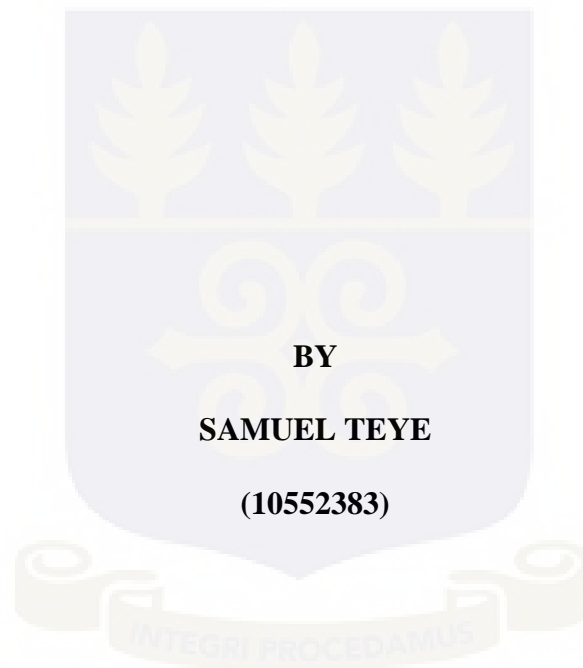


**BIOLOGICAL, ENVIRONMENTAL AND OCCUPATIONAL HEALTH SCIENCES
SCHOOL OF PUBLIC HEALTH
COLLEGE OF HEALTH SCIENCES
UNIVERSITY OF GHANA, LEGON**

**RADIATION PROTECTION FOR PATIENTS UNDERGOING SIMPLE
RADIOGRAPHIC EXAMINATION IN SOME SELECTED HEALTH
FACILITIES IN ACCRA**



**A DISSERTATION SUBMITTED TO THE DEPARTMENT OF
BIOLOGICAL, ENVIRONMENTAL AND OCCUPATIONAL HEALTH
SCIENCES, SCHOOL OF PUBLIC HEALTH, UNIVERSITY OF GHANA,
IN PARTIAL FULFILLMENT FOR THE AWARD OF THE MASTER OF
SCIENCE (MSc) OCCUPATIONAL MEDICINE DEGREE**

JULY, 2016

DECLARATION

I, SAMUEL TEYE declare that except for people's investigations which have been duly acknowledged, this work is the result of my own original research, and that this dissertation, either in whole or in part has not been presented elsewhere for another degree.

.....
SAMUEL TEYE
STUDENT

.....
DATE

.....
DR. URI SELORM MARKAKPO
SUPERVISOR

.....
DATE



DEDICATION

This work is dedicated to my dear wife, Antoinette Yayra Teye.



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DEFINITION OF TERMS

Dosimetry- The measurement of the absorbed dose delivered by ionizing radiation.

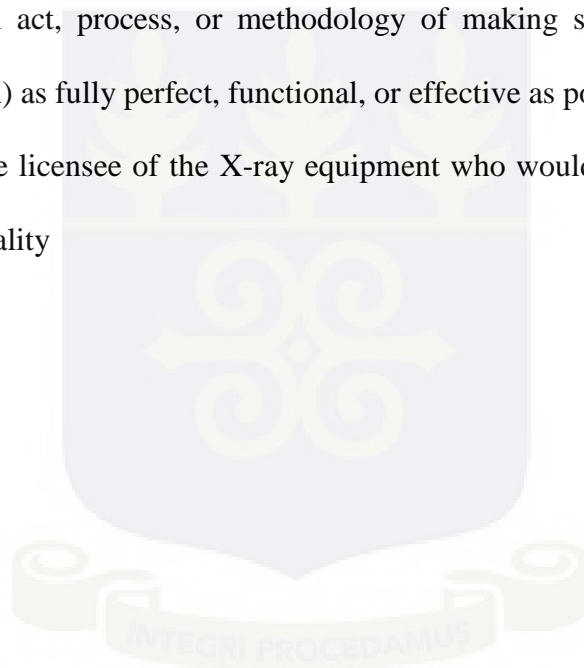
Stochastic effect- The effects that occur by chance and which may occur without a threshold level of dose, whose probability is proportional to the dose and whose severity is independent of the dose.

Deterministic effect- The effect that has a threshold below which the effect does not occur.

Justification- The action of showing something to be right or reasonable.

Optimization- An act, process, or methodology of making something (as a design, system, or decision) as fully perfect, functional, or effective as possible.

Legal Owner- The licensee of the X-ray equipment who would be held responsible in case of any eventuality



LIST OF ACRONYMS

ACR:	American College of Radiology
AEC:	Automatic exposure control
ALARA:	As low As Reasonable Achievable
AP:	Antero-posterior
APM:	Application Performance Management
BSS:	Basic Safety Standards
CEC:	Committee of European Commission
DRL:	Diagnostic Reference Level
EBP:	Evidence Based Problem
GAEC:	Ghana Atomic Energy Commission
GHS:	Ghana Health Services
GSR:	Global Symposium for Regulators
Gy:	Gray
IAEA:	International Atomic Energy Agency
ICRP:	International Committee for Radiation Protection
IR:	Ionizing Radiation
KPA:	Kilo Amperage
MA:	Milli-Amperage
MOH:	Ministry Of Health
mSV:	Milli-Sievert
NRA:	Nuclear Regulatory Authority
PA:	Postero-anterior
PACS:	Picture Archiving and Communication System
PI:	Performance indicator

PRM: Patients Radiation Manual

QA: Quality Assurance

RHS: Radiation Health Services

RPA: Radiation Protection Authority

UNSCEAR: United Nation Scientific Committee on Effect of Atomic Radiation



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ABSTRACT

The use of X-rays in medical diagnostic radiology has increased globally. The medical use of X-ray for diagnosis of illness is subject to the principles of justification and optimization for the protection of exposed individuals. Medical X-ray accounts for the largest exposure of humans to man-made ionizing radiation. Exposure of individuals can lead to long-term stochastic effects. Over exposure of humans in interventional procedures can also lead to deterministic effects such as skin burns in the short term. Even though, measures are put in place to protect the operators of the X-ray equipment, including radiologists, there are no systems to protect patients undergoing radiological examinations. To circumvent this problem therefore, this study was conducted to determine whether safety precautionary measures necessary for shielding patients contact to unsafe dose of radioactivity were being adhered to or not. The factors that affect patient protection include equipment performance, operator knowledge and skills in exposing the patient correctly to obtain the best diagnostic image with a minimum dose to the patient and monitoring and evaluation of patient dose to ensure consistency with Institutional Diagnostic reference level.

