. Details of the pilot study are presented in Chapter Three.

1.9.1.6 Method of data analysis

Data analysis entails categorising, ordering, manipulating, summarising, and describing the data in meaningful patterns (Brink *et al.*, 2012:177). Descriptive and inferential statistics were employed with the help of a statistician at Nelson Mandela Metropolitan University to analyse the collected data. Details regarding data analysis are presented in Chapter Three.

1.9.2 Phase two: guideline development

Guidelines are sets of statements or principles that help practitioners to make decisions about care in specific clinical circumstances. These statements are usually research based (Nursing Resources, 2016:1). Practice guidelines include recommendations, intended to optimise patient care, that are informed by a review of evidence, and an assessment of the benefits and harms of alternative care options (Institute of Medicine, 2011:4). The aim of this study was to develop a draft guideline in order to facilitate sound knowledge and practices of radiographers regarding infection control in radiology departments in government referral hospitals in Malawi. The findings of the first phase of the study, and reviewed literature, are used to compile the draft guideline. Information concerning guideline development, the method and format used are discussed in Chapter Three.

1.10 QUALITY OF RESEARCH

In order to ensure that a research study is of an acceptable standard, attention should be given to its validity and reliability. According to Brink *et al*. (2012:169), validity and reliability are fundamental measurements of an instrument to ensure that the findings are credible and trustworthy. Chapter Three presents a discussion on how validity and reliability were maintained throughout the study.

1.11 ETHICAL CONSIDERATIONS

Burns and Grove (2009:83), define ethics as adherence to moral principles in research, such as justice, the rights of participants, together with the rights of others who are in the setting. Three ethics principles that guided the researcher during the research process were respect for persons, beneficence, and justice (Brink *et al*., 2012:34). These principles, including their adherence in the study, are discussed in Chapter Three.

1.12 DISSEMINATION OF RESULTS

According to Brink *et al.* (2012:98), a research project is meaningless if no one ever hears about it. Therefore, the researcher will communicate the study findings to the relevant stakeholders of the study. A formal report will be given to the university library for display of the results. The researcher also intends, with the help of his academic supervisors, to publish the results in a peer-reviewed journal. Findings will also be presented at a relevant conference. Copies of the reports will be given to the Ministry of Health and Population in Malawi, and the four hospital directors of the government referral hospitals used in the study.

1.13 CHAPTER LAYOUT

In order to ease the reading of the study report, the chapters have been structured as follows.

Chapter One: Overview of the study
Chapter Two: Literature review
Chapter Three: Research design and methods
Chapter Four: Data analysis and discussion of the results of the questionnaire (phase one)
Chapter Five: The guideline development (phase two)
Chapter Six: Conclusions, recommendations, and limitations

1.14 CONCLUSION

Infection control plays an important role in reducing HAIs. The latter are the major causes of deaths and prolonged hospital stay among patients. Since radiographers work within radiology departments, can control HAIs by implementing SICP. As such, radiographers need to adhere to SICP, in order to help in eliminating or reducing these infections. It is therefore necessary that radiographers have sufficient knowledge and adequate skilled practices regarding infection control in the radiology department. However, it appears that there is a discrepancy in terms of implementation of SICP by radiographers in government referral hospitals in Malawi. This assumption led to the researcher conducting this study. The aim of this study was to explore and describe the knowledge and practices of radiographers regarding infection control in radiology departments in government referral hospitals in Malawi in order to develop a draft guideline for infection control to facilitate sound knowledge and practices of radiographers in these departments regarding infection control. The discussion in this chapter centered on a brief overview of the topic being researched. The problem statement, research questions, rationale of the study, purpose of the study, and research objectives, were outlined within the context of the topic. The researcher discussed the paradigmatic perspective of the study. A brief summary of the research design and methods, reliability, validity, and ethical considerations, was presented. The research design and method are discussed in detail in Chapter Three. The next chapter presents the literature review that guided the development of the questionnaire to explore and describe the knowledge and practices of radiographers regarding infection control in radiology departments in government referral hospitals in Malawi, namely phase one of the study.

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION

The introduction and background of this study were presented in the previous chapter. The purpose of the study in terms of the research problem and questions, as well as objectives were also presented. This chapter presents literature review in terms of infection control, which underpins the study. It is important to use literature in order to identify concepts and terms for inclusion in a questionnaire, to be used in the first phase of the study, to explore and describe the knowledge and practices of radiographers regarding infection control in radiology departments in government referral hospitals in Malawi. The following are addressed in this chapter: the meaning and types of healthcare associated infections (HAIs) and their causes and transmission; the chain of infection and how to break it; the burden, impact and economic costs of HAIs: infection control; the role of radiographers in infection control; radiographic equipment and accessories susceptible to infection in a radiology department; infection control procedures in a radiology department; studies on the knowledge and practices of radiographers regarding infection control, and challenges in the implementation of infection control.

2.2 THE MEANING AND TYPES OF HEALTHCARE ASSOCIATED INFECTIONS

Rapid advancements in the medical sciences have changed the understanding of the diseases down to molecular levels and in turn revolutionised the diagnostics and therapeutics. Similarly, architectural and engineering progression has reshaped the outlooks of the hospitals with the aim of comforting the patients. Despite such advances, hospital environments continue to remain a source of HAIs (Ikram & Satti in: Sudhakar, 2012:3).

According to Kolmos, in Sudhakar (2012:21), HAIs are infections that patients acquire while they are in contact with a healthcare system. Contact includes all procedures associated with diagnostics, treatment and care. Five types of HAIs are highlighted, namely, surgical site infections (SSI), pneumonia, urinary tract infections, blood stream infections and gastroenteritis (Ireland Health Service Executive, 2016:1).

SSI refers to infections occurring at a site where a surgical procedure was performed. Usually risk is stratified by the length of surgery, site of infection, degree of anticipated contamination and a patient's general health. SSI can occur when bacteria (germs) enter a surgical incision, which then may lead to redness, swelling or pain at the site as the body tries to fight the infection. SSI can be superficial (affecting the skin only) or more severe (affecting the tissues/muscles under the skin) and cannot always be prevented (Mahon, Lehman & Manuselis, 2011:50).

Pneumonia is an infection of the lungs that can cause mild to severe illness. Symptoms include cough, shortness of breath and fever. Treatment of in-patients for pneumonia can be due to community-acquired infections, or hospital-acquired pneumonia. The latter usually occurs in intensive care patients who require assistance with breathing (on a life support machine or ventilator). Pneumonia can be a severe infection and can be fatal (Ireland Health Service Executive, 2016:1).

Urinary tract infections occur when germs or microorganisms enter a person's bladder via the urethra. Bacteria that enter the bladder, can multiply and may cause bladder infections. There are several causes of urinary tract infections (UTIs): improper personal hygiene, sexual activity, and/alcohol caffeine and inadequate fluid intake, for example. Patients who have a catheter inserted into their bladder, to drain urine, are more likely to develop a urinary tract infection (Bloomsburg University, 2015:1).

Blood stream infections occur when bacteria or other organisms enter the blood. In healthcare, these infections are associated with central lines. Patients with central lines are at an increased risk for blood stream infections; the presence of a catheter serves as an entry point for organisms outside the body to enter the blood stream, which can cause local or wide infections with a potential for serious complications. Blood stream infections are serious infections and can be fatal (Pennsylvania Department of Health, 2012:1).

Gastroenteritis is inflammation of the bowel caused by an infection. Symptoms include diarrhoea, vomiting and tummy cramps. Gastroenteritis is commonly acquired in the community and, those affected (especially the elderly and children) may be admitted to hospital due to dehydration. Hospital– acquired gastroenteritis is commonly caused by *Clostridium difficile* and the winter vomiting bug (norovirus). Norovirus is usually a mild illness. For a small number of immune-compromised patients, *Clostridium difficile* can be a severe infection, and in rare cases can be fatal (Ireland Health Service Executive, 2016:2).

2.3 THE CAUSES AND TRANSMISSION OF HEALTHCARE ASSOCIATED INFECTIONS

2.3.1 Causes of healthcare associated infections

HAIs are caused by microorganisms. An understanding of commonly encountered microorganisms is essential for good infection control. Microorganisms that cause HAIs are referred to as pathogenic microorganisms. They are classified into five groups: bacteria, viruses, pathogenic fungi, protozoa, and parasites (Lister & Inamdar, 2013:18).

Bacteria are microscopic, single-cell organisms with a simple internal organisation. They are autonomously replicating unicellular organisms lacking an organised nucleus and have a single circular chromosome of double-stranded DNA. Morphologically there are three general bacteria: cocci or spheres, bacilli or rods, and spirals. Some bacteria produce a highly resistant resting form known as the endospore, which is highly resistant to the external environment. Endospores are survival forms of bacteria that are produced most often in response to nutritional deprivation. Some common bacterial infections are streptococcal pharyngitis (strep throat), *Klebsiella* pneumoniae infection (bacterial pneumonia), and *Clostridium botulinum* infection (food poisoning) (Alder & Carlton, 2016:210).

Viruses are much smaller than bacteria. They are subcellular disease causing organisms. A fully developed viral particle is called a virion. A virus has a protein coat (the capsid) and does not have organised cellular structures. Some viruses are enveloped and others are not. Enveloped viruses, such as influenza, human immunodeficiency virus (HIV) and hepatitis B, use spikes to attach to host cells. Some viruses, such as rhinoviruses that cause the common cold, do not have an envelope and spikes, thus the capsid assists the viruses in attaching to host cells. Viruses cannot survive independently. Although they may survive outside the body for a time, they can only grow inside cells of the body. Common viruses include the Epstein-Barr virus, which causes infectious mononucleosis, and varicella which causes chickenpox and herpes zoster (Ehrlich & Coakes, 2017:135).

Fungi can be macroscopic, as in the case of mushrooms and puffballs, or microscopic such as moulds or yeasts. A mould, which causes infections in humans is *Trichophtyon rubrum.* It is one cause of ringworm, and it may infect nails. A common yeast infection is thrush caused by *Candida albicans.* Fungi are eukaryotic organisms with nucleus and membrane-bound organelles. Fungi can be distinguished from bacteria because intracellular organelles can be visualised within a fungal cell. Fungi can cause superficial and deep diseases. The former are cutaneous, growing on or under the skin, and the latter are systemic diseases that colonise most of the body (Alder & Carlton, 2016:211).

Protozoa are microscopic organisms, but larger than bacteria. Protozoa are complex single-celled animals that generally exist as free-living organisms. However, a few protozoa are parasitic and live within the human body. Protozoa can infect the gastrointestinal, genitourinary, respiratory and circulatory systems. Common protozoal diseases include; amebiasis, giardiasis, trichomoniasis and toxoplasmosis (Ehrlich & Coakes, 2017:137).

Worms are not always microscopic in size but pathogenic worms do cause infection and some can spread from person to person. Examples include threadworm and tapeworm. Head lice and scabies are types of parasites found external to the body (Lister & Inamdar, 2013:18).

2.3.2 Transmission of healthcare associated infections

HAIs are transmitted in health care settings by several routes, and the same microorganisms may be transmitted by more than one route (Canadian Committee on Antibiotic Resistance, 2007:10). According to Green and Gammouh (2012:6), the routes for HAIs transmission are through contact, droplets and airborne. The other modes of transmission of HAIs are common vehicle and vector borne. These routes are discussed below.

Contact transmission of HAIs can occur by direct, or indirect, host to host contact. Direct contact occurs when microorganisms are transferred from one person to another. It can involve contact with blood, body fluids, excretions or secretions; during patient care by healthcare workers or a guardian; and during interactive activities in playrooms or lounge between patients. Indirect contact involves the transfer of microorganisms through contaminated intermediate objects, substances or people. It can occur when inadequate handwashing is performed by a care provider, equipment is not cleaned, disinfected or sterilised adequately between handling patients, and when blood borne pathogens are transferred by used sharps or used needle–stick injuries, transfusion or injection (Alder & Carlton, 2016:214).

Droplet contamination involves infectious droplets that are expelled (e.g. when sneezing, coughing speaking or singing). The infectious droplets are too heavy to float in the air and are transferred less than 2 meters from the source of the droplets. Spread may be by a direct or indirect droplet. During direct droplet transmission, the droplets reach mucous membranes or they are inhaled, whereas indirect transmission is when droplets fall onto surfaces or hands and are then transmitted to mucous membranes or food. The latter method of transmission is often more efficient than direct transmission. Infections spread this route include the common cold, influenza, meningitis, diphtheria, pertussis, and respiratory syncytial viruses. Droplets can also contaminate the surrounding environment and lead to indirect contact transmission (Ehrlich & Coakes, 2017:141).

According to Gilmore, in International Federation of Infection Control (2011:159), small particles carrying microbes can remain airborne; they may be transferred via air currents for more than 2 meters from the source as droplet nuclei or on skin scales. These particles are then inhaled. Examples of microbes spread in this manner are varicella, measles, and pulmonary tuberculosis. Airborne transmission occurs from dust that contains spores or droplet nuclei. Droplet nuclei are particles of evaporated droplets containing microorganisms (Ehrlich & Coakes, 2017:141).

Common vehicle transmission applies to microorganisms transmitted by contaminated items such as food, water, and medications, to multiple hosts and can cause explosive outbreaks. Control requires use of appropriate standards for handling food, water, and preparing medications (Canadian Committee on Antibiotic Resistance, 2007:11).

Vector borne transmissions occur due to vectors such as mosquitoes, flies, fleas, bugs, sand flies, rats, ticks, and other vermin transmitting microorganisms. Many are bloodsucking insects that ingest disease-producing microorganisms during a blood meal from an infected host (human or animal) and later inject them into a new host during their next blood meal (WHO, 2014:9).

2.4 THE CHAIN OF INFECTION AND HOW TO BREAK IT

According to Lister and Inamdar (2013:20), the way by which HAI is spread can be thought of as a continuous chain with six links: the source, reservoir, way out of the body, method of transmission, person at risk, and way into the body. These links are often referred to as the chain of Infection. In order to control infection or stop it spreading, one or more links in the chain must be broken. This can be achieved through practicing infection control precautions. The six links, and how each link can be broken, are outlined below.

2.4.1 Link 1: Sources of microorganisms

Sources of microorganisms are sometimes called infectious agents or pathogenic organisms. The main types of human HAIs include bacteria (e.g. salmonella), viruses (e.g. hepatitis A, B or C), fungi or yeasts (e.g. Candida). Infected people may act as a source of infection for others because the microorganisms may be found in certain body fluids and could be passed to others (Lister & Inamdar, 2013:20). This link can be broken through rapid and accurate identification of organisms through diagnosis which is followed by treatment (Leeds, Grenville & Lanark District Health Unit, 2012:5).

2.4.2 Link 2: Reservoirs for microorganisms

Reservoirs are places where organisms may live, survive, and thrive in sufficient numbers to pose a threat. Such an environment must provide moisture, nutrients and a suitable temperature. Reservoirs can include humans (patients and radiographers), animals, the environment, and nonhuman ones (e.g. food or water). Contaminated food may act as a reservoir for example if it is contaminated with salmonella. Other examples of nonhuman reservoirs for microorganisms in a radiographic context, include anatomical markers, x-ray cassettes, lead rubber aprons, horizontal and erect x-ray couches (bucky tables and stands) towels, flannels and wash bowls (Ehrlich & Coakes, 2017:139). This link can be broken by ensuring that radiographic staff use disinfectants to clean their work environment and equipment, and to use sterilised items in interventional procedures (Scotland. National Health Service Handbook, 2008:7).

2.4.3 Link 3: The way microbes leave the body

The way microbes leave the body is sometimes referred to as the portal of exit. This exit allows infectious agents to escape their reservoir. From the human reservoir, this exit includes: blood through open wound needle puncture site, breaks in the skin or mucous membrane, respiratory tract via nose or mouth (sneezing, coughing, breathing, talking), endotracheal tubes, gastrointestinal tract which includes mouth (saliva, vomitus), anus feaces/diarrhoea, drainage tubes, and urinary tract which includes exit of infectious agents through urine. In the gastrointestinal tract, for example, salmonella leave the body in faeces and, if diarrhoea is present, high numbers of salmonella microbes are excreted. Tuberculosis uses the same entry and exit point: it is inhaled and exhaled which involves the use of the respiratory tract (Leeds Grenville & Lanark District Health Unit, 2012:2). This link can be broken by handwashing, use of PPE, safe handling of blood and body fluids, cough etiquette, and safe handling and disposal of waste (Scotland. National Health Service Handbook, 2008:7).

2.4.4 Link 4: The methods of spreading microbes from person to person

The method of spread of microbes is sometimes termed mode of transmission. HAIs are spread in several ways. Microorganisms can be transmitted exogenously from outside the body or endogenously from inside the body. This transmission can occur by direct or indirect host to host contact injection. Unwashed hands are the most common way through which infection is spread through direct or indirect contact (Alder & Carlton, 2016:214). The other routes for transmission of HAIs are droplets and airborne (Green & Gammouh, 2012:6). This link can be broken through isolation, environmental sanitation, disinfection and handwashing (Leeds, Grenville & Lanark District Health Unit, 2012:5).

2.4.5 Link 5: A susceptible person (person at risk of infection)

People are at risk of developing infection if they are in contact with an organism in sufficient numbers to cause illness. Immunity to some infections can be developed after being infected (e.g. chickenpox) or after immunisation (e.g. hepatitis B). Certain people are more susceptible, or at greater risk of infection, for a variety of reasons. Young children or the very old are more at risk because their immune system may not be developed or may be waning. In addition, some medications such as steroids can increase infection risk (Lister & Inamdar, 2013:21). This link can be broken through treatment of underlying diseases, flu and pneumococcal immunisation, and recognition of high-risk patients (Scotland. National Health Service Handbook, 2008:7).

2.4.6 Link 6: Microbes enter the body

In link 6, microbes enter the body. The process or stage is sometimes known as portal of entry. In order for microbes to cause infection they must enter the body. Different organisms have different ways of entering our bodies. For example, salmonella need to be ingested. Some organisms may cause infection if they are inhaled (e.g. tuberculosis). Others, such as hepatitis B, enter the bloodstream via broken skin or wound, injection, or sexual intercourse. Some microorganisms tend to enter the body through the respiratory tract, urinary tract, gastrointestinal tract, mucous membranes of the eyes, nose or mouth, and the blood stream (Ehrlich & Coakes, 2017:140). This link can be broken through personal hygiene, first aid and handwashing (Leeds, Grenville & Lanark District Health Unit, 2012:5).

2.5 THE BURDEN, IMPACT AND ECONOMIC COSTS OF HEALTHCARE ASSOCIATED INFECTIONS

HAIs cause a burden and impact on a healthcare system as well as economic costs.

2.5.1 The burden and impact of healthcare associated infections

According to Raka and Mulliqi-Osmani in Sudhakar (2012:67), HAIs represent one of the commonest adverse events during delivery of healthcare, complicating 5 – 10 % of admissions to acute care hospitals in industrialised countries. Pooled prevalence of HAIs in Europe is 7.1%, with range of 3.5 – 11.3%, as reported by the European Centre for Diseases Prevention and Control (ECDPC) in 2008. More than 4 million patients are affected by HAIs every year in Europe, and 1.7 million in the USA. In developed countries, approximately 25 – 30% of patients admitted to intensive care units (ICU) are affected by HAIs. Urinary tract infections constitute a predominant portion of HAIs with 30 – 40 % of the overall infections. According to Ehrlich and Coakes (2017:147), approximately 722,000 patients, admitted to hospitals each year, acquire HAIs. The Centre for Disease Control (CDC) estimates that 75,000 patients die each year of HAIs.

According to Allegranzi, Nejad, Castillejos, Kilpatrick, Kelley and Mathai (2011:3), surgical site infection (SSI) is the most surveyed and frequent type of infection in developing countries, with incidence rates from 1.2 to 23.6 per 100 surgical procedures, and a pooled incidence of 11.8%. By contrast, SSI rates vary between 1.2% and 5.2% in developed countries. Incidence of ICU-acquired infection was at least 2-3 fold higher than in high-income countries; device-associated infection densities up to 13 times higher than in the USA were reported in some studies. Many studies underscore the importance of HAIs in developing countries, where an average of 4384 children die every day because of HAIs (Kramer & Khan, 2010:28).

A study done in South Africa revealed that 417 HAIs were detected among 1,347 paediatric hospitalisations. Furthermore, the overall HAIs incidence rate was at 31/1000 patients' days with a period prevalence of 22/100 admissions (Dramowski & Whitelaw, 2017:58). No information could be added concerning local Malawi because there is no literature coming so clear on prevalence of HAIs, most information talks of literature related to infection to do with aids, TB etc.

2.5.2 The economic costs of healthcare associated infections

According to Friedman *et al*. (2011:372), HAIs have considerable economic impact on healthcare services and the cost of national care. Measuring the cost of HAIs is difficult; the financial impact varies between different healthcare systems. Hospitalisation costs may be due to use of antibiotics administered to patients with HAIs. Costs of HAIs may also be due to increased length of hospitalisation and potential intensive care unit stay. Intervention costs may include tests performed, or barriers (e.g. gown and gloves) used in treatment and management of a patient with HAIs. Costs may also be in the form of a nurse or physician's time. The outpatient/community costs may be due to physician visits, use of antibiotics, home health visits, and rehabilitation centre stay. Patient costs/outcomes may be related to mortality, morbidity, lost wages due to absence at work, and travel expenses to and from the hospital (Friedman *et al*., 2011:372).

According to Ehrlich and Coakes (2017:147), HAIs are one of the leading causes of death in the USA, and amounts to US$28 – 34 billion (360.36 – 437.58 billion South African Rand or 20,186.88 – 24,512.64 billion Malawi kwacha) in healthcare costs. In 2002, 99,000 USA deaths were attributed to HAIs, with an associated cost of 6.5 billion dollars (WHO, 2011:20). One study in the USA noted that the direct hospital-related financial burden was estimated to be between 25.0 and 31.5 billion dollars (321.75 – 405.405 billion South African Rand or 18,024 – 22,710.24 billion Malawi kwacha) per year. Another USA study found that each HAI adds US$12,197 (156,975.39 South African Rand or 8,793,549.12 Malawi kwacha) in incremental costs to hospitals (Kilgore *et al*., 2008:101 & 104).

A study in Turkey suggested that a patient with HAI spent an additional 23 days in hospital compared with a patient not affected with a HAI. The extra cost for an infected patient was calculated as US$2,026 (26,074.62 South African Rand or 1,460,664.96 Malawi kwacha (Esatoglu, Agirbas & Onder, 2006:137). In Mexican intensive care units (ICUs), the overall cost of one single HAI episode was US$12,155 (156,434.85 South African Rand or 8,763,268.8 Malawi kwacha). In several ICUs in Argentina, the overall extra cost estimates for catheter-related bloodstream infection, and healthcare associated pneumonia, averaged US$4,888 (62,908.56 South African Rand or 3,524,052.48 Malawi kwacha) and US$2,255 (29,021.85 South African Rand or 1,625.764 Malawi kwacha) per case respectively (WHO, 2011:21).

2.6 INFECTION CONTROL

The historical perspective of infection control as well as the standard infection control precautions are discussed.

2.6.1 The historical perspective of infection control

The recognition of importance of infection control dates back to biblical times, and it is still important today. To promote infection control leper colonies were instituted to separate infected people from the rest of the population. A bell warned people to stay away. In 1965, when there was an outbreak of plague, dead bodies, due to the disease, were collected at night to minimise contact with healthy human beings (Perry, 2007:1). Doctors used protective clothing (a gown, mask and gloves) to prevent themselves from being contaminated by plague despite the fact that the design of these protective materials was very primitive.

In the early 1800s, an Hungarian obstetrician, Semelweiss noted that more mothers died from infections after childbirth when doctors and medical students delivered babies compared to when midwives did so. He observed that medical staff came from a post-mortem room to a delivery room without washing their hands. He deduced this practice lead to cross infection when delivery babies. He implemented handwashing with chloride of lime. This resulted in a decrease in infection and death rates almost instantaneously (Perry, 2007:2).

Florence Nightingale was the first nurse to recognise the importance of infection control. During the Crimean War, she noted that more soldiers, at the Scutari Hospital, died from infections than their war injuries. Although she did not believe in the presence of microorganisms, she recognised that placing together a large number of sick people together in an area with inadequate space, light and ventilation, contributed to the spread of infection. She introduced many hygiene protocols, and through collection of appropriate data it was observed that there was a reduction in terms of rates of infection (Perry, 2007:2). Some of the principles applied by Florence are still relevant today. She believed that if proper sanitary precautions were applied, it was possible to treat patients with infectious diseases in wards without danger to other patients. Her approach is still echoed today in the principles of universal or standard precautions. A new era in infection management began with the advent of penicillin in the 1940s. This antibiotic meant that infections could be treated and deaths, due to infection, were avoided. Control of infection became less important since treatment was available. In the late 1950s, a pandemic of infections due to *Staphylococcus Aureus* drove hospitals to reconsider infection control measures (Perry, 2007:2).

According to Ehrlich and Coakes (2017:153), when infectious disease was rampant, those infected were often quarantined. All members of a household were prevented from leaving the home, and visitors were barred entry. Diseases for which quarantine was authorised, and are still authorised, include tuberculosis, cholera, diphtheria, plague, smallpox, yellow fever, and viral haemorrhagic fever. Decades ago, hospitals developed policies that involved separating patients, admitted with infectious diseases, from other patients. Contact with other persons was rigidly controlled. This isolation was a logical outgrowth of the practice of quarantine, and these techniques provided for specialised methods of asepsis when the danger of disease transmission was exceptionally high. Although isolation techniques were effective when used correctly, no mechanisms existed for the prevention of infection in asymptomatic individuals.

Before SICP, universal precautions (1985), and body substance precautions (1987), were used to control the transmission of HAIs. Under universal precautions, all patients were treated as potential reservoirs of infection. The system was based on use of barriers such as gloves and masks for all contacts with blood and certain body fluids known to carry blood-borne pathogens, rather than focusing on the isolation of a patient with a diagnosed blood-borne disease. Because the universal precautions placed emphasis on blood-borne infections, and did not include precautions for contamination by feaces, nasal secretions, sputum, sweat, tears, urine and vomitus, a new system, called body substance precautions, was introduced. The system focused on the use of barriers for all moist and potentially infectious body substances from all patients and was developed to protect healthcare workers from acquiring and transmitting HAIs from all pathogens. Due to the weaknesses of the features of both the universal precautions and body substance precautions, in 1996 the CDC recommended the introduction of SICP which combined the features of both precautions (Ehrlich & Coakes, 2017:153).

2.6.2 The standard infection control precautions

SICP represent minimum infection control measures that apply to all patient care regardless of suspected or confirmed infection status of a patient, in any setting where healthcare is delivered. These evidence-based practices are designed to both protect healthcare personnel and prevent the spread of infections among patients. SICP replace earlier guidance relating to universal precautions and body substance isolation (National Centre for Emerging & Zoonotic Infectious Diseases, 2011:2). These infection control precautions include hand hygiene (including handwashing, drying, alcohol hand rub and removal of jewellery), respiratory and cough hygiene, PPE (including gowns, aprons, face masks and eye goggles), occupational exposure management including sharps, management of care equipment, safe care of linen including uniforms, control of environment and safe waste disposal (United Kingdom. National Health Services Professionals Handbook, 2010:1-2).

