UNIVERSITY OF NAIROBI

EVALUATION OF RADIATION PROTECTION (KNOWLEDGE, ATTITUDE AND PRACTICES) AND RADIATION SIDE EFFECTS AWARENESS AMONG HEALTH WORKERS IN BUNGOMA COUNTY REFERRAL HEALTH FACILITIES

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DECLARATION

I, **Dr Moses Gachigi Macharia,** do hereby declare that this proposal based on actual and original work carried out by me.

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ACRONYMS AND ABBREVIATIONS

ALARA	As Low as Reasonably Achievable
ERC	Ethics Review Committee
ICRP	International Commission on Radiological Protection
KNH	Kenyatta National Hospital
MPD	Maximum Permissible Dose
NACOSTI	National Commission for Science, Technology and Innovation
RPC	Radiation Protection Culture
SPSS	Statistical Package for Social Sciences
UNSCEAR	United Nations Scientific Committee on the Effects of Atomic Radiation
UoN	University of Nairobi
DDIRM	Department of Diagnostic Imaging and Radiation Medicine.
WHO	World Health Organization
MOH	Ministry of Health
PPD	Personal Protective Devices
PPE	Personal Protective Equipment
TLD	Thermoluminescent dosimeter

OPERATING DEFINITIONS

Radiation Protection: It is the protection of individuals from adverse effects resulting from exposure to harmful ionizing radiation, including the means to achieving the protection. (IAEA, 2016)

Radiation: In this context, it is the energy emanating from diagnostic equipment and travels via space with the ability to penetrate human or material surfaces.

Ionizing radiation: This is a term given to forms of radiation that are energetic enough to displace orbiting electrons from the atoms in the absorbing medium, thus forming positive ions.

Radiation Adverse Effects: The negative effects that result from radiation exposure.

ABSTRACT

Study background: There has been an increase in ionizing radiation producing diagnostic equipment in Kenya. While its use is highly beneficial in medical diagnosis, exposure to high doses of ionizing radiation to patients and health workers are hazardous. Hence, health workers must have adequate knowledge of radiation protection to ensure their safety and that of their patients. However, the knowledge and practices of healthcare workers regarding radiation protection in Western Kenya are largely unknown due to the paucity of data.

Broad objective: To assess the knowledge, attitude, and practices on radiation protection and radiation side effects awareness among health workers in the Bungoma County Referral Health Facilities.

Study design and sites: A cross-sectional observational study was carried in Bungoma County Referral Health Facilities (Bungoma County Referral Hospital and Webuye County Hospital).

Participants and methods: The study included nurses, clinical officer interns, clinical officers, medical officer interns, medical officers, residents and specialists in the study facilities. A sample size of 339 conveniently selected health workers was included in the study. Research assistants were employed for the actual data collection after a one-day training exercise. Data was collected using a semi-structured questionnaire. Descriptive statistics were used to analyze the data with mean or median for continuous variables and frequency and percentages for the categorical variables. The Chi-square test was used to determine the association between knowledge, attitude, and practices with p-value of < 0.05 considered statistically significant.

Utility of the study: The study aimed to identify gaps in knowledge on radiation protection and radiation side effects in order to inform the need and design of interventions measures.

1.0 CHAPTER ONE: INTRODUCTION

1.1 Background

Radiation protection is concerned with protecting people and their environment from the adverse effects caused by ionizing radiation. It encompasses all activities and measures put in place to minimize exposure of patients and workers to radiation during x-ray exposure (1).

The critical aim of radiation protection is to define ways of protecting people from harmful ionizing radiation (2). In the use of all ionizing examinations, The As Low as Reasonably Achievable (ALARA) principle has to be maintained

The fundamental principles regarding radiation protection include optimization, justification, and dose limitation.

These principles are defined as follows:

i. The Principle of Justification: Any decision that alters the radiation exposure situation should do more good than harm. (3)

ii. The Principle of Optimization of Protection: The likelihood of incurring exposure, the number of people exposed, and the magnitude of their individual doses should all be kept as low as reasonably achievable, taking into account economic and societal factors. (3)

iii. The Principle of Application of Dose Limits: The total dose to any individual from regulated sources in planned exposure situations other than medical exposure of patients should not exceed the appropriate limits. (3)

With an understanding of these principles, only exposing people who are likely to get maximum benefits from the exposure to ionizing radiation (justification), ensuring that the doses of radiation exposure do not exceed the required amount for diagnosis (optimization) and minimizing the exposure time are the essential means of attaining radiation protection. Likewise, utilization of immobilizers, positioning aids, devices to limit beam size, and the state and type of x-ray machines have an important role in radiation protection. Besides, installed radiation protection instruments like personnel exit monitors, area radiation monitors, contamination monitors, and portable instruments like lead rubber shields, survey meters, and dosimeters are critical. Other radiation protection measures include regular servicing of x-ray machines and quality assurance checks (4).

Uncontrolled ionizing radiation exposure has been proven scientifically to damage living tissues when exposure dosage is high. It also increases the risk of tumors, cancer, and genetic malformation (5). Despite these facts, ionizing radiation's utilization has increased tremendously worldwide from the time x-ray was discovered in 1895. Medical utilization of ionizing radiation currently accounts for more than 95% of human-made radiation exposure, ranking second to natural background radiation (6). With the increasing utilization of computer tomography (CT) in developing countries, recent data show that approximately 3.6 billion imaging per year were conducted globally, resulting in 70% global collective effective dose for diagnostic medical procedures (7).

In the past 15 years, there has been a 3-fold increase in CT scan examinations, contributing to approximately 60% of the total dose associated with x-ray examination (Hart et al., 2010). The most common CT scan examination in patients - the head CT scan - produces an effective dose of approximately 4 mSv while the coronary angiography and abdomen CT examination can be up to 32 mSv and 25 mSv in that order (8).

The yearly allowed dose for certified radiation workers by the International Commission on Radiation Protection is 20 mSv annually, while that for the public is 1 mSv. The organ and tissue effective dose is sometimes projected to exceed that, as shown in epidemiological studies, resulting in increased deterministic effects (9). The common use of ionization radiation for therapeutic and diagnosis procedures necessitating high doses like intervention radiology and computer tomography presents health and safety concerns to the patient and health providers (10).

Even at lower levels, the biological radiation effects are public health concerns and can lead to stochastic effects, like cancer (11). Continued long term exposure is the most significant concern due to the radiation accumulation for the health workers career, which can result in an accumulative risk (12).

In most instances, health workers who work in areas that utilised ionizing radiation but not in radiation-related occupations do not have adequate knowledge regarding the risks of radiation exposure and the steps to follow in order to reduce the likely risks. These included physicians, nurses, technicians and other staff in these areas. (13). Lack of adequate knowledge regarding radiation protection and poor practises was reported among cardiologists in a study conducted in Karachi (14). It has also been pointed out that having knowledge alone does not always translate into better practises with regards to radiation protection. This has been linked to the effects of negative attitude on radiation protection practices, limiting knowledge utilisation in practice (4).