To achieve the study objectives therefore, the level of protection patients received during simple radiographic examinations in the Korle-Bu Teaching hospital and the Ridge hospital, was evaluated.

A cross-sectional study design was used in this research. A total of 175 participants were selected conveniently from the Korle-Bu Teaching and the Ridge hospitals. A self-administered structured questionnaire was administered to obtain scientific and personal data. The entrance surface dose of radiation was measured using Multi-Purpose Detector. From the study, the performance indicator of protection measured was 1.6 (80%), Safety operations by management 1.06 (53%), Safety operations by radiographers 1.79 (89.5%),

patients' safety and knowledge 0.89 (44.5%), investigations and quality assurance 1.6 (80%), local rules and supervision 1.29 (64.5) and clinical dosimetry 1(50%).

There were no radiation survey meters in both facilities. Radiographers did not weigh patients to estimate their doses. Majority of Physicians were unaware of the accepted exposure dose of various segments of the human body. Due to poor record keeping, enquiries of previous radiographic examinations from patients were not conducted. Finally, patients at Ridge Hospital were exposed to relatively higher doses of radiation even though both facilities were within the diagnostic reference range for Ghana.

Keywords: Deterministic, stochastic, dosimetry, justification, optimization, ionizing radiation.



CHAPTER ONE

INTRODUCTION

1.1 Background

In November 1895, Von Rontgen of Wurzburg, Germany, discovered the X-ray while working with a Crookes' tube (Berkeley, 1989). In 1896, Henri Becquerel also discovered radioactivity while working on X-ray (Radiation Protection Dosimetry, 2015). Radiology is the scientific use of X-rays and other high energy radiations for diagnosis and treatment (Sharma et al., 2016). Radioactive material or device is any substance that emits electromagnetic waves. The emission of electromagnetic particles is called radiation and the disintegration or breaking down of the atoms into ions is called ionization. Electromagnetic waves that are capable of disintegrating atoms into ions are known as ionizing radiations.

The knowledge of the harmful effects of ionizing radiation has since been documented. However, accidents that result in people getting injured still persist irrespective of the considerable development in radiation safety (Bengtsson, 1978).

Every material in nature has energy called the latent energy, which is an inherent property of the material. All materials have a fundamental elementary unit known as the atom. Each atom has subdivisions known as protons, neutrons and electrons. When the atoms of a particular substance have an unequal number of protons and neutrons, the substance is rendered unstable in electromagnetic energy and will therefore emit the excess energy in order to become stable. A radioactive material is therefore any substance that is unstable due to an unequal number of protons and neutrons and will release energy in a process called radioactive decay in order to be stable.

Radiation protection is a term applied to concepts, requirements, technologies and activities that are aimed at protecting people (Cunningham et al., 2004). Diagnostic and interventional radiology, are vital parts of present day medical practice (Inkoom et al., 2012). Improvements in X-ray imaging technology, coupled with developments in digital technology have had a significant impact on the practice of radiology. This comprises improvements in image quality, reductions in dose and a broader range of available applications resulting in better patient diagnosis and treatment (Heath et al., 2011). Nonetheless, the basic principles of X-ray image formation and the risks related with X-ray exposures have not changed significantly. X-rays have the potential for destroying healthy cells and tissues; therefore, all medical procedures involving X-ray equipment must be carefully controlled. In all facilities and for all types of equipment, procedures must be in place to ensure that exposures to patients, staff and the public are kept as low as reasonable achievable (ALARA).

Diagnostic X-rays account for a greater proportion of exposure of humans to ionizing radiations (Inkoom et al., 2012). On assessment of the global population dose of medical exposures to ionizing radiation from 1997 to 2007, the 2008 United Nations Scientific Committee on the effect of Atomic Radiation (UNSCEAR) reports that medical exposure continues to be the largest source of man-made exposure to ionizing radiation and it keeps growing substantially (Inkoom et al., 2012). Though individual doses associated with conventional radiography are mostly small, examinations concerning computed tomography and radioscopy can be significantly higher. However, a well-designed, installed and maintained X-ray equipment and the thorough use of appropriate procedures by trained operators reduce undue patients' exposure without decreasing the value of medical information that is derived (Schandorf & Tetteh, 1998). Mostly, X-ray machine operators

are aware of the problems associated with over exposures. However, the fundamental requirements are often not adhered to.

Over exposure to X-ray beams, poor infrastructure and unnecessary X-ray referrals are among factors reported to cause high exposure dose to patients above international recommendations (Schandorf & Tetteh, 1998a; Schandorf & Tetteh 1998b).

According to the 1998 report of UNSCEAR the need for radiation protection exists because exposure to ionizing radiation can result in damaging effects that manifest not only in the exposed individuals but also in their descendants. These effects are called somatic and genetic effects, respectively. Somatic effects are characterized by noticeable changes occurring in the organs of the exposed individual. The changes may appear within a few hours, or after many years, depending on the amount and duration of exposure to the individual (Harrison et al., 1983). Genetic effects however, are characterized by chromosomal damage in germ cells leading to mutation that give rise to genetic defects (abnormalities) such as leukemia (Akrobortu et al., 2013). Busch (1997) reported that, while the amount of dose of diagnostic radiation required to induce genetic defects may be small and may seem to cause no immediate noticeable damage, they are an equal cause for concern because of the ultimate consequences on the exposed individual.

1.2 Problem statement

The regulations for use of ionizing radiations (IRs) in medicine and industry have been in existence for years now, however, some health professionals, X-ray operators and technicians are still unaware of these regulations. As such, the aforementioned individuals are often not compliant to such regulations (Kyei & Antwi 2015). The knowledge,

awareness and adherence to these regulations are key to reducing the level of exposure to IRs and the associated deleterious consequences (Dewi et al., 2010).