Handwashing is a routine practice in all patient care practice. It is the single most important means of controlling the spread of infection. It involves removal of contaminants (transients) as well as resident microorganisms. Washing hands is both a physical and a chemical process (Alder & Carlton, 2016:218). One of the commonest ways in which pathogenic microorganisms are transported is through hands. Good hand hygiene is an important practice in reducing transmission of HAIs during delivery of healthcare. Hand hygiene refers to all processes, including handwashing using soap and water, and hand decontamination achieved using other solutions e.g. alcohol hand rub (United Kingdom. National Health Services Professional Handbook, 2010:3). There are three levels of hand hygiene. Level one aims at rendering the hands physically clean and removing pathogenic microorganisms picked up during activities considered ‘social’ activities (transient microorganisms). Level two aims at removing or destroying transient microorganisms. Level three aims at removing or destroying pathogenic microorganisms and substantially reduce resident pathogenic microorganisms during times when surgical procedures are being carried out. Hand hygiene should be performed before touching a patient, before an aseptic/clean procedure, after body fluid exposure risk, after touching a patient, and after touching patient surrounding (United Kingdom. National Health Services Professional Handbook, 2010:3). According to Mahon *et al*., (2011:75), it is advisable to wash hands after removing gloves, between clients/residents, before contact with clean items, and after contact with blood or body fluid exposure risk.

Adequate hand drying plays a critical step in the hand hygiene procedure. It removes any remaining residual moisture that may facilitate transmission of microorganisms. Hands that are not dried properly are assumed to increase the risk of harbouring microorganisms. Clean disposable paper towels should be used to thoroughly dry all areas of the hands (United Kingdom. National Health Services Professionals Handbook, 2010:6). Hand hygiene, when entering or leaving a ward/clinical/patient area, can be performed using an alcohol-based hand rub when hands are contaminated, but are not visibly soiled. An alcohol rub or gel is more effective in reducing the number of bacteria on hands than handwashing with plain or antimicrobial soap. An alcohol rub or gel reduces the number of bacteria on hands by one hundred-fold or more in just 15 seconds (Green & Gammouh, 2012:7-8). Alcohol-based hand rub can also be used following handwashing, when performing aseptic techniques for example, to provide a further cleansing effect. Alcohol-based hand rub is however not effective against spore forming organisms (e.g. *Clostridium difficile*). The steps to perform hand hygiene, using an alcohol-based hand rub, are the same as when performing handwashing (United Kingdom. National Health Services Professionals Handbook, 2010:6). Alcohol-based rub products should not be used on visibly soiled hands, or in place of soap and water, when body fluids are involved. It should be thought as an addition to soap and water rather than a substitute and should not be used when dealing with *Clostridium difficile* (Lister & Inamdar, 2013:26). According to the Canadian Committee on Antibiotic Resistance (2007:27), it is important to remove hand and arm jewellery when washing hands. Jewellery is very hard to clean and also hides bacteria and viruses. Rings, bracelets, watches, earrings and body piercings can all harbor germs. Jewellery must also be removed when working in clinical care settings to prevent the spread of microorganisms by contact with contaminated jewellery. It is advisable for staff providing healthcare to remove jewellery at the start of their working day (Lister & Inamdar, 2013:27).

Due to the recent global influenza pandemic, respiratory and cough hygiene has been added to SICP. Respiratory hygiene and cough etiquette should be applied as a SICP at all times. Respiratory and cough hygiene is designed to minimise the risk of cross-transmission of respiratory illness (pathogens). The measures to be followed in respiratory hygiene include covering nose and mouth with disposable single use tissues when sneezing, coughing, wiping and blowing nose and disposal of used tissues into a waste bin. Other measures to be adhered to include washing hands, with non-antimicrobial liquid soap and water, after coughing, sneezing, using tissues, or after contact with respiratory secretions or objects contaminated by these secretions, and keeping contaminated hands away from the mucous membranes of eyes and nose (Infection Control Team, 2016:12). Airborne precautions are designed to reduce risk of dust particles containing infectious organisms or airborne droplet nuclei to a susceptible person. Healthcare workers and visitors entering the room of an infectious person must therefore wear disposable masks. Disposable masks provide a defense against airborne infections (Ehrlich & Coakes, 2017:161).

PPE is one element of SICP which applies to contact with blood, body fluids, non-intact skin and mucous membranes. PPE protects patients from microorganisms that could be present on healthcare workers in a healthcare setting. This type of equipment provides a physical barrier between microorganisms and the wearer, thereby preventing microorganisms from contaminating hands, eyes, mouth, clothing, hair and shoes. PPE also prevents microorganisms from being transmitted to other patients and staff. The benefit of wearing PPE is twofold: offering protection to both patients and guardians. PPE used in healthcare settings include gloves, aprons, gowns, face/mouth masks and eye goggles (Kenya. Ministries of Public Health and Sanitation & Ministry of Medical Services, 2010:26-27). Disposable sterile gloves are the most worn PPE. It is mandatory to wear them for all invasive procedures, and in all activities, that have been assessed as carrying a risk of exposure to blood, body fluids, secretions or excretions and where non-intact of skin is anticipated. They however must not be worn as an alternative to hand hygiene. They must be changed after each procedure. Important to wash hands prior to applying and after removal of gloves. Gloves should be removed promptly after use and hand hygiene performed before touching clean items and environmental surfaces; before touching eyes, nose and mouth; and before being in contact with other patients. They must also be removed prior to contact with other items (e.g. door handles, telephone and pens) (Wakefield & Kirklees Council, 2014:29). Care should be taken when removing used gloves to avoid contamination of hands and clothing. The wrist end of the glove should be handled and the glove should be pulled down gently over the hand, turning the outer contaminated surface inward while doing so. Used gloves are then disposed of inside out, preferably with the second glove also pulled over the first while removing it so that they are wrapped together. Used gloves are considered to be clinical waste. They must never be placed on environmental surfaces, but disposed of safely, and immediately following use, into appropriate receptacles. Hand hygiene should be performed immediately after the removal and disposal of gloves (United Kingdom. National Health Services Professionals Handbook, 2010:12).

Gowns are used to help protect uncovered skin and to prevent soiling of clothing during procedures and patient activities that are likely to generate splashes or sprays of blood, body fluids, secretions or excretions. Gowns are used to reduce the risk of transmitting germs from client to client. Impermeable gowns are preferable as compared to permeable gowns. Gowns are either re-usable or disposable, and should be long sleeved. Gowns should not be worn outside the area for which they are intended, and soiled gowns should be removed as soon as possible. Gowns should be washed or disposed of between patients. Aprons are used when limited contamination is likely. Aprons are used to protect clothing or surfaces from contamination. Plastic aprons are recommended for procedures during which splashes or spillage of blood, body fluids, secretions or excretions are likely. An apron could be worn beneath a gown. Aprons are disposable and should be disposed of between patients (Kenya. Ministries of Public Health and Sanitation & Ministry of Medical Services, 2010:36 & 38).

Face mask and eye goggles are used to protect the mucous membranes of the eyes, nose and mouth during procedures and patient care activities likely to generate splashes or sprays of blood, body fluids, secretions and excretions. Goggles should provide adequate protection when the risk of splashing is present. They must wrap around the eye area to ensure that side areas are protected. Face shields or visors should be considered instead of a surgical mask and or goggles where there is a higher risk of splattering of blood/other body fluids. Face masks should be removed immediately following a procedure (Lemass, McDonnel, Connor & Rochford, 2013:18).

According to United Kingdom. National Health Services Professionals Handbook, (2010:17), occupational exposure, including needle stick (sharps) injury, refers to the following injuries or exposures: percutaneous (injury from needles, instruments, bone fragments, human bites that break the skin), exposure of broken skin (abrasions, cuts, eczema), and exposure to mucous membranes including the eye, nose and mouth. Adherence to precautions is essential while providing patient care in order to avoid occupational exposure to microorganisms that may be found in blood and other body fluids. It must always be assumed that every person encountered could be carrying potentially harmful microorganisms that might be transmitted and cause harm to others. Therefore, precautions to prevent exposure to these and subsequent harm in others receiving or providing care must be taken. The greatest occupational risk of transmission of a blood-borne virus (BBV) is through parenteral exposure (e.g. a needle stick injury, particularly hollow bow needles). Risks also exist from splashes of blood/body fluids and excretions/secretions. Needle stick (or sharps) injuries includes items such as used needles, sharp-edged instruments, broken glassware, any other item that may be contaminated with blood or body fluids and may cause laceration or puncture wounds, such as razors, sharp tissues, spicules of bone and teeth (United Kingdom. National Health Services Professionals Handbook, 2010:19). It is advisable never to recap, resheath or bend used needles. It is also important that used sharps are never passed by hand from person to person. The person using a needle or sharp has the responsibility to dispose it safely, and must ensure that used needles, or sharps, are always disposed into sharps' containers immediately after use (Canadian Committee on Antibiotic Resistance, 2007:28).

Workers need to take care of their small wounds and cuts which occur as a result of occupational exposure (WorksafeBC, 2012:3). Proper care of small cuts and wounds (e.g. wound dressing) may make the workers feel better in 3 – 4 days. The healing process of small cuts and wounds is more effective if they are dressed, and the dressing is kept clean and dry. Wound dressing also prevents spread of infection from one worker to another.

Management of healthcare equipment is an element of SICP that applies to blood or other body fluids, mucous membranes or non-intact skin. Equipment used on patients/clients can become contaminated with blood, other body fluids, secretions and excretions during the delivery of healthcare. Healthcare equipment must be managed appropriately to limit the risk of contamination with pathogenic microorganisms or infectious agents during healthcare delivery. Healthcare equipment is classified as single use, single patient use, reusable invasive equipment, and reusable non-invasive equipment (Infection Control Team, 2016:15). It should be stored properly according to vendor guidelines. General principles to be followed are: check cleanliness of equipment prior to use, and ensure that it is cleaned and dried before storage; avoid storing healthcare equipment on the floor; and cover healthcare equipment where appropriate. Procedures for management of care of equipment should be performed: on a routine scheduled basis, when equipment is visibly dirty, immediately when spillages or contamination with blood/other body fluids has occurred, and whenever a patient is discharged (e.g. used or unused equipment in a care environment) (United Kingdom. National Health Services Professionals Handbook, 2016:11).

Safe management of linen is an element of SICP. Linen may be contaminated with blood or body fluids, excretions or secretions during the delivery of healthcare. Soiled fabric/linen, used within healthcare settings, can harbor large numbers of potentially pathogenic microorganisms. Appropriate precautions are important to ensure that people or the environment are not exposed to contamination to/from linen as this could results in transmission of microorganisms. Precautions apply to storage, handling, bagging and transporting of linen; all the stages in linen management. Linen management guidelines contain three categories of linen: used linen, infected linen and soiled line. Used linen refers to all used linen, except linen from infectious (or isolated) patients or those suspected of being infectious. Infected linen applies to linen that has been used by a patient known or suspected to be carrying potentially pathogenic microorganisms. Soiled linen refers to linen contaminated with blood or other body fluids (Lead Nurse Infection Prevention & Control, 2015:16-17). Linen must be safely managed to prevent it being a hazard leading to spread of potentially pathogenic microorganisms to those receiving healthcare. Protective measures include wearing of a disposable apron when handling used linen, holding used linen away to avoid contamination of personal clothing, and performing hand hygiene following handling of linen and removal of a disposable apron (United Kingdom. National Health Services Professionals Handbook, 2010:21-22). Uniforms, as part of linen, are assumed to harbor pathogenic microorganisms. Some good practices for care of uniforms: wear a clean uniform at the start of each shift, wear short sleeved tops or shirts, uniform to be changed immediately if it is heavily soiled or contaminated, wash uniforms at the hottest programme suitable for the fabric (e.g. wash for 10 minutes at 60 degrees C) to remove most microorganisms (Lister & Inamdar, 2013:30).

According to the Infection Control Team (2016:15), a healthcare setting contains a diverse population of microorganisms. This must be considered when caring for those who are susceptible to infection. Potentially pathogenic microorganisms can be detected in air, water, and on surfaces. It is the responsibility of the person in charge to ensure that a healthcare environment is safe for practice (this includes environmental cleanliness/maintenance). A healthcare environment must be visibly clean, free from non-essential items and equipment to facilitate effective cleaning, well maintained, in good state of repair, and routinely cleaned in accordance with the laid down standard infection control precautions (Infection Control Team, 2016:16). Maintaining a tidy, well organized, 'clutter free' environment, is important for effective environment management. This could involve effective organisation of storage equipment, reviewing cleaning processes, and minimising waste. There is also a need to ensure that equipment used for cleaning the environment is clean, fit for purpose and in good state of repair. Clinical equipment needs to be stored in a dedicated area (not in clinical rooms or bathrooms). Equipment purchased/used for storage (e.g. shelves, units, and lockers) should have easy to clean, smooth surfaces and be water resistant. Environment in this discussion refers to general horizontal surfaces in a patient's/client's environment, and frequently touched surfaces in the environment or beds, trolleys, chairs, lockers, couches and chest stands in a radiology department. Cleaning of the environment should be undertaken when it is visibly dirty or dusty, immediately when spillages occur, and in relevant care settings, whenever a patient is discharged from their care environment (United Kingdom. National Health Services Professionals Handbook, 2010: 24).

Waste disposal items should be disposed of immediately and should never be kept for long times in their designated areas. Waste at a clinical setting includes healthcare/clinical waste, special/hazardous waste, and domestic waste. Healthcare waste is produced as a result of health activities (e.g. soiled dressings, linen, sharps), special waste arises from the delivery of healthcare in both clinical and non-clinical settings, and includes hazardous substances (e.g. chemicals, pharmaceuticals), domestic waste includes glass, paper, plastics, metals, cardboard which are regarded as dry recyclates. The following guidelines should be used for safe and appropriate waste disposal. Waste containers for holding waste should be of an appropriate strength to ensure they are capable of containing waste without spillage or puncture. Bag holders, particularly in healthcare settings, should be pedal operated so that hands do not become contaminated during waste disposal. Approved sharps containers or boxes to be used. They must be assembled correctly following the manufactures' instructions. Hygiene waste to be disposed into appropriate receptacles and never dispose waste in already full receptacles (Infection Control Team, 2016:17-18). Sharp containers must be placed in a safe position within the treatment room to avoid accidental tipping over. They must be out of reach of small children. It is important to ensure that sharp containers are sealed when they have been filled to the line marked on the container, and then collected for disposal (Australian Dental Association Handbook, 2012:16). SICP can only be correctly applied if healthcare workers understand their roles in infection control.

2.7 THE ROLES OF RADIOGRAPHERS IN INFECTION CONTROL

Radiographers play a leading role in infection control. According to section 15 of the Health and Care Professions Council's (HCPC) of 2013, standards of proficiency of radiographers, requires that they need to understand and maintain a safe practice environment at all times. There are several ways in which radiographers can ensure that they maintain a safe practice environment. They need to apply health and safety legislation, and relevant safety policies and procedures such as incident reporting in the workplace, and be able to act in accordance to their guidelines. They need to establish safe environments for practice, which minimises risks to service users and fellow members of staff, including the use of hazard control; particularly infection control. They need to work safely by being able to select appropriate hazard control and risk management, reduction or elimination techniques in accordance with health and safety legislation. Radiographers also need to know the correct principles and applications of disinfectants, methods for sterilisation and decontamination, and recommendations dealing with waste and spillage correctly (Health & Care Professional Council Handbook, 2013:18-19).

Radiographers play a leading role in infection control by recognising the potential for spread of infection, and minimising hazards through application of SICP. Radiographers are able to achieve this by a number of ways: understanding and describing the mode of transmission of microorganisms, possessing evidence of current knowledge of infection control practices, practicing infection control including hand hygiene and equipment cleanliness procedures, complying with standard precautions guidelines, and adhering to protocol as regard to the use of PPE (Australian Institute of Radiography Handbook, 2013:23). Radiographers play a leading role in infection control by ensuring that they understand and follow the principles and practice of infection control, and minimise the risks of HAIs. Radiographers seek to advise patients and trainee radiographers on how to avoid HAIs and report instances where HAIs may arise from activities a radiographer has witnessed (Freeman, 2008:6). Infection control in a radiology context includes radiographic equipment and accessories that can also cause HAIs.

2.8 RADIOGRAPHIC EQUIPMENT AND ACCESSORIES SUSCEPTIBLE TO INFECTION IN THE RADIOLOGY DEPARTMENT

A radiology department plays a role in offering diagnosis to in-patients in all wards, ICU, HDU, and out-patients in all departments (Ochie & Ohagwu, 2009:31). A radiology department thus is an infection risk. It has the potential to spread infection from radiographic equipment to patient and staff and vice versa since the same radiographic equipment is for several patients each day.

According to Chingarande & Chidakwa (2013:2), radiographic equipment that is susceptible to infection includes x-ray cassettes, lead rubber aprons, anatomical markers, x-ray couches (horizontal bucky table), erect stands, and chin rests, x-ray console, the x-ray exposure button, x-ray tube handle, x-ray tube housing, viewing box, the film-hopper handle and the cassette hatch handle, to list a few examples. Other accessories that are used in the radiology department and are thus susceptible to infection include sand bags, pressure foam pads, non-stationery grids and patients' gowns. Some equipment and accessories are in contact with patients and radiographers, while others are only in contact with radiographers. The former includes x-ray cassettes, lead rubber apron, anatomical marker, x-ray couches (horizontal bucky), erect stands, sand bags, pressure foam pads, non-stationery grids and patient gown. The latter includes the x-ray console, x-ray exposure button, x-ray tube handle, x-ray tube housing, viewing box, film-hopper handle and the cassette hatch handle. The presence of microorganisms on some of the equipment can be attributed to inadequate cleaning (Chingarande & Chidakwa, 2013:2).

Ochie and Ohagwu (2009) conducted a study in Nigeria to identify nosocomial bacteria commonly found on x-ray equipment and accessories in a radiology department, and the effectiveness of common disinfecting agents. The findings were that an x-ray couch, an erect bucky, control console, exposure button, patient gowns, and x-ray cassettes, all carried a risk of harbouring HAIs (Ochie & Ohagwu, 2009:33). X-ray cassettes were the most frequently contaminated radiographic equipment (Ochie & Ohagwu, 2009:34). A study was conducted in East England to investigate infection control for x-ray cassettes in a diagnostic imaging (Fox & Harvey, 2008). Their finding also showed that x-ray cassettes harboured bacteria, including potential pathogens such as *Staphylococcus aureus*. They underscored that x-ray cassettes therefore had the potential to act as a vector for cross infection between patients and departments (Fox & Harvey, 2008:310).

A study in East of England was done to determine whether lead rubber aprons pose an infection risk, in terms of the use of adequate infection control measures; the results were that there was microbial growth on lead rubber aprons (Boyle & Strudwick, 2010:302). An Australian study was conducted by Worrall (2012) regarding radiographer infection control compliance to assess whether radiology departments were a potential source of nosocomial infection. This study found that microbial-sensitive and antimicrobial-resistant pathogens were present on radiographic surfaces. The horizontal bucky, erect bucky and the chin rest, displayed the most alarming surface swab result, culturing staphylococci and coliforms bacteria (Worrall, 2012:3).

While radiographers focus on x-ray cassettes, couches, and other big equipment items, they tend to forget small radiographic accessories like anatomical markers. Radiographers have their own anatomical markers for use on patients. Tugwell and Maddison (2011:119), concluded in their study that anatomical markers are a reservoir for bacteria because they found them to be highly contaminated with various organisms.

It is reasonable to unequivocally conclude, from the above discussed studies, that radiographic equipment and accessories are susceptible to infection in a radiology department. What can radiographers do to curb the spread of infections in radiology departments? According to Chingarande and Chidakwa (2013:3-4), damp dusting should be done every morning on all equipment, for example, door handles, lead rubber aprons, viewing boxes, and the handles of pass through hatches. Radiographers should also clean, wash and disinfect anatomical markers to reduce bacterial load. Disinfectant wipes of alcohol gel to be used at least once a week to clean anatomical markers (Tugwell & Maddison, 2011:119). Bacteria on cassettes can be controlled or minimised by placing them in a smooth-fitting plastic bag or protective cover when attending to patients in isolation rooms (Ehrlich & Coakes, 2017:163). Radiographers need to effectively clean lead rubber aprons to prevent them from harbouring bacteria (Boyle & Strudwick, 2010:300).

2.9 INFECTION CONTROL PROCEDURES IN THE RADIOLOGY DEPARTMENT

SICP are designed and universally acknowledged to reduce the risk of transmission of unrecognised sources of blood-borne and other pathogens in healthcare institutions. They also reduce the risk of transmission from recognised sources of infection by including precautions for modes of transmission (Ehrlich & Daly, 2009:157). Infection control procedures applied in the radiology departments constitute ideas borrowed from SICP. Infection control procedures, in radiology departments, are classified into two broad categories: routine departmental cleaning, and personnel practices (Ehrlich & Daly, 2009:404).

2.9.1 Routine departmental cleaning

Routine departmental cleaning covers cleaning of counters and surfaces that are frequently in contact with personnel who: handle patients, open and close storage areas containing linen, non-sterile medical supplies, sterile supplies, and use lead rubber aprons and gloves, mobile x-ray machines, x-ray machines, tables, vertical bucky stands, wheelchairs and stretchers (Ehrlich & Daly, 2009:404). Counters and surfaces frequently in contact by personnel who handle patients should be cleaned using a disinfectant, detergent or germicide impregnated disposable cloth (Ehrlich &

Coakes, 2017:453). The counters and surfaces should be wiped down twice daily. The counters and surfaces may include work areas in radiography rooms, counters surrounding reception desks, image processing counters and counters in image viewing areas. The shelves and doors of storage areas containing linen and non-sterile medical supplies should be wiped weekly using a disinfectant comprising diluted bleach, or a germicide cloth. Attention should also be given to storage areas containing sterile supplies. Radiographers need to daily dust these areas, and on a weekly basis remove all items from shelves in order to wash the surfaces using a disinfectant. Expiry dates must be checked, to re-sterilise or replace supplies whose shelf-life has expired.

Radiographers should undertake infection control measures of lead rubber aprons and gloves, mobile x-ray machines, fixed x-ray machines, x-ray couches and erect stands, wheelchairs and stretchers, as explained above. Lead rubber aprons and gloves should be cleaned weekly using a disinfectant of diluted bleach, or germicide cloths, and also immediately following contact with blood or body fluids. Mobile x-ray machines should be cleaned weekly using disinfectant or a germicide cloth. Particular attention should be given to the x-ray tube, tube arm, and collimator, which are suspended over patients. It is always necessary to wipe thoroughly a mobile x-ray machine before entering surgery units, ICU, HDU, neonatal nurseries, and patient rooms designated for protective precautions (Ehrlich & Daly, 2009:404). According to Eze, Chiegwu and Okeji (2013:1411), x-ray equipment and accessories should be properly disinfected immediately after use and before the next patient is attended to. X-ray couch, cassettes, chest stands and anatomical markers should be disinfected in between patients; the control panel and exposure buttons should be disinfected each day. The x-ray machines, tables and vertical stands should be thoroughly washed with a disinfectant, dilute solution or germicide cloth after patient contact. The overhead tubes, spot film devices, image intensifiers and television monitors should be daily dusted. The overhead tracks for ceiling–mounted equipment should be dusted weekly using a vacuum cleaner, and control stands, spot film devices, and the entire radiography table, should be washed with a disinfectant (Ehrlich & Coakes, 2017:453). Radiographers should ensure that all reusable radiographic equipment is cleaned and reprocessed appropriately prior to use to another patient. Reusable radiographic equipment must be cleaned and reprocessed (disinfection or sterilisation) according to the manufacturer's instructions. Since radiographic equipment, including anatomical markers, is used on more than one patient, adequate cleaning and disinfecting of equipment before use on another patient is required (National Infection Control Guidelines, 2016:18 & 28).

2.9.2 Personnel practices

Routine departmental cleaning may not be enough to combat infection. Attention therefore needs to be given to practices of personnel in a radiology department. All personnel in a radiology department should apply infection control measures, including hand hygiene and good personal hygiene (Ehrlich & Daly, 2009:405).

Hand hygiene means that radiographers should wash their hands with a non-antimicrobial or antimicrobial soap. Radiographers should always wash their hands when they are visibly dirty or contaminated with blood or body fluids, before eating and after using a restroom, after blowing or wiping nose, and if exposure to bacteria is suspected or proven. Handwashing helps remove spores. An alcohol-based hand rub, or handwashing is necessary when reporting for duty, between examinations of patients, before donning sterile gloves, following removal of gloves, following contact with a patient’s intact skin and on completion of duty (Ehrlich & Coakes, 2017:454; Eze, Chiegwu & Okeji, 2013:1411). Radiographers should adopt a culture of proper handwashing at the end of procedures of the day. Radiographers attend to patients in isolation areas or rooms hence they need to follow the correct method for removal the contaminated isolation attire/ gown. When removing such attire/gown, its contaminated outer surface gown should never be in contact with a radiographer’s body or clothes. It is advisable to fold the contaminated surface of the attire or gown inwards when removing it in readiness for discarding (Ehrlich & Coakes, 2017:164 & 166).

According to Ehrlich and Daly (2009:405), good personal hygiene is important for infection control in a radiology department. This requires radiographers to bath and wash hair regularly, wear clean uniforms and duty shoes, change clothing that is soiled in the process of patient care before continuing work, and pay attention to fingernails and jewellery. It is advisable for radiographers to keep their fingernails short to prevent them harbouring bacteria. Jewellery is a source of HAI therefore it should not be worn when attending to patients. Good personal hygiene can be promoted by ensuring that radiographers do not report for duty when affected by contagious skin diseases, acute upper respiratory infections, and other communicable diseases.

2.10 STUDIES ON THE KNOWLEDGE AND PRACTICES OF RADIOGRAPHERS REGARDING INFECTION CONTROL

This section covers literature in terms of the theoretical perspective of the study and previous studies done on infection control procedures among radiographers. Several studies reveal that knowledge and practices on SICP for radiographers play a critical role in the control of HAIs.

2.10.1 Knowledge of radiographers regarding infection control

A cross-sectional study was conducted in Sri Lanka by Jayasinghe and Weerakoon (2014) to assess the prevention of nosocomial infections and the knowledge and practicing of standard precautions of 213 radiographers at radiology clinics in the government and private sector, respectively. The study tool was a questionnaire based on international standards to measure knowledge using four ratings: weak, moderate, good and excellent (Jayasinghe & Weerakoon, 2014:14). The majority were rated as having good knowledge.

A study was conducted in Enugu, Nigeria by Okaro, Eze and Ohagwu (2010) regarding the knowledge of 24 radiographers on blood and body fluid precaution measures. The study used a four-point Likert scale (poor, moderate, good and very good) to determine their knowledge: 58.3% (n=14) of the radiographers were rated good in knowledge despite various sources of awareness (Okaro *et al*., 2010:12). A study by Luntsi, Nwobi, Ochie, Nkubli, Abubakar, Njiti, Moi and Abubakar (2014), was conducted on the practice of universal precautions against body fluid infections among radiographers in some teaching hospitals in Northern Nigeria; the findings were that 87.3% (n=55) of the radiographers had good knowledge in terms of universal infection precaution measures (Luntsi *et al*., 2014:80).