Knowledge of radiation protection and exposure measurement among African intervention radiologists was also low, with low usage of radiation protection equipment. The lack of

protection tools and limited knowledge regarding exposure monitoring and radiation protection were associated with the limited ionizing radiation self-protection in the participants (15).
Kenya has a nuclear regulatory act providing guidelines for protecting the public and health workers from the dangers associated with using equipment and materials that are likely to produce high ionizing radiation. The Act spells out the formation of the nuclear regulatory authority and its mandate of implementing the Act's provision and any other regulations under the Act's mandates to offer the public and health providers protection from the effects of ionizing radiation (16).
However, there is limited local data on knowledge and practices of clinicians on ionizing radiation protection. A study conducted at Kenyatta National Hospital found that most health workers had limited knowledge of ionizing radiation protection and did not consider it a factor in deciding to send a patient for imaging. Besides, only one participant had attended a continuous medical education on ionizing radiation (17).

Having a clear understanding of the radiation protection principles and their use in practice is vital for all health workers. However, there are misconceptions regarding radiation that are common, resulting in fear and concerns with the ability to affect patients' care (17) negatively. In some instances, the physicians underestimate their likely risk of exposure to ionizing radiation (18). Awareness levels regarding radiation protection play a role in influencing the behaviour of healthcare workers. If they have adequate knowledge of radiation safety, they are likely to act in a way that will ensure safety without the occurrence of adverse events due to high ionizing radiation exposure (19).
Hence, there is a need for a comprehensive evaluation of practises and competencies of healthcare workers dealing with ionizing radiation equipment, especially regarding the additional safety awareness which needs to be addressed to achieve the needed safety knowledge and practises among healthcare providers. This will increase the understanding and knowledge of radiation protection and safety principles among healthcare providers (20). To achieve this, it is essential to understand what the health providers know and their practices regarding radiation protection to identify gaps that require interventions**.** This study aimed to assess what the health care workers in Bungoma know regarding radiation protection and its effects.

2.0 CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

This chapter reviews the knowledge, attitude and practices of health workers on radiation hazards as well as radiation protection methods and the associated factors. It is divided into five sections, with the first and second sections dealing with health workers' knowledge on radiation hazards and radiation protection methods, respectively. The third section is on attitude, while the fourth section reviews health workers practices on radiation protection. The last part is on the factors associated with health workers' knowledge and practices on radiation protection.

2.2 Knowledge of Radiation Protection among Health Workers

In a review of studies assessing knowledge, attitude, and practices of healthcare workers on radiation protection, 41 studies were found, of which 33 had assessed their knowledge. Knowledge was grouped as poor, average, and sufficient in most or low and high. From a meta-analysis of the studies, the lowest level of knowledge was 2%, while the highest was scored at 95%. More than half of the individual study participants had good level of knowledge on radiation protection. The knowledge levels ranged from 39-76%, 59-95% and 10-94% for dentists, radiologists, and medical students, respectively (21).

A study conducted in Italy assessing radiation protection among Italian radiographers found that only 12.1% had attended regular radiation protection training. While most (90%) radiographer report to be aware of radiation protection issues, most were found to underestimate the radiation doses of nearly all radiological procedures. Only a few participants claimed that abdominal ultrasound and magnetic resonance imaging exposed patients to ionizing radiation. Of the radiographers included, 7.0% stated that mammography does not make use of ionizing radiation. Cancer induced by radiation was thought by half of the participants not to be dependent on gender or age (22).

In a study conducted in United States among 267 cardiology fellows, 82% had been formally trained on radiation safety, 58% knew their hospital work policy on pregnancy radiation, and 60% were aware regarding how to contact the radiation safety officer of their hospital (23).

Another study conducted in the USA among American Society of Radiological Technologists, Association of Interdisciplinary Doctor of Health Sciences, American Academy of Physician Assistants, Health Physics Society, American Academy of Health Physics members found that most of them (89%) consistently wore dosimeters, while 6% did not wear them consistently or were not required to do so. Most (70.4%) reported knowing their approximate occupation radiation exposure in the previous year. None of the physician assistant included in the study was aware of their radiation exposure associated with their occupation (20).

Most of the medical physicists were aware of their occupational exposure. Previous year exposure was known by 88.8% of the nuclear medicine technologists, 67.3% of radiology technologists and 52.3% other categories of healthcare workers. Among the participants, 64% had participated in radiation safety training at their institution of work, less than half did not have an opportunity to get periodic training on radiation safety. Only nuclear medicine technologists and physicians had received periodic training on radiation safety, with 78.5% of other healthcare professional cadres, 68.2% of medical physicists, 60.5% of radiologist technologists and 33.3% of physician assistants received it. Most of the study participants reported being aware of the contacts of the facilities radiation safety officer (RSO) and the facility's worker policy on pregnant radiation, with only 16% being unaware of it. Most of the participants suggested the need for further training on the biological effects of radiation and radiological emergency procedures (20).

A study carried out at Suez Canal University hospital in Egypt involving physicians reported most not having received radiation safety training, and most had not read about radiation safety. Among the participating physicians, 63.3% identified chest x-ray equivalent dose correctly, 60% correctly identified the required radiation equivalent dose. However, less than half could identify the equivalent chest x-rays number for different radiological investigations (24).

In South Africa, a study among nurses in Northern Gauteng State Hospitals found that most nurses had not received any radiation safety training, and 63% had never received radiation safety lessons while in college. Most were not aware of the radiation-safe distance, more than half were not aware of radio-sensitive human body organs, and most were also not aware of the radio-opaque devices. Nearly half of the nurses did not wear dosimeter while in radiology suites (25).

In Northern Nigeria, a facility study found that in excess of half of the health workers knew of dosimeters as the device used for measuring radiation exposure, 30% were aware of the required ionizing radiation dose limit for health personnel aged 18 and above per year. However, the knowledge of these was not associated with their socio-demographic information. While most participants knew of the protective devices they could use to minimize ionization radiation exposure, approximately half of them (53%) had in-depth knowledge of the different personal protective devices (PPDs) they could use (26). Most identified lead apron as a PPD to minimize exposure, but only a small number knew of lead gloves, gonad shield, thyroid shields, and lead goggles. Many males and married individuals had a high level of knowledge of PPDs than their female and single counterparts (26).

In a study conducted at Kenyatta National Hospital (KNH) among clinicians, it was found that more residents, consultants, and medical officers were able to identify imaging modalities that produce ionizing radiation than clinical officers. Having received training on ionization radiation was associated with a high level of knowledge of imaging modalities that produce ionizing radiation. The length of experience, area of training, and having received formal training on ionizing radiation significantly influenced the clinicians' knowledge (17).

2.3 Knowledge of Radiation Adverse Side Effects

According to the findings of the study conducted in Nigeria, most of the study participants knew that ionizing radiation exposure could result in body harm and cause sicknesses. Approximately half had better understanding of the hazards of radiation. The commonly known hazard associated with ionizing radiation among the participants included infertility among women and men exposed to the radiation and development of congenital abnormalities born of mothers exposed to the ionizing radiation during pregnancy. Only a few knew that death could result from ionizing radiation exposure. More males were aware of the hazards of ionizing radiation compared to females. Professional health workers, including physicians, nurses, and imaging specialists, had a high level of knowledge of ionizing radiation hazards compared to staff involved in administrative duties and support staff (26).

In Ghana, a study assessing nurse's awareness of ionizing radiation found that 95.3% of the nurses identified x-rays as sources of ionizing radiation but were unaware of other ionizing radiation types. 47% demonstrated no knowledge of the subject. They could therefore not provide any explanation. While 37% were determined to have average knowledge, 16% of them were graded poorly. No nurses were categorized as having very good knowledge of the subject. Ionizing radiation was indicated by more than 16% of the participants to be directly detectable by human senses (27).