Secondly, most studies in radiology have focused on the protection of the worker through the use of dosimeter (Breitenstein & Seward, 2001). The perception is that, workers spend more time in areas of ionizing radiation and as such, it is they who need protection. For this reason, during simple radiographic examination, X-ray operators are stationed in a separate protected room, leaving the patient alone in an area that is charged with IR.

Finally, since institutional health and safety practices stipulate that healthcare facilities should be places for acquiring quality healthcare rather than contracting diseases (Brennan et al., 1991), it is imperative to set up safety measures to protect patients undergoing radiographic procedures or examinations.

1.3 Justification

X-rays are very useful in diagnosis and treatment of diseases. However, they are ionizing radiations and can therefore lead to various deleterious health outcomes such as cancers especially when there is over exposure during radiological examinations. In view of this, the findings of this study would enhance accreditation and regular monitoring of X-ray facilities to ensure that only qualified personnel and good equipment are used in radiological examinations necessary to ensure protection of patients against unsafe doses of X-ray.

Also, findings from this research would add to the knowledge of the roles that owners of X-ray machines ought to possess in order to ensure protection of clients against harmful dose effects ionizing radiations. This will also serve as a protocol to be followed during

employment of qualified personnel and the procurement of certified equipment in radiological examinations.

Furthermore, this study would provide critical knowledge on the need for X-ray facilities to be manned/operated by only technically qualified personnel who regularly undertake refresher courses in order to ensure that patients are exposed to only safe doses of X-ray during radiological examinations.

Lastly, this study would provide the critical evidence needed to support the importance of standardized and regularly maintained X-ray equipment and functional radiation monitoring and control system in administering safe doses of X-ray necessary to protect patients against excessive radiation exposure.

1.4 Research questions

1. Do X-ray facilities at the Korle-Bu Teaching and Ridge hospitals meet International safety standards set for patients?
2. Do Radiographers at the Korle-Bu Teaching and Ridge Hospitals have adequate training and certification?
3. Are patients at the Korle-Bu Teaching and Ridge Hospitals exposed to safe ionizing radiation doses that are consistent with international safety standards?
4. Are physicians at the Korle-Bu Teaching and Ridge Hospitals aware of the harmful effects of X-rays?

1.5 General Objective

To investigate the level of protection for patients against unsafe levels of radiation doses during radiological examination in X-ray facilities in Accra

1.6 Specific Objectives

1. To assess safety standards at the X-ray facilities in Korle-Bu Teaching and Ridge Hospitals.
2. To assess the level of training and certification of radiographers at the X-ray facilities
3. To determine the actual doses of ionizing radiation that patients are exposed to during radiological examination at the Korle-Bu Teaching Hospital and Ridge Hospital.
4. To assess the knowledge of physicians on the hazardous effect of X-rays on patients during radiological examination

1.7 Conceptual framework

Figure 1 describes the conceptual framework for this research

Legal owners of X-ray facilities set up rules and regulations that ensure reduction in exposure of patients against radiation. These legal owners also ensure that qualified X-ray machine operators are employed. Periodically, they also advocate for in-service training to increase the knowledge of X-ray technicians, which also help in the reduction in exposure of patients to IR. Legal owners put in place systems to keep records of the patients' histories at the X-ray facilities. This ensures that technicians keep records of previous encounters, thus reducing unnecessary and repeated examinations. Such practices reduce the long-term effect of patient's exposure to ionizing radiation. Patients, who are also knowledgeable in

radiation related issues are also better equipped to protect themselves from unnecessary exposure to IR by observing and adhering strictly to instructions given.

Safety features at the radiological department are also necessary to prevent overexposure of patients to ionizing radiations. Physicians also justify X-rays in patients before they are taken. Lastly, when legal owners ensure quality assurance, there is reduction in exposure of clients to IR in the radiological departments.