A descriptive cross-sectional study was conducted in Ghana by Antwi *et al.* (2015), to assess the appropriate use of infection control principles/measures among 72 radiographers, and to also establish whether infection control guidelines were necessary during radiological examinations in the public hospitals. The data collection too was a questionnaire. The results were that all 72 radiographers had fair knowledge on infection control precaution measures (Antwi *et al*., 2015:10).

Radiographers (n=51) were rated to be highly knowledgeable of standard infection control precautions with a score of 100% (Udoh, Ugwu & Akaka, 2011:18) in a cross-sectional study conducted in South East Nigeria. Radiographers (n=84) had good knowledge with regards to infection control in a quantitative study conducted in North Wales by Dumbarton (2007:150). The aim of the study was to investigate the knowledge and practices of radiographers regarding infection control within a diagnostic imaging department at a cancer hospital and infectious disease unit.

The findings of study, conducted in India by Sukumar and Yadav (2012), were that radiographers' knowledge of infection control was low in terms of HAIs and equipment spreading infection in radiology departments. The radiographers were not aware of equipment that spreads infection in a radiology department (Sukumar & Yadav, 2012:151).

Radiographers had low levels of knowledge in infection control (Worrall, 2012:3). This was ascertained in a survey conducted in Queensland, Australia, in metropolitan and rural radiology hospitals. The purpose of the survey was to gain information on infection control, compliance, influences and training among radiographers.

2.10.2 Practices of radiographers regarding infection control

The reviewed studies reveal different results in terms of levels of practice. The studies are grouped in terms of good score, moderate score and low score. A good score, with a rating of 89%, was obtained in a study conducted in Ghana by Antwi *et al.* (2015). They assessed radiographers on the appropriate use of infection control principles/measures during practice, and to also establish whether infection control guidelines are necessary on infection control during radiological examinations in public hospitals (Antwi *et al.,* 2015:8). A prospective study by Luntsi *et al.* (2014) on the practice of universal precautions against body fluid infections among radiology staff in some teaching hospitals in Northern Nigeria revealed that the practices of radiology staff regarding infection control was good with a rating of 72.7% (n=46) (Luntsi *et al*., 2014:80).

A moderate score, with a rating of 66.66%, was obtained in a study in Sri Lanka by Jayasinghe and Weerakoon (2014). Their study assessed radiographers' prevention of nosocomial infections, their knowledge and practicing standard precautions (Jayasinghe & Weerakoon, 2014:14).

The level of infection control in terms of practice by radiographers, in South East Nigeria, was low (Udoh *et al*., 2011:21). A similar finding applied to radiographers' infection control practice in Bangor (Dumbarton, 2007). Hand decontamination, prior to patient contact, was found in 4% occasions (n=34), and afterwards in 17% of occasions (n = 145). Equipment was cleaned on 4% occasions (n = 30); 56% of pieces of equipment were found to be have unacceptable levels of bacterial contamination (Dumbarton, 2007:1). Radiographers' infection control practices were found to be low in a study conducted in Queensland, Australia by Worrall (2012).

Studies, relating to infection control in in Malawi were done by Rawlins, Lacoste, Ncube, Necochea and Bossemeyer in 2004. Their aim was to assess the implementation of infection prevention measures by health workers in government and mission hospitals. Kalata, Kamanga and Muula conducted a study, in 2013 at the Queen Elizabeth Central Hospital in Blantyre, to assess adherence to hand hygiene protocol by clinicians and medical students. Radiographers were not included in both of these studies.

In conclusion, the literature reviewed included studies conducted in countries outside Malawi. From the reviewed studies, contradictory findings were reported, in terms of different sample sizes of radiographers. The findings, from mainly developed countries, represent health system structures that have different socioeconomic background and statuses, including material resources for infection control. Malawi is a resource constrained developing country, hence this study targets radiographers, specifically those in a government health system structure.

2.11 CHALLENGES IN THE IMPLEMENTATION OF INFECTION CONTROL

According to Travers, Herzig, Pogorzelska-Maziarz, Carter, Cohen and Semeraro (2015:2 & 4) knowledge, training and workload were perceived to be challenges in the implementation of infection control. Lack of knowledge and occupational in-service training by radiographers impede information delivery and limit the ability to effectively implement and adhere to infection control practices. In other words, a person who does not have adequate knowledge of infection control may face challenges to apply SICP. To do so means being conversant with steps to be followed in implementing infection control practices. On the other hand, a person who does have adequate knowledge in infection control, but does not attend occupational in-service training may result in a challenge or a gap in terms of implementation of modern or updated infection control methods. The latter are necessary for curbing microorganisms which continue to be resistant to various infection control methods. Workload tends to prevent radiographers from effectively carrying out everyday practices. Even though radiographers are aware of infection control practices, adherence to these infection control practices may be low because of an increased or excessive workload. This often means being in a hurry to finish one task and move on to another. An increased workload may occur due to inadequate numbers of radiographers working in a radiology department.

Ogoina, Pondei and Isichel (2015:21) point out that lack of appropriate, or adequate, resources to practice infection control, and lack of infection prevention and control committees (IPACs), are some of the challenges that hinder the implementation of SICP. Inadequacy, in terms of resources, may include lack of resources such as PPE (gloves, aprons, gowns, face/mouth masks and eye goggles). The absence of PPE may put a radiographer and a patient at risk. They would be exposed to infection because of lack of a barrier to offer protection from both microorganisms and body fluids or spills. IPACs are necessary for promotion of good infection control practices. Their role mitigates the risk of HAIs by acting as focal authorities for promotion of infection control practices. IPACs conduct regular infection control training for staff in a healthcare setting. The absence of an IPAC makes it difficult for a hospital to implement SICP because such a committee champions the implementation of infection control practices and designs activities or plans in-service infection control training.

According to Raka and Mulliqi-Osmani in Sudhakar (2012:66), lack of commitment to healthcare, and inadequate salaries, pose a big challenge in the implementation of infection control. Hospital policy-makers are not committed to improving healthcare.

Allocation of funds have often been disproportionate to the priorities set by policy-makers. Priority in the allocation of funds has often been directed to visible targets within the society such as schools, infrastructure and security. Healthcare is frequently far behind thus the issue of infection control has not been recognised as a priority. The proportion of funds devoted to control of HAIs is usually insufficient. Healthcare workers' motivation for quality healthcare is low due to inadequate salaries. Due to being demotivated, healthcare workers view implementation of SICP as a waste of time. The result is that SICP has not been fully implemented in hospitals thereby posing a risk to radiographers and patients.

2.12 CONCLUSION

An in-depth discussion of the literature reviewed was presented in this chapter. The discussion included: the meaning and types of healthcare associated infections; the causes and transmission of HAIs; the chain of infection and how to break it; the burden, impact and economic costs of HAIs; infection control; the role of radiographers in infection control; radiographic equipment's and /accessories susceptible to infection in radiology departments; and infection control procedures in a radiology department. Studies on knowledge and practices of radiographers, regarding infection control as well as the challenges in the implementation of infection control, were also discussed. The literature is therefore used to develop a self-administered questionnaire to explore and describe the knowledge and practices of radiographers regarding infection control in radiology departments in government referral hospitals in Malawi: phase one of the study. The next chapter discusses the research design and methods used in the study.

CHAPTER THREE

RESEARCH DESIGN AND METHODS

3.1 INTRODUCTION

In the previous chapter a literature review, including knowledge and practices of radiographers regarding infection control, was done. This chapter describes the approach used to achieve the aim of the study, namely, to explore and describe the knowledge and practices of radiographers regarding infection control in radiology departments in government referral hospitals in Malawi in order to develop a draft guideline for infection control in order to facilitate sound knowledge and practices of radiographers regarding infection control. A discussion is presented on research design and methods, including the research population, sampling method, data collection, pilot study, data analysis of phase one (the self-administered questionnaire), and the guideline development in phase two. Validity and reliability of data are outlined, as well as ethical considerations applied in the study.

3.2 RESEARCH DESIGN

Research design is regarded as a plan or guide for provision of sound answers to research questions. Research design, as a plan or strategy, moves from the underlying philosophical assumptions to specifying the selection of respondents, data gathering method to be used, and data analysis to be done (Maree, 2016:72). In this study, a quantitative, exploratory and descriptive design, that was contextual in nature, was employed to achieve the study objectives.

3.2.1 Quantitative research

Groove, Gray and Burns (2015:32), refer to quantitative research as a formal, objective, rigorous systematic process for generating numerical information about the world. Quantitative research is conducted to describe new situations, events or concepts (Sharma, 2014:41). According to Groove *et al*. (2015:32), quantitative research examines the relationship among variables, and determines global effectiveness of treatments or interventions on selected health outcomes. A research strategy is quantification in both data collection and analysis (Bryman, 2012:35).

Quantitative research answers research questions from the viewpoint of a researcher, and uses questionnaires, surveys, observation, and experiment, for collection of data (Armstrong, 2009:181). A self-administered questionnaire is used for data collection in this study. Data collection pertains to knowledge and practices of radiographers regarding infection control.

According to Choy (2014:101), quantitative research has both advantages and disadvantages. Its advantage is that it can be administered and evaluated quickly, and is cost-effective when time and resources are limited. Respondents' replies can be tabulated within a short timeframe. Another advantage is that data are collected rigorously, using appropriate methods, and analysed critically in terms of reliability (ACAPS, 2012:6). Zawawi (2007:3), points out that quantitative research is advantageous because it provides a wide coverage of a range of situations. According to Burns and Grove (2009:22), the strength of quantitative design is because its focus is concise, objective and reductionist. Reductionism involves breaking the whole into parts, to examine the latter. A quantitative researcher remains detached during a study, and tries not to influence it with personal values. The strengths of a quantitative study are that is has precise estimates, it is relatively easy to use for a simple analysis using relevant analytical software, it is based on statistical theories and it is verifiable (Chemaly, 2012:47). Quantitative research makes aggregating and summarising data easier and opens the possibility of statistical analysis (Babbie, 2008:25).

Disadvantages of quantitative research include there is no human perception and beliefs incorporated, there could be lack of resources for large scale research, and there is no depth experience description (Choy, 2014:101). It is a long hard road, with elusive data on one side and stringent requirements on the other (Berg & Lune, 2012:4). Data interpretation and analysis may be more difficult. Zawawi (2007:3), points out that it is somewhat inflexible and artificial. It provides very little understanding towards actions demonstrated by people and thus makes it difficult to predict any changes in the future. The instrument or method chosen is subjective and research is dependent upon the tool chosen. There is lack of independent thought by a researcher when dependent on an instrument or mathematics used to extract or evaluate data, individuals' decisions are not evaluated, based on their culture or social interactions, decisions are made without any regard to predict behaviour. Furthermore, all individuals are measured the same way: in terms of their experiences, backgrounds, intelligence, independent thought and ability to change decisions at any given point in time, for example (Ford & Gonzales, 2010:5).

Having considered the advantages and disadvantanges, the researcher chose a quantitative research approach for several reasons. It allows for generalisability of the findings to a specific context (Cottrell & McKenzie, 2011:7). It makes aggregating and summarising of data easier, and opens the possibility of statistical analysis (Babbie, 2008:25). Numerical data are used to obtain information about the world (Burns & Grove, 2011:20). This study did collect numerical values from respondents by systematically determining the level of knowledge and practice of radiographers regarding infection control. Further, quantitative research allows for data to be quickly collected within a short period. It allows for identifying the variables reflected in a problem statement and ensures that these are assessed in a manner which is both reliable and valid (Houser, 2015:33).

Quantitative research has the ability to control the context of research through collection of information under conditions of control which ensure that bias is minimised, and precision and validity are maximised (Brink *et al*., 2012:11). In terms of this study, both measurement and interview bias were some of the conditions minimised by selecting a quantitative research approach. To minimise measurement bias, the researcher assessed the tool for its validity and reliability. Interview bias was achieved or controlled through the use of a self-administered questionnaire based on literature and an existing questionnaire. This prevented the researcher influencing information by either asking leading questions or putting words into the respondents' mouths, which is common in qualitative research. It allowed for the collected data to be analysed quickly, and there was some anonymity, in a sense that there was less interaction between the researcher and the respondents; and this was useful when dealing with the study topics (Robinson, 2014:1).

3.2.2 Exploratory research

According to Ramasawmy (2011:32), exploratory research involves gathering information or developing ideas about an issue in a research problem or context. Exploratory research is not only a simple description, or the frequency of occurrence of a phenomenon: it is an in-depth exploration, and a study, of its related factors to improve further understanding about a less-understood phenomenon (Sharma, 2014:168). An exploratory study aims at gaining insight into a situation, phenomenon, community or an individual (De Vos *et al*., 2011:95). According to Blanche, and Durrheim, Painter (2006:44), it is used to undertake a preliminary investigation into a relatively unknown area of research. In this study, the reason for performing an exploratory design was because such a study has never been done in the chosen setting. The reviewed literature revealed a paucity of research with regard to the knowledge and practices of radiographers regarding infection control in radiology departments in government referral hospitals in Malawi. This gap motivated the researcher to conduct an explorative study in terms of the knowledge and practices of radiographers regarding infection control in radiology departments in government referral hospitals in Malawi.

The strength of exploratory research is that it does not only simply describe or look at the frequency of occurrence of a phenomenon, but it is an in–depth exploration, and a study of its related factors to improve further understanding about a less understood phenomenon (Sharma, 2014:168). This type of research is limited in a sense that it does not provide final and conclusive answers to research questions tackled in a study (Brown, 2006:43). It seldom offers adequate answers to research questions, even though it can hint at answers and give direction as to which research methods could provide definitive answers. Further, exploratory research is seldom definitive in a sense that the individuals studied may not be typical of the larger population of interest, thus the sample is likely not a representative one (Babbie, 2014:91).

Exploratory research was chosen because of the flexibility of data sources. Data sources in this study were published literature, and primary data from the respondents. Another advantage of using this approach was that not a great deal of time could be spent with the respondents in obtaining data; the design was thus time saving and cheap in terms of the costs involved in conducting the study.

3.2.3 Descriptive research

Descriptive research uses both quantitative and qualitative methods. In descriptive research, the emphasis in the collection of data is on structured observation, questionnaires and interviews, or survey studies (Brink *et al*., 2012: 113). A self-administered questionnaire in this study was used to collect quantitative data. Descriptive research provides an accurate account of characteristics of an individual or group in real-life situations for purposes of discovering new meaning and describing what exists (Burns, Grove & Gray, 2013:692). According to Gomm (2009:92), the data in descriptive research is normally displayed in graphs, tables, frequency distributions, scatter grams and circle diagrams. In descriptive research, descriptive questions are used for gathering of facts, for example what and how questions (Engel & Schutt, 2013:18). Data in this study are displayed in graphs, tables, frequency distributions and circle diagrams. Descriptive questions were used in gathering of facts. Examples of such questions used in this study are: what is the knowledge of radiographers regarding infection control in radiology departments in government referral hospitals in Malawi? what are radiographers' practices regarding infection control in radiology departments in government referral hospitals in Malawi?

Descriptive research design may be used for identification of problems with current practice, for justification of current practice, for making judgments or determining what other professionals in similar situations are doing (LoBiondo–Wood & Haber, 2014:198). Descriptive research's strength is that it helps to gain more information about characteristics within a field of inquiry. It also does not involve manipulation of variables and these are studied as they exist in the real world (Sharma, 2014:167). According to Mitchell and Jolley (2010:205-206), its disadvantage is that a researcher might find a relationship between two variables, but still not be able to say why this relationship exists because no explanation has yet been given. Another disadvantage is that there is indication of determining cause and effect relationships; the aim rather is to describe situations and events and to determine accurately what the real situation is (Babbie & Mouton, 2010:93).

In this study, a descriptive research was appropriate because more information could be gained about characteristics, such as the knowledge and practices regarding infection control within a particular field of study. The other reason for choosing it was that it provided a picture of a situation as it naturally occurred (Burns & Grove, 2011:256). Polit and Beck (2008:192) stated that the purpose of a descriptive research design is to observe, describe, and document aspects of a situation as it naturally occurs. It was used in this study to describe the knowledge and practices of radiographers regarding infection control in radiology departments in government referral hospitals in Malawi.

3.2.4 Contextual research

This study utilised a contextual research design. According to Burns and Grove (2009:694), contextual design can influence the implementation of an intervention and outcome of a study, therefore a researcher must be sensitive to the context of the research. Contextual research informs a reader about the context in which the study is conducted (Blanche *et al*., 2006:275). It seeks to ascertain what exists in the social world and the way it manifests itself (Ritchie, Lewis, Nicholls & Ormston, 2014:31), and a study can be conducted in various settings (Botma, Greeff, Mulaudzi & Wright, 2010:188). In Malawi, there are 31 radiology departments: 27 in government district hospitals, and four in government referral hospitals. The research study was conducted in the latter's radiology departments (n=4). These hospitals provide tertiary healthcare, which consists of highly specialised services. They are tertiary referral hospitals and teaching hospitals. They provide services to patients referred from the secondary level of healthcare (district hospitals). They are in urban centres and have the following departments: radiology, laboratory, pharmacy, dental, eye, ICU, HDU, anaesthetic, orthopaedics, paediatrics, obstetrics and gynaecology, surgical and medical departments. They also have operating theatres.

Invasive interventional radiological procedures are performed at these hospitals. Such procedures attract pathogenic microorganisms which means a possible increase of HAIs. This study was applicable to its context because the respondents (radiographers) are confronted daily with the need to apply infection control practices.

3.3 RESEARCH METHODS

Research methods provide researchers with procedures or means they can follow in their process of acquiring knowledge in order to reach the research objectives (Botma *et al.*, 2010:41). The research methods used in the two phases in this study are discussed.

3.3.1 Phase one: questionnaire

Phase one addressed the first objective, namely, to explore and describe the knowledge and practices of radiographers regarding infection control in radiology departments in government referral hospitals in Malawi. The research population, sampling method, data collection, pilot study, and data analysis, are discussed in terms of research methods.

3.3.1.1 Research population

Nieswiadomy (2012:37) defines research population as a complete set of individuals or objects that possess common characteristics of interest to a researcher. According to Burns *et al*., 2015:250), a research population includes the target and accessible population, respectively. The former is the entire set of individuals or elements who meet the sampling criteria. The latter is a portion of a target population to which the researcher has reasonable access. In this study, the target population was all radiographers (n=80) who were registered with the Medical Council of Malawi, and worked in the radiology departments in the four government referral hospitals in Malawi. In accordance with ethics principles of anonymity, in this study the four hospitals are referred to as hospital A, B, C, and D, respectively. The target population comprised 14 (hospital A), 25 (hospital B), 13 (hospital C), and 28 (hospital D) radiographers. Six radiographers who participated in the pilot study are not included in this research population.

According to Burns and Grove (2009:345), inclusion criteria are specific characteristics that potential respondents must possess to be part of the accessible population. Exclusion criteria are those characteristics that can cause a person or element to be excluded from the accessible population (Nieswiadomy, 2012:38). Exclusion criteria involve filtering out those with specific characteristics that are not relevant to the study to be undertaken (Burns & Grove, 2009:345). The inclusion criteria for this study were all permanently employed radiographers who reported for duty. They had to be proficient in English as the questionnaire was in English. The exclusion criteria were all radiographers who were on annual, sick or maternity leave during the data collection period.

3.3.1.2 Sampling method

Sampling involves selecting a group of people, events, objects or other elements with which to conduct the study. A sampling method defines the selection process; the sample defines the selected group of people or elements (Groove *et al*., 2015:249). Census sampling was used in this study as it ensures a highly accurate, and concrete description of a phenomenon without any element of bias, and also that all the elements are taken into consideration without any chance of being left out (Prasad, 2015: 2). In this study, only radiographers employed at the four government referral hospitals were included. This was a limited population. To ensure that all registered radiographers, working in radiology departments of the four government referral hospitals, could participate in the research study meant that census sampling had to be used. This type of sampling gave all radiographers an equal chance to participate in the study. The sample size (n=62) was representative of radiographers who were on duty during the data collection process.

3.3.1.3 Data collection

Groove *et al*. (2015:47), refer to data collection as the precise, systemic gathering of information relevant to the research purpose or the specific objectives, questions or hypothesis of a study. The data collection instrument, and data collection process, in this study are discussed.

3.3.1.3.1 Data collection instrument

During data collection, in order to measure study variables, researchers use a variety of techniques such as observation, interview, questionnaires, scales and biological measures (Groove *et al*., 2015:47). A self-administered structured questionnaire was used in this study. The purpose of a self-administered structured questionnaire is to elicit responses from respondents for data collection. This type of questionnaire also aims to elicit information, which would provide insight into the nature of the problem (Annum, 2016:1). Questionnaires help gather information on matters of fact or opinion (Armstrong, 2009:183).

According to Brink *et al*. (2012:153), questionnaires have advantages and disadvantages. Their advantages include that they are: a quick way of obtaining data from a large group of people; less expensive in terms of time and money, and easy to test reliability and validity. They allow respondents to feel a greater sense of anonymity thus are more likely to provide honest answers if there is no face-to-face interaction between a researcher and them during completion of a questionnaire. There is no influence by a researcher and respondents do not feel being coerced. A standardised format is used thus an interviewer's mood does not influence respondents, and this reduces bias. Further, questionnaires are effective in gathering factual evidence (Armstrong, 2009:184).

Questionnaires are also disadvantageous in several ways (Brink *et al*., 2012:153). They are not always completed by respondents and thus could result in a low response rate. Mailing of questionnaires may be expensive. Respondents may fail to answer some of the questions. Respondents must be literate to complete a questionnaire. With the use of questionnaires there is no opportunity to clarify any questions that may be misunderstood by respondents (Brink *et al*., 2012:153). Some respondents may fail to mark responses to all of the questions, especially on long questionnaires (Burns & Grove, 2011:353) thus the incomplete nature of the data can threaten the validity of the instrument. Questionnaires are not useful for researchers who are investigating how or why things are happening. It is also impossible to assess the degree of subjectivity that has crept in when expressing opinions (Armstrong, 2009:184).

A questionnaire, as a data collection instrument, was used in this study for several reasons. It allowed for the data to be collected quickly from a relatively large targeted population spread over the four referral hospitals. This was cost-effective and also saved time. The researcher wanted to promote ethics in terms of anonymity in collecting the data through ensuring that the researcher was not aware of the respondents who completed the questionnaires (Brink *et al*., 2012:153). The questionnaire reduced the incidence of bias, because it was a uniform question presentation. The data were easily analysed and analysis was done using a computer software package (Fox & Bayat, 2007:88).

The statements and questions in the data collection instrument were related to Nightingales' theory (see Chapter One, section 1.6) and prepared by reviewing literature from previous studies and books on related topics (see Chapter Two, sections: 2.6.2, 2.8, and 2.9) as well as an existing questionnaire of a study done by

Jayasinghe and Weerakoon in (2014). Permission to use their questionnaire was obtained before developing the questionnaire (see Annexures E, I and J). Some of the statements and questions in their existing questionnaire (see Annexure J) were adapted without revision and were as follows.

- Statement B2: Invasive procedures do not increase the risk of healthcare associated infections.
- Statement 5. When there is a risk of splashes or spray of blood and body fluids, the radiographers must wear nothing and question.
- Question C13: Do you wear protective gloves and coats during procedures where there is potential for blood splatter?

The statements and questions that were adapted with some revisions were as follows.

Part B: knowledge regarding infection control

- Statement B1. The environment (air, water, inert surfaces) is the major source of pathogenic microorganisms responsible for healthcare associated infections. This statement initially read: the environment (air, water, inert surfaces) is the major source of bacteria responsible for healthcare associated infections.
- Statement B3: Standard infection control precautions include the recommendations to protect ourselves, patients and our fellow healthcare workers. This statement initially read: standard precautions include the recommendations to protect both patients and the healthcare workers.
- Statement B4: The standard infection control precautions recommend the use of gloves for each radiological procedure. This statement initially read: the standard precautions recommend the use of gloves for each procedure (see Annexure J).

Part C: practices regarding infection control

- Question C3: Do you wash your hands with soap before and after touching any patient? This question initially read: do you wash hands before touching the patient?

- Question C5: Do you wear a mask when there is a potential to be exposed to airborne droplets or dust particles? This question initially read: do you wear a mask when there is a potential to be exposed to respiratory aerosols?
- Question C6. Do you cover your open cuts and wounds that you have during clinical work? This question initially read: do you cover your open cuts and wounds during clinical work? (See Annexure J).

All other statements and questions were developed by the researcher after reviewing relevant literature on infection control. After revising the above statements and questions, the data collection instrument was in English and comprised four parts: A, B, C and D (see Annexure A).

Part A: demographic information

Four statements were used to gather demographic data: gender, age, level of education, and years of work experience as a qualified radiographer.

Part B: knowledge regarding infection control

There were 16 statements comprising a three-point Likert scale to assess the knowledge levels of radiographers regarding infection control in radiology departments in government referral hospitals in Malawi.

Part C: practices regarding infection control

There were 16 multiple choice questions to determine the practices of radiographers regarding infection control in radiology departments in government referral hospitals in Malawi.

Part D: additional questions

There were two closed-ended and two open-ended questions. The closed-ended questions aimed at investigating whether the respondents had attended any occupational in-service training sessions during employment as a radiographer. The open-ended questions aimed at determining factors outside the scope of practice that affected the implementation of SICP by the respondents, as well as obtaining recommendations/suggestions from them on how to improve infection control in their radiology departments.

3.3.1.3.2 Data collection process

After approval of the research proposal, and having obtained permission from the Faculty Postgraduate Studies Committee (FPGSC) of the Nelson Mandela Metropolitan University (NMMU) (now referred to as Nelson Mandela University), the researcher contacted the hospital directors of the four government referral hospitals in September 2016. The researcher needed to obtain approval from the hospital managers to conduct the study in the respective radiology departments by November 2016 (see Annexure H) before permission was obtained from the NHSRC as per policy in Malawi. Permission to conduct the study was granted to the researcher by the NHSRC in December 2016 (see Annexure G). The heads of radiology departments, at the selected hospitals, were then contacted telephonically by the researcher. The research process, and how it would be conducted, was explained to them. A date to meet with each head of radiology was agreed on. The appointment was to visit the respective study sites. The researcher requested the respective heads of radiology departments to gather the radiographers in the boardrooms for a briefing of the research study to be conducted.