2.4 Attitude of Health Personnel on Radiation Hazards and Protection

In the recent review by Behzadmehr et al., (21), 6 of the 41 included studies had assessed the attitude of the health personnel on radiation protection, being mostly classified as positive or negative attitude. The lowest and highest reported positive level of attitude was 61% and 88%, respectively. A study looking at the attitude of health workers on radiation protection in Iran found than only less than half believed film badge was the suitable monitoring device for staff absorbed dose measurement. Some did not trust the equipment and safety standards put in place at their place of work, with most believing that it was more dangerous to work with radiation than other medical areas. Most believed that they would not choose a career involving use of radiation if they had the chance to choose their career again. A small proportion felt that healthcare-related setting occupation exposure while pregnant could be associated with high fetal defects risks (28).

In the study carried out in Egypt, 65% of the participating physicians believed that radiation protection procedures and policies in their facility were easy to understand and clear, with more than half being confident of the precautions in place for radiation protection. Most were also aware of the contact person at the facility for radiation protection issues. Half were of the feeling that they had the ability to explain the necessary radiation protection precautions to their patients and visitors at the facility. Most were of the feeling that their safety was not guaranteed while managing their patient's radiological procedures. Most were of the feeling that their facility conducted monitoring of their radiation exposure at the facility (24).

2.5 Practices on radiation protection among health workers

In the review by Behzadmehr et al. (21), 15 of the 41 included studies had assessed the radiation protection practices of health workers, being mainly classified as good, average or poor. Most studies found health workers to have average practices.

In the United stated, the study involving cardiology fellows found that approximately half of them always put on dosimeters. However, most were not aware of their radiation exposure levels for the previous year. Most were aware of the recommended levels of radiation exposure. On protective measures, 62% conducted their work together with attending physicians who adhere to the "as low as reasonably achievable" (ALARA) strategy while carrying out procedures such as catheterization with lead shields being used by 93%, thyroid collars by 94%. Radiation protection googles being used by 31%, while 55% used dosimeters, and 27% used RadPad (23).

In the study by Alavi and colleagues in Iran, it was found that most of the health personnel had personal dosimeters and more than half reported having worked in a radiation work environment without having their dosimeters on. Others reported having used their dosimeter in non-recommended sites (28).

In a study involving physicians serving in cardiology catheterization laboratories carried out in Africa, less than half had undergone radiation protection training. A majority used lead aprons consistently as recommended. Similarly, most (77%) made use of their thyroid shields.

However, only a small number of utilized eyeglasses protection. The use of dosimeter was also low, with only 37.7% using them. A majority also reported the presence of the lead shield mounted in their ceiling. Most knew their lead exposure in the previous year, with the exposure ranging from less than 2 to 30 mSv; however, some did not know their dose levels (15).

In the study done in Nigeria, most participating health workers considered themselves at high risk of radiation exposure and considered radiation safety essential. Most (76%) reported putting on a PPD during working hours to minimize hazardous radiation exposure. However, the consistent use of their PPD was found to be very low. Those who reported using dosimeters consistently were found to have them during the assessment (26).

In Uganda, a study conducted among public health dental officers and dentist reported some degree of access to x-ray machines at 30% for the public health dental officers. An assessment of the machines and equipment used found that most were not to the standard used in European countries. Most of the dentists made use of x-ray machines which had mechanical timers, but a good number (28%) utilized x-ray machines which did not have visual warning signals, while 17% made use of those machines with no functional audio warning signals. The majority of the machines used were more than 30 years old, and only 15% of the participating dentist could remember the machine's maintenance's last date. Most reported standing at safer distances during radiation exposure. However, 10% demonstrated standing in the path of the beams during the procedure. More than half (69%) were not aware of any Uganda specific regulations regarding radiographic safety in dental procedures, with 42% reporting having never received any traini9ng on safety in radiology. On safety device use, most reported use of lead aprons during the radiological examination of their patients and 74% said they conducted quality assessments of the films they used (29).

In the study among clinicians at KNH, it was found that only a few considered ionizing radiation as a key issue in sending patients for imaging, and they rarely informed their patients of the likely risks of ionizing radiation. Only one of the 170 participants had ever attended continuous medical education on ionizing radiation protection (18).

2.6 Factors Associated with Knowledge and Practices of Health Workers on Radiation Hazards and Protection.

In the study among health workers in Iran, radiation workers practices and attitude were significantly associated with their sex, with women having significantly better radiation protection practices. Compared to other health workers, those with a degree in radiology had better knowledge levels. On regression analysis, marital status, education level and field of study had a significant association with knowledge level. Besides, there was a significant association between attitude and in-service training on radiation protection. The radiation protection practices were significantly predicted by years of experience and gender of the health personnel (28).

In the study among cardiologist fellows in the US, years of cardiology fellowship were a significant predictor of RadPads use. The lowest use in all procedures was found among those fellows with more training years. On multivariate analysis, having received formal radiation protection was significantly associated with knowledge on past radiation exposure dose, knowledge on safe exposure levels, knowledge of the facility radiation protection officer's name, 100% use of RadPads and dosimeters. Knowledge of the last time personal lead had been inspected for cracks was associated with knowledge of the previous years' radiation exposure levels. The use of dosimeters and Radpads while conducting procedures was more likely in fellows whose colleague physicians utilized the strategy of ALARA (23).

2.7 Problem Statement

Yearly, about 7 million health workers globally are exposed to ionizing radiation doses in line with their duty (45). Hence, the utilization of ionizing radiation has both advantages and disadvantages. While the benefits of its use to the patient are enormous, inappropriate and unskilled utilization of the technologies associated with radiation can result in a health hazard that can harm the radiation health worker and the patients (30). Reactions might result due to exposure to ionizing radiation (stochastic effects or deterministic effects) (31). Hence, there is an urgent need for greater attention to reducing unnecessary radiation exposure to patients, health workers and the public (32).

Besides, the scope of percutaneously performed procedures has increased steadily. The complexity of these procedures in terms of technicality and anatomy necessitates longer fluoroscopy and time for image capture leading to high radiation exposure to both the interventional health providers and the patients (33). Such procedures lead to diverse new groups of health providers, including the anesthesiologist, interventional health staff and operating room health staff who assist in the procedures to be exposed to radiation from fluoroscopy and interventional CT imaging. Therefore, the health workers taking part in such procedures must have knowledge regarding radiation exposure and are offered the necessary equipment to monitor and protect themselves (34).

A review conducted regarding health providers' knowledge of radiation protection shows that most of the available studies are from high-income countries. The review found that most health professionals did not have adequate knowledge regarding radiation dose and the linked effects of imaging procedures (35-39). Studies among medical students also reported that they did not have adequate knowledge of radiation doses and the effects associated with radiation exposure (22, 40).

However, health workers' knowledge and practices on radiation safety and risks remain highly unexplored, especially in Sub-Saharan Africa. There is a dearth of research work on the area in Kenya, hence a gap in knowledge and limited data to inform policies and interventions measures.