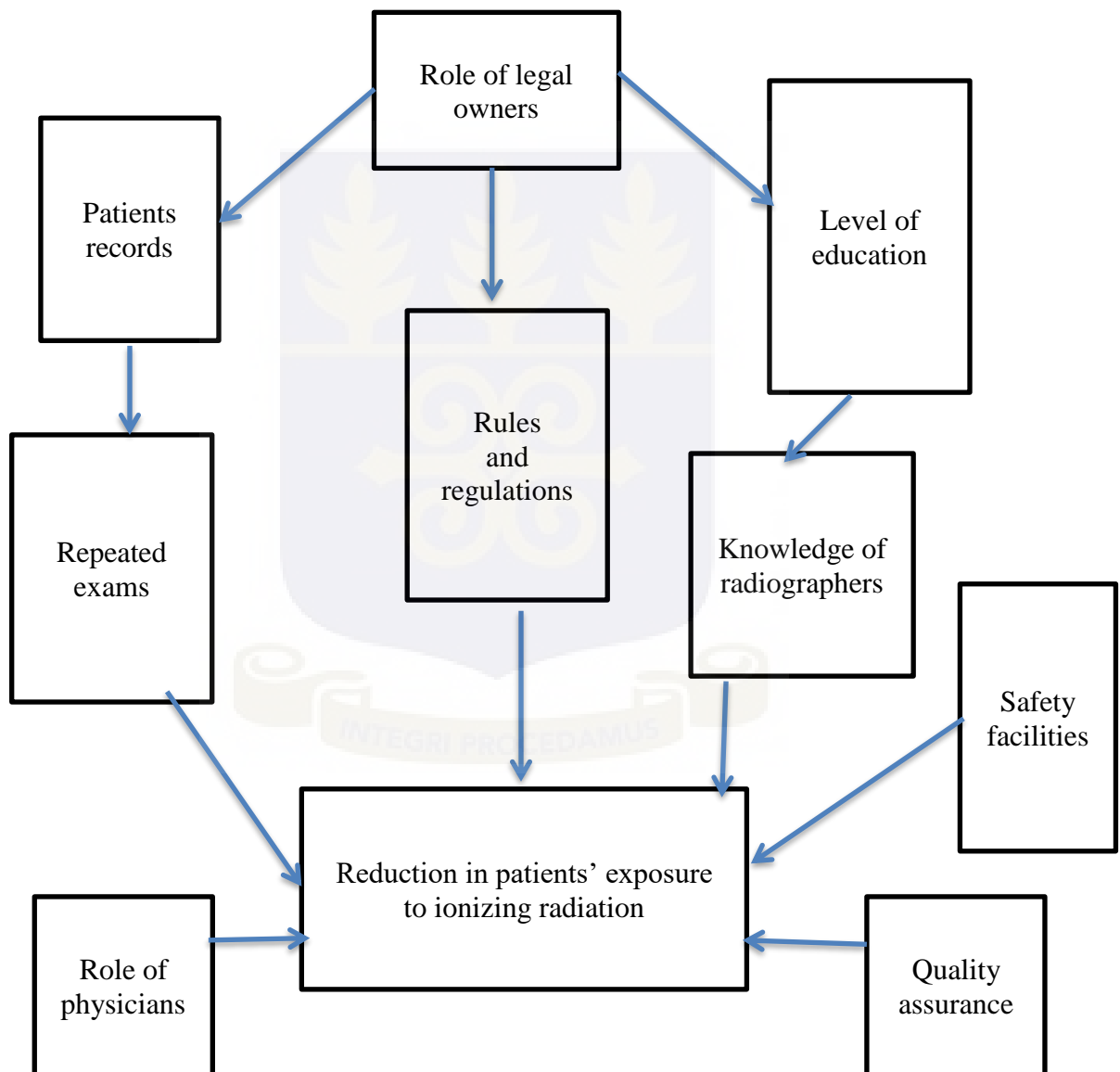


Figure 1: Conceptual Framework

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

The increase in concerns about radiation doses that patients are exposed to, together with the increase in incidence of cancer over the years, have led to the need and establishment of stringent radiation requirements for patient's protection (Schandorf & Tetteh, 1998). The referring physician has the primary responsibility of justifying all radiological examinations while the imaging team's key obligation is to enhance examination (IAEA, 2009). The facility's quality assurance and personnel training which focus on radiation safety are critical for applying the principle of radiation protection to X-ray imaging exams (Inkoom, 2012). This chapter broadly reviews related studies on factors that reduce exposures of humans subjected to ionizing radiations during simple radiographical examinations.

2.2 X-ray

An X-ray is an imaging test that views the inner part of the body without having to make an incision. It was made a public tool in 1896 where it was first used to view the hand of Albert Von Kölliker, an Anatomist (Newman, 2016). Currently, X-rays are used for various reasons. For example, the mammogram is used to examine the breast for pathologies and the barium enema is used to detect pathologies of the bowel (Cancer Research, 2016). X-rays are also used in conditions such as; Arthritis, Bone cancers, lung pathologies, fractures, digestive problems, foreign body ingestion and tooth decay. X-rays are usually performed in the X-ray department, the dental clinic or a clinic that specializes in diagnostic procedures (Newman, 2016).

2.2.1 Key components of the x-ray generating unit

An X-ray machine generates a controlled beam of radiation used in creating pictures of the internal aspects of the human frame. Any X-ray machine consists of four major parts: the X-ray tube, the transformer, the tube stand and the control panel (Veterinary Radiology, 2006).

The X-ray tube: This is an essential part of the machine, which is remote because it is contained in a protective housing. It is responsible for the production of X-rays, as such, without this working effectively, there will be little chance of X-rays functioning in the precise manner. The tube generates sufficient rays so that, when they are directed toward the body, images can be read (TECH-FAQ, 2016).

The transformer: This is an electromagnetic apparatus employed to regulate the voltage of incoming electrical energy to suitable levels without significant loss of energy. It also transmits electrical energy from one circuit to another by joint electromagnetic induction. Transformers are important in X-ray machines so that current distributed through the mains may be changed into suitable forms for the use of an X-ray tube (Veterinary Radiology, 2006). Transformers include:

- ❖ An autotransformer: This allows for the correction of variations in the main input voltage before the current is supplied to the high-tension transformer (Veterinary Radiology, 2006).
- ❖ A step-down or filament transformer: This allows for the distribution of a suitable current to the cathode filament (Veterinary Radiology, 2006).
- ❖ A high-tension transformer: This creates current of a sufficiently high voltage needed to generate X-rays. In instances where transformers are not sited directly

adjacent to the tube, insulated high-tension cables connect the two parts. High tensions transformers are mostly kept in oil baths for purposes of insulation (Veterinary Radiology, 2006).

The tube stand: This supports the x-ray tube during radiography. It consists of various forms of suspensions and may vary from small table top stands; larger mobile floor stands to overhead ceiling mountings (Veterinary Radiology, 2006)

The control panel: It is a distinct unit linked electrically to the x-ray device. It is made up of switches and meters to select kVp (Kilo Voltage Peak), mA (MiliAmperage) and exposure time (Veterinary Radiology, 2006).

- ❖ On-off switch: This is the main switch that either turns “on” or “off” the unit. The switch allows for the flow of current to the tube when it is put “on” and stops the same action when put “off”. In order to circumvent any form of accidental exposure, it is key to put the switch “off” when machine is not in use (Veterinary Radiology, 2006).
- ❖ Voltmeter and voltage compensator control: Usually, x-rays machines are constructed to run on a 220-voltage power source. A voltmeter computes the voltage of electric current while a voltage compensator permits alteration of the voltage (Veterinary Radiology, 2006).
- ❖ Milliammeter control: This is positioned within the high-tension circuit and shows the current passing through the tube during a definite X-ray exposure (Veterinary Radiology, 2006).
- ❖ Timer: This regulates the duration of time the machine generates X-rays. It is usually designated with the alphabet “s” (exposure time in seconds) and it is merged with the mA control (Shepard ,2009)

2.2.2 How the X-ray machine works

In the inside of the X-ray tube lies a filament or a cathode emitter which discharges accelerated electrons. The emitted electrons when discharged travel to the metal anode. The variation in voltage between the cathode and anode is enormously high resulting in the creation of an electron beam. This beam strikes a central point within the anode. A portion of the beam is converted into an X-ray photon (TECH-FAQ, 2016). X-ray photons move in different directions until they are controlled. A console operator regulates the exact current and voltage to form an X-ray beam, which is aimed at the targeted organ. X-rays are absorbed by the dense part of the body, as such; the skin, blood vessels and tissues within the body are unable to absorb them because they are soft. Bones however will because they are solid. Through the mechanism of absorption, the X-ray device is able to create images which make it possible for specialist to view and determine aspect of the bones which are broken (TECH-FAQ, 2016).