During the meeting, respondents were briefed about the research study and the process. The briefing took place during the lunch hour (the time patients did not need to be attended to) and lasted 40 – 50 minutes. The purpose of the study and its significance was provided to the potential respondents. They were informed that a self-administered questionnaire was to be used for the collection of data. During completion of the questionnaire, the respondents were not allowed to access any information. This was done to prevent them from cross-checking answers. Respondents were also advised that conferring when completing their questionnaire was not allowed. Thereafter, the participants who were willing to complete the questionnaire, were requested to sign the consent form (see Annexure D) to participate in the study. The completed consent forms were collected by the researcher. Completion of the self-administered questionnaires was done in two groups at each referral hospital in order to ensure that patients were attended to. After signing the consent forms, self-administered questionnaires were given to the first half of the respondents who did not have to attend to patients. To prevent them from conferring with others, they were requested to exit the venue one at a time after completing the questionnaire. They had to place the completed questionnaires in sealed marked boxes as they exited the venue. The other half of respondents were then requested to complete their questionnaire, and when done to place them in the sealed marked boxes. On average, each respondent completed the self-administered questionnaire in 15 – 20 minutes. The researcher collected the sealed boxes the same day soon after the second group of respondents finished completing the self-administered questionnaire. The data collection process was conducted in January 2017. The process was the same for each of the four hospitals and took between to 3 - 4 hours at each facility. The reason for the increased number of hours in collecting data at each facility was attributed to the fact that data collection was done in groups.

3.3.1.4 Pilot study

A pilot study is used to develop and refine an intervention, a measurement method, a data collection tool or the data collection process (Burns & Grove, 2013:46). According to Botma *et al*., (2010:275), a pilot study helps in determining the clarity, ambiguity in the instrument, as well as whether there are potential embarrassing and/or culturally sensitive issues present in the instrument. A pilot study is carried out at the end of the planning phase of research in order to explore and test the research elements to make relevant modifications in research tools and methodology (Sharma, 2014:41). A pilot study was conducted in two government district hospitals shortly after approval from the NHSRC was obtained in December 2016. Convenience sampling was used to identify two government district hospitals within travelling distance for the researcher to conduct the pilot study. The radiology departments in the two government district hospitals differed from the radiology departments in the four government referral hospitals under study. They do not offer computer tomography services, and are smaller compared to the radiology departments in government referral hospitals. Despite the differences between these radiology departments, the researcher used radiographers, from government district hospitals, in the pilot study because the infection control principles the radiographers must adhere to are the same. This was done as they were not in the target population. This meant that the sample size of radiographers in radiology departments in government referral hospitals was not compromised.

In order to recruit six radiographers from two hospitals (three from each hospital) census sampling was used. Each of the two district hospitals had three radiographers as per the establishment. Radiographers from the two district hospitals were chosen because they were expected to have the same knowledge as their peers at the radiology departments in the governmental referral hospitals since they were trained at the same institution.

The results of the pilot study showed some ambiguities and difficulties of some areas of the questionnaire. For example, there was not an option to select if a respondent had never attended an occupational in-service training in D1. The final questionnaire included a ‘none’ option. The addition of this option was essential as it ensured that there were no gaps in the data capturing software spreadsheet. The respondents (n=6) of the pilot study did not form part of the population of the main study. The results were used as a quality control before commencement of the main study.

3.3.1.5 Data analysis

According to De Vos *et al*. (2011:249), data analysis entails the breaking down of the collected data into principal parts in order to obtain answers to research questions. The analysis involves categorising, ordering, manipulating, and summarising of data. Completeness of the self-administered questionnaires was checked by the researcher before capturing the data using a Microsoft Excel spreadsheet. A statistician at the NMMU assisted with the data analysis. In this study, descriptive and inferential statistics were employed to analyse the data obtained from parts A, B and C of the self-administered questionnaire. The two questions in part D (D1 and D2) were also analysed using descriptive and inferential statistics (see Annexure A). Descriptive statistics was used in categorising, organising and summarising the data. Frequency distributions in the sample data were used to make inferences about the population. Inferential statistics was used to test the relationship between variables. Chi-square tests and t-tests were used for the inferential statistics with Cramer’s V, and Cohen’s d statistics as measures of practical significance. Visual basic for applications (VBA) package for Social Science–Statistica, developed on a Microsoft platform, was used for both the descriptive and inferential statistics in analysing the data. Findings are explained by using tables, graphs and pie charts.

In part D of the questionnaire, questions D3 and D4 (see Annexure A) were analysed manually using thematic analysis because of the nature of the open-ended questions.

3.3.2 Phase Two: guideline development

Phase two addressed the second objective for the study: to develop a draft guideline for infection control in order to facilitate sound knowledge and practices of radiographers regarding infection control. Guidelines assist in bridging practice and research. They are developed by professional organisations or convened expert panels based on evidence (LoBiondo-Wood & Haber, 2014:22). The draft guideline was developed based on the data derived from the questionnaire (phase one).

Based on the National Institute for Health and Care Excellence (NICE) (2012:15), seven main steps were adapted and used in the development of the draft guideline for infection control in order to facilitate sound knowledge and practices of radiographers regarding infection control. The steps are presented below.

Step1: consider guideline remit

During this step, one identifies the scope/objectives and purpose of a guideline. The purpose of the guideline formulated in this research study was for implementation to facilitate sound knowledge and practices of radiographers towards infection control. Detailed information, as to why the guideline is needed, is discussed in the problem statement and rationale (see 1.2 and 1.4).

Step 2: identifying key issues to be included in the guideline

The step involves setting the methods to be used and describes what should be included in the development of the guideline. During this step, the researcher planned the procedures to be followed and, what should to be included in the guideline based on the data derived from the self-administered questionnaire (see Chapter 4).

Step 3: undertake scoping literature search

This step involves reviewing literature to answer research questions before development of guidelines. The aim is to ensure that developed guidelines are based on reviewed literature. The researcher conducted a critical literature review in developing the data collection instrument. This was done with the help of his academic supervisors, and the statistician. The aim was to explore gaps in terms of knowledge and practices of radiographers (see Chapter Two). The literature review was also used to substantiate the findings from the questionnaire in phase one (see Chapter Four).

Step 4: start drafting the plan and prepare the first draft

Drafting the guideline was done from the data derived from the literature review and from the questionnaire used in phase one (see Chapter Five).

Step 5: hold stakeholder workshop

During this step, experts in a particular field are identified to ensure validity of guidelines. They tend to be people who bring as wide a perspective of views as possible. The experts are then called for a meeting to review draft guidelines. For the scope of this study, an expert panel did not review the draft guideline. The developed guideline is still considered a draft until reviewed by an expert panel. However, the draft guideline was reviewed by the researcher's supervisors. They are experienced in developing guidelines in the fields of radiography and nursing (see Chapter Five). Review of the draft guideline by an expert panel is a recommendation as stated in Chapter 6.

Step 6: consult on the draft scope

In this step, the issues raised during a workshop or meeting are taken into consideration. The issues or comments raised are followed by refining draft guidelines. In this study, the comments raised by the supervisors were taken on board to assist in the revision of the draft guideline. A review of the draft guideline, by an expert panel, is recommended (see Chapter 6).

Step 7: finalise the scope after consultation

This step marks the end of the development process of draft guidelines. It involves finalising the scope in the light of comments received. This step was not in the scope of the research study. However, relevant suggestions, made by the researcher's supervisors, that might make the guideline more useful, and so facilitate sound knowledge and practices of radiographers regarding infection control, were not ignored. This entailed removing areas considered to be of lower priority (see Chapter 5). As stated in steps 5 and 6, an expert panel should review the draft guideline (see Chapter 6).

In terms of the format of the draft guideline, the researcher, with the assistance of the supervisors, included the following guideline headings, based on an adapted version of AGREE II (AGREE Next Steps Consortium, 2009:2) (see Annexure K): purpose of the guidelines, the rationale for the guidelines, and the actions that should assist in achieving the desired outcomes. The developed guidelines describe clinically effective measures that should be used by radiographers for infection control.

According to Mark and Linskey (2010:28), guidelines have the potential to improve patient care and clinical outcomes for individual patients, and in so doing they help lower overall health systems costs. In this study, the developed draft guideline, when further developed and implemented, is expected to optimise knowledge and practices of radiographers regarding infection control in radiology departments. Furthermore, when the final guideline is implemented, it may help improve patient care and clinical outcomes for radiographers, as well as reducing costs associated with infection control.

3.4 QUALITY OF RESEARCH

Validity is a measure to which an instrument adequately represents the underlying construct that it is supposed to measure (Bhattacherjee, 2012:58). Reliability refers to the extent to which a research instrument consistently measures a concept (Groove *et al*., 2015:287). Researchers need to consider the validity and reliability of their measuring study instruments if the research study is to bring out acceptable high quality results. In this study, the validity and reliability of the instrument used were crucial for maintenance of the quality of the research methods.

3.4.1 Validity

Validity is concerned with the integrity of conclusions that are generated from a piece of research (Bryman, 2012:47). According to Babbie and Mouton (2010:213), validity is an important quality of an instrument and measures what it claims to measure. In order to ensure validity in this study, the researcher requested evaluation of the data collection instrument by his supervisors, and a statistician, before proceeding with the collection of data. They checked whether the instrument was constructed using concepts from literature found in the study. The researcher also ensured validity by making sure that the same type of data collection instrument, evaluated by both the supervisors and statistician, was the one used by all respondents. According to Maree (2016:240), there are four types of validity: content validity, face validity, construct validity, and criterion validity. Content validity, and face validity, as applied by the researcher, are discussed below.

3.4.1.1 Content validity

Content validity refers to the extent to which an instrument covers the complete content of the particular construct that it is set out to measure (Maree, 2016:240). In order to ensure content validity in this study, the researcher read several books and journal articles from related studies before constructing the instrument in order to gain in-depth knowledge of the relevant literature. The data collection instrument's content validity was evaluated by the researcher's supervisors.

3.4.1.2 Face validity

Face validity refers to the extent to which an instrument appears to measure what it is supposed to measure. Face validity is essentially based on an intuitive judgement made by experts in the field (Brink *et al*., 2012:166). To ensure face validity in this study, the researcher requested a statistician to evaluate and verify the data collection instrument. The instrument was also submitted to the departmental research committee. The committee, as well as a panel of experts in the field of radiography at the Ministry of Health headquarters in Malawi, assessed the face validity of the questions formulated. Face validity was also ensured by conducting a pilot study. To ensure the face validity of the draft guideline, the researcher requested his supervisors to review it.

3.4.2 Reliability

Reliability is concerned with whether the results are repeatable. The term is commonly used in relation to whether the measures that are devised for concepts are consistent (Bryman, 2012:47). According to Maree (2016:238), there should be a degree of similarity of results or findings when the instrument is used at different times or administered to different respondents from the same population. In this study, the researcher adapted an existing questionnaire in order to ensure reliability. Furthermore, a pilot study was conducted before the actual study in order to ensure reliability of the instrument. This was done to compare and check whether the results from various pilot study sites were similar. Based on the results of the pilot study, the instrument was found to be reliable by the researcher. Reliability of the data collection instrument was also ensured by submitting the instrument to experts in order to ensure that the information gathered was relevant to the research study. Reliability of the guideline was ensured by basing the draft guideline from data from the self-administered questionnaire (phase one), and literature as well as underpinning it with the conceptual framework. The method that was used, as well as the format to be developed, were clearly outlined (see 3.3.2).

3.5 ETHICAL CONSIDERATIONS

Research, however novel its discoveries, is only of any value if it is carried out honestly. Results from any study cannot be trusted if a researcher acted unethically. Therefore, working with human participants in a research project requires a researcher to consider ethical issues (Walliman, 2011:42). Research ethics is about setting standards for conducting research that minimise the possibility of doing harm rather than good. A moral stance is taken, in relation to a research activity, which states that research should only be undertaken for good reasons whereby respondents do not suffer harm because of their involvement in a study (Denscombe, 2012:122). According to Denscombe (2012:128), there are three core themes evident in all codes of research ethics. Although codes vary somewhat in terms of their emphasis, and the way they formulate the ideas, it is easy to see the legacy of the Nuremberg Code, and the Declaration of Helsinki, in all of them. The themes include no harm, voluntary consent, and scientific integrity. Researchers need to consider fundamental ethical principles and scientific integrity as they conduct their research studies.

3.5.1 Fundamental ethical principles

As mentioned in Chapter One, there were three fundamental ethical principles that guided the researcher during the research process: respect for persons, beneficence, and justice. These principles are based on the human rights that need to be protected in research namely, right to self-determination, privacy, anonymity and confidentiality, fair treatment and to being protected from discomfort and harm (Brink *et al*., 2012:34). Ethical principles and their application in the study are discussed below.

3.5.1.1 Respect for persons

According to the Canadian Institutes of Health Research's, Tri-Council Policy Statement (TCPS) (2010:8), respect for persons incorporates the dual moral obligations to respect autonomy, and to protect those with developing, impaired or diminished autonomy. In this study, respect for persons was achieved through informing the respondents about the nature of the study and that they had a right to decide on whether or not to participate in the study, without the risk of penalty or being forced. Respondents were also informed during briefing meetings that they had the right to withdraw from the study at any time they wanted to (Brink *et al*., 2012:35). Denscombe (2012:129), states that a researcher has the obligation to provide respondents with sufficient information about the purpose of the research, and the nature of their involvement, for them to decide whether or not to participate. This is why the notion of informed consent lies at the heart of ethical research.

3.5.1.2 Principle of beneficence

According to Botma *et al*. (2010:20), the principle of beneficence is grounded in the premise that a person has the right to be protected from harm and discomfort. In support of this, De Vos *et al.* (2011:58) point out that the risk of a study should not exceed its potential benefits. According to Denscombe (2012:128), research should avoid harm being caused to those who participate in the research. Researchers need to consider protecting respondents from the following kinds of harm: psychological harm (e.g. feelings of stress, loss of confidence), social harm (e.g. having reputation ruined, having relationships damaged), and physical harm (e.g. causing illness, infection or even disability). Researchers need to take all reasonable precautions to protect the interests of respondents and to ensure, as far as it is reasonably possible to do so, that no one is directly harmed because of their participation in a research study (Denscombe, 2012:128). In this study, there was no harm for the participants. The study should be of benefit to the respondents because the findings were used for development of the draft guideline. The guideline's recommendations were important in terms of implementation of SICP in their departments.

3.5.1.3 Principle of justice and respect of rights

Botma *et al*., (2010:19), refer to justice as a principle whereby all participants involved in a research study are treated fairly. This is done to prevent one group benefiting to the detriment of another. In this study, all radiographers in the four government referral hospitals took part in the research study. The respondents were not selected based on race, social class or culture. Everyone had an equal chance to participate in the study. Justice was also ensured by briefing all potential respondents in the study sites before they completed the questionnaire, as well as ensuring that the same instrument was used for gathering data.

Special consideration must be given to the right to privacy and confidentiality/anonymity for research participants (Brink *et al*., 2012:35). In this study, the names of respondents were not used on the self-administered questionnaire. Codes and numerical figures were used to analyse the data and to present the findings. The researcher also ensured that the completed questionnaires were kept under lock and key. Confidentiality was achieved by ensuring that the completed questionnaires were placed in sealed boxes by the respondents, instead of them being handed to the researcher. This meant the researcher was not aware of the identity of those who had completed them.

3.5.2 Scientific integrity

According to Denscombe (2012:128), researchers are expected to approach their research in a way that upholds professional standards by ensuring it makes use of suitable methods. Research that employs methods, that are not best available, will inevitably produce findings that are not of the highest quality. At best, this will waste the time of respondents, and other stakeholders, involved in the study. At worst, the use of inappropriate or poor methods might cause harm to participants. In this study, the researcher used a self-administered questionnaire as a method of gathering data.

This data collection instrument did not produce any harm to the respondents as no sensitive questions were asked. The self-administered questionnaire produced findings that were of high quality in the sense that its format was standard for all respondents, and was not dependent on the mood of the interviewer (Brink *et al.*, 2012:140).

Linked to scientific integrity is that a researcher should be competent to conduct an investigation. A researcher is expected to be proficient in the use of the methods and techniques involved in research, and have appropriate experience and qualifications to carry out research. The demands of a specific research project, in other words, should not exceed the capabilities of a researcher (Denscombe, 2012:129). In this study, the researcher had appropriate clinical experience and qualifications to understand the background of the study. He was guided by his supervisors, who are experienced researchers, on how to conduct the study. Furthermore, before commencing the study, the questionnaire, in terms of the aim and objectives of the study, was assessed by the Departmental Research Committee (DRC), FPGSC, the Research Ethics Committee of the University, and panel of experts in the field of radiography based in the Ministry of Health headquarters in Malawi.

3.5.3 Permission to conduct the study

In line with ethical considerations, the researcher sought permission from the FPGSC and Research Ethics Committee of NMMU (currently named Nelson Mandela University) (see Annexure F). Approval from the hospital directors of the four government referral hospitals (see Annexures C and H) and the NHSRC to conduct this study in Malawi was requested (see Annexure B) and obtained (see Annexure G). Permission was also requested from the author to use their questionnaire before developing the data collection instrument. The author granted use of their questionnaire (see Annexure E and I).

3.6 CONCLUSION

The research was quantitative, explorative, descriptive and contextual in nature. The aim of the study being to explore and describe the knowledge and practices of radiographers regarding infection control in radiology departments in Malawi to develop a draft guideline in order to facilitate sound knowledge and practices of radiographers regarding infection control in these settings. A self-administered questionnaire was used as a data collection instrument to explore and describe the knowledge and practices of radiographers regarding infection control in four radiology departments in Malawi (phase one). The collected data were analysed by a statistician through descriptive and inferential statistics. The data is used by the researcher to develop a draft guideline for infection control in order to facilitate sound knowledge and practices of radiographers regarding infection control in radiology departments in government referral hospitals in Malawi (phase two). The researcher took into consideration validity and reliability, as well as ethical aspects of the research during the conduction of the study. The next chapter presents a discussion on data analysis as well as the results of phase one of the study.

CHAPTER FOUR

DATA ANALYSIS AND DISCUSSION OF THE RESULTS OF THE QUESTIONNAIRE (PHASE ONE)

4.1 INTRODUCTION

In Chapter One, an overview of the research study was presented. In Chapter Two, the literature review was discussed. Chapter Three dealt with a discussion of the research design and method. This chapter consists of data analysis of the questionnaire, and the results obtained. The latter are used to guide the researcher in developing a draft guideline for infection control to facilitate sound knowledge and practices of radiographers regarding infection control in radiology departments in in government referral hospitals in Malawi (phase two).

4.2 DATA COLLECTION

Eighty self-administered questionnaires were to be handed to radiographers in the radiology departments in four government referral hospitals in Malawi. Ten radiographers were on leave, and 8 were carrying out mobile radiography in the wards, ICU, HDU and theatre on the day of data collection. There was thus a response rate of 89% as 62 out of the 80 self-administered questionnaires were completed.

The self-administered questionnaire (see Annexure A) used for gathering data had four parts: A, B, C and D. Part A addressed the demographic data of the respondents. Part B addressed the level of knowledge of the radiographers regarding infection control in the radiology department. Part C addressed the practices of radiographers regarding infection control in the radiology department. Part D addressed additional relevant questions regarding infection control.

4.3 DATA ANALYSIS OF THE QUESTIONNAIRE

Data analysis was done with the assistance of the statistician from the NMMU. The researcher captured the data on a spreadsheet using a Microsoft software programme (EXCEL). The captured data when then analysed, by a statistician, in the form of descriptive and inferential statistics as discussed in Chapter 3. The findings are presented as bar graphs, pie charts and tables.

The scores for knowledge and practice were calculated as follows to ensure values between 0 and 100.

Knowledge score = (Number of correct responses to items B1 to B16)/ 16 x 100.

Practice score = [(Number of “Always” responses to items C1 to C16) x 2 + (Number of “Sometimes” responses to items C1 to C16)] / 32 x 100.

According to the calculations of the statistician, knowledge scores ranging from 38.00 – 69.00 indicated lower knowledge, scores between 69.0 – 88.00 indicated average knowledge, and scores between 88.00 and 100.00 indicated higher knowledge. Any score below 38.00 was an indication of knowledge deficit. For practice, a score of 41.00 – 50.75 indicated lower practice, scores between 50.75 – 77.25 indicated average practice, and scores between 77.25 and 97 were an indication of higher practice.

The findings of each part of the questionnaire are presented.

4.4 PART A: DEMOGRAPHIC INFORMATION

Part A included four statements: gender, age, level of education and years of work experience as a qualified radiographer.

4.4.1 Gender

Most respondents were males (85%, n=53) and 15% (n=9) were females as evident in Figure 4.1. In Malawi, most radiographers are males. In South Africa where the radiography profession is dominated by females (Health Professions Council of South Africa register (HPCSA), 2016). The gender statistics of training as of 2016 indicate there are 209 trained radiographers; 13 are females (Malawi College of Health Sciences (MCHS), 2016).

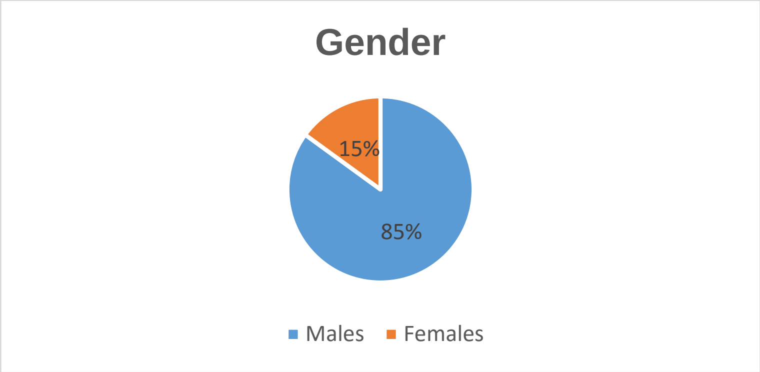


Figure 4.1: Gender distribution (n=62)

4.4.2 Age

Figure 4.2 depicts the age groups of the respondents. The majority (84%, n=52) were between 20 and 39 years, and 16% (n=10) between 40 and 59 years of age. The age distribution data show that most of the respondents were young radiographers, namely >40 years of age. Ten were between 40 and 59 years. This can be attributed to the fact that in 1988 radiography training in Malawi was phased. The finding that fifty-two respondents were between 20 – 39 years can be attributed to the resumption of training of radiographers at the Malawi College of Health Sciences in 1999 (MCHS, 2000).

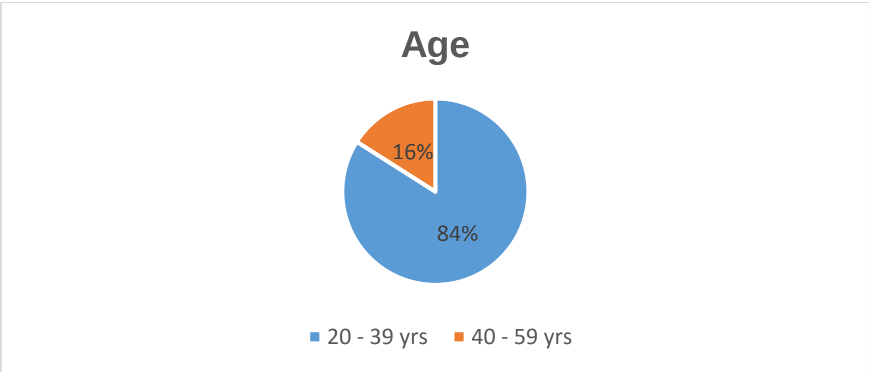


Figure 4.2: Age distribution (n=62)

4.4.3 Level of education

Out of the 62 respondents 3% (n=2) had a master's degree, 24% (n=15) had a bachelor's degree, and 73% (n=45) were diploma holders as presented in Figure 4.3. The fact that most are in possession of a diploma (n=45) can be attributed to the fact that there are no training institutions that offer undergraduate and post-graduate degrees in radiography in Malawi. Radiographers who want to attain a bachelor or master's degree need to study outside the country. Most radiographers cannot afford to do so.

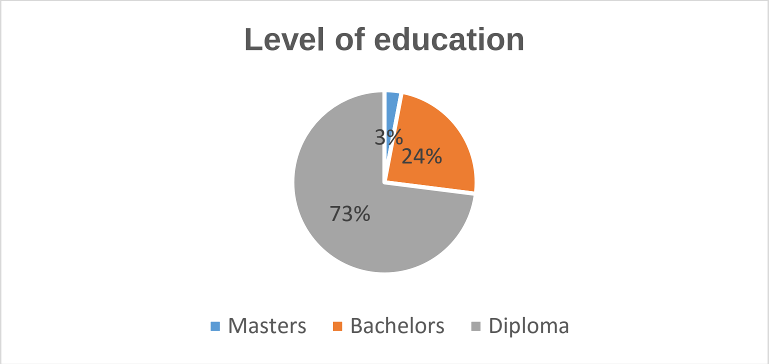


Figure 4.3: Level of education (n=62)

4.4.4 Years of work experience as a qualified radiographer

Of the 62 respondents 13% (8) had worked in a radiology department for less than one year, 37% (23) had 1 – 5 years' working experience, and 50% (31) had > 5 years' working experience. The results indicate that the majority of the respondents had > 5 years of work experience as practicing radiographers as depicted in Figure 4.4.

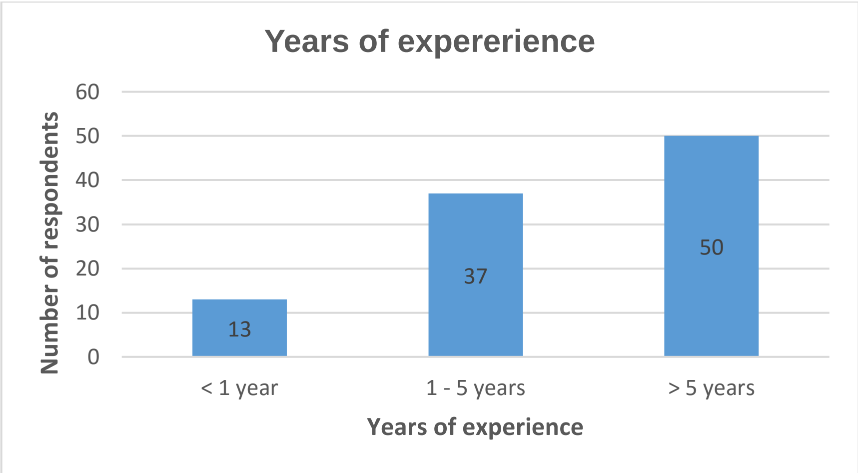


Figure 4.4: Years of work experience (n=62)

4.5 PART B: KNOWLEDGE REGARDING INFECTION CONTROL

This part of the questionnaire assessed the level of knowledge of radiographers regarding infection control in radiology departments in the four government referral hospitals in Malawi. The respondents were given 16 statements and had to choose from a Likert Scale ranging from 1 to 3 (agree, disagree, don't know). Table 4.1 indicates the responses for each statement.