2.8 Justification

With the advancement of imaging technology, the utilization of ionizing radiation for beneficial diagnosis purposes have increased in recent times globally (41). This has been especially in the medical sector, where a marked increase in the demand for radiological imaging for medical purposes, including therapeutic and diagnosis. X-ray imaging reports inform approximately 30-50% of the medical diagnosis (18). Hence, exposure to ionizing radiation by health workers in the medical sector is inevitable (32). The utilization of radiation to improve public health exposes the health workers and their patients to ionizing radiation that is potentially hazardous (42).

Radiation protection culture (RPC) consists of the practices, policies, attitudes, and priorities regarding radiation safety. A dynamic process requiring continuous evaluation and improvements, using both qualitative and quantitative approaches to look at how well the implementation of RPC is and achieving the intended goals, is the foundation of RPC programs. Such programs are vital parts of the routine clinical practice and necessitate an in-depth understanding of radiation-associated risks, safety guidelines and involvement of all key stakeholders. Lack of teamwork and in-depth knowledge are the main barriers of the RPC program implementation (10). For the RPC program to be successfully established and operationalized, employees, authorities, patients, and professionals need to fully understand RPC's impact and role in the health system and be able to bridge the gap between theory and practice.

Available studies have presented varied knowledge, attitudes, and radiation protection practices in different countries (28, 43). With some demonstrating that those health workers with a high level of knowledge on radiation protection may negatively affect the subject. The striking feature was the fact that most of these studies were conducted in high-income countries

(21) with limited data from developing countries like Kenya hence the need for such local data to inform local practices.

Knowledge of radiation adverse effects and radiation protection is paramount for all health workers. Although several health personnel cadres are professionally not involved directly with radiology procedures, handling patients referred for radiological examinations is included in their duties. Regarding nurses working in these study sites, their lines of duty involve contact with mobile diagnostic imaging facilities. Knowledge of radiation protection is therefore necessary for ensuring effective medical, occupational and public radiation protection. Hence, it is vital to assess the level of awareness among different health cadres to provide comprehensive data to inform local policies and the need for interventions.

Assessment of baseline understanding of radiation adverse effects and practices in radiation protection is crucial in enabling the design of appropriate policies to prevent unnecessary exposure to ionizing radiation among all health workers and patients. Therefore, this study aims to assess awareness of radiation protection and adverse radiation effects among health workers in Kenya.

2.9 Research Questions

a) What is the level of knowledge on radiation protection methods and radiation adverse effects among the health workers in Bungoma County Referral Health Facilities?

b) What is the attitude of health workers on radiation protection and radiation adverse effects in Bungoma County Referral Health Facilities?

c) What are the practices on radiation protection among health workers in Bungoma County Referral Health Facilities?

d) What factors are associated with health workers' knowledge and practices on radiation protection and radiation adverse effects awareness in Bungoma County Referral Health Facilities?

2.10 Objectives

2.10.1 Broad Objective

To assess the knowledge, attitude, and practices on radiation protection and radiation adverse effects awareness among health workers in the Bungoma County Referral Health Facilities.

2.10.2 Specific Objectives

a) To establish the level of knowledge of radiation protection methods and radiation adverse effects among the health workers in Bungoma County Referral Health Facilities.

b) To assess the attitude of health workers on radiation protection and radiation adverse effects in Bungoma County Referral Health Facilities.

c) To determine the practices on radiation protection among health workers in Bungoma County Referral Health Facilities.

d) To determine the factors associated with health workers' knowledge and practices on radiation protection and radiation adverse effects awareness in Bungoma County Referral Health Facilities.

3.0 CHAPTER THREE: METHODOLOGY

3.1 Study Design

This was a cross-sectional study that simultaneously assessed the knowledge and practices of health personnel regarding radiation protection as well as the side effects and the associated factors (Setia, 2016).

3.2 Study Setting

The study was conducted at level five and four facilities in Bungoma Counties: Bungoma County Referral Hospital and Webuye County Hospital. Bungoma County has 105 public health facilities with 32 nurses per 100,000 people, six doctors per 100,000 people and 11 clinical officers per 100,000 people (44).

3.3 Study Population

Selected health workers, including radiologists, radiology technologists, nurses, clinical officer interns, clinical officers, medical officer interns, medical officers, dentists, dental technology officers, residents and consultants working in the two facilities in Bungoma County and formed the study population.

3.4. Inclusion criteria

- Health workers of the specified cadres who were on duty during the study period.
- Those who consented to participate in the study.

3.5. Exclusion criteria

- Those on leave.
- Undergraduate and Diploma students of the different cadres on attachment at the facilities.

3.6 Sample Size

The study sample size was determined using fisher's formula for sample size calculation.

$$n = \frac{z^2pq}{d^2}$$

Where n= desired sample size (if the population is greater than 10,000).

Z=Standard normal deviation at the required confidence interval. In this case it is 1.96

P=the proportion in the target population estimated to have characteristics being measured. (0.5) q = (1-p)

Hence q = (1-0.5)

d = the level of statistical significance was set as 0.05

Hence $n = \frac{(1.96)^2 \ (0.05)\ (0.05)}{(0.05)^2}$

$= \frac{0.9604}{0.0025}$

$= 384$

3.7 Sampling Technique

Convenient sampling was used in selecting health personnel to participate in the study. This is a non-probabilistic sampling method with sample selected from eligible individuals who are easy to reach or readily available to participate in the study. For this present study, the health workers of the specified cadres at the two facilities were selected as they became available until the sample size was reached.

3.8 Data Tools and Data Collection

3.8.1 Data Collection Tools

A semi-structured questionnaire was used in the data collection, with both open ended and closed ended questions. The questionnaire was divided into four sections. The first section was on the participants' demographic information, including information regarding their age, gender, religion, profession, highest level of education, and years of working experience. The second part was on their knowledge on radiation protection and adverse effects, which consisted of questions looking at their knowledge of annual dose limits, ALARA principle and radiation protection training. The third section was on the attitude of the respondents. The last part of the questionnaire assessed practices of radiology department staff regarding radiation protection at their workstation, including their adherence to radiation protection practice.

3.8.2 Data Collection

The researcher recruited radiographer technicians and clinical officer research assistants to help with the data collection in the different facilities. The research assistants were trained on research ethics and data collection using the study tools. After training, the researcher, with the help of the research assistant, administered the questionnaires after obtaining written consent from the participants.

Data on the participants' demographic characteristics, including their gender, profession, highest level of education and years of work experience was obtained.

Regarding knowledge on radiation protection and radiation adverse effects, data on their formal radiation protection training and their knowledge of the hospital radiation safety officer, radiation hazards, radiation personal protective devices, ALARA principle, principles of reducing radiation exposure and sources of ionizing radiation was collected.

On attitude, data was collected regarding their attitude on importance of radiation safety, personal occupational exposure risk and if they considered radiation exposure effects to be a health concern during their practice.

In addition, radiation protection practices of radiology department staff was assessed, including their use of radiation protection devices, if their lead-based protection devices are routinely monitored, if they adhere to the recommended guidelines and procedures. This includes wearing of TLD, lead apron, thyroid collar and ensuring adequate distance from radiation procedure.

3.9 Pre-test

A pilot study was carried out at Webuye County hospital among 10 conveniently selected health personnel working in at the facility to assess the validity and reliability of the study tools and methods. Necessary changes were made to the study tools before the final study was conducted.

3.10 Validity and Reliability

The content and face validity of the questionnaire used was evaluated by a team of experts at University of Nairobi, the radiology department. The reliability of the tool was assessed using the Cronbach's alpha and test-retest reliability assessed by administering the questionnaire to the same pilot individuals two weeks apart and the test-retest correlation coefficient used to determine the test re-test reliability.