2.2.3 Benefits of X-ray

The discovery of X-rays represented major advancement in medicine. X-ray imaging exams are recognized as a valuable medical tool for a wide variety of examinations and procedures (Woodford, 2009). They are used to:

1. Painlessly assist in diagnosing diseases and monitor therapy
2. Support medical and surgical treatment planning and
3. Guide medical personnel as they insert catheters, stents, or other devices inside the body, treat tumors, or remove blood clots or other blockages.

2.3 Biological Effects of Radiation

Radioactive emissions that are sucked into the flesh, set off physical and chemical reactions that cause biological changes (UNSCEAR, 2000). These harmful outcomes are either somatic (occur in tissues of the irradiated person) or hereditary (occur in progeny of the irradiated person) (Brenner et al., 2003).

There is an incessant procedure of injury and repair of cells in many organs and tissues of the body. A rise in the degree of loss after contact with radioactivity may result in the growth of the replacement rate, however, to sustain the work of the organs, the total cells present are sometimes reduced (Sikand et al., 2003). The structures of the body are mostly not affected by the damage to the large number of cells. If the damage is however significant, it may lead to tissue malfunction. The likelihood of causing such an injury is usually negligible at lesser doses, however the gravity of the injury intensifies with an increase in the dose. This effect is called deterministic (Tapio, 2013).

The symptoms of deterministic effect include cataract, non-malignant damage to the skin, gonadal cell damage, cell depletion of the bone marrow and cell depletion in other organs causing severe impairment of organ functions (Towner et al., 2013).

The outcome is usually different if the irradiated cells are modified rather than destroyed. The clone of cells resulting from the reproduction of a modified but viable somatic cell is almost always removed or isolated by the body's defenses. Other than that, after a prolonged delay called the latent period, it may result in the development of cancer. The probability that a cancer will develop is dependent on the dose. However, the gravity of the malignancy is not affected by the initial quantity. The damage sustained is termed stochastic which means "of a random or statistical nature". If the initial injury occurred in the stem cells of the reproductive organs, the impact might be seen in the next generations (Heath et al., 2011).

2.2.4 Hazard and Risks of radiation

When radiation was firstly used in the field of medicine, the primary concern was the danger evolving from the contact of some few workers to fairly huge dosages (Brenner et al., 2003). Currently, the harmful impact of radiation is seen when many workers are subjected to a fairly insignificant amount of radiation dosage. The expected damage is seen as minute rise in the prevalence of cancer (Brenner et al., 2003).

Epidemiological data on cancer are being collected from individuals who have been exposed therapeutically, survivors of nuclear attacks and occupationally exposed persons. The danger associated with radiation induced fatal cancers at low doses was 5×10^{-2} per Sv average for all genders (Brenner et al., 2003).

Genetic effects associated with ionizing radiation have not been detected in individuals and genomic probabilities estimated are mostly centered on animal research. The principal cause

for severe genetic complaints from low dose is predicted to be 0.5×10^{-2} per Sv (Breen & Murphy, 1995)

The effect of radioactivity depends on the exposure time relative to conception. The death of the conceptus usually occurs when their numbers become insignificant thus any injury occurring at the cellular level will also result in the death of the conceptus causing stochastic effects which is seen in conscious babies (Sikand et al., 2003; Newman, 2016). Deformities may also present in growing organs that exposed to radioactivity during the process of organogenesis. These outcomes in humans are usually generated from animal experiment and it is estimated to be about 0.1Gy (Newman, 2016).

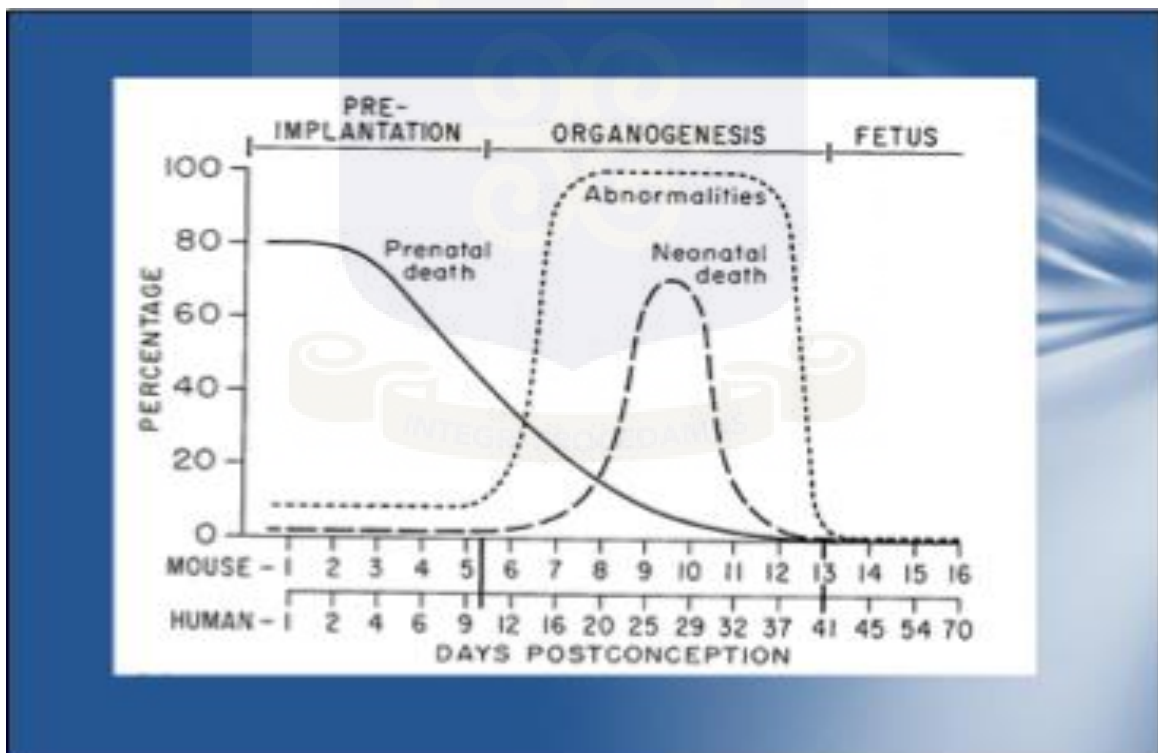


Figure 2: Effect of exposure to radiation relative to conception

Source: University of Florida, Environment Health science Research Centre (2004).