Table 4.1: The frequency of respondents' responses to knowledge in infection control

Statements	Correct answer	Correct		Incorrect		I don't know	
		n	%	n	%	n	%
B1. The environment (air, water, inert surfaces) is the major source of pathogenic microorganisms responsible for healthcare associated infections.	Agree	61	98	1	2	0	0
B2. Healthcare associated infections may be transmitted via medical equipment such as syringes.	Agree	60	97	2	3	0	0
B3. Invasive procedures do not increase the risk of healthcare associated infections.	Disagree	49	79	7	1	6	10
B4. Standard infection control precautions include the recommendations to protect ourselves, patients and our fellow healthcare workers.	Agree	61	98	1	2	0	0
B5. The standard infection control precautions recommend the use of gloves for each radiological procedure.	Agree	49	83	8	14	2	3
B6. When there is a risk of splashes or spray of blood and body fluids, the radiographers must wear nothing.	Disagree	50	81	12	19	0	0
B7. Hands are the most common way in which microorganisms might be transported and subsequently cause healthcare associated infections.	Agree	58	94	3	5	1	2

Statements	Correct answer	Correct		Incorrect		I don't know	
		n	%	n	%	n	%
B8. The steps for performing hand hygiene using alcohol-based hand rub are the same as when performing handwashing.	Agree	38	61	14	23	10	16
B9. Alcohol – based hand rubs are not effective against spore forming organisms e.g. *Clostridium difficile*.	Agree	14	23	23	37	25	40
B10. There is need to recap the needle after use.	Disagree	28	45	32	52	2	3
B11. Used needles should be bent before disposal	Disagree	42	68	16	26	4	6
B12. Sharp containers must be sealed before they are taken away.	Agree	60	97	1	2	1	2
B13. Radiographers' uniforms are a serious source of infection.	Agree	32	52	27	44	3	5
B14. Tip of natural fingernails for radiographers should be kept as short as possible to prevent finger tips from harbouring bacteria.	Agree	53	85	5	8	4	6
B15. It is believed that anatomical markers harbour microorganisms if not disinfected.	Agree	51	82	7	11	4	6
B16. Waste should be disposed of immediately after use.	Agree	55	89	7	11	0	0

A discussion of each result is presented below.

4.5.1 B1: The environment (air, water, inert surfaces) is the major source of pathogenic microorganisms responsible for healthcare associated infections

The Infection control team (2016:15) stated that potentially pathogenic microorganisms can be detected in air, water and on surfaces, which agrees with statement B1 above. Most of the respondents, 98% (n=61), correctly selected 'agree' for B1. Only 2% (n=1), selected ‘disagree’. None selected ‘I don’t know’. The findings show that most respondents knew that the environment (air, water, inert surfaces) is the major source of pathogenic microorganisms responsible for HAIs. They thus have sufficient knowledge in terms of bacteria being a major source responsible for HAIs.

4.5.2 B2: Healthcare associated infections may be transmitted via medical equipment

Alder and Carlton (2016:214), point out that HAIs can be transmitted through indirect contact when the medical equipment is not cleaned, disinfected or sterilised adequately between patients, which agrees with statement B2 above. The majority of the respondents, 97% (60) selected the correct answer ‘agree’ for statement 2. Three percent (n=2) selected ‘disagree’ which was the incorrect answer. None selected ‘I don’t know’. It is evident that the majority were knowledgeable that HAIs may be transmitted via medical equipment such as syringes. In view of these results it is reasonable to assume that the majority of the respondents would take precautionary measures in handling medical equipment to control the spread of HAIs. Necessary precautionary measures refer to cleaning, disinfection, and sterilisation to ensure the medical equipment is clean.

4.5.3 B3: Invasive procedures do not increase the risk of healthcare associated infections

As highlighted by Rutala and Weber (2008:8), the major risk of invasive procedures is the introduction of pathogens that can lead to HAIs, which disagrees with statement B3 above. Most the respondents, 79% (49) correctly selected ‘disagree’. The incorrect answer ‘agree’ was selected by 11% (n=7). Ten percent (n=10) selected ‘I don’t know’. These results show that the majority of the respondents know that an invasive procedure does increase the risk of HAIs, hence are obliged to take necessary steps in infection control when carrying out invasive procedures. The results indicate the respondents would more than likely follow necessary infection control precautions such as wearing PPE when carrying out invasive procedures.

4.5.4 B4: Standard infection control precautions include the recommendations to protect ourselves, patients and our fellow healthcare workers

As indicated by the National Centre for Emerging and Zoonotic Infection Diseases (2011:2), SCIP are designed to protect healthcare personnel, and also prevent spread of HAIs among patients, which agrees with statement B4 above. The majority of the respondents, 98% (n=61), selected the correct answer 'agree', and 2% (n=1) selected 'disagree'. None selected 'I don't know'. The majority had sufficient knowledge that SICP include the recommendations to protect both patients and healthcare workers. With sufficient knowledge, a respondent's priority should be to ensure patients and fellow healthcare workers are protected from the spread of HAIs. The finding shows the respondents are knowledgeable in terms of their responsibility to protect themselves, patients and fellow healthcare workers. It is therefore likely that they would take the necessary infection control precautions such as wearing PPE or providing PPE to fellow healthcare workers, cleaning equipment, and providing clean gowns to the patients. Such measures would reduce the risks for HAIs.

4.5.5 B5: The standard infection control precautions recommend the use of gloves for each radiological procedure

Wakefield and Kirklees Council (2014:29) state that gloves must be changed after each procedure, which agrees with statement B5 above. The correct answer 'agree' to statement B5 was selected by 83% (n=49) of the respondents. On the other hand 14% (8) selected 'disagree', and none selected 'I don't know'. The majority of respondents had sound knowledge on the use of gloves for each radiological procedure, thus indicating most would use gloves for each radiological procedure to reduce the risk of HAIs. This implies most respondents would use gloves, and by doing so there would a reduction in terms of spread of infection due to use gloves for each radiological procedure.

4.5.6 B6: When there is a risk of splashes of blood and body fluids, the radiographers must wear nothing

The University of Tasmania Work Health and Safety Policy (2015:6) states that PPE provides a barrier between a source and operator. PPE protects risk of transmission of infectious agents to patient, and risk of contamination of clothing and skin of healthcare workers by patients' blood, body substances and secretions or excretions. Hence healthcare workers should be encouraged to wear PPE, which disagrees with statement B6 above. The correct answer 'disagree' to this statement was selected by 81% (n=50) of the respondents. The incorrect answer 'agree' was selected by 19% (n=12), and none selected 'I don't know'. This quantitative data indicate the majority had enough knowledge about the need to wear PPE whenever there is a risk of splashes or spray of blood and body fluids during a radiological procedure. This finding is important since most respondents know that when there is a risk of splashes of blood and body fluids, radiographers must wear something to take necessary infection control precautionary measures. It is reasonable to assume the respondents would be likely to follow these measures. The majority would use PPE to protect themselves from splashes or spray of blood and body fluids when they perform a radiological procedure.

4.5.7 B7: Hands are the most common way in which microorganisms might be transported and subsequently cause healthcare associated infections

According to the United Kingdom National Health Services Professional Handbook (2010:3), hands are one of the commonest ways in which pathogenic microorganisms are transported, which agrees with statement B7 above. The majority of the respondents, 94% (n=58) correctly selected 'agree' to this statement; 5% (n=3) selected 'disagree', and 2% (n=1) selected 'I don't know'. It is evident from the data that the majority have sufficient knowledge that hands are the most common way in which microorganisms might be transported and subsequently cause HAIs. The findings imply the majority of respondents have knowledge about their hands spreading HAIs. The finding is important because radiographers must know the importance of keeping their hands clean at all times to prevent the spread of HAIs.

4.5.8 B8: The steps for performing hand hygiene using alcohol-based hand rub are the same as when performing handwashing

The United Kingdom National Health Services Professionals Handbook's (2010:6) states the steps to perform hand hygiene using alcohol-based hand rub are the same as when performing handwashing, which agrees with statement B8 as above. The correct answer ‘agree’ was selected by 61% (n=38) of the respondents, whereas 23% (n=14) selected ‘disagree’. Sixteen percent (n=10) selected ‘I don’t know’. The data shows that most respondents had sufficient knowledge in differentiating between steps for performing hand cleaning using an alcohol-based hand rub, and the steps when performing handwashing. However, almost a quarter of the respondents did not have knowledge that hand hygiene steps, when using an alcohol-based hand rub, are the same as when performing handwashing. It seems that this is an area in which training is needed so that those who did not know the steps, would learn to adhere to steps in performing an alcohol-based hand rub in order to reduce the risk for HAIs.

4.5.9 B9: Alcohol–based hand rubs are not effective against spore forming organisms e.g. *Clostridium difficile*

According to the United Kingdom’s National Health Services Professionals Handbook (2010:6), alcohol-based hand rub is not effective against spore forming organisms e.g. *Clostridium difficile* which agrees with statement B9 above. Less than a quarter, namely 23% (n=14) of the respondent selected the correct answer ‘agree’; whereas 37% (n=23) incorrectly selected ‘disagree, and 40% (n=25) selected ‘I don’t know’. It is evident from the data that the majority had insufficient knowledge that alcohol-based hand rubs are not effective against spore forming organisms. This implies respondents thought alcohol-based rubs are effective against spore forming organisms. The finding is important because 48 out of 62 respondents (37%; n=23, and 40%; n=25) either erroneously believe alcohol-based hand rubs are effective against spore forming organisms, or do not know at all. This implies that this gap in knowledge could promote a further growth or increase in spore forming organisms which could lead to spread of HAIs, making it difficult to control the infection. It seems that this is an area in which training should be done to improve their understanding about effectiveness of alcohol-based rub in infection control and thus reduce the spread of HAIs.

4.5.10 B10: There is need to recap the needle after use

The Canadian Committee on Antibiotic Resistance (2007:28) states that it is advisable never to recap a used needle to prevent needle prick injuries. A used needle could miss the cap and stab the hand holding it, or it could pierce the cap and stab the hand holding it, which disagrees with statement B10 as above. The correct answer 'disagree' was selected by 45% (n=28) of the respondents whereas 52% (n=32 selected 'agree', and 3% (n=2) selected 'I don't know'. The majority had insufficient knowledge on whether to recap a needle after use. The finding shows that not all respondents know to not recap a used needle. This finding implies that over 50% of the respondents probably would recap a used needle which could lead to needle stick injuries, which could result in the spread of HAIs. Therefore, further training should be included about safe practices of not recapping used needles in terms of HAIs.

4.5.11 B11: Used needles should be bent before disposal

The Canadian Committee on Antibiotic Resistance (2007:28) advises healthcare workers never to bend a used needle before disposal, which disagrees with statement B11 above. The correct answer 'disagree' was selected by 68% (n=42) of the respondents; 26% (n=16) selected 'agree', and 6% (n=4) selected 'I don't know'. The majority thus have sufficient knowledge that used needles should not be bent before disposal. Bending a used needle could result in needle stick injuries. Conversely not bending used needles helps to reduce the spread of HAIs. Ideally all respondents should have known to not bend a used needle, and the above results indicate that further training could be done in order to follow proper procedures in disposing of sharps in order to reduce the risks for HAIs.

4.5.12 B12: Sharp containers must be sealed before they are taken away

The Australian Dental Association Handbook (2012:16) states that sharp containers should be sealed when they have been filled to the line marked on the container, and then collected for disposal, which agrees with statement B12 above. The correct answer 'agree' was selected by 97% (n=60) of the respondents; 2% (n=1) selected 'disagree', and 2% (n=1) selected 'I don't know'. The data show that a vast majority of the respondents had sufficient knowledge on ensuring that the sharp containers are sealed before they are taken away. The finding is important because it shows that, apart from two respondents, the rest did have knowledge about following proper procedures in disposing waste therefore reducing the risks for HAIs. Since the majority would close sharp containers, before they are a taken away, implies that the risk of injuries should be minimal during disposal of the containers in dedicated areas or sites.

4.5.13 B13: Radiographers' uniforms are a serious source of infection

Lister and Inamdar (2013:30) opined that uniforms are part of linen thus are assumed to harbour pathogenic microorganisms, which agrees with statement B13 above. More than half, 52% (n=32), of the respondents correctly selected 'agree' whereas 44% (n=27) selected 'disagree', and 5% (n=3) selected 'I don't know'. These results indicate that more than half of the respondents had knowledge that radiographers' uniforms are a serious source of infection. As such, uniforms need to be changed at the start of each shift or immediately after they are heavily soiled or contaminated. The finding however shows that almost half of respondents apparently did not know that uniforms are a serious source of infection. This indicates the need for further training for radiographers to know the importance of keeping their uniforms clean or tidy at all times in order to reduce the spread of HAIs.

4.5.14 B14: Tip of natural fingernails for radiographers should be kept as short as possible to prevent finger tips from harbouring bacteria

Enrlich and Daly (2009:405), pointed out that radiographers need to keep their fingernails short in order to prevent them from harbouring bacteria, which agrees to statement B14 above. The majority of the respondents, 85% (n=53), correctly selected 'agree'; 8% (n=5) selected 'disagree', and 6% (n=4) selected 'I don't know' The data shows that the majority of the respondents had sufficient knowledge on ensuring that tips of natural fingernails were kept as short as possible to prevent finger tips from harbouring bacteria. Adequacy in knowledge helps to keep the fingertips of the respondents free from bacteria. This is essential in reducing the spread of infection, particularly as the respondents are always in contact with patients in a radiology department. The finding is important because it shows that the majority of respondents know that fingernails should be short to keep them free from bacteria at all times and reduce the spread of HAIs.

4.5.15 B15: It is believed that anatomical markers harbour microorganisms if not disinfected

Tugwell and Maddison (2011:19) state that radiographic markers are highly contaminated with various organisms thus serve as a reservoir of bacteria, which agrees with statement B15 above. The correct answer 'agree' was selected by 82%

(n=51) of the respondents; 11% (n=7) selected 'disagree', and 6% (n=4) selected 'I don't know'. It is evident from the data that the majority of the respondents had sufficient knowledge that anatomical markers harbour microorganisms if not disinfected. This implies that the majority of the respondents would disinfect their anatomical markers and in so doing there would be a reduction in terms of spread of HAIs. The finding is important because it shows that the majority know that anatomical markers may introduce HAIs if not disinfected, and the importance of disinfecting them to reduce the spread of HAIs.

4.5.16 B16: Waste should be disposed of immediately after use

The Infection Control Team (2016:17) state waste disposal items should be disposed of immediately and should never be kept for long times in their designated areas, which agrees to statement B16 above. The correct answer 'agree' was selected by 89% (n=55) of the respondents; 11% (n=7) selected 'disagree'. None selected 'I don't know'. The data show that the majority of the respondents had enough knowledge in terms of the need to dispose waste immediately after use. This indicates that they would ensure that their radiology departments would always by tidy thus reducing the spread of HAIs. The finding is important because it shows that the majority of respondents have knowledge of immediate waste disposal and are therefore more likely to properly employ safe waste disposal practices, thus reducing the spread of HAIs.

4.6 STATEMENTS WITH HIGH VERSUS LOW KNOWLEDGE SCORES

Overall, the following five statements had mostly correct answers. More than 93% of the respondents selected the correct answer for each of the statements (from highest to lowest).

- Statement B1: The environment (air, water, inert surfaces) is the major source of pathogenic microorganisms responsible for healthcare associated infections (98%, n=61).
- Statement B4: Standard infection control precautions include the recommendations to protect ourselves, patients and our fellow healthcare workers (98%, n=61).

- Statement B2: Healthcare associated infections may be transmitted via medical equipment (97%, n=60).
- Statement B12: Sharp containers must be sealed before they are taken away (97%, n=60).
- Statements B7: Hands are the most common way in which microorganisms might be transported and subsequently cause healthcare associated infections (94%, n=58).

Overall the below two statements had mostly incorrect answers. Less than 50% of the respondents selected the correct answer for each of the statements (from highest to lowest).

- Statement B10: There is need to recap the needle after use (45%, n=28).
- Statement B9: Alcohol–based hand rubs are not effective against spore forming organisms e.g. *Clostridium difficile* (23%, n=14).

4.7 KNOWLEDGE SCORES

Table 4.2 shows the range of scores obtained by the respondents regarding knowledge.

Table 4.2: Frequency distribution of knowledge scores

Knowledge scores (%)	**Respondents**	
	n	**%**
1. 100	1	2
2. 90 - 99	5	8
3. 80 - 89	25	40
4. 70 - 79	14	22
5. 60 - 69	11	18
6. 50 - 59	3	5
7. 38- 49	3	5
Total	**62**	**100**

The following can be stated from the information in Table 4.2.

- One (2%) scored 100%.
- Five (8%) scored 90 – 99%.
- Twenty-five (40%) scored 80 – 89%.
- Fourteen (22%) scored 70 – 79%.
- Eleven (18%) scored 60 – 69%.
- Three (5%) scored 50 – 59%.
- Three (5%) scored 38 – 49%.

The data in Table 4.2 show that fifty-nine (95%) of the respondents achieved scores ranging from 50 – 100%, while 5%(n=3) had scores ranging from 30 – 49%.

Knowledge is known to have an influence on infection control. In order to evaluate the influence of knowledge in infection control, respondents were asked to answer 16 Likert–Scale statements with a total score of 100. Distribution of the respondents' knowledge towards infection control is shown in Table 4.3.

Table 4.3: The distribution of respondents' knowledge level towards infection control

Knowledge level	Number (n=62)	Percent (%)
1. Higher (88 to 100)	6	10
2. Average (69 to 88)	39	63
3. Lower (38 to 69)	17	27
Total	**62**	**100**
Mean = 76.82 SD = 12.63	**Min = 38**	**Max = 100**

As indicated in Table 4.3, only 10% (n=6) of the respondents had 'higher' knowledge; 63% (n=39) of had 'average' knowledge; and e 27% (n=17) had lower knowledge in infection control. The mean knowledge score for all respondents was 76.82 out of possible 100 points (SD 12.63). The maximum and minimum range of knowledge was 38 and 100, respectively.

The mean knowledge score for all respondents was 76.82 out of possible 100 points (SD 12.63) which depicts an average knowledge score. This finding is similar to published studies. Antwi *et al*. (2015) found that the level of knowledge was fair among radiographers in Ghana. Jayasinghe and Weerakoon (2014) found that the level of knowledge among radiographers in Srilanka was good. Okaro *et al*. (2010) found that the level of knowledge of radiographers in Enugu, Nigeria, was good.

However, the average knowledge score of this study are slightly better than two studies in the literature. A study conducted by Sukumar and Yadav (2012) found that the level of knowledge was low among radiographers in India. Worrall (2012) reported that the level of knowledge in infection control among radiographers in Queensland was low.

Practices regarding infection control in Part C of the questionnaire are discussed below.

4.8 PART C: PRACTICES REGARDING INFECTION CONTROL

This part of the self-administered questionnaire explored the practices of knowledge of radiographers regarding infection control in radiology departments in the four government referral hospitals in Malawi. There were 16 questions. A Likert Scale ranging from 1 to 3 (always, sometimes & never) was used. Table 4.5 provides the responses for each of the individual statement.

Table 4.4: The frequency of responses to practice in infection control

Questions	Correct answer	Correct		Sometimes		Never	
		n	%	n	%	n	%
C1. Do you wear protective gloves and coats during procedures where there is potential for blood splatter?	Always	46	74	16	26	0	0
C2. Do you wash your hands after removing gloves?	Always	30	48	31	50	1	2
C3. Do you wash your hands with soap before and after touching any patient?	Always	12	19	46	74	4	6

Questions	Correct answer	Correct		Sometimes		Never	
		n	%	n	%	n	%
C4. Do you wash your hands at the end of shift before leaving work?	Always	30	48	29	47	3	5
C5. Do you wear a mask when there is a potential to be exposed to airborne droplets or dust particles?	Always	39	63	23	37	0	0
C6. Do you cover your open cuts and wounds that you have during clinical work?	Always	41	66	20	32	1	2
C7. Do you damp dust the radiographic x-ray equipment each day you start your work?	Always	22	35	37	60	3	5
C8. Do you cover the x-ray cassette with a plastic when examining patients in isolation?	Always	57	92	5	8	0	0
C9. Do you provide each patient with a fresh gown each time he/she attends to a radiological procedure requiring a gown?	Always	15	24	26	42	21	34
C10. Do you remove your jewellery when performing a radiological procedure?	Always	20	32	17	27	25	40
C11. Do you cleanse and disinfect the x-ray couch and chest stand with antiseptic solution after every patient contact?	Always	10	16	43	69	9	15
C12. Do you disinfect the x-ray mobile unit when a radiological procedure is complete?	Always	9	15	34	55	19	31
C13. Do you make use of a different anatomical marker for each radiological procedure?	Always	6	10	9	15	47	76
C14. Do you check the radiographic equipment for cleanliness prior using them on other patients?	Always	31	50	30	48	1	2

Questions	Correct answer	Correct		Sometimes		Never	
		n	%	n	%	n	%
C15. Do you cleanse and disinfect the anatomical marker and lead rubber apron with antiseptic solution every week?	Always	6	10	27	44	29	47
C16. Do you fold the contaminated surface of an isolation attire or gown inwards when removing the gown in readiness for discarding?	Always	27	44	17	27	18	29

The results of each question are presented below.

4.8.1 C1: Do you wear protective gloves and coats during procedures when there is potential for blood splatter?

In terms of the literature, the Wakefield and Kirklees Council (2014:29) highlight that gloves must be worn for all activities that have been assessed as carrying a risk of exposure to blood, body fluids and secretions or excretions. The correct answer 'always' was selected by 74% (n=46) of the respondents on the question if they would wear protective gloves and coats during procedures when there is potential for blood splatter. However, 26% (n=16) of the respondents indicated 'sometimes' to this question. None selected 'never'. It is evident from the data that the majority of the respondents would wear protective gloves and coats during procedures when there is a potential for blood splatter. Ideally all of the respondents should have confirmed use of PPE. Since not all did, means they would be a risk because PPE does protect one from blood splatter. Therefore, the importance of wearing protective gloves and coats during procedures when there is a potential for blood splatter should be addressed.

4.8.2 C2: Do you wash your hands after removing gloves?

Mahon *et al*. (2011:75) state that hands should be washed after removal of gloves. Ehrlich and Coakes (2017:454) recommend that radiographers should always perform handwashing following the removal of gloves. The correct answer 'always' was selected by 48% (n=30) of the respondents, and 50% (n=31) selected 'sometimes'. Only 2% (n=1) selected 'never' on the question if they wash their hands after the removal of gloves. One can assume therefore that over half of the respondents (52%, n=32) would not wash hands after removing gloves. The finding is important because this could create a risk of exposure to HAIs since some gloves might have microscopic holes. The finding implies the practice of infection control was low for the majority of respondents in terms of washing hands after removing gloves and this should be addressed.

4.8.3 C3: Do you wash your hands with soap before and after touching any patient?

Hands are a major source of spread of infection. Eze *et al*. (2013:1411) underscored that radiographers should wash their hands by scrubbing with soap and water, alcohol or antiseptics after attending to a patient and before attending to the next patient. Nineteen percent of the respondents (n=12) selected the correct answer 'always' to the question if they would wash their hands with soap before and after touching any patient. However, the majority, 74% (n=46) selected 'sometimes', and 6% (n=4) selected 'never'. It is evident from the data that only 19% (n=12) indicated they wash their hands before and after touching a patient. The majority indicated they do not wash their hands before and after patient. This poses a great risk, and increases the chances of spread of HAIs from staff to patients or vice versa, which should be addressed.

4.8.4 C4: Do you wash your hands at the end of shift before leaving work?

Hands are one of the major ways through which HAIs are spread from one place to another. Ehrlich and Coakes (2017:454) recommend radiographers should perform handwashing on completion of duty. Further, Eze *et al.* (2013:1411) recommended that radiographers should also acquire the culture of proper handwashing with soap and water, alcohol or antiseptics, at the end of procedures of the day. The correct answer 'always' was selected by 48% (n=30) of the respondents on the question if they wash their hands at the end of shift before leaving work. However, 47% (n=29) of the respondents selected 'sometimes', and 5% (n=3) selected 'never'. The data shows that the majority (n=32) do not always wash their hands at the end of shift before leaving work. Failure do so means they could carry infection from the workplace to their homes. The finding is important because it shows that the majority of respondents (n=32) do not routinely wash their hands, at the end of a shift, before leaving work. This practice increases the risk of spread of HAIs from work to home which should be addressed.

4.8.5 C5: Do you wear a mask when there is a potential to be exposed to airborne droplets or dust particles?

Ehrlich and Coakes (2017:161) indicate that disposal masks provide a defence against infection; healthcare workers and visitors need to wear them whenever they enter a room of an infectious person. The correct answer 'always' was selected by 63% (n=39) of the respondents, and 37% (n=23) selected 'sometimes' on the question if they would wear a mask when there is a potential to be exposed to airborne droplets or dust particles. None selected 'never'. It is evident that the majority would wear a mask when there is a potential to be exposed to airborne droplets or dust particles. This practice ensures there would be a reduction in the spread of HAIs due to airborne droplets and dust particles. However, 37% of the respondents do not routinely wear a mask when there is a potential to be exposed to airborne droplets or dust particles and this should be addressed.

4.8.6 C6: Do you cover your open cuts and wounds that you have during clinical work?

WorksafeBC (2012:3) stated workers need to cover small wounds and cuts. The correct answer 'always' was selected by 66% (n=41) of the respondents; 32% (n=20) selected 'sometimes' and 2% (n=1) selected 'never' to the question if they would cover open cuts and wounds that they have during clinical work. The majority of respondents cover cuts and wounds during clinical work. However, more than a quarter would not cover small wounds and cuts. The finding is important because it shows that not all of the respondents would cover their open cuts and wounds during clinical work: this could increase the spread of HAIs and needs to be addressed.

4.8.7 C7: Do you damp dust the radiographic x-ray equipment each day you start your work?

Chingarande and Chidakwa (2013:4) found that radiographers did damp dust the radiographic equipment every morning before commencing radiological procedures.

The correct answer ‘always’ was selected by 35% (n=22) of the respondents on the question if they would damp dust the radiographic x-ray equipment each day before work was started. However, the majority 60% (n=37) selected ‘sometimes’, and 5% (n=3) selected ‘never’. It is therefore evident that the majority of respondents would not damp dust the radiographic equipment each day when they start work. This means that the equipment could be dusty and this could harbour microorganisms. The spread of HAI’s in their radiology departments would probably be increased. This practice needs to be addressed.

4.8.8 C8: Do you cover the x-ray cassette with a plastic when examining patients in isolation?

Ehrlich and Coakes (2017:163) state that image receptors (x-ray cassettes) should be placed in a smooth-fitting plastic bag, or protective cover, when attending to patients in isolation rooms. The correct answer ‘always’ was selected by 92% (n=57) of the respondents on the question if they would cover the x-ray cassette with a plastic when examining patients in isolation. However, 8% (n=5) selected ‘sometimes’. None selected ‘never’. The data show only five indicated they would not cover an x-ray cassette with a plastic or non-porous material, when examining patients in isolation. Since the majority (n=57) would do this means the spread of HAIs, from isolated patients, would be reduced.

4.8.9 C9: Do you provide each patient with a fresh gown each time he/she attends to a radiological procedure requiring a gown?

The Ministries of Public Health and Sanitation in Kenya, and the Ministry of Medical Services (2010:36 & 38) highlighted that gowns should be washed or thrown out between patients. Twenty-four percent of the respondents (n=15) correctly selected ‘always’ on the question if they would provide each patient with a fresh gown each time he/she attends to a radiological procedure requiring a gown. However, 42% (n=26) selected ‘sometimes’, and 34% (n=21) selected ‘never’. It is evident from the results that the majority would not provide each patient with a fresh gown for radiological procedures that require a gown be worn. The ramifications of not providing a fresh gown to patients are that there could be a high possibility of spread of microorganisms from patient to patient. The finding is important because it shows that the majority of respondents do not provide each patient with a fresh gown each time a radiological procedure, requiring a gown. Failure to provide a clean gown means exposing patients to HAI risks and this practice should therefore be addressed.