3.11 Data Management and Analysis

The data will be entered into the Epi-data software for cleaning and management. The data was be imported into IBM Statistical Package for Social Sciences (SPSS) version 23.0 for analysis. The knowledge and practices of the participants were scored as low or high knowledge and good or poor practice depending on the mean score of the participants regarding the different knowledge and practices questions. Both descriptive and inferential analysis were used in the analysis. For descriptive, the measures of central tendency (mean, median and mode) and the measures of dispersion (interquartile range and standard deviation were used for continuous variables such as age and years of experience, while frequency tables and proportions were used for categorical variables. The Chi-square test and fisher's exact test were used to determine the association between different categorical variable. A p-value < 0.05 was considered to be statistically significant.

3.12 Data Presentation

The results of the study have been presented in the form of tables, charts and prose format.

3.13 Ethical Considerations

Ethical review and approval was obtained from the University of Nairobi/ Kenyatta National Hospital Ethics Review Committee (ERC). A permit was obtained from the National Commission for Science Technology and Innovation (NACOSTI) before the study was conducted. Permission was obtained from each of the facility management before the study.
Written consent was obtained from each individual participant after explaining the nature and purpose of the study. No personal identifiers were collected, and the hard copy questionnaires are stored in a lockable cabinet. The data was entered into a password-protected laptop and has been shared only between the student and the supervisors.

4.0 CHAPTER FOUR: RESULTS

A total of 396 questionnaires were filled. 57 questionnaires were omitted due to data being incorrectly or incompletely filled questionnaires and from respondents who did not meet the inclusion criteria.

The data of 339 healthcare workers drawn from Bungoma County Referral Health Facilities was reviewed. Summary data and comparative analyses on radiation protection are presented below.

4.1 Demographic characteristics of health workers

Demographic data are presented in table 4.1 below. Most participants were female (51.0%), nurses (48.1%), with a diploma (65.8%), and a cumulative medical experience of ≥5 years (51.9%).

Table 1. Demographic characteristics of healthcare workers from Bungoma County Referral Health Facilities

Demographic characteristics	**Category**	**N (339)**	**%**
Gender	Male	166	49.0
	Female	173	51.0
Profession	Nurse	163	48.1
	Clinical officer	103	30.4
	Medical doctor	51	15.0
	Radiographer	11	3.2
	Anesthetist	2	0.6
	HTS	2	0.6
	Nutritionist	2	0.6
	Public Health Officer	2	0.6
	Plaster technician	1	0.3
	Community oral health officer	1	0.3
	Social worker	1	0.3
Highest education level	Certificate	21	6.2
	Diploma	223	65.8
	Undergraduate degree	67	19.8
	Master's degree	25	7.4

	PhD	2	0.6
	Higher diploma	1	0.3
Experience in years	< 5 years	163	48.1
	≥ years	176	51.9

4.2 Knowledge on radiation protection and adverse effects

Only 25.4% had attended a formal radiation protection course at the time of conducting the study while 38.9% were knowledgeable of contacts of the hospital's radiation safety officer (table 4.2).

Table 2. Knowledge on radiation protection and adverse effects by healthcare workers from Bungoma County Referral Health Facilities

		N (339)	**%**
Formal radiation protection course attendance	Yes	86	25.4
	No	253	74.6
Knowledge of contacts of hospital's radiation safety officer	Yes	132	38.9
	No	207	61.1
Radiation hazards known			
Acute radiation sicknesses such as nausea and vomiting		202	59.6
Skin injuries such as erythema, skin pigmentation		233	68.7
Cataract of the eye lens		181	53.4
Bone marrow depression		223	65.8
Infertility in men and women		227	67.0
Congenital malformations in exposed babies		262	77.3
Cancers such as skin cancer, leukaemia		251	74.0
Death		130	38.3
Knowledge of PPEs for reducing radiation exposure			
Lead goggles		233	68.7
Lead apron		291	85.8
Lead gloves		143	42.2
Thyroid shield		98	28.9
Gonad shield		104	30.7
Knowledge of "ALARA"	Know	93	27.4

	Don’t know	246	72.6
Knowledge of principles for reducing radiation exposure	Know	3	0.9
	Don’t know	336	99.1
Sources of ionizing radiation			
Ultrasonography	True	210	61.9
	False	129	38.1
MRI	True	275	81.1
	False	64	18.9
LASERs	True	258	76.1
	False	81	23.9
Radionuclide studies	True	263	77.6
	False	76	22.4
Switching off X-rays stops radiation production	True	273	80.5
	False	66	19.5
Knowledge of radiation protection	Adequate	87	25.7
	Inadequate	252	74.3

Questioned on known radiation hazards, 59.6%, 68.7%, 53.4%, and 65.8% knew acute radiation sicknesses such as nausea, skin injuries such as erythema and pigmentation, cataracts of the eye lens, and bone marrow depression respectively. Most respondents were also knowledgeable of infertility in men and women (67.0%), congenital malformations in exposed babies (77.3%), and cancers such as leukaemia and skin cancer (74.0%) but death featured in only 38.3% of responses. While radionucleotide studies were correctly identified as a source of ionizing radiations by most respondents (77.6%), ultrasonography, MRI, and LASERs were incorrectly identified as sources of ionizing radiations by most respondents (61.9%, 81.1%, 76.1% respectively). X-ray machines were correctly identified as a source of ionizing radiation by 80.5% of respondents. Overall, 87 of 339 health workers evaluated (25.7%) demonstrated adequate knowledge of radiation protection and adverse effects.

Factors are associated with health workers' knowledge of radiation protection and radiation adverse effects

Demographic factors were associated with knowledge on radiology protection and radiation adverse effects (table 4.3). Nurses and clinical officers were 0.12 (95% CI=0.03-0.44) times, P=0.001, 0.25 (95% CI=0.07-0.87) times, P=0.024, less likely to demonstrate adequate knowledge of radiology protection and adverse effects compared to radiographers. Healthcare workers who had completed a radiation protection training course were 3.07 (95% CI=1.84-5.09) times more likely to demonstrate adequate knowledge of radiation protection and radiation adverse effects compared those who had not enrolled for or completed the course (P<0.001), while healthcare workers with <5 years of experience were 1.66 (95%CI=1.01-2.70) times more likely to demonstrate adequate knowledge of radiation protection and radiation adverse effects compared to those with ≥5 years of experience (P=0.042). though HCWs with certificate, diploma, and undergraduate qualification were 0.46 (95% CI=0.13-1.57), 0.45 (95% CI=0.19-1.07), and 0.59 (95% CI=0.23-1.49) were less likely to demonstrate adequate knowledge of radiation protection and radiation effects compared to those with a master's level of education, the difference was not significant (Table 4.3).