Table 1: Spontaneous-Incidence and Sensitivity of Various Tissues to Radiation-Induced Cancer

Site or Type of Cancer	Spontaneous Incidence	Radiation Sensitivity
Most Frequent Radiation-Induced Cancers		
Female breast	Very high	High
Thyroid	Low	Very high, especially in females
Lung (bronchus)	Very high	Moderate
Leukemia	Moderate	Very high
Alimentary tract	High	Moderate to low
Less Frequent Radiation-Induced Cancers		
Pharynx	Low	Moderate
Liver and biliary tract	Low	Moderate
Pancreas	Moderate	Moderate
Lymphomas	Moderate	Moderate
Kidney and bladder	Moderate	Low
Brain and nervous system	Low	Low
Salivary glands	Very low	Low
Bone	Very low	Low
Skin	High	Low
Magnitude of Radiation Risk Uncertain		
Larynx	Moderate	Low
Nasal sinuses	Very low	Low
Parathyroid	Very low	Low
Ovary	Moderate	Low
Connective tissue	Very low	Low
Radiation Risk Not Demonstrated		
Prostate	Very high	Absent?
Uterus and cervix	Very high	Absent?
Testis	Low	Absent?
Mesothelium	Very low	Absent?
Chronic lymphatic leukemia	Low	Absent?

*Adapted from Committee on Radiological Units, Standards and Protection: *Medical Radiation: A Guide to Good Practice*. Chicago: American College of Radiology, 1985.

2.2.5 The goal of Radiological Protection

The main goal of radiological safety, as documented in ICRP Publication 60, is to offer protection to human beings without overly reducing the useful effects of radiation exposure. Various structures in the medical field expect an approach that is unique to radiological safety:

(a) The contact to the patient is calculated. The principal aim in radiotherapy is mainly for

diagnostic purposes or to conduct interventional radiology thus the dose is introduced methodically to prevent biases in the intended effects.

(b) The client-staff protection: Shielding both the client and medical staff from harmful radiation source is essential.

(c) In radiotherapy, the main goal is to terminate the target tissue however, there are instances where there is damage to some surrounding tissues.

(d) Hospital and radiology facilities have to be cited such that, exposure to the public is significantly reduced. This is mainly because, managing public exposure is difficult.

2.3 Role of legal owners of radiologic facilities in ensuring safety.

When setting up or planning for radiation protection for an X-ray facility, it is inadequate to simply design protective thicknesses of X-ray facility wall and other standard apparatus (IAEA, 2001). There is a need to take an interest in the organization of the whole radiological department. Radiation protection should not be forgotten once the protective equipment has been installed. Its purpose must be clearly understood and good radiation protection practices must be encouraged until they become habitual. A certain measure of responsibility for radiation protection is held at all levels of the hospital, from the employing authority to the workers carrying out radiological procedures. The authority responsible for the establishment of X-ray facility is ultimately accountable for the safety of all staff, clients and people who might come within range of any radiation from the X-ray equipment. It is important therefore that hospital administrators set up a radiation safety committee. The committee designates a radiation protection officer who supervises the safety of all radiation area (Manual of radiation protection in hospitals and general practice, volume 3).

The Patients Radiation Protection Manual (2013), recommends that legal owners must make sure that, all persons using ionizing radiation have the appropriate qualifications, authorization, registration and training required to carry out their functions in compliance with the regulations and are aware of their responsibilities.

Also, legal owners are expected to appoint a Radiation Safety Committee and a Radiation Safety officer. These persons are required to perform regular radiation protection survey (Mann & Williams, 2003). Legal owners must also ensure that, X-ray machines are periodically recalibrated (APM report, No. 38). The onus lies on the legal owners to ensure that, there are adequate signage showing areas of high ionizing radiations and important protocols with standard operating Procedures (SOPs) in the X-ray department (Hazardous substance Act, 1991). The legal owner is obliged to have documented processes to explain conventions for patient safety. These include: Identification of patients, use of diagnostic reference levels, identification of referrer, practitioners, operators; authorization and justification of all exposures (IAEA, 2004).

2.4 Level of education in radiography

A study by Schandorf & Tetteh (1998) showed that, until recently, all radiologists in Ghana were trained abroad. Dark room attendants are given 3 months on the job training in dark room procedures, which include mixing of chemicals, film processing and basic photography relevant to darkroom work. The Minimum requirements are O levels and one A' level pass in science. Currently, most Radiographers and X-ray technicians are trained locally in Ghana for a period of 3 years with a curriculum that covers anatomy and physiology, general physics, radiological physics, hospital practice, care of patients and radiography equipment and techniques (Global Symposium for Regulators, 2016).

Kyei et al (2015) recognises that Radiography education has undergone enormous change in the United Kingdom, with newly qualified radiographers graduating with Bachelor's degrees from a university. The motivation for this change was recognized by the College of Radiographers which instituted an educational model, which was to be used in providing trainees with the requisite skill and discipline for radiography practice (Kyei et al., 2015; Jette et al., 2003). This model is not in line with informed educational and vocational training practice. The responsibility for the curriculum design has been handed over to the radiography education establishments who are free to determine both delivery methods and content. Consequently, the tertiary training that radiography students undergo today is quite different from the radiography school experience of the past, and will continue to evolve. The variation between experiences afforded by different degree-awarding courses is however yet to be identified (Sluming, 1996).

The training of staffs involved in using new radiological technique during radiography was essential. Busch (1997) recommend that this training should include basic aspects of radiation protection for patients and staff, details of the operation of the installed X-ray systems, use of visualization units, post processing capabilities, and the operation of the Picture archiving and communication system (PACS), if one is installed. In Ghana, the Radiation Protection Institute (RPI) of the Ghana Atomic Energy Commission, in collaboration with the International Atomic Energy Agency (IAEA), has developed a lot of expertise in the training of occupationally exposed workers in Ghana and the rest of Africa, spanning a period of almost two decades (Boadu et al., 2011). The foregoing therefore highlights the importance of relevant education in radiography in order to ensure the adequate protection for patients against over exposure to ionizing radiation (Boadu et al., 2011; Jette et al., 2003).