4.8.10 C10: Do you remove your jewellery when performing a radiological procedure?

Jewellery is assumed to harbour microorganisms like bacteria. Lister and Inamdar (2013:27) maintain that it is advisable for staff, providing healthcare, to remove jewellery at the start of a working day. Ehrlich and Daly (2009:405) underscored that radiographers should be encouraged to remove jewellery when attending to patients. It is believed that jewellery harbours bacteria and therefore may be a source of HAIs. Thirty-two percent (n=20) of the respondents correctly selected 'always' on the question if they would remove their jewellery when performing a radiological procedure. However, 27% (n=17) selected 'sometimes', and 40% (n=25) selected 'never'. The data show that the majority do not remove their jewellery when performing a radiological procedure. This implies there could be increased chances of spread of HAIs from radiographers to patients which would make the implementation of infection control difficult. This practice should be addressed.

4.8.11 C11: Do you cleanse and disinfect the x-ray couch and chest stand with antiseptic solution after every patient contact?

Ehrlich and Coakes (2017:453) indicate that x-ray machines, tables and vertical stands should be thoroughly washed with disinfectant, dilute solution or a germicide cloth after patient contact. Sixteen percent (n=10) of the respondents selected the correct answer 'always' on the question if they would cleanse and disinfect the x-ray couch and chest stand with antiseptic solution after every patient contact. However, 69% (n=43) selected 'sometimes', and 15% (n=9) selected 'never'. It is evident from the results that the majority of the respondents do not clean and disinfect, the x-ray couch and chest stand, with an antiseptic solution after every patient contact. Therefore, transfer of HAIs from one patient to another could increase considering that the same x-ray couch and chest stand could be used by several patients without being cleaned or disinfected. A failure by radiographers to cleanse and disinfect equipment presents an increased risk to most patients being exposed to HAIs harboured in equipment and this practice should be addressed.

4.8.12 C12: Do you disinfect the x-ray mobile unit when a radiological procedure is complete?

According to Eze *et al*. (2013:1411), x-ray equipment and accessories should be properly disinfected immediately after use, and before the next patient is attended to. Only 15% (n=9) of the respondents correctly selected 'always' on the question if they would disinfect the x-ray mobile unit after completion of a radiological procedure. More than half, 55% (n=34) selected 'sometimes', and 31% (n=19) selected 'never'. The data show that the majority do not disinfect x-ray mobile units when a radiological procedure is complete. Such poor infection control practice increases the possibility of spread of HAIs from one person to another, and from one department to the other. This finding is important because it shows that the majority of respondents do not practice good infection control prevention and implies that an x-ray mobile unit could be used for several days, without being disinfected, on many patients, in many departments, and by many of the respondents. This practice should be addressed.

4.8.13 C13: Do you make use of a different anatomical marker for each radiological procedure?

Ten percent (n=6) of the respondents selected 'always'. This is the correct answer. However, 15% (n=9) respondents selected 'sometimes', and 76% (n=47) selected 'never'. This means the majority of the respondents do use the same marker on all radiological procedures. Anatomical markers harbour microorganisms (Tugwell & Maddison,2011:19). They could act as a means by which HAIs could also be spread. However, considering that the same anatomical marker could be used on a number of patients in various departments, this implies that the spread of HAIs was high amongst the staff, patients, and the departments. According to the National Infection Control Guidelines (2016:28), it is advisable to dedicate the use of medical equipment to a single patient to avoid sharing of pathogens. The findings of this this question do not comply with the 2016 guidelines. The finding is important because it shows the majority of respondents make use of the same anatomical marker for each radiological procedure. This implies there is an increased spread of HAIs from radiographers to patients as result of use of the same anatomical marker for each radiological procedure and this practice should be addressed.

4.8.14 C14: Do you check the radiographic equipment for cleanliness prior using them on other patients?

According to the National Infection Control Guidelines (2016:18) radiographers should ensure that all reusable radiographic equipment is clean and reprocessed appropriately prior to use on another patient. On the question if they would check the radiographic equipment for cleanliness prior using them on patients, 50% (n=31) of the respondents selected the correct answer: 'always'. However, 48% (n=30) selected 'sometimes'. Only 2% (n=1) selected 'never'. These results show that almost half of the respondents check radiographic equipment for cleanliness prior to usage. Conversely, the possibility of radiographic equipment harbouring HAIs could be high because the other half sometimes check the cleanliness of radiographic equipment. The finding is important for two reasons. It shows the need for radiographers to practice the importance of checking equipment for cleanliness before use. It also implies that patients could be exposed to unclean equipment harbouring HAIs as a result of failure by radiographers to check their cleanliness before use, which is a practice that should be addressed.

4.8.15 C15: Do you cleanse and disinfect the anatomical marker and lead rubber apron with antiseptic solution every week?

Tugwell and Maddison (2011:119) indicate that radiographers need to clean their anatomical markers regularly with either disinfectant wipes or alcohol gel, preferably at least once a week. Ehrlich and Daly (2009:404) also highlighted that lead rubber aprons should be cleaned weekly using disinfectant dilute bleach or germicide cloths. A very small minority, 10% (n=6) of the respondents selected 'always': the correct answer on the question if they cleanse and disinfect the anatomical marker and lead rubber apron with antiseptic solution every week. However, 44% (n=27) selected 'sometimes', and 47% (n=29) selected 'never'. Based on these results, it is evident the majority do not cleanse and disinfect anatomical markers, and lead rubber aprons, with an antiseptic solution every week. These items harbour microorganisms. Failure by the majority of the respondents to cleanse and disinfect them could lead to an increase in the number of microorganisms and an increase in spread of HAIs, which is a practice that should be addressed.

4.8.16 C16: Do you fold the contaminated surface of an isolation attire or gown inwards when removing the gown in readiness for discarding?

Ehrlich and Coakes (2017:164 & 168) highlight that the outer (contaminated) surface of a gown should be folded inward when isolation attire is removed. This ensures a radiographer is never in contact with the contaminated outer surface. In this question, 76% (n=47) of the respondents selected ‘always’: the correct answer to the question whether they would fold the contaminated surface of an isolation attire or gowns inwards when removing the gown in readiness for discarding. However, 15% (n=9) selected ‘sometimes’, and 10% (n=25) selected ‘never’. It is thus evident that the majority do fold contaminated attire or gowns inwards when removing them in readiness for discarding. This helps to reduce the spread of HAIs. However, ideally all respondents should fold the contaminated surface of an isolation attire or gown inwards when removing the gown in readiness for discarding and this practice should be addressed.

4.9 QUESTIONS WITH HIGH VERSUS LOW PRACTICE SCORES

The below two questions had the most correct answers. More than 74% of the respondents selected the correct answer for each of the questions (from highest to lowest).

- Question C8: Do you cover the x-ray equipment with a plastic when examining patients with isolation? (84%, n=57).
- Question C1: Do you wear protective gloves and coats during procedure where there is potential for blood splatter? (74%, n=46).

Overall the below seven questions had the most incorrect answers. Less than 40% of the respondents selected the correct answer for each of the questions (from highest to lowest).

- Question C7: Do you damp dust the radiographic x-ray equipment each day you start your work? (35%, n=22).

- Question C10: Do you remove the jewellery when performing a radiological procedure? (32%, n=20).
- Question C9: Do you provide each patient with a fresh gown each time he/she attends to a radiological procedure requiring a gown? (24%, n=15).
- Question C3: Do you wash your hands with soap before and after touching any patient? (19%, n=12).
- Question C11: Do you cleanse and disinfect the x-ray couch and chest stand with antiseptic solution after every patient contact? (16%, n=10).
- Question C13: Do you make use of a different anatomical marker for each radiological procedure? (10%, n=6).
- Question C15: Do you cleanse and disinfect the anatomical marker and lead rubber apron with antiseptic solution every week? (10%, n=6).

4.10 PRACTICE SCORES

Table 4.5 presents the range of scores obtained by the respondents regarding practice.

Table 4.5: The frequency distribution of practice scores

Knowledge scores	**Respondents**	
	n	**%**
1. 100	0	0
2. 90 – 99	8	13
3. 80 – 89	4	6
4. 70 – 79	11	18
5. 60 – 69	7	11
6. 50 – 59	26	42
7. 38- 49	6	10
Total	**62**	**100**

As evident in Table 4.5 the range of scores is as follows.

- None of the respondents scored 100%.
- Eight (13%) of the respondents scored 90 – 99 %.
- Four (6%) of the respondents scored 80 – 89%.
- Eleven (18%) of the respondents scored 70 – 79%.
- Seven (11%) of the respondents scored 60 – 69%.
- Twenty-six (42%) of the respondents scored 50 – 59%.
- Six (10%) of the respondents scored 38 – 49%.

Forty-two percent of the respondents scored 50 – 59% in terms of their levels of practice. Practice is known to have influence in infection control. In order to determine the influence of practice in infection control, respondents were asked to answer 16 Likert–Scale questions. Table 4.6 indicates the distribution of respondents' practice level towards infection control.

Table 4.6: The distribution of respondents' practice level towards infection control

Practice level	Number (n=62)	Percent (%)
1. Higher (77.25 to 97.00)	16	26
2. Average (50.75 to 77.25)	30	48
3. Lower (41.00 to 50.75)	16	26
Total	**62**	**100**
Mean = 65.26 SD = 16.07	**Min = 41**	**Max = 97**

Respondents obtained a total score of 97. As indicated in Table 4.6, only 26% (n=16) of the respondents had 'higher' practice knowledge; 48% (n=30) of them had 'average' practice knowledge, and 26% (n=16) had lower knowledge in infection control. The mean practice score for all respondents was 65.26 out of a possible 97 points (SD 16.07). The maximum and minimum range of knowledge was 41 and 97, respectively. The results reveal that the level of practice of respondents regarding infection control was average.

It is evident from the data generated that the total level of practice of respondents regarding infection control was average (65.26%). This finding is similar to a study done in Srilanka by Jayasinghe and Weerakoon in 2014 among 213 radiographers. Their results were that that the level of practice among radiographers regarding infection control was moderate (66.66%). The result of this study depicts slightly better results as compared to similar studies. Udo *et al*. (2011) found there was poor practice regarding infection control among 51 radiographers in South East Nigeria. Compliance with infection control practice was low among 84 radiographers in Bangor (Dumbarton, 2007). Contrasting results were also obtained in Queensland, Australia by Worrall (2012) as compliance with infection control among radiographers was poor. A study done by Luntsi *et al*. (2011) found that the level of practice was good among radiographers in teaching hospitals in Northern Nigeria; Antwi *et al*. (2014) found there was good practice, with a rating of 89%, among 72 radiographers in Ghana.

4.11 RELATIONSHIP BETWEEN DEMOGRAPHIC VARIABLES AND KNOWLEDGE AND PRACTICE SCORES

The Chi-square test was used to investigate the association between the variables age, level of education, years of work experience, and level of knowledge and practice. The knowledge score with practice score was also compared. A P-value of <0.05 was considered significant. The data are presented in Table 4.7.

Table 4.7: Association between respondents' socio-demographic characteristics and scores

Variable 1	Variable 2	P – Value (* Significant)
Age group	Knowledge score	0.038*
Age group	Practice score	0.562
Level of education	Knowledge score	0.776
Level of education	Practice score	0.312
Years of work experience	Knowledge score	0.446
Years of work experience	Practice score	0.127
Knowledge score	Practice score	0.113

Table 4.7 shows that there was only a significant association between age and knowledge score ($P<0.05$). Older respondents were more likely to have more knowledge than younger respondents. However, there was no statistically significant association between age and practice ($P>0.05$).

Furthermore, amongst the respondents within the age group of 20 – 39, 44% (n=23) had higher knowledge scores, and 56% (n=29) had lower knowledge scores. And amongst the same respondents, 50% (n=26) had higher practice scores, and 50% (n=26) had lower practice scores. The findings also show that amongst the respondents within the age group 40 – 59, 80% (n=8) had higher knowledge scores and 20% (n=2) had lower knowledge scores. Furthermore, amongst the same respondents, 40% (n=4) had higher practice scores, and 60% (n=6) had lower practice scores. The results are presented in Table 4.8.

Table 4.8: Relationship between demographic variables and knowledge and practice scores

Variable	Knowledge scores		Practice scores	
	Higher	Lower	Higher	Lower
Age				
20 – 39	44% (23)	56% (29)	50% (26)	50% (26)
40 – 59	80% (8)	20% (2)	40% (4)	60% (6)
Level of education				
Diploma	49% (22)	51% (23)	44% (20)	56% (25)
Bachelors/Masters	53% (9)	47% (8)	59% (10)	41% (7)
Years of work experience				
0 – 5 years	45% (14)	55% (17	58% (18)	42% (13)
> 5 years	55% (17)	45% (14)	39% (12)	61% (19)

In terms of level of education, as evident in Table 4.8, 49% (n=22) of respondents with a diploma had higher knowledge scores, and 51% (n=23) had lower knowledge scores. And amongst the same group, 44% (n=20) had higher practice scores while 56% (n=25) had lower practice scores. The findings also show that amongst the respondents with bachelors/masters qualifications, 53% (n=9) had higher knowledge scores and 47% (n=8) had lower knowledge scores. And amongst the same group, 59% (n=10) had higher practice scores, and 41% (n=7) had lower practice scores.

The results of levels of experience, as evident in Table 4.8, show that amongst the respondents with 0 – 5 years of experience, 45% (n=14) had higher knowledge scores, and 55% (n=17) had lower knowledge scores. And amongst the same group, 58% (n=18) had higher practice scores; 42% (n=13) had lower practice scores. The findings also show that amongst the respondents with > 5 years of experience, 55% (n=17) had higher knowledge scores, and 45% (n=14) had lower knowledge scores. And amongst the same respondents, 39% (n=12) had higher practice scores, and 61% (n=19) had lower practice scores.

It can be concluded from the findings in Table 4.8 that older respondents had higher knowledge scores, however they had low practice scores. Respondents who had higher levels of education (bachelors/masters degrees) had both higher knowledge scores and higher practice scores. The respondents who had more years of work experience had higher knowledge scores but low practice scores. We can conclude that older age, higher level of educations, and more years of work experience all resulted in a higher knowledge scores, however only age was found to be significant. Furthermore, older age and more years of work experience equate to one achieving low practice score.

4.12 RELATIONSHIP OF KNOWLEDGE SCORE AND PRACTICE SCORE

Table 4.9 is a contingency table showing the scores of knowledge equated against scores of practices.

Table 4.9: Contingency table – knowledge score versus practice score

Part B: Knowledge Score	Part C: Practice Score							
	Lower [41.00 to 50.75)		**Average [50.75 to 77.25]**		**Higher (77.25 to 97.00]**		Total	
Lower [38.00 to 69.00]	7	41%	8	47%	2	12%	17	100%
Average (69.00 to 88.00]	7	18%	18	46%	14	36%	39	100%
Higher (88.00 to 100.00]	2	33%	4	67%	0	0%	6	100%
Total	**16**	**26%**	**30**	**48%**	**16**	**26%**	**62**	**100%**

The discussion that follows equates higher knowledge scores against practice scores, average scores of knowledge against practice scores, and lower scores of knowledge against practice scores.

4.12.1 The higher score of knowledge against practice

Thirty-three percent (n=2) of the respondents had 'higher' knowledge scores (88 to 100) but they had 'lower' practice scores (41.00 to 50.75). Further, 67% (n=4) of the respondents had 'higher' knowledge scores (88 to 100), but they had 'average' practice scores (50.75 to 77.25). None of the respondents had 'higher' knowledge (88 to 100) scores and 'higher' practice scores.

4.12.2 The average score of knowledge against practice

Thirty-six percent (n = 14) of the respondents had 'average' knowledge scores (69 to 88) and 'higher' practice scores (77.25 to 97.00). Further, 46% (n=18) of the respondents had 'average' knowledge scores (69 to 88) and 'average' practice scores (50.75 to 77.25). Eighteen percent (n=7) of the respondents had 'average' knowledge scores (69 to 88), but they had a 'lower' practice score (41.00 to 50.75).

4.12.3 The lower score of knowledge against practice

Twelve percent (n=2) of the respondents had 'lower' knowledge scores (38 to 69), but they had 'higher' practice score (77.25 to 97.00). Further, 47% (n=8) of the respondents had 'lower' knowledge scores (38 to 69) and 'average' practice scores (50.75 to 77.25). Forty–one percent (n=7) of the respondents had 'lower' knowledge scores (69 to 88) and 'lower' practice scores (41.00 to 50.75).

As shown in Table 4.9, it is evident that respondents with higher knowledge score had a lower practice score while respondents with average knowledge score had average practice score. Respondents with a lower knowledge score had a lower practice score. It can be concluded that a higher knowledge score does not equate to a higher practice score.

Part D results are presented below.

4.13 PART D: ADDITIONAL RELEVANT INFORMATION REGARDING INFECTION CONTROL

This section assessed two closed-ended and two open-ended questions about additional information regarding infection control in radiology departments in four government referral hospitals in Malawi. The two analysed closed-ended questions (D1 and D2) pertain to attendance of occupational in-service training sessions on infection control. They aimed at determining whether the respondents had attended occupational in-service training sessions on infection control, and the number that they attended. Table 4.10 indicates the frequency of responses on the statements D1 and D2.

Table 4.10: The frequency of responses as regards to attendance of occupational in-service training sessions on infection control

Occupational in-service training sessions attended	Yes			No	
	n	% that attended	% entire sample	n	% entire sample
1. None				32	52
2. One	20	67	32		
3. Two to Three	8	27	13		
4. Four or more	2	6	3		
Total	30	100	48	32	52

The data in Table 4.10 indicate that 48% (n=30) of the respondents had attended occupational in-service trainings on infection control. The majority, namely 52% (n=32), had never attended occupational in-service trainings on infection control.

Of the 48% (n=30) of the respondents who had attended the occupational in-service trainings on infection control, 67% (n=20) had attended a single infection control in service training session. This translates to only 32% of entire sample of respondents. Twenty-seven (n=8) of the respondents had attended two to three occupational in-service trainings on infection control, which is only 13% of the entire sample of respondents. Furthermore, amongst those who had attended occupational in-service trainings, 6% (n=2) of the respondents had attended four or more occupational in-service trainings, which is only 3% of the entire sample of respondents. The attendance of occupational in-service trainings by respondents is important in the sense that it helps improve or update the respondents' knowledge and skills with regards to recent or current methods for controlling HAIs.

The first open-ended question (D3) explored factors outside the scope of practice that affect how the respondents (radiographers) implement the SICP. All 62 respondents completed this question. The number of responses was not limited. The responses (from the most frequent response to the least frequent response) are indicated in Table 4.11.

Table 4.11: The factors outside the scope of practice affecting implementation of infection control

Factors	Respondents	
	n	%
Inadequate resources for infection control	42	68
Increased workload in the radiology department	13	21
Lack of infection control training sessions	12	19
Inadequate funding for buying infection control materials	11	18
Lack of standard infection control guidelines	9	15
Lack of management and radiology staff commitment in implementation of infection control	5	8
Inadequate waiting space making implementation of infection control difficult	4	6
Inconsistent monitoring of infection control processes	2	3
Lack of motivation to carry out infection control practices	2	3

In terms of what is the major factor, outside the scope of practice that affected the implementation of SICP in the radiology departments in the four government referral hospitals, the result was inadequate resources for infection control amongst other factors.

The second open-ended question (D4) addressed recommendations that would help improve infection in the radiology departments. All 62 respondents completed this question. Many recommendations were provided as there was no limit stated. The responses (from the most frequent response to the least frequent response) are presented in Table 4.12.

Table 4.12: Recommendations to improve infection control

Factors	Respondents	
	n	%
Need for on job in-service trainings in infection control/enhance continuous professional development	40	65
Adequate resources should be procured for infection control	31	50
Development of infection control national guidelines for radiographers	12	19
Radiographers need to attend workshops	9	15
Radiology department should be given enough funds for infection control	6	9
Radiography course at the training institution to include infection control in relation to radiology department	5	8
Recruitment of infection control officers in the radiology department	2	3
Provision of civic education in infection control to patients	2	3

As shown in Table 4.12, the major change, to be implemented to enhance or improve infection control in the radiology departments in the four government referral hospitals, was the need for the Ministry of Health, and stakeholders, to conduct regular in-service trainings regarding infection control. Respondents believe that the attendance of such trainings could enhance continuous professional development (CPD).

4.14 CONCLUSION

This chapter provided a detailed description of the findings of phase one. The results were discussed according to individual and overall scores of the knowledge and practices statements and/questions. The overall scores for knowledge were then tested for any statistically significant relationship between them and socio-demographic characteristics. The results were that the respondents had average knowledge as well as average practice in terms of infection control. A significant association was also revealed between age and knowledge of the respondents. The results showed that the knowledge of the respondents was not statistically significant on the level of practice they had regarding infection control. The factor that most influenced not implementing SICP was inadequate resources. The recommendation is for more in-service training. A discussion on the draft guideline development, namely phase two of the study, is presented in the next chapter.

CHAPTER FIVE

GUIDELINE DEVELOPMENT (PHASE TWO)

5.1 INTRODUCTION

Chapter One presented the introduction and overview of the study. Chapter Two presented the literature review. Chapter Three presented research design and methods used to conduct the study. Chapter Four provided data analysis and interpretation of the results. The results guided the researcher in developing a draft guideline for infection control to facilitate sound knowledge and practices of radiographers regarding infection control in radiology departments in government referral hospitals in Malawi. The draft guideline developed is presented in this chapter.

5.2 GUIDELINE FOR INFECTION CONTROL

This section outlines the summary of the draft guideline: its title, purpose, scope, target group and development of the draft guideline using the format of an adapted version of the AGREE II tool (AGREE Next Steps Consortium, 2009:2).

5.2.1 Guideline title

Guideline for infection control in radiology departments in government referral hospitals in Malawi.

5.2.2 Purpose

The draft guideline is for further development and implementation to facilitate sound knowledge and practices of radiographers regarding infection control in radiology departments in government referral hospitals in Malawi. The guideline provides comprehensive and standardised information regarding infection control. It is specifically intended to:

- Prevent the spread of cross infection.
- Uphold standards of safe practice.
- Protect both radiology staff and every individual in their care at all times from the transmission of infection during radiological procedures whether the risks is known or unknown.

- Ensure maximum protection of patients, guardians and visitors against infection.
- Act as a reference for all members of staff working in a radiology department or new staff members being oriented and those that bring patients from other departments as well.

5.2.3 Scope

The scope of the draft guideline pertains to the objectives and the target group. The practices and procedures described in this guideline are intended for use in the radiology departments of all four government referral hospitals in Malawi.

5.2.4 Target group

This draft guideline is intended for use by radiographers working in radiology departments in four government referral hospitals in Malawi, new staff members being oriented, and those that bring patients from other departments, as well as guardians in these hospitals.

5.2.5 Development of the draft guideline

The draft guideline was developed after data analysis of a self-administered questionnaire following a study conducted in the four referral hospitals in Malawi. Upon analysing this questionnaire, the researcher identified gaps in terms of knowledge and practices of the respondents, which are further outlined in paragraph 5.3. The researcher developed the draft guideline based on the NICE method (NICE, 2012:15) (see 3.3.2). For the format of the draft guideline, an adapted version of the AGREE II tool for guideline development was used (AGREE Next Steps Consortium, 2009:2) (see Annexure K).

5.2.5.1 Stakeholder involvement

The draft guideline was developed with the input from 62 respondents (radiographers) who completed a questionnaire on their knowledge and practices regarding infection control, supervisors and literature.

5.2.5.2 Review of the guideline

The draft guideline was not submitted to an expert panel for review in Malawi. It was reviewed by the researcher's supervisors. They are experienced in the development of guideline in the fields of radiography and nursing. An expert panel review was not conducted as this was not the scope of the study. The draft guideline was mainly developed for accomplishing the study or training programme. However, before implementing the guideline it is recommended that it should be further developed by means of an expert review panel.

5.3 GAPS IDENTIFIED IN THE STUDY

Although, the respondents that completed the questionnaire had average knowledge and practice scores regarding infection control, eleven gaps were identified by the researcher that are relevant for practicing radiographers upon analysing the gathered data from the parts B and C of the questionnaire. When only <75% of the respondents indicated the correct answer to any of the knowledge statements (see Table 4.1) or practice questions (see Table 4.4), this was considered a gap and included in this section. Twenty-two gaps were categorised by the researcher into three major aspects derived from the conceptual framework (Florence Nightingale's environmental theory) (see1.6) and linked to a set of recommendations as follows.

5.3.1 Personal cleanliness

- Respondents were not aware that the steps for performing hand hygiene using alcohol-based hand rub are the same as when performing handwashing (see set of recommendations 1. Hand hygiene).
- The majority of the respondents were not aware that alcohol–based hand rubs are not effective against spore forming organisms e.g. *Clostridium difficile* (see set of recommendations 1. Hand hygiene).
- Respondents do not wear protective gloves and coats during procedures where there is potential for blood splatter (see set of recommendations 3. Personal protective equipment).
- The majority of the respondents do not wash their hands after removing gloves (see set of recommendations 1. Hand hygiene).

- The majority of the respondents do you wash their hands at the end of shift before leaving work (see set of recommendations 1. Hand hygiene).
- The majority of the respondents do not wash their hands with soap before and after touching the patient (see set of recommendations 1. Hand hygiene).
- Respondents do not wear a mask when there is a potential to be exposed to airborne droplets or dust particles (see set of recommendations 3. Personal protective equipment).
- Respondents do not cover your open cuts and wounds during clinical work (see set of recommendations 2. Personal hygiene).
- The majority of the respondents do not remove jewellery when performing a radiological procedure (see set of recommendations 2. Personal hygiene).
- The majority of the respondents do not fold the contaminated surface of an isolation attire or gown inwards when removing the gown in readiness for discarding (see set of recommendations 3. Personal protective equipment).
- Respondents were not aware that radiographers' uniforms are a serious source of infection (see set of recommendations 3. Personal protective equipment).

5.3.2 Cleanliness of rooms (environment)

- The majority of the respondents do not damp dust the radiographic x-ray equipment each day when they start their work (see set of recommendations 6: Housekeeping, and set of recommendations 7: Routine infection control practices)**.**
- The majority of the respondents do not provide each patient with a fresh gown each time a patient undergoes a radiological procedure requiring a gown (see set of recommendations 3: Personal protective equipment).
- The majority of the respondents do not cleanse and disinfect the x-ray couch and chest stand with antiseptic solution after every patient contact (see set of recommendations 6: Housekeeping, and set of recommendations 7: Routine infection control practices).
- The majority of the respondents do not disinfect an x-ray mobile unit when a radiological procedure is complete (see set of recommendations 7: Routine infection control practices).