Table 3. Factors are associated with health workers' knowledge of radiation protection and radiation adverse effects

		Adequate (N=87)	**Inadequate (N=252)**	**OR (95% CI)**	**P value**
Profession	Medical doctor	18 (35.3)	33 (64.7)	0.31 (0.09-1.24)	0.082
	Nurse	29 (17.8)	134 (82.2)	0.12 (0.03-0.44)	**0.001**
	Clinical officer	31 (30.1)	72 (69.9)	0.25 (0.07-0.87)	**0.024**
	Radiographer	7 (63.6)	4 (36.4)	Reference	
	Anaesthetist	1 (50.0)	1 (50.0)	0.57 (0.03-13.4)	0.715
	COHO	1 (100)	0 (0.0)	-	-
	HTS	0 (0.0)	2 (100)	-	-
	Nutritionist	0 (0.0)	2 (100)	-	-
	PHO	0 (0.0)	2 (100)	-	-

	Plaster technician	0 (0.0)	1 (100)	-	-
	Social worker	0 (0.0)	1 (100)	-	-
Education	Certificate	5 (23.8)	16 (76.2)	0.46 (0.13-1.57)	0.243
	Diploma	52 (23.3)	171 (76.7)	0.45 (0.19-1.07)	0.067
	Undergraduate	19 (28.4)	48 (71.6)	0.59 (0.23-1.49)	0.285
	Master's	10 (40.0)	15 (60.0)	Reference	
	PhD	1 (50.0)	1 (50.0)	1.50 (0.07-30.1)	0.781
	Higher diploma	0 (0.0)	1 (100)	-	-
Experience	<5 years	50 (30.7)	113 (69.3)	1.66 (1.01-2.70)	**0.042**
	5+ years	37 (21.0)	139 (79.0)	Reference	
Radiation course	Yes	37 (43.0)	49 (57.0)	3.07 (1.84-5.09)	**0.001**
	No	50 (19.8)	203 (80.2)	Reference	

COHO = Community Oral Health Officer

PHO = Public Health Officer

4.3 Attitudes of health workers on radiation protection and radiation adverse effects

Almost all (99.1%) found radiation safety important. Around 73.2% considered themselves to be at a high risk of occupational exposure to radiation hazards, while a majority 63.4% reported that they were always concerned about the effects of ionizing radiation on their health. Overall, 88.2% demonstrated good attitudes on radiation protection and radiation adverse effects (Table 4.4).

Table 4. Attitudes of health workers on radiation protection and radiation adverse effects

Attitudes		**N (396)**	**%**
Do you consider radiation safety to be important?	Yes	336	99.1
	No	3	0.9
Do you consider yourself at high risk of occupational exposure to radiation hazards?	Yes	248	73.2
	No	91	26.8
Concerned about the effects of radiation on your health?	Never	7	2.1

	Sometimes	117	34.5
	Always	215	63.4
Attitude on radiation	Good	299	88.2
	Poor	40	11.8

Demographic factors were associated with health worker attitudes (table 4.5).

Table 5. Factors associated with health worker attitudes on radiation protection/ adverse effects

Variable	Category	Poor (40)	Good (200)	OR (95% CI)	P value
Profession	Medical doctor	6 (11.8)	45 (88.2)	1.33 (0.16-16.7)	0.799
	Nurse	17 (10.4)	146 (89.6)	1.16 (0.16-13.4	0.887
	Clinical officer	13 (12.6)	90 (87.4)	1.44 (0.19-16.8)	0.734
	Radiographer	1 (9.1)	10 (90.9)	Reference	
	Anaesthetist	0 (0.0)	2 (100)	-	-
	COHO	0 (0.0)	1 (100)	-	-
	HTS	1 (50.0)	1 (50.0)	10.0 (0.27-203.1)	0.134
	Nutritionist	0 (0.0)	2 (100)	-	-
	PHO	1 (0.0)	1 (0.0)	10.0 (0.27-203.1)	0.134
	Plaster technician	0 (0.0)	1 (100)	-	-
	Social worker	1 (100)	0 (0.0)	-	-
Education	Certificate	2 (9.5)	19 (90.5)	0.22 (0.04-1.24)	0.065
	Diploma	23 (10.3)	200 (89.7)	0.24 (0.10-0.62)	**0.001**
	Undergraduate	7 (10.4)	60 (89.6)	0.24 (0.08-0.75)	**0.012**
	Master’s degree	8 (32.0)	17 (68.0)	Reference	
	PhD	0 (0.0)	2 (100)	-	-
	Higher diploma	0 (0.0)	1 (100)	-	-
Experience	<5 years	17 (10.4)	146 (89.6)	0.77 (0.39-1.54)	0.451
	5+ years	23 (13.1)	153 (86.9)	Reference	

Knowledge	Inadequate	30 (11.9)	222 (88.1)	1.04 (0.49-2.12)	0.918
	Adequate	10 (11.5)	77 (88.5)	Reference	

Health workers with a diploma and undergraduate qualification were 0.24 (95% CI=0.10-0.62), P=0.001, and 0.24 (95% CI=0.08-0.75), P=0.012, less likely to have a poor attitude towards radiation protection and its adverse effects compared to those with a master's degree. Inexperienced workers were less likely to have a poor attitude compared to experienced ones but the difference was not significant.

4.4 Practices on radiation protection among radiology department health workers

Only 2(14.2%) respondents used all PPDs 100% of the time. Most (85.8%) did not know the last time lead was checked for cracks. During procedures, a majority maintained 1–2-meter distance from radiation sources (87.5%), adhered to radiation protection guidelines (81.3%), and wore a lead apron (62.5%). Only 37.5% and 31.3% wore a thyroid collar and a TLD respectively. Of the 14 radiology staff evaluated, 7 (50.0%) demonstrated optimal radiation protection practices.

Table 6. Practices on radiation protection among radiology department health workers

Practices		**N (14)**	**%**
Percentage of the time with all radiation PPDs	0%	7	50.0
	25%	1	7.1
	50%	1	7.1
	75%	3	21.4
	100%	2	14.3
When was your lead last checked for cracks?	Don't know	12	85.8
	1 month	1	7.1
	3 months	1	7.1
Practices during procedures			
Wear TLD		5	35.7
Wear lead apron		10	71.4
Wear thyroid collar		6	42.9

Ensure 1–2-meter distance from the radiation source		13	92.9
Adhere to radiation protection guidelines		12	85.7
Radiation protection practices			
Optimal		7	50.0
Non-optimal		7	50.0

5.0 CHAPTER FIVE: DISCUSSION

The aim was to evaluate the knowledge, attitudes, and practices of health workers on radiation protection and its adverse effects at Bungoma County referral health facilities. Three hundred and thirty-nine (339) health workers routinely exposed to ionizing radiations at work, a majority of them being female nurses with a diploma and more than five years of experience, were evaluated using a self-administered questionnaire. From the data, knowledge on radiation protection and adverse effects was suboptimal in most cases with knowledge on personal protective equipment for radiation protection and adverse effects and sources of ionizing radiation being the least known. Attitudes on radiation protection were good in most cases, but half of the healthcare workers evaluated did not follow the recommended radiation protection protocols for health care workers. Even though the factors associated with poor radiation protection practice were not evaluated due to the small sample size (14) a few modifiable and non-modifiable risk factors for poor knowledge and attitudes on radiation protection and its adverse effects were identified. Non-attendance of radiation protection and having a low educational qualification were the main risk factors for poor knowledge and attitudes respectively. These results are discussed in detail in subsequent sections.