2.5 Knowledge in radiography

In Ghana, no research has been done to bring to bear the importance of attitudes, beliefs, knowledge in the quality of service provided by radiographers, though an unpublished work has been done by a Physical therapist towards Evidence Based Practice (EBP) (Kyei et al., 2015). A study conducted in the United Kingdom indicated that radiographers had less knowledge of EBP than physiotherapists, occupational therapists, dietitians, speech and language therapists, and psychologists (Upton, 2006). Jette et al (2003) & Anderson et al (2005) also showed that physiotherapists in the United States of America generally held positive attitudes and beliefs regarding EBP. Other studies largely focused on radiographers' use of evidence, and application of literature as a determinant of patient management. In these studies, respondents were diverse in expressing whether or not they had the knowledge and skills necessary for EBP (Innvaer et al., 2002; Brownson et al., 2009). Also, in a study conducted by Kyei et al (2015), it was demonstrated clearly that additional studies are required towards improvement of evidence based radiography practice in Ghana.

In a research performed by Andersson et al (2011) to determine the association of radiographers' self-assessed level and use of competencies with some sociodemographic and situational factors. It was found that both the level and use of several competencies differed in line with age, number of years in present position and workplace. A regression model, however, revealed that these three factors explained a relatively small part of competency. Accordingly, the authors concluded that a multidimensional situation with other possible factors of importance, such as the radiographer's own level of knowledge, may contribute towards the quality of service delivered by the radiographer. For the first time in the literature, the present work examined technical knowledge in plain radiography amongst a cohort of radiographers and identified three independently associated factors: Academic degree, Grade

Point Average and previous refresher course(s) as factors that contributed towards the quality of service delivered by the radiographers (Anderson et al., 2011; Upton, 2006). While no significant role was found for age, sex and work experience, in conformity with the previous report, a significant association was observed between the level of knowledge and job placement (Farajollahi et al., 2014).

2.6 Dose assessment

UNSCEAR (2008) estimates that there are approximately 3.6 billion diagnostic X-rays undertaken annually. X-ray investigation based on medical and scientific judgment of a doctor is beneficial to the clients (IAEA, 2004). Exposure to harmful X-ray dosages is therefore unnecessary (Reena et al., 2015). The key principle of optimization requires that individual doses should be kept to the barest minimum while maintaining economic and social factors. The reduction of exposure is significant when optimum care is undertaken during X-ray examinations, without necessarily impairing their diagnostic value (Radiation Health Series 1, 2004).

Currently in diagnostic radiology, the screen-film system is replaced with the digital X-ray system (Lu et al., 2003; Rowlands, 2002). There has been an increase in the use of these X-ray machines over the past years (Aldrich et al., 2006)). As a result of this, UNSCEAR (2008) indicated that institutional DRLs are established to manage exposure of patients to radiation from these X-ray devices. International Basic Safety Standards (BSS) for Protection against Ionizing Radiation and for the Safety of Radiation Sources published by the International Atomic Energy Agency (IAEA) in 1996 recommended the establishment of Dose Guidance Levels (DGLs/DRLs) for medical exposures to ensure protection of the patients and maintain appropriate level of good practice.

Diagnostic Reference levels (DRL) were described as values of measured radiation above which a specified action or decision should be taken. The use of these levels could avoid unnecessary or unproductive work and could help in the effective deployment of resources. Reference levels could be helpful in radiological protection by drawing attention to situations of potentially high radiation risk. In table 2 below, the United Kingdom (UK) has the least DRL in all categories of radiological examinations. Ghana's DRLs are found between that of UK and Germany's, which have higher DRLS.

Table 2: Comparison of proposed DRL for Ghana with national DRLs of different countries

Examination	Entrance surface dose (mGy)					
	Ghana ^a	France	USA	Germany	Switzerland	UK
Skull PA	3.4	5	-	5	5	2
Chest PA	0.50	0.3	0.25	0.3	0.3	0.15
Lumbar spine AP	6.3	10	5	10	10	5
Abdomen AP	6.6	10	4.5	10	-	4
Pelvis AP	6.0	10	10	10	10	4
Thoracic spine AP	3.1	-	-	7	-	4

^aThird quartile of entrance surface air kerma of all the regions.

Source: Radiation Protection Institute, GAEC (2014).

Sharma et al (2012) describes that the x-ray technology used on the patient will affect the dose the patient receives and will also affect the image quality. In this study, Sharma et al (2012) describes that, the dose of IR received by the patient rest on the X-ray beam, the beam current, the time of exposure, the image recording system and the x-ray generator. A study by Johnston & Brennan (2000) in an Irish hospital realized that doses received by patients varied by up to a factor of 75 for lumbar spine AP examinations.

Furthermore, in a study by Eze et al (2012), it was found that most radiographers by reason of their training, job experience and continuous professional education were conversant with optimal exposure factors in their centers. However, the newly qualified ones were not and may engaged in some practices that may overexpose people to radiations.

As a result of this, International organizations have suggested the application of DRLs in diagnostic radiology.

2.7 Working Protocol

X-ray machine operators must ensure that referrers are advised on the referral criteria, based on the recommendation of the Practitioner in charge (ICRP, 2008). Also, it is the responsibility of the radiation worker to protect patients, self, staff and the members of the public against unnecessary exposure to ionizing radiation. These standard operating procedures could only be adhered to if there were standard working protocols for reference (IAEA, 2004). Medical radiation protection is an important aspect of quality care that X-ray departments are expected to provide for their patients. A research by Schandorf et al (1995) indicated that even though, the consumption of ionizing radiation is not too extensive in Ghana as compared with the industrialized world, there is the need to establish protocols to protect patients against the hazardous effects of ionizing radiations.

The need to justify, optimize and limit X-ray exposures has been recommended by the ICRP 60 (1991). Until this recommendation was made, it was common knowledge that, clinical benefits of diagnostic radiography procedure to the patient far out-weighed the risk thus making all examinations justified. Although this assumption is still valid, there is the need to optimize the application of ionizing radiation within the concept of a reference level of

exposure as spelt out in the standard working protocols (IAEA, 2004). The theoretical background for radiation protection recommended by ICRP provides the basis for all activities and guidance applicable to specific situations of the use of ionizing radiation (ICRP, 2008). It is difficult to ascertain if those justification and dose optimizations are being adhered to as there is no current data in the hospitals to prove it. Because of the unpredictable nature of effects of ionizing radiation from medical X-rays, several countries are putting up various forms of control measures to regulate its application without compromising patient management.