- Half of the respondents do not make use of a different anatomical marker for each radiological procedure (see set of recommendations 7: Routine infection control practices).
- The majority of the respondents do not check the radiographic equipment for cleanliness prior to using them on other patients (see set of recommendations 5: Decontamination and cleaning, and set of recommendations 7: Routine infection control practices).
- The majority of the respondents do not cleanse and disinfect anatomical markers and lead rubber aprons with antiseptic solution every week (see set of recommendations 7: Routine infection control practices).

5.3.3 Health of houses

- The majority of the respondents were not aware that they should not recap a needle after use (see set of recommendations 4: Safe handling of sharps and sharp containers).
- Respondents were not aware that needles should not be bent before disposal (see set of recommendations 4: Safe handling of sharps and sharp containers).

Two additional gaps were identified by the researcher that are relevant for practicing radiographers upon analysing the gathered data from the parts D of the questionnaire. These need to be addressed at a managerial level in the four government referral hospitals because they are managerial in nature. These gaps are therefore not categorised under the aspects of the conceptual framework (Nightingale's environment theory) used in the study. These two gaps are as follows.

- The majority of the respondents have never attended occupational in-service training sessions on infection control.
- There are inadequate resources for infection.

The two gaps identified in part D are addressed in the next chapter 6 (see 6.4.1 and 6.4.2).

Based on the 20 identified gaps, seven sets of recommendations were developed and included in the draft guideline.

5.4 INFECTION CONTROL DRAFT GUIDELINE FOR THE RADIOGRAPHERS IN RADIOLOGY DEPARTMENTS IN GOVERNMENT REFERRAL HOSPITALS

5.4.1 Set of recommendations 1: Hand hygiene

The objective of the first set of recommendations was to ensure that radiographers have adequate knowledge and practices to mechanically remove soil and debris from the skin and reduce the number of transient microorganisms.

Hand hygiene is one of the most important procedures for preventing the spread of disease. It is essential that radiographers take responsibility to ensure that the care provided is carried out in a safe manner. The transmission of microorganisms from one service user to another via hands, or from hands contaminated from the environment, can result in adverse outcomes. Hand hygiene technique is more important than the solution used. There are three main level of hand hygiene: routine handwashing, aseptic handwashing, and surgical handwashing (Harrogate & District NHS Foundation Trust, 2016a:4-5).

According to Alder and Carlton (2016:2190), hands must be washed before and after performing invasive procedures and after touching body fluids, blood, secretions, excretions, and contaminated items regardless of whether gloves are worn. Alcohol-based hand rubs gel/foams are the preferred method for hand hygiene when hands are not soiled and are physically clean. Alcohol-based rubs are very effective antimicrobial agents. They should be applied to hands for minimum of 15 to 20 seconds, using an adequate volume to completely wet the hands. Alcohol-hand rubs can be used for hand decontamination where accesses to hand wash facilities are not adequate (Lemass *et al*., 2013:12).

- The following recommendations are made with regards to moments for hand hygiene.
- Before touching a patient.
- Before clean/aseptic procedure.
- After body fluid exposure risk.
- After touching a patient.

- After touching patient surroundings.
- At the end of a shift (WHO, 2012b:22).

With regard to effective handwashing technique, the following recommendations are made.

- Wet the hands under tap running water.
- Apply liquid soap or an antimicrobial liquid.
- The hand wash solution must come into contact with all the surfaces of the hands.
- Rub together the hands vigorously for a minimum of 10 – 15 seconds.
- Attention should be given to the tips of fingers and the areas between the fingers.
- Rinse the hands thoroughly.
- Dry the hands using good quality paper towel (Loveday, Wilson, Pratt, Golsorkhi & Tingle, 2014:4)

The recommendations for an alcohol-hand rub technique are as follows.

- Ensure you are 'bare below the elbows'
- Apply enough antiseptic hand rub to cover the entire surface of hands and fingers (about a teaspoonful).
- Ensure the solution covers the wrist surfaces.
- Rub the solution vigorously into hands, especially between fingers and under nails until the solution has dried (about 20-30 seconds) (Harrogate and District NHS Foundation Trust, 2016a:9).

To be effective, an adequate amount of hand rub solution should be used: effectiveness increases with increased amount of hand rub.

5.4.2 Set of recommendations 2: Personal hygiene

The objective of the second set of recommendations was to ensure that radiographers have adequate knowledge and practices of their personal hygiene to reduce the number of microorganisms that may be present in their bodies and those that may harbor in their jewellery.

According to Seenivasan, Mary, Priya, Devi and Nathini (2016:8), personal hygiene helps maintain health and prevent the spread of diseases. Personal cleanliness is important in all areas of the establishment since it does not only affect a radiographer, but other people too. If a radiographer carries dirt on his or her body or if he or she has not showered for some time, bacteria will start to grow on his/her body. A radiographer then smells stale and sweaty, which is not pleasant for patients, guardians and fellow healthcare workers (Netherlands Development Organisation (SNV), 2014:20). Apart from practicing personal hygiene, radiographers should remove their jewellery during the course of duty as it hides bacteria and viruses (Lister & Inamdar, 2013:27).

The following recommendations are made as regards to the rules of personal hygiene.

- Shower, bath or wash thoroughly every day.
- Keep hair and nails short, clean and neat.
- Cover open cuts and wounds.
- Brush teeth at least twice daily and use a breath refresher as needed throughout your shift.
- Always wear clean clothes (Netherlands Development Organisation (SNV), 2014:20).
- Always remove jewellery during a radiological procedure (Lister & Inamdar, 2013:27).

5.4.3 Set of recommendations 3: Personal protective equipment (PPE)

The objective of the third set of recommendations was to ensure that radiographers have adequate knowledge and practices to protect themselves, fellow healthcare workers and patients from microorganisms from contaminating hands, eyes, clothing, hair and shoes. The set of recommendations also aims at preventing microorganisms from being transmitted from patients to staff and vice versa.

PPE provides a barrier between a patient and radiographer to prevent exposure to skin and mucous membranes. PPE must be used when contact with body fluids, blood, secretions and excretions is possible. The equipment includes gloves, gowns, facemasks and protective eye wear (Alder and Carlton, 2016:219). Selection of PPE is based on the nature of patient interaction and potential for exposure to bloody, body fluids or infectious agents. PPE reduces, but does not completely eliminate the risk of acquiring an infection (National Infection Control Guidelines, 2016:15).

With regard to principles of using PPE, the following recommendations are made.

- Assess the risk of exposure to blood, body fluids, excretions or secretions and choose items of PPE accordingly.
- Use the right PPE for the right purpose.
- Avoid any contact between contaminated (used) PPE and surfaces, clothing or people outside the patient care area.
- Discard used PPE appropriately in designated disposal bags.
- Do not share PPE. Always use or provide a new PPE to a patient.
- Change PPE completely and thoroughly wash hands each time you leave a patient to attend to another patient or another duty (Kenya. Ministry of Public Health and Sanitation & Ministry of Medical Services, 2010:26).

With regards to removing an isolation attire, the following recommendations are made.

- Pull and tear gown to remove.
- Remove gloves as gown sleeves are pulled off. Fold contaminated surface inward.
- Discard gown and gloves.
- Remove mask. It is contaminated therefore handle by ties only and discard.
- Remove a cap or hood.
- Repeat hand hygiene.

5.4.4 Set of recommendations 4: Safe handling of sharps and sharp containers

The objective of the fourth set of recommendations was to ensure that radiographers have adequate knowledge and practices to avoid occupational exposure to microorganisms that may be found in blood and other body fluids which may occur due to needle stick (sharp) injuries.

Needle stick injuries, and other injuries, from sharp objects occur to radiographers annually. All used sharps must be placed in a designated puncture-resistant container, commonly called a sharps container (Alder & Carlton, 2016:220). Precautions should be taken to prevent injuries when handling needles, scalpels and other sharp instruments, devices during radiological procedures, cleaning and disposal (National Infection Control Guidelines, 2016:17).

With regard to safe use of sharps, the following recommendations are made.

- Sharps must not be passed directly from hand to hand.
- Handling of sharps should be kept to a minimum.
- Used needles must not be recapped.
- Used needles must not be bent, or disassembled after use (Loveday *et al*., 2014:5).

The recommendations for managing sharps and sharp containers are as follows.

- Position the sharp end of instruments away from self and others.
- Dispose of used sharps immediately in designated puncture and leak-proof containers labelled with a biohazard symbol.
- If injured by sharps, contact supervisor immediately.
- Put sharps containers as close to the point of use as possible and practical, at a convenient height and ideally within arm's length.
- Label sharps containers clearly with a biohazard symbol so that people will not unknowingly use them as garbage or trash container.
- Keep sharps containers in the area where sharps are being used.
- Do not place sharp containers where people might accidentally put their hands on them.
- Do not fill sharps containers above the three-quarters full mark.
- Seal the container when it is three-quarters full and do not reopen it. Never reopen, empty or reuse a sharps container after closing and sealing it (Kenya, Ministry of Public Health and Sanitation & Ministry of Medical Services, 2010:42).

5.4.5 Set of recommendations 5: Decontamination and cleaning

The objective of the fifth recommendation was to ensure that radiographers have adequate knowledge and practices to prevent potentially harmful microorganisms reaching a susceptible host in sufficient numbers to cause infection.

Decontamination is a collective term to describe the processes of cleaning, disinfection and sterilisation used to render equipment safe for further use on patients and handling by staff (Lead Nurse Infection Prevention & Control, 2015:4). According to the Infection Prevention and Control Team (2016:6), decontamination prevents infectious agents, or other contaminants, reaching a susceptible site in sufficient quantities to cause infection or any other harmful response. All equipment must be adequately decontaminated in between use and between service users use. The three levels of decontamination are cleaning, disinfection, and sterilisation (Harrogate & District NHS Foundation Trust, 2016b:5).

Cleaning refers to physically removing soiling along with most pathogens using detergents (enzymatic and soap), water and friction. This is a pre-requisite to successful disinfection and sterilisation (Infection Prevention and Control Team, 2016:7). After decontamination and prior to disinfecting or sterilising, all instruments and equipment must be cleaned to remove organic materials or chemical residue (Harrogate & District NHS Foundation Trust, 2016b:5).

With regards to decontamination the following recommendations are made.

- Decontaminate large surfaces or instruments that might have come into contact with blood and body fluids. Wipe them with a cloth soaked in the chlorine solution.
- Immediately after use, place all instruments in an approved disinfectant such as chlorine solution for 10 minutes to inactivate most organisms including HBV and HIV.
- Remove instruments from chlorine solution after 10 minutes and immediately rinse them with cool water to remove residual chlorine before thoroughly cleaning them.

- Once instruments and other items have been decontaminated, they can be cleaned and sterilised or high-level disinfected.
- Dry the instruments thoroughly (Kenya, Ministry of Public Health and Sanitation & Ministry of Medical Services, 2010:72).

The recommendations for general principles for cleaning are as follows.

- Always clean from the least contaminated area toward the more contaminated area and from the top down.
- Avoid raising dust.
- Do not contaminate yourself or clean areas.
- Clean all equipment that comes into contact with patients after each use.
- Use a cloth moistened with disinfectant such as Sani-Cloths or Clorox wipes.
- Dry the equipment in a drying cabinet or by using a clean lint-free cloth (Ehrlich & Coakes, 2017:157-158).

5.4.6 Set of recommendations 6: Housekeeping

The objective of the sixth set of recommendations is to ensure that radiographers have adequate knowledge and practice to reduce the number of microorganisms that may come into contact with staff, patients, visitors and the community in order to provide a clean and pleasant atmosphere for patients and staff.

Housekeeping refers to the general cleaning of a radiology department. It includes cleaning of floors, walls, equipment, tables, and other surfaces. It reduces the incidence of airborne infections and transfer of pathogens by fomites. A clean, dry environment discourages the growth of microorganisms. Radiographers are responsible for inspecting the work area regularly and maintaining the standards of medical sepsis (Ehrlich & Coakes, 2017:157).

The recommendations for housekeeping are as follows.

Dusting

- Cleaning cloths or mops are wetted with cleaning solution contained in a basin or bucket.

- Dry dusting should be avoided; dust cloths and mops should never be shaken to avoid the spread of microorganisms.
- Avoid raising dust.
- Dusting should be performed in a systematic way, using a starting point as a reference to ensure that all surfaces are reached.
- When doing high dusting (ceiling tiles and walls) check for stains that may indicate possible leaks.

Chairs, lamps, tables, tabletops, chest stands, hand rails and counters

- Wipe daily and whenever visible soiled with a damp cloth, containing disinfectant cleaning solution.
- A disinfectant should be use when contamination is present such as for blood or other body fluid spills.

Waste containers

- Clean contaminated waste containers after emptying each time. Clean non-contaminated waste containers when visibly soiled and at least once a week. Use disinfectant cleaning solution and scrub and remove soil and organic matter (Kenya, Ministry of Public Health and Sanitation & Ministry of Medical Services, 2010:53-56).

5.4.7 Set of recommendations 7: Routine infection control practices

The objective of the seventh set of recommendations is to ensure that radiographers have adequate knowledge and practices to minimise the risk for transmission of infection among patients and personnel in the radiology departments.

Routine, thorough cleaning of equipment in the x-ray room is part of a hospital's hygiene programme. Equipment such as x-ray tables, vertical stands, portable x-ray machines, cassettes, lead rubber gloves and aprons, and anatomical markers, to name a few, can become contaminated quickly when used and can be a reservoir of pathogenic bacteria if not cleaned and disinfected before the next use. Radiographers therefore need to ensure that all radiographic equipment is cleaned and disinfected in readiness for the next radiographic procedure (Pyrek, 2014:3).

The following recommendations are made as regard to the routine infection control practices to be followed in a radiology department.

- Clean all radiologic equipment on a routine basis (e.g. weekly), when obviously soiled or not soiled.
- All radiographic accessories labelled for single use should not be reused.
- Reusable radiographic accessories should be cleaned or decontaminated so that all visible matter/debris is removed prior to placing accessories in the central processing and distribution container in readiness for sterilisation.
- Clean thoroughly x-ray tables, vertical stands, and any other items that come into contact with patients. This must be done in between patients or between cases.
- Portable radiographic equipment must be cleaned and disinfected before and after entering the room of a patient or ward (UNC Health Care, 2016:3).
- Dust daily the overhead tube, spot film devices, image intensifiers and television monitors.
- Dust weekly the overhead tracks for ceiling-mounted equipment using a vacuum cleaner.
- Wash weekly control stands and spot film devices with disinfectant.
- Lead rubber gloves and aprons should be cleaned weekly using disinfectant, dilute bleach or a germicide cloth (Ehrlich & Coakes, 2017:453).
- Clean, wash and disinfect anatomical markers with gel at least once a week and use only once per patient (Tugwell & Maddison, 2011:119).
- All portable x-ray cassettes and grids should be covered with a disposal, clear plastic cassette cover to prevent contamination.
- Clean all anatomical markers, positioning pads, and sponge pads with an approved disinfectant after each patient or radiographic procedure.
- Always provide a patient with clean attire such as a clean hospital gown for all radiological examinations requiring the use of a gown. (UNC Health Care, 2016:3-5).

5.5 CONCLUSION

The draft guideline summary was presented in this chapter. It can be further developed and implemented in order to facilitate sound knowledge and practices of radiographers in radiology departments in government referral hospitals in Malawi. The draft guideline is applicable to the four referral hospitals in this study since it is based on data gathered from respondents at these hospitals. Similar issues or gaps, however, may be observed in other hospitals. In order for the draft guideline to be applicable to other hospitals, research needs to be done in such hospitals. The next chapter concludes the research study. It describes the limitations and recommendations related to the study.

CHAPTER SIX

CONCLUSIONS, RECOMMENDATIONS AND LIMITATIONS

6.1 INTRODUCTION

The previous chapter presented the draft guideline development, which was phase two, of this study. In this final chapter, the results of the study findings of both phase one and phase two are summarised**.** Recommendations and limitations of the study are discussed**.**

6.2 SUMMARY OF THE RESEARCH PROCESS

A two-phased study was undertaken to explore and describe the knowledge and practices of radiographers regarding infection control in radiology departments in government referral hospitals in Malawi in order to develop a draft guideline for infection control in order to facilitate sound knowledge and practices of radiographers regarding infection control in these hospitals.

The background of the study highlighted discrepancies in terms of application of SICP by radiographers in radiology departments in government referral hospitals in Malawi. Poor adherence to SICP by radiographers leads to an increase in terms of cost associated with buying materials necessary for combating HAIs, which affects radiology departments' budgets. The problem statement highlighted the discrepancies that exist in radiology departments in government referral hospitals. Its aim was developing a draft guideline for infection control in order to facilitate sound knowledge and practices of radiographers regarding infection control in these hospitals.

The specific objectives of the study were as follows.

- To explore and describe the knowledge and practices of radiographers regarding infection control in radiology departments in government referral hospitals in Malawi (phase one).
- To develop a draft guideline for infection control in order to facilitate sound knowledge and practices of radiographers regarding infection control in radiology departments in government referral hospitals in Malawi (phase two).

Objective one, in phase one, on exploring and describing the knowledge and practices of radiographers regarding infection control in radiology departments in government referral hospitals in Malawi, was achieved through a self-administered questionnaire (see Chapter Four).

The literature review in Chapter Two included: the meaning and types of HAIs, causes and transmission of HAIs, the chain of infection and how to break it, the burden, impact and economic costs of HAIs, infection control, the role of radiographers in infection control, radiographic equipment and accessories susceptible to infection in the radiology department, infection control procedures in a radiology department, and studies, on the knowledge and practices of radiographers regarding infection control and challenges in implementation of infection control.

In phase one, a quantitative research design and methodology process, that was explorative, describe and contextual in nature, was applied to address the research objectives and the research questions. Quantitative research was used to identify variables reflected in the problem statement and to ensure they were assessed in a manner which was both reliable and valid. Exploratory research was used to explore current knowledge and practices of radiographers regarding infection control in radiology departments in government referral hospitals in Malawi. Descriptive research was used to describe the knowledge and practices of radiographers regarding infection control. Contextual research was used to inform readers about the context in which the study took place, namely radiography departments in four government referral hospitals in Malawi.

The study utilised a census sampling technique as the sampling method. A self-administered questionnaire was used as a tool for collection of data. Descriptive and inferential statistical methods were utilised in analysing the collected data. The target population of 80 respondents was identified and the sample size was 62 respondents, which constitutes those who completed the self-administered questionnaires. Validity was ensured by requesting academic supervisors, and a statistician, to evaluate the questionnaire, before commencing the collection of data. A pilot study, and the use of a self-administered questionnaire approved by a statistician, supervisors and panel of experts in the field of radiography, added to ensuring reliability of the study.

In phase two, a draft guideline, including seven sets of recommendations, was developed based on data in phase one, and categorised according to three major aspects of Nightingale's environmental theory: personal cleanliness, cleanliness of rooms (environment), and health of houses. The draft guideline was developed based on the steps of NICE (2012:5). The format of the draft guideline was an adapted version of the AGREE II tool (AGREE Next Steps Consortium, 2009:2). The researcher identified the scope of the guideline, which involved identifying why it was needed. This was followed by planning of the procedure to be followed as well as what to be included in the guideline. Critical review of literature for development of the instrument was done with the help of academic supervisors. Drafting of the guideline was then done from the data derived literature and a reviewed questionnaire. This was followed by the review of the guidelines by the supervisors who are experienced in guideline development. Comments raised by them were considered. This assisted the researcher in the revision of the draft guideline. Areas considered to be of lower priority were removed and after relevant revisions, the researcher formulated and presented the final draft guideline.

The main findings in phase one and phase two are presented in the section that follow.

6.3 MAIN FINDINGS

Main findings are addressed for phase one and phase wo.

Main findings for phase one

This phase addressed objectives one and two. The findings below address questions on knowledge and practices of radiographers regarding infection control in radiology departments in government referral hospitals in Malawi. The findings were concluded from the results, and compared to the literature review. Details of the findings are presented in Chapter Four.

6.3.1 Demographic data

The findings on demographic data pertain to gender, age, level of education and experience.

Out of the 62 respondents, the majority were males; the majority were below 40 years; the majority were diploma holders; and 50% had worked for more than 5 years (Figures 4.1, 4.2, 4.3 and 4.4).

Part B of the self-administered questionnaire is discussed next.

6.3.2 Knowledge of radiographers regarding infection control

The following conclusions can be drawn from part B of the self-administered questionnaire. The best statements in terms of knowledge, as shown in Figure 4.2, were as follows.

- Statement B1: The environment (air, water, inert surfaces) is the major source of pathogenic microorganisms responsible for healthcare associated infections (98%, n=61).
- Statement B4: Standard infection control precautions include the recommendations to protect ourselves, patients and our fellow healthcare workers (98%, n=61).

Overall the worst statement, in terms of knowledge as shown in Figure 4.2, was as follows.

- Statement B9: Alcohol–based hand rubs are not effective against spore forming organisms e.g. *Clostridium difficile* (23%, n=14).

The conclusion that can be drawn from part B (knowledge regarding infection control section) of the self-administered questionnaire is that the respondents had average knowledge regarding infection control (see Table 4.3). The findings also revealed that there was a significant association between age and knowledge ($P<0.05$). Older respondents were more likely to have more knowledge than younger respondents because they have increased exposure to clinical practice or work (see Table 4.7).

Part C of the self-administered questionnaire is discussed next.

6.3.3 Practices of radiographers regarding infection control

The following conclusions can be drawn from part C of the self-administered questionnaire. The best answered question, in terms of practice as shown in Figure 4.4, was as follows.

- Question C8: Do you cover the x-ray equipment with a plastic when examining patients with isolation? (84%, n=57).

Overall the worst answered question in terms of practice, as shown in Figure 4.4, was as follows.

- Question C15: Do you cleanse and disinfect the anatomical marker and lead rubber apron with antiseptic solution every week? (10%, n=6).

The conclusion that can be drawn from part C (practice regarding infection control section) of the self-administered questionnaire is that the respondents had average practice regarding infection control (see Table 4.6). The findings revealed that there was no statistically significant association between age and practice ($P>0.05$) (see Table 4.7).

Overall, the knowledge of the respondents was not statistically significant on the practice of respondents regarding infection control.

Part D of the self-administered questionnaire is discussed next.

6.3.4 Additional relevant information regarding infection control

The following conclusions can be drawn from part D of the self-administered questionnaire.

Of the 62 respondents in the study, the majority had not attended any occupational in-service training, and, amongst those who had, very few had attended more than one occupational in-service training (see Table 4.10)

The respondents revealed that inadequate resources for infection control were the major factor outside the scope of practice that affected the implementation of infection control (see Table 4.11).

The respondents revealed that the major thing that needed to be done to improve infection control in the radiology departments in the four government referral hospitals was regular attendance of in-service trainings regarding infection control in order to enhance continuous professional development (see Table 4.12).

The conclusion that follow can be drawn from part C (practice regarding infection control section) is that more than half of the respondents had never attended any occupational in-service training in infection control, and that inadequate or lack of resources hamper the implementation of SICP; and implementation SICP can only be improved through regular attendance of in-service trainings regarding infection control by the respondents.

The results of the study revealed a significant association between age of the respondents and knowledge score ($P<0.05$). This could be explained in terms of older respondents were more likely to have more knowledge than younger respondents because they have increased exposure to clinical practice or work (see Table 4.7).

Main findings for phase two

Seven sets of recommendations were developed for radiographers practicing in radiology departments in the four government referral hospitals based on the findings of phase one**.** The developed sets of recommendations include: hand hygiene, personal hygiene, personal protective equipment (PPE), safe handling of sharps and sharp containers, decontamination and cleaning, housekeeping and routine infection control practices (see Chapter Five).

The study is linked to the Florence Nightingale’s environmental theory. The three major areas of the theory linked to the study include personal cleanliness, cleanliness of rooms (environment), and health of houses. Personal cleanliness and personal hygiene encourage radiographers to wash their hands frequently and to always maintain their cleanliness and groom their external body in order to control the spread of infection. Cleanliness of rooms assesses them for dampness and dust or mildew; as such, rooms should be kept free from dust, dirt and dampness. Health of the houses assesses the surrounding environment (radiology department) for pure air and cleanliness by removing waste around radiology departments in order to ensure that the environment is clean and has clean air.

6.4 SIGNIFICANCE OF THE STUDY

The study is the first in the field of radiography in Malawi. Results of this study should contribute to the body of knowledge of radiography practice as they should inform practicing radiographers, heads of departments, the Ministry of Health and Population, and other health practitioners, about the current practices and knowledge of radiographers in government referral hospitals in Malawi. The draft guideline for infection control should facilitate sound knowledge and practices regarding infection control among practicing radiographers in these departments. The draft guideline should also help improve the implementation of SICP both at operational and managerial levels. Results of the study also contribute to the body of knowledge of radiography education and development of further research on infection control in the radiography profession, specifically in the African context.

6.5 RECOMMENDATIONS OF THE STUDY

The analysis of the data revealed that the respondents (radiographers) had average knowledge as well as average practice scores regarding infection control. Based on the findings of the study the following recommendations are made regarding radiography practice, radiography education and radiography research.

6.5.1 Recommendations for the radiography practice

The following recommendations relate to radiography practice.

- Review of the draft guideline by an expert panel is recommended.
- The reviewed draft guideline should be implemented by radiographers in order to improve their knowledge and practices regarding infection control.
- As radiographers in this study indicated they had sufficient knowledge regarding infection control, yet did not adhere to practices on the same aspects of infection control, management of the hospital should conduct a contextual analysis regarding the reasons for infection control principles not being adhered to.

- Hospital management should procure adequate resources for infection control for prevention of HAIs.
- The radiology departments should recruit infection control officers who would be responsible for collecting, analysing and providing infection data, consulting on infection risk assessment, prevention and control strategies. Report should be given to hospital management at least annually.

6.5.2 Recommendations for the radiography education

The following recommendations are made in terms of radiography education.

- After the guideline is reviewed, the developed final guideline should be incorporated into the radiography curriculum at the training institution so that trainee radiographers are kept abreast of the guideline before they complete their studies.
- Hospital management should conduct occupational in-service trainings on infection control at least once every year for enhancement of continuous professional development or practice. Some training the radiographers need to attend include improve their infection control knowledge and practice: performing hand hygiene using alcohol-based hand rub and effectiveness of alcohol-based hands against spore forming organisms, disposal of needles after use.
- The radiographers need to attend international meetings or congress at least once every two years in order to keep abreast with changes and new developments in infection control.

6.5.3 Recommendations related to radiography research

The study was conducted in radiology departments in government referral hospitals, the results cannot therefore be generalised to other contexts. The following recommendations are made regarding future research in radiography.

- There is a need for further exploration of which resources are required for a successful implementation of SICP as well as the reasons for not adhering to the SICP in the government referral hospitals, including the radiographers' attitude towards infection control.

- There is a need to repeat the study in radiology departments in government district hospitals in order to explore and describe the knowledge and practices of radiographers in such settings. And based on that, the draft guideline can be further developed and reviewed. A future study should include an expert panel to review the developed guideline.
- After the guideline is further developed and reviewed, it should be implemented using an intervention study using a pre-and-post knowledge and practice questionnaire as well as workshops on the guideline, in order to evaluate the guideline's effect on the knowledge and practices of radiographers on infection control.
- The guideline, once reviewed and further developed, should be updated with recent literature at least every five years so that the recommendations in the guideline are current.