5.1 Knowledge of radiation protection methods and radiation adverse effects

Knowledge of radiation protection and its adverse effects was suboptimal among health care workers stationed at Bungoma County referral health facilities. From the data, only 25.7% demonstrated adequate knowledge of radiation hazards, PPEs use for reducing radiation exposure, and sources of ionizing radiations. Most health care workers had not completed a radiation protection course and were not knowledgeable of the contact information radiation protection officers in their units. Even though the knowledge of radiation protection hazards such as sickness, skin and eye injuries, bone marrow depression, and congenital malformations in the exposed were mostly good, knowledge of personal protective equipment for radiation exposure such as thyroid shields, gonad shields, and lead gloves were low. Almost all healthcare workers evaluated were unaware of the principles of radiation exposure and the definition of "ALARA", while most incorrectly identified ultrasonography, MRI, and LASERS as sources of ionizing radiations. These findings were similar to the findings of Thambura et al. in South Africa that most nurses were not trained on radiation protection and its adverse effects and had poor knowledge overall (27). However, the findings deviated from the findings of other studies from Italy (28), the United States (20), Egypt (29), and Nigeria (30) that health workers were well trained and had in-depth knowledge of radiation protection. We recommend retraining of health care workers in Bungoma county on radiation protection and its adverse effects build capacity on radiation protection.

5.2 Attitudes of health workers on radiation protection and radiation adverse effects

The attitudes on radiation protection and its adverse effects were mostly good. Close to 90% demonstrated good attitudes towards radiation protection, with almost all workers considering radiation protection to be important. A majority also considered themselves at risk of radiation exposure and were always concerned about the effects of radiation on their health. The data was comparable to the findings of a systematic review conducted by Behzadmehr et al. that health personnel mostly have a positive attitude on radiation protection (61-88%) (21). It was also comparable with findings in Egypt where over 65% of physicians demonstrated good attitudes towards radiation protection (29) and in Nigeria (30) and Kenya (15) that attitudes toward radiation protection among healthcare workers were mostly good. This should be encouraged as good attitudes can improve adherence to recommended safety protocols and lower the incidence of adverse outcomes such as birth defects, skin and bone complications, and mortality.

5.3 Practices on radiation protection among health workers

From the data, adherence to recommended radiation protection protocols was modest. While a majority maintained the recommended 1–2-meter distance from radiation sources and wore lead aprons while tending to patients, the use of thyroid collars and TLDs was low at <40% of all health care workers evaluated. Leads were rarely checked for cracks. Overall, only 14.2% of healthcare workers used all PPDs 100% of the time, even though they are a requirement. The data is comparable with findings from Uganda that utilization of all PPDs while conducting X-rays was poor (31) and in Nigeria that consistent usage of PPDs by health care workers was low (30). Healthcare workers should be encouraged to use all PPDs and get their lead-based protective gear checked consistently, as these were common foresight in the population studied. Sensitization campaigns that can improve adherence to recommended protocols or policies on radiation protection can also help.

5.4 Factors associated with health workers' knowledge and attitudes on radiation protection and radiation adverse effects

Risk factors for poor knowledge included non-attendance of a radiation protection course, experience, and academic qualification. Overall, health workers who had not completed a training course in radiology protection, those who were more experienced, and those who were not radiographers were the most affected. Risk factors for poor attitudes included higher educational qualification with masters' degrees holders compared to degrees and certificate holders being more likely to have poor attitudes on radiation protection. This data is consistent with findings from the USA that having formal radiation protection training increases knowledge of radiation protection (32). It was also consistent with findings of a significant correlation between education and the knowledge and attitudes of health care workers on radiation protection and its adverse effects. This calls for continuous sensitization campaigns for health workers who have not received formal training on radiation protection as it is a strong predictor for radiation protection knowledge and awareness.

5.5 STUDY LIMITATIONS

- Incompletely answered forms. These were omitted from the study.
- Forms answered by non-target personnel. These were omitted from the study.

5.6 CONCLUSIONS

- Knowledge of radiation protection and its adverse effects was low. Only 25.7% demonstrated adequate knowledge of radiation protection and its adverse effects.
- Attitudes on radiation protection were good. About 88.2% demonstrated good attitudes towards radiation protection and its adverse effects
- Radiation protection practices were modest. Half (50%) demonstrated good radiation protection practices.
- Professional qualification, experience, education level, and formal training on radiation protection were correlates of radiation protection knowledge and attitudes

5.7 RECOMMENDATIONS

- Interventions that can improve awareness and of radiation protection and radiation adverse effects are warranted in Bungoma county referral health facilities.
- Ensuring regular use of PPDs and radiation monitoring equipment is warranted.

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APPENDICES

Appendix I: Work Plan

Activity	2020		2021	2021			
	Aug	Sept-Dec	Jan	Feb-May	June	July	Aug
Concept Formulation							
Proposal writing and presentation							
Incorporation of comments							
Proposal resubmission and ethical approval							
Actual data collection							
Data analysis							
Report writing and presentation							

Appendix II: Research Budget

BUDGET				
Item	**Quantity**	**Unit**	**Rate**	**Amount**
Equipment				
SPSS licence	1	Number	15,000	15,000
Laptop	1	Number	50,000	50,000
Flash disk	1	Number	2,000	2,000
Data collection				
Pens	10	Number	25	250
Printing of questionnaire and consent form	400	Number	30	12, 000
Clip Boards	2	Number	275	550
Biro pens	4	Number	20	100
Data collection research assistants	4	Number	20,000	80,000
Others				
Binding	4	Number	100	400
Pilot Study			1	10,000
Airtime	1	Number	3,500	3,500
IREC fees	1		10,000	10,000
Miscellaneous			10%	9,040
Total				**192,840**

Appendix III: Consent form

PARTICIPANT INFORMATION AND CONSENT FORM

FOR ENROLLMENT IN THE STUDY

Title of Study: Evaluation of radiation protection and radiation side effects awareness among health workers in Western Kenya

Principal Investigator\and institutional affiliation: Moses Macharia: University of Nairobi.

Introduction: I am Dr Moses Macharia, a Masters in radiology student at the University of Nairobi. I am conducting a study on health workers' knowledge, attitude, and practice on radiation protection in Bungoma County Level four and five Facilities. The purpose of this consent form is to give you the information you will need to help you decide whether or not to be a participant in the study. Feel free to ask any questions about the purpose of the research, what happens if you participate in the study, the possible risks and benefits, your rights as a volunteer, and anything else about the research or this form that is not clear. When I have answered all your questions to your satisfaction, you may decide to be in the study or not. This process is called 'informed consent'. Once you understand and agree to be in the study, I will request you to sign your name on this form.

i) Your decision to participate is entirely voluntary.
ii) You may withdraw from the study at any time without necessarily giving a reason for your withdrawal.
iii) Refusal to participate in the research will not affect you in any way.
iv) I will give you a copy of this form for your records.

This study has approval by The Kenyatta National Hospital-University of Nairobi Ethics and Research Committee protocol No ____________________________

What is this study about?

This study seeks to evaluate radiation protection and radiation side effects awareness among health workers in Western Kenya. There will be approximately 384 participants in this study purposively chosen. We are asking for your consent to consider participating in this study.

What will happen if you decide to be in this research study?

If you agree to participate in this study, the following things will happen:

You will be issued with a questionnaire by the researcher to go and fill after which you will return it to the researcher or research assistants on the same day. The questionnaire will take you approximately 30 minutes to complete. The questionnaire covers aspects on your personal information, your knowledge, attitude, and practices with regards to radiation protection. Your practices with regards to radiation protection may also be observed.