One such control is the guidelines that have been published by the Royal College of Radiologist (2003), “Making the best use of a department of clinical radiology” and the “Referral guidelines for imaging” by the European Commission (2000). These developments heighten the need to develop radiation protection and safety culture in developing countries such as Ghana where radiation protection infrastructure might not be on the same level as in most developed countries. A standard working protocol is therefore of utmost importance to serve as a reference to guide radiologists in the safe execution of their duties without causing harm to themselves, patients and others.

2.8 Record keeping

Medical records are kept for the benefit of both patient and the referring clinician (Tevie et al., 2012). American Heritage Medical Dictionary (2004) defines Medical record as a chronologically written account of a patient's examination and treatment that includes the patient's medical history and complaints, the physician's physical findings, the results of diagnostic tests and procedures, and medications and therapeutic procedures. Although the primary function of patient's record is to support patient's care, it also enhances continuation

of comprehensive care (Mann & Williams 2003). Aziz & Rao (2002) in their study in the developing countries observed that record-keeping systems were inadequate with about 52.2% of the records being difficult to retrieve within an hour. Some of the records were poorly designed and there was the use of multiple patient health records by patients (Aziz & Rao, 2002). Currently in Ghana, existing record keeping system in most hospitals is poorly designed. This affects monitoring, supervision and effective decision making on some diseases (Danquah et al., 1997). Some studies have also noticed duplication, incomplete and improper data entering as major impediments by administrators in defining health issues (Ali & Kuroiwa, 2007). To strengthen health delivery therefore, medical record keeping must be emphasised (Oazi et al., 2008). In a study conducted by Williams et al (2014), 57.6% of the respondents indicated that patients' previous records were not considered. The radiographers in Koforidua were adhering to the guidelines of considering previous X-ray exposure history of patients before exposing patients to X-ray radiations (IAEA, 2001; HSWA, 1974). This enquiry was necessary to prevent exposure of patients to excessive dose of radiation, especially in circumstances where the information required could be obtained from the previous x-ray images of the patient (Dobrev et al., 2008; Heath et al., 2012). A mean weighted score of 2.10 to 2.43 implied that the required provisions were not being followed. The probability that a patient's previous X-ray history would be considered before a new X-ray exposure was prescribed, ranges from 18.9% to 21.1%. The importance of this cannot be over emphasized, especially, in the light of the fact that every radiation dose counts in the total wellbeing of the patient, and also that dose effects may vary for individuals, hence a standard dose may not be safe for every person.

The protection of foetuses against exposure radiation is a major concern to health Physicists and Oncologists (Salerno et al., 2015). Although some claim that the radiation impact during

X-ray examination on a foetus is negligible, others are of the view that extreme care is required to protect all pregnancies and hence the need for this information from females of child bearing age (11-55 years), (IAEA, 2001; HSWA, 1974). In a study by William et al (2014) in Ghana, 35.2% out of 668 female participants indicated that, they were asked “whether or not they were pregnant” while 50.2% indicated that the issue was not raised. An enquiry about the likelihood of pregnancy before an X-ray examination had a weighted mean score ranging from 2.06 in Accra to 2.39 in Cape Coast, with the overall score of 2.21. The probability that a woman of child bearing age scheduled for an X-ray imaging procedure would be asked of the possibility of being pregnant ranges from 18.6% in Accra to 20.8% in Takoradi and Cape Coast respectively.

2.9 Quality control

The World Health Organization (1982) defines quality assurance (QA) programme in diagnostic radiology as an organized effort by the staff operating a facility to ensure that the diagnostic images produced are of sufficiently high quality so that they consistently provide adequate diagnostic information at the lowest possible cost and with the least possible exposure of the patient to radiation. The quality assurance programme in any facility should comprise basic principles of training, specialization, multi-disciplinary teamwork, the use of set targets, performance indicators and audits (Akrobotu et al., 2013).

In Ghana, the Radiation Protection Board (RPB), was initially the national competent regulatory authority responsible for authorization and inspection of practices through quality control checks using radiation sources and radioactive materials (Radiation Protection Instrument LI 1559, 1993). The PNDC law 308 was an amendment of the Atomic Energy Act 204 of 1963 (Atomic Energy Act 204, 1963), which has been superseded by the

Atomic Energy Act 588 of 2000 (Atomic Energy Act 588, 2000). However, before the inception of RPB, the Health Physics Department of the Ghana Atomic Energy Commission (GAEC) was providing quality control and other services like environmental monitoring and film badge services in Ghana (Emi-Reynolds et al., 1982). Currently, the Nuclear Regulatory Authority (NRA) which was established in August 2015 through an act of parliament is the independent body responsible for ensuring that, radiation safety requirements in medical facilities are met (Nuclear Regulatory Authority Act, ACT 895). They are mandated to certify qualified organizations and experts to carry out quality assurance for medical facilities.

For instance, the Radiation Protection Institute of GAEC, in collaboration with the IAEA, has in the previous years developed a lot of expertise in the training of occupationally exposed workers in Ghana and the rest of Africa, spanning a period of almost two decades (Boadu et al., 2011). These locally trained experts could be used to provide a critical review of all quality assurance procedures that are developed for screen-film systems.

Radiology practice establishes a Quality Assurance program, which places emphasis on image quality optimization and client dose reduction. The extent of the quality assurance program is dependent on complications arising from the radiological practice. The elements of the quality assurance program outlined below include a system of checks and procedures to ensure that the aims of the quality assurance program enunciated above are met.

The legal owner should seek the advice of a qualified expert on matters relating to image quality optimization, patient dosimetry and other matters relating to radiation protection as required to ensure optimum quality (IAEA, 2002).

A study by Schandorf & Tetteh in 1998 in Ghana showed that there was no established testing for newly installed X-ray equipment. Also, periodic performance and routine checks following major repairs of faulty equipment to ensure self-consistency of equipment performance were not conducted. In addition, they stated that there was no formal policy on quality assurance programmes for radiological services in Ghana.

From their study, Schandorf & Tetteh (1998) observed that, Human and Equipment were the two main factors affecting quality assurance