6.6 LIMITATIONS OF THE STUDY

The following limitations of the study were identified.

- The results may not represent all radiographers in Malawi because the study was limited to radiology departments in four government referral hospitals. However, these were the hospitals with the most invasive radiological procedures thus risk for HAIs is therefore greater.
- From the 80 self-administered questionnaires that were handed out, only 62 responded. A follow-up could have been done to enhance the respondents, however resources were a constraint; respondents could have searched for answers upon conferring with their colleagues which could have influenced the results.
- The study developed a draft guideline, but did not use an expert panel to finalise it, nor was it implemented to evaluate its effectiveness. However, review of the guideline was not part of the scope of the study thus recommendations are made for follow-up research to further develop and implement the draft guideline.

- Attitudes of radiographers regarding infection control were not measured because of the difficulties in measuring them. Recommendations were made for future studies to be conducted.

6.7 CONCLUSION

This chapter summarised the research problem and questions identified in Chapter One. It can be concluded, based on the findings of the study, that radiographers working in radiology departments in four government referral hospitals had average knowledge as well as average practice scores in terms of infection control. The draft guideline that was developed is to be distributed for use in hospitals where the study was conducted so that the radiographers are made aware of what they can do to improve their knowledge and practices towards infection control. The recommendations identified ways to further facilitate sound knowledge and practices of radiographers regarding infection control. This demonstrates that the researcher achieved the objectives set out at the start of the research study.

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ANNEXURE A: QUESTIONNAIRE ON KNOWLEDGE AND PRACTICES OF RADIOGRAPHERS REGARDING INFECTION CONTROL IN RADIOLOGY DEPARTMENTS IN MALAWI

For office use only	

QUESTIONNAIRE ON KNOWLEDGE AND PRACTICES OF RADIOGRAPHERS REGARDING INFECTION CONTROL IN RADIOLOGY DEPARTMENTS IN MALAWI[1]

INSTRUCTIONS: This questionnaire will take approximately 15-20 minutes to complete. Your identity will remain anonymous as your name will not be asked. The information given will only be used for research purposes.

Part A: Demographic information

Please mark one response with X against the chosen option in the boxes in each of the following statements.

A1. Gender

Male	
Female	

A2. Age

20 – 39 years	
40 – 59 years	
Over 60 years	

[1] Adapted from: Jayasinghe, RD. and Weerakoon, BS. 2014. Prevention of nosocomial infections and standard precautions: Knowledge and practice among radiographers in Srilanka. *Journal of Medical & Allied Sciences*, 4(1): 9 – 16.

A3. Level of education

Diploma	
Bachelor’s Degree	
Masters	

A4. Work experience as a qualified radiographer

< 1 year	
1 – 5 years	
> 5 years	

Part B: Knowledge regarding infection control

Please indicate the extent to which you agree or disagree with the following statements [MARK **X** AGAINST EACH CHOSEN OPTION]

Statement	**Agree**	**Disagree**	**I don’t know**
B1. The environment (air, water, inert surfaces) is the major source of pathogenic microorganisms responsible for healthcare associated infections.			
B2. Healthcare associated infections may be transmitted via medical equipment such as syringes.			
B3. Invasive procedures do not increase the risk of healthcare associated infections.			
B4. Standard infection control precautions include the recommendations to protect ourselves, patients and our fellow healthcare workers.			
B5. The standard infection control precautions recommend the use of gloves for each radiological procedure.			
B6. When there is a risk of splashes or spray of blood and body fluids, the radiographers must wear nothing.			
B7. Hands are the most common way in which microorganisms might be transported and subsequently cause healthcare associated infections.			

B8. The steps for performing hand hygiene using alcohol-based hand rub are the same as when performing hand washing.			
B9. Alcohol – based hand rubs are not effective against spore forming organisms e.g. *Clostridium difficile*.			
B10. There is need to recap the needle after use.			
B11. Used needles should be bent before disposal			
B12. Sharp containers must be sealed before they are taken away.			
B13. Radiographers' uniforms are a serious source of infection.			
B14. Tip of natural fingernails for radiographers should be kept as short as possible to prevent finger tips from harbouring bacteria.			
B15. It is believed that anatomical markers harbour microorganisms if not disinfected.			
B16. Waste should be disposed of immediately after use.			

Part C: Practices regarding infection control

Please indicate to what extent you engage in the following activities [MARK **X** AGAINST EACH CHOSEN OPTION]

Question	**Always**	**Sometimes**	**Never**
C1. Do you wear protective gloves and coats during procedures where there is potential for blood splatter?			
C2. Do you wash your hands after removing gloves?			
C3. Do you wash your hands with soap before and after touching any patient?			
C4. Do you wash your hands at the end of shift before leaving work?			
C5. Do you wear a mask when there is a potential to be exposed to airborne droplets or dust particles?			
C6. Do you cover your open cuts and wounds that you have during clinical work?			

C7. Do you damp dust the radiographic x-ray equipment each day you start your work?			
C8. Do you cover the x-ray cassette with a plastic when examining patients in isolation?			
C9. Do you provide each patient with a fresh gown each time he/she attends to a radiological procedure requiring a gown?			
C10. Do you remove your jewellery when performing a radiological procedure?			
C11. Do you cleanse and disinfect the x-ray couch and chest stand with antiseptic solution after every patient contact?			
C12. Do you disinfect the x-ray mobile unit when a radiological procedure is complete?			
C13. Do you make use of a different anatomical marker for each radiological procedure?			
C14. Do you check the radiographic equipment for cleanliness prior using them on other patients?			
C15. Do you cleanse and disinfect the anatomical marker and lead rubber apron with antiseptic solution every week?			
C16. Do you fold the contaminated surface of an isolation attire or gown inwards when removing the gown in readiness for discarding?			

Part D: Additional relevant information

Please, mark X against each of the chosen option or write in the spaces provided for additional answers

D1. Have you ever attended occupational in-service training sessions on infection control?

Yes	
No	

D2. If yes on D1, how many occupational in-service training sessions have you attended?

1	
2 - 3	
4 + more	
None	

D3. What factors outside your scope of practice affects how you implement standard infection control precautions?

____

D4. What recommendations will you give with regard to improvement of infection control in your radiology department?

____

Thank you for the time to complete this questionnaire

ANNEXURE B: LETTER REQUESTING PERMISSION FROM THE MALAWI NATIONAL HEALTH SCIENCES RESEARCH COMMITTEE TO CONDUCT RESEARCH IN GOVERNMENT REFERRAL HOSPITALS

Malawi College of Health Sc.
P.O. Box 30368
Lilongwe 3
Malawi.
6 November 2016

The Chairperson
National Health Sciences Research Committee
P.O. Box 30377
Lilongwe 3
Malawi.

Dear Sir,

RE: REQUEST FOR PERMISSION TO CONDUCT RESEARCH IN RADIOLOGY DEPARTMENTS IN GOVERNMENT REFERRAL HOSPITALS IN MALAWI

My name is Denis Nyirenda, and am a Masters student at Nelson Mandela Metropolitan University (NMMU) in Port Elizabeth. The research l wish to conduct for my Master's dissertation/thesis is entitled: *Knowledge and practices of radiographers regarding infection control in radiology departments in Malawi*. The project is being conducted under the supervision of Dr. W. ten Ham-Baloyi and Mrs. Razana Williams.

The goal of the study is to explore and describe knowledge and practices of radiographers regarding infection control in radiology departments in Malawi. The results of this study will inform practicing radiographers, heads of departments and the Ministry of Health and Population and other health practitioners about the current practices and knowledge of radiographers in government referral hospitals in Malawi. The draft guideline for infection control will facilitate sound knowledge and practices regarding infection control among practicing radiographers in these departments. This is expected to enable the implementation of SICP both at operational and managerial levels. Results of the study will also contribute to the body of knowledge of radiography practice, radiography education and development of further research agenda in the radiography profession, specifically in the African context.

I wish to collect data from radiographers working in government referral hospitals. The data will be collected through use of a self-administered questionnaire. The questions in the questionnaire shall relate to knowledge and practices.

Respondents will not be coerced and they may withdraw from participating in the study at any time. The information gathered will be managed confidentially. The actual names of the respondents will be replaced with pseudonyms. There are no direct benefits for the respondents, but the guidelines developed from the study will be of benefit to their future patients.

I am hereby seeking your consent to conduct research in radiology departments in government referral hospitals in Malawi. I have attached a copy of my proposal which include the copies of the consent forms to be used in the research process, as well as copies of approval letters which I received from the Nelson Mandela Metropolitan University Faculty of Health's Research, Technology and Innovation (FRTI) committee and the Nelson Mandela Metropolitan University's Research Ethics Committee (Human).

Upon completion of the study, I undertake to provide the Ministry of Health a copy of the summary report. If you require any further information, do not hesitate to contact me or 00265995165686 or s216181526@nmmu.ac.za.

Thank you for your time and consideration in this matter.

Yours sincerely,

D.C.G. Nyirenda

ANNEXURE C: LETTER REQUESTING PERMISSION FROM HOSPITAL DIRECTORS TO CONDUCT RESEARCH IN RADIOLOGY DEPARTMENTS IN GOVERNMENT REFERRAL HOSPITALS IN MALAWI

Malawi College of Health Sc.
P.O. Box 30368
Lilongwe 3
Malawi.
8 September 2016

The Hospital Director
YYYYYY Referral Hospital
P.O. Box **XXXXX**
Malawi.

Dear Sir,

RE: REQUEST FOR PERMISSION TO CONDUCT RESEARCH IN THE RADIOLOGY DEPARTMENT AT YOUR REFERRAL HOSPITAL

My name is Denis Nyirenda, and am a Masters student at Nelson Mandela Metropolitan University (NMMU) in Port Elizabeth. The research I wish to conduct for my Master's dissertation/thesis is entitled: *Knowledge and practices of radiographers regarding infection control in radiology departments in Malawi.* The project is being conducted under the supervision of Dr. W. ten Ham-Baloyi and Mrs. Razana Williams.

I wish to collect data from radiographers working at your hospital. The data will be collected through use of a self-administered questionnaire. The questions in the questionnaire shall relate to knowledge and practices.

Respondents will not be coerced and they may withdraw from participating in the study at any time. The information gathered will be managed confidentially. The actual names of the respondents will be replaced with pseudonyms. There are no direct benefits for the respondents, but the guidelines developed from the study will be of benefit to their future patients.

I am hereby seeking your consent to conduct research at your referral hospital. The letter from National Health Sciences Research Committee is attached. I have attached a copy of my proposal which include the copies of the consent forms to be used in the research process, as well as copies of approval letters which I received from the Nelson Mandela Metropolitan University Faculty of Health's Research, Technology and Innovation (FRTI) committee and the Nelson Mandela Metropolitan University's Research Ethics Committee (Human).

Upon completion of the study, I undertake to provide your hospital a copy of the summary report. If you require any further information, do not hesitate to contact me on 00265995165686 or s216181526@nmmu.ac.za.

Thank you for your time and consideration in this matter.

Yours sincerely,

D.C.G. Nyirenda

ANNEXURE D: RESPONDENT LETTER AND CONSENT FORM

Malawi College of Health Sc.
P.O. Box 30368
Lilongwe 3
Malawi
8 September 2016

Dear Sir/Madam,

RE: REQUEST FOR PERMISSION TO INTERVIEW PARTICIPANT

My name is Denis Nyirenda, and am a Masters student at Nelson Mandela Metropolitan University (NMMU) in Port Elizabeth. The research I wish to conduct for my Master's dissertation/thesis is entitled: *Knowledge and practices of radiographers regarding infection control in radiology departments in Malawi*. The project is being conducted under the supervision of Dr. W. ten Ham-Baloyi and Mrs. Razana Williams at Nelson Mandela Metropolitan University.

The goal of the study is to explore and describe knowledge and practices of radiographers regarding infection control in radiology departments in Malawi. The results of this study will inform practicing radiographers, heads of departments and the Ministry of Health and Population and other health practitioners about the current practices and knowledge of radiographers in government referral hospitals in Malawi. The draft guideline for infection control will facilitate sound knowledge and practices regarding infection control among practicing radiographers in these departments. This is expected to enable the implementation of SICP both at operational and managerial levels. Results of the study will also contribute to the body of knowledge of radiography practice, radiography education and development of further research agenda in the radiography profession, specifically in the African context.

I am hereby seeking your consent to participate in this study. The data will be collected through use of a self-administered questionnaire. The questions in the questionnaire shall relate to knowledge and practices.

You should not feel coerced. You may withdraw at any time and information will be managed confidentially. The actual names of the participants will be replaced with pseudonyms. There are no direct benefits for you, but the guidelines developed from the study will be of benefit to your patients.

Upon completion of the study, I undertake to provide your institution with a bound copy of the full research report. If you require any further information, do not hesitate to contact me on 00265995165686 or s216181526@nmmu.ac.za.

Thank you for your time and consideration in this matter.

Yours sincerely,

D.C.G. Nyirenda

Knowledge and practices of radiographers regarding infection control in radiology departments in Malawi

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

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

I may seek further information on the project from DCG Nyirenda on:

Cell: 00265995165686 Tel: 002651756908

Fax: 002651753144 Email: s216181526@nmmu.ac.za

________________________ ________________________

Name Signature

____

Date

ANNEXURE E: LETTER REQUESTING PERMISSION TO ADAPT THE QUESTIONNAIRE

Malawi College of Health Sc.
P.O. Box 30368
Lilongwe 3
Malawi
1st June 2016

Professor Ruwan Duminda Jayasinghe
Department of Oral Medicine and Periodontogy
University of Peradeniya
Peradeniya – 20400
Srilanka

Dear Sir,

RE: REQUEST TO ADAPT THE RESEARCH STUDY QUESTIONNAIRE

My name is Denis Nyirenda, and am a Masters student at Nelson Mandela Metropolitan University (NMMU) in Port Elizabeth. The research I wish to conduct for my Master's dissertation/thesis is entitled: *Knowledge and practices of radiographers regarding infection control in radiology departments in Malawi*. The project is being conducted under the supervision of Dr. W. ten Ham-Baloyi and Mrs. Razana Williams.

I have written this letter to request for your permission to adapt your questionnaire on your study on Prevention of nosocomial infections and standard precautions: Knowledge and practice among radiographers in Srilanka above study which is in *Journal of Medical & Allied Sciences 2014, (1):09-16*.

Your consideration will be highly appreciated.

Yours Sincerely,
Denis Nyirenda

ANNEXURE F: FPGSC AND RESEARCH ETHICS COMMITTEE OF NMMU APPROVAL

Nelson Mandela Metropolitan University

for tomorrow

Copies to:

Supervisor: Prof RM van Rooyen

Co-supervisor: Ms R Williams

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

Student number: 216181526

Contact person: Ms M Afrikaner

6 September 2016

Mr DCG Nyirenda
PO Box 30368
Lilongwe 3
Malawi
265
109

FINAL RESEARCH/PROJECT PROPOSAL

QUALIFICATION: MTECH RADIOGRAPHY

TITLE OF PROPOSAL: KNOWLEDGE AND PRACTICES OF RADIOGRAPHERS REGARDING INFECTION CONTROL IN RADIOLOGY DEPARTMENTS IN MALAWI

Please be advised that your final research proposal was approved by the Faculty Postgraduate Studies Committee (FPGSC).

FPGSC grants ethics approval. The ethics clearance reference number is **H16-HEA-RAD-004** and is valid for three years.

We wish you well with the study.

Kind regards,

Ms M Afrikaner
Faculty Postgraduate Studies Committee (FPGSC) Secretariat: Faculty of Health Sciences

ANNEXURE G: MALAWI NATIONAL HEALTH SCIENCE RESEARCH COUNCIL (NHSRC) APPROVAL

Telephone: + 265 789 400
Facsimile: + 265 789 431

All Communications should be addressed to:

The Secretary for Health and Population

In reply please quote No.
....

MINISTRY OF HEALTH AND POPULATION
P.O. BOX 30377
LILONGWE 3
MALAWI

12th December, 2016

Denis Nyirenda
Malawi College of Health Sciences
Lilongwe

Dear Madam,

RE: PROTOCOL # 16/12/1707: KNOWLEDGE AND PRACTICES OF RADIOGRAPHERS REGARDING INFECTION CONTROL IN RADIOLOGY DEPARTMENTS IN MALAWI

Thank you for the above titled proposal that you submitted to the National Health Sciences Research Committee (NHSRC) for review. Please be advised that the NHSRC has **reviewed** and **approved** your application to conduct the above titled study.

- **APPROVAL NUMBER : 1707**
- The above details should be used on all correspondences, consent forms and documents as appropriate.
- **APPROVAL DATE : 12/12/2016**
- **EXPIRATION DATE**
  This approval expires on **11/12/2017**. After this date, this project may only continue upon renewal. For purposes of renewal, a progress report on a standard form obtainable from the NHSRC Secretariat should be submitted one month before the expiration date for continuing review.
- **SERIOUS ADVERSE EVENT REPORTING:** All serious problems having to do with subject safety must be reported to the NHSRC within 10 working days using standard forms obtainable from the NHSRC Secretariat.
- **MODIFICATIONS**: Prior NHSRC approval using forms obtainable from the NHSRC Secretariat is required before implementing any changes in the protocol (including changes in the consent documents). You may not use any other consent documents besides those approved by the NHSRC.
- **TERMINATION OF STUDY**: On termination of a study, a report has to be submitted to the NHSRC using standard forms obtainable from the NHSRC Secretariat.
- **QUESTIONS**: Please contact the NHSRC on phone number *+265 888 344 443* or by email on mohdoccentre@gmail.com.
- **OTHER**: Please be reminded to send in copies of your final research results for our records (Health Research Database).

Kind regards from the NHSRC Secretariat.

SECRETARY FOR HEALTH
2016 -12- 12
P.O. BOX 30377, CAPITAL CITY, LILONGWE 3

....

For: **CHAIRPERSON, NATIONAL HEALTH SCIENCES RESEARCH COMMITTEE**

Promoting Ethical Conduct of Research[1]

Executive Committee: *Dr B. Chilima (Chairperson), Dr B. Ngwira (Vice-Chairperson)*
Registered with the USA Office for Human Research Protections (OHRP) as an International IRBIRB Number IRB00003905 FWA00005976

ANNEXURE H: HOSPITAL DIRECTORS FROM THE FOUR GOVERNMENT REFERRAL HOSPITALS APPROVAL

[redacted]

All communications should be addressed to:
The Hospital Director

In reply please quote No. QEC/GEN/2

[redacted]
MALAWI

03rd November 2016

The Chairperson
NHSRC
P. 0. Box 30377
Lilongwe 3

Dear Sir,

RE: KNOWLEDGE AND PRACTICES OF RADIOGRAPHERS REGARDING INFECTION CONTROL IN THEIR DEPARTMENT BY MR D. NYIRENDA

We are writing in support of the above named study that it can take place at this hospital as envisaged. Its goal is to determine the knowledge and practices of radiographers in infection prevention.

We hope that the findings will further inform the effective utilization of infection prevention guidelines by practicing radiographers and other staff that work in radiology departments.

[redacted]

HOSPITAL DIRECTOR

[redacted]

[redacted]

MALAW

1ST SEPTEMBER 2016

Ref : nhsrc 2016

The Chairman,

National Health Sciences research Committee,

Ministry of Health,

P.O. Box 30377,

Lilongwe 3.

Dear Sir,

RE: LETTER OF SUPPORT FOR A STUDY TITTLED : KNOWLEDGE AND PRACTICES OF RADIOGRAPHERS REGARDING INFECTION CONTROL IN RADIOLOGY DEPARTMENTS IN MALAWI

I am writing this letter of support for this study named above. The proposal is being submitted to the National Health Sciences Research Committee for review.

The study will help to ascertain the knowledge and practices of radiographers regarding infection prevention in radiology departments in Malawi.

I support this study and look forward to your favorable review

Yours Sincerely,

[redacted]

Hospital Director [redacted]

[redacted]

Please address all communications to:
The Hospital Director

[redacted]

MALAWI

29th September, 2016

The Chairperson
National Health Sciences Research Committee
Ministry of Health
P.O Box 30377
Blantyre

Dear Sir,

LETTER OF NO OBJECTION

The Management of [redacted] Hospital is pleased ro inform you that Denis Nyirenda would like to conduct a study at the facility as a study site and the management has no objection.

The title of research 1s ***"Knowledge and*** *Practices of* ***Radiographers regarding Infection control*** *in Radiology* ***Departments in Malawi".***

Your consideration will be greatly appreciated. Thanks in advance

Yours faithfully

[redacted]

HOSPITAL DIRECTOR

[redacted]

In reply please quote No.................................

[redacted]

October 04, 2016

Denis Nyirenda
Nelson Mandela
Metropolitan University
Faculty of Health Sciences
Republic Of South Africa

Dear Sir,

APPROVAL TO CONDUCT A RESEARCH STUDY AT [redacted] HOSPITAL

Refer to your letter dated September 2016 in which you requested for permission to conduct a study titled **"Knowledge and Practices of Radiographers regarding infection control in radiology departments in Malawi"** at our institution [redacted] Hospital).

I am pleased to inform you that your request has been approved. You will be required to present this letter to the in-charge of the department you have selected before you can start your data collection.

Yours sincerely,

[redacted]

For: THE HOSPITAL DIRECTOR

ANNEXURE I: LETTER OF APPROVAL TO ADAPT THE QUESTIONNAIRE

Prof. Ruwan Jayasinghe <ruwanduminda@yahoo.com> Today at 16:36

To denis nyirenda < nyirendadenis@yahoo.co.uk

10 June 2016

Herewith I am granting permission to use the questioners used by me in my research.

With Regards

Ruwan

Prof. Ruwan D. Jayasinghe BDS(SL), MS(Col)
Professor in Oral Medicine and Radiology and Specialist in OMF Surgery,
Dept. of Oral Medicine and Periodontology,
Faculty of Dental Sciences,
University of Peradeniya,
Peradeniya
(94) 0777 373689

Director, Centre for Research in Oral Cancer

ANNEXURE J: THE ADAPTED QUESTIONNAIRE

A study on **"Prevention of nosocomial infection and standard precautions: knowledge and practice among radiographers in Sri Lanka"[2].**

****INSTRUCTION:** Please, tick the relevant box for any option chosen or write in the space provided for additional answers.

[A] Personal Information:

1. Which age group do you belong to?
(a) 20-29 yrs
(b) 30-39 yrs
(c) 40 – 49 yrs
(d) 50 yrs and above

2. Gender
(a) Male
(b) Female

3. Place of work?
(a) Teaching Hospital
(b) Government hospital (other than teaching)
(c) University
(d) Private Hospital / Clinic
(e) Others, specify……………………………

4. What is your highest educational qualification regarding to your profession?
(a) M Sc
(b) B Sc
(c) Diploma
(d) Others, specify.………………….

5. Number of years of radiography practice?
(a) Less than 1 year
(b) 1 – 5 years
(c) 6- 10 years
(d) More than 10 years

6. Have you ever received occupational training on blood and body fluid universal precautions
(a) Yes
(b) No

[B] Knowledge regarding infection control

7. The environment (air, water, inert surfaces) is the major source of bacteria responsible for nosocomial infection.
(a) Agreed (b) Disagreed (c) Don't Know

8. Invasive procedures do not increase the risk of nosocomial infection.
(a) Agreed (b) Disagreed (c) Don't Know

[2] Jayasinghe, RD. and Weerakoon, BS. 2014. Prevention of nosocomial infections and standard precautions: Knowledge and practice among radiographers in Srilanka. *Journal of Medical & Allied Sciences*, 4(1): 9 – 16.

9. *Standard Precautions* include the recommendations to protect both patients and the health workers.
(a) Agreed (b) Disagreed (c) Don't Know

10. *The standard precautions* recommend use of gloves for each procedure
(a) Agreed (b) Disagreed (c) Don't Know

11. When there is a risk of splashes or spray of blood and body fluids, the healthcare workers must wear nothing
(a) Agreed (b) Disagreed (c) Don't Know

12. Instead of surgical and antiseptic hand washing alcohol-based hand rub will be use
(a) Agreed (b) Disagreed (c) Don't Know

[C] Practice regarding infection control

13. Do you wear protective gloves & coats during procedures where there is the potential for blood splatter?
(a) Always (b) Sometimes (c) Never

14. Do you change your personal protective habits if you know the patient has Hepatitis B or C?
(a) Always (b) Sometimes (c) Never

15. Do you wash your hands before touching the patient?
(a) Always (b) Sometimes (c) Never

16. Do you wash your hands after touching the patient and every clinical exposure?
(a) Always (b) Sometimes (c) Never

17. Do you wear a mask or respirator when there is a potential to be exposed to respiratory aerosols?
(a) Always (b) Sometimes (c) Never

18. Do you cover the open cuts and wounds during clinical work?
(a) Always (b) Sometimes (c) Never

Thank you for your kind co-operation!!

ANNEXURE K: THE AGREE II TOOL AND APPLICATION

Domains and Items of the AGREE II tool[3]	**Items used for the draft guideline for infection control**
Domain 1. Scope and Purpose	
1. The overall objective(s) of the guideline is (are) specifically described.	See 5.2.2 Purpose
2. The health question(s) covered by the guideline is (are) specifically described.	See 5.2.3 Scope
3. The population (patients, public, etc.) to whom the guideline is meant to apply is specifically described.	See 5.2.4 Target group
Domain 2. Stakeholder Involvement	
4. The guideline development group includes individuals from all the relevant professional groups.	
5. The views and preferences of the target population (patients, public, etc.) have been sought.	See 5.2.5.1 Stakeholder involvement
6. The target users of the guideline are clearly defined.	See 5.2.4 Target group
Domain 3. Rigour of Development	
7. Systematic methods were used to search for evidence.	
8. The criteria for selecting the evidence are clearly described.	
9. The strengths and limitations of the body of evidence are clearly described.	
10. The methods for formulating the recommendations are clearly described.	See 5.2.5 Development of the draft guideline
11. The health benefits, side effects, and risks have been considered in formulating the recommendations	
12. There is an explicit link between the recommendations and the supporting evidence.	See 5.4 Sets of recommendations

[3] AGREE Next Steps Consortium. 2009. The AGREE II Instrument. http://www.agreetrust.org. (Update 2013, September) [Electronic version] Retrieved 26 April 2017.

13. The guideline has been externally reviewed by experts prior to its publication.	
14. A procedure for updating the guideline is provided.	See 5.2.5.2 Review of the guideline
Domain 4. Clarity of Presentation	
15. The recommendations are specific and unambiguous.	
16. The different options for management of the condition or health issue are clearly presented.	
17. Key recommendations are easily identifiable.	See 5.4 Sets of recommendations
Domain 5. Applicability	
18. The guideline describes facilitators and barriers to its application.	
19. The guideline provides advice and/or tools on how the recommendations can be put into practice.	
20. The potential resource implications of applying the recommendations have been considered.	
21. The guideline presents monitoring and/or auditing criteria.	
Domain 6. Editorial Independence	
22. The views of the funding body have not influenced the content of the guideline.	
23. Competing interests of guideline development group members have been recorded and addressed.	