After the filling the questionnaire, we will ask for a telephone number where we can contact you if necessary. If you agree to provide your contact information, it will be used only by people working for this study and will never be shared with others. The reasons why we may need to contact you include: to contact you in case we need further information, to share the study findings and engage you in case of interventions.

Are there any risks, harms discomforts associated with this study?

One potential risk of being in the study is loss of privacy. We will keep everything you tell us as confidential as possible. We will use a code number to identify you in a password-protected computer database and will keep all our paper records in a locked file cabinet. However, no system of protecting your confidentiality can be absolutely secure, so it is still possible that someone could find out you were in this study and could find out information about you. However, we will take all necessary measures as required to protect your identity.

Also, answering questions in the questionnaire may be uncomfortable for you. If there are any questions you do not want to answer, you can skip them. You have the right to refuse the interview or any questions asked during the interview.

Are there any benefits being in this study?

There are no direct monetary benefits in participating in this study. However, the information you provide will help us better understand health workers practices and knowledge regarding radiation protection hence informing policies and interventions.

Will being in this study cost you anything?

The study participation will not cost you anything except the time (30 minutes) you will spend on filling the questionnaire.

Will you get refund for any money spent as part of this study?

You will not get any monetary compensation for your participation in this study. However, the study findings will be key in identifying the knowledge gaps in health workers radiation protection and possibly informing interventions.

What if you have questions in future?

If you have further questions or concerns about participating in this study, please email, call or send a text message to the researcher on.

E-mail: mgachigi85@gmail.com

Phone no: +254703211868

For more information about your rights as a research participant you may contact the Secretary/Chairperson, Kenyatta National Hospital-University of Nairobi Ethics and Research Committee Telephone No. 2726300 Ext. 44102 Email: uonknh_erc@uonbi.ac.ke.

What are your other choices?

Your decision to participate in research is voluntary. You are free to decline participation in the study and you can withdraw from the study at any time without injustice or loss of any benefits.

Consent form (statement of consent)

Participant's statement

I have read this consent form. I have had the chance to discuss this research study with the researcher. I have had my questions answered in a language that I understand. The risks and benefits have been explained to me. I understand that my participation in this study is voluntary and that I may choose to withdraw any time. I freely agree to participate in this research study. I understand that all efforts will be made to keep information regarding my personal identity confidential.

By signing this consent form, I have not given up any of the legal rights that I have as a participant in a research study.

I agree to participate in this research study: **Yes** **No**

I agree to provide contact information for follow-up: Yes No

Participant signature ________________________ **Date** ________________

Researcher's statement

I, the undersigned, have fully explained the relevant details of this research study to the participant named above and believe that the participant has understood and has willingly and freely given his/her consent.

Researcher's Name: ______________________________________ **Date**: ________________

Signature ____

Role in the study: ____________________________ *[i.e., study staff who explained informed consent form.]*

Appendix IV: Questionnaire

This questionnaire is divided into four parts.

Section A: Demographic information

1. Gender.

a) Male ☐ b) Female ☐

2. What is your profession?

a) Radiologist ☐ b) Medical doctor ☐ c) Nurse

d) Clinical officer ☐ e) Pharmacist ☐

f) Others, ☐specify

3. What is your highest level of education?

a) Certificate ☐ b) Diploma ☐ c) Undergraduate degree ☐

d) Master's Degree ☐ e) PHD ☐ f) others, ☐ specify

4. Years of work experience. ___________________________________

Section B: Knowledge on radiation protection and adverse effects

1. Have you attended any formal radiation protection courses?

☐Yes ☐No

2. Do you know the contact information of your hospital's radiation safety officer?

☐Yes ☐ No

3. Which of the following do you know as radiation hazards (harm to the body or sickness due to exposure to ionizing radiations)?

a) Acute radiation sickness such as nausea and vomiting ☐
b) Skin injuries such as erythema, skin pigmentation, dermatitis, hair loss and skin desquamation ☐
c) Cataract of the eye lens ☐
d) Bone marrow depression ☐
e) Infertility in men and women ☐
f) Congenital malformations in babies delivered by pregnant women exposed to ionizing radiations ☐
g) Cancers such as skin cancer, leukemia ☐
h) Death ☐

4. Which of the following do you know as a personal protective device for reducing radiation exposure?

a) Lead goggles ☐

b) Lead apron ☐

c) Lead gloves ☐

d) Thyroid shield ☐

e) Gonad shield ☐

5. What does “ALARA” stand for? ___________________________________

6. What are the three principles for reducing radiation exposure? ___________________

9. The following are sources of ionizing radiation:

a) Ultrasonography

☐True ☐ False

b) MRI

☐True ☐ False

c) LASERs

☐True ☐ False

d) Radionuclide studies

☐True ☐ False

10. X-ray systems produce radiation electronically, so turning the switch to off or unplugging the machine stops radiation production.

☐True ☐ False

Section C: Attitude

1. Do you considered radiation safety to be important?

Yes ☐ No ☐

2. Do you consider yourself at high risk of occupational exposure to radiation hazards?

Yes No

3. Are you concerned about the effects of radiation to your health?

a) Never ☐

b) Sometimes ☐

c) Always ☐

Section D: Practices (To be completed by radiology department staff only)

1) What percentage of the time do you use the following: radiation protection goggles—thyroid collar—lead shield—radiation badge/dosimeter—RadPad for procedures?

☐0%

☐25%

☐50%

☐75%

☐100%

2) When was your lead last checked for cracks?

a) 1 month ☐

b) 3 months ☐

c) 6 months ☐

d) 12 months ☐

e) Do not know ☐

3) Wear TLD during procedure

Yes ☐ No ☐

4) Wear lead apron during procedure

Yes ☐ No ☐

5) Wear thyroid collar during procedure.

Yes ☐ No ☐

6) Ensure 1-2 metre distance from radiation source during procedure.

Yes ☐ No ☐

7) Adhere to radiation protection guidelines during procedure.

Yes ☐ No ☐

Appendix III: Consent form

PARTICIPANT INFORMATION AND CONSENT FORM
FOR ENROLLMENT IN THE STUDY

Title of Study: Evaluation of radiation protection and radiation side effects awareness among health workers in Western Kenya

Principal Investigator\and institutional affiliation: Moses Macharia: University of Nairobi.

Introduction: I am Dr Moses Macharia, a Masters in radiology student at the University of Nairobi. I am conducting a study on health workers' knowledge, attitude, and practice on radiation protection in Bungoma County Level four and five Facilities. The purpose of this consent form is to give you the information you will need to help you decide whether or not to be a participant in the study. Feel free to ask any questions about the purpose of the research, what happens if you participate in the study, the possible risks and benefits, your rights as a volunteer, and anything else about the research or this form that is not clear. When I have answered all your questions to your satisfaction, you may decide to be in the study or not. This process is called 'informed consent'. Once you understand and agree to be in the study, I will request you to sign your name on this form.

i) Your decision to participate is entirely voluntary.
ii) You may withdraw from the study at any time without necessarily giving a reason for your withdrawal.
iii) Refusal to participate in the research will not affect you in any way.
iv) I will give you a copy of this form for your records.

This study has approval by The Kenyatta National Hospital-University of Nairobi Ethics and Research Committee protocol No ____________________________

What is this study about?

This study seeks to evaluate radiation protection and radiation side effects awareness among health workers in Western Kenya. There will be approximately 384 participants in this study purposively chosen. We are asking for your consent to consider participating in this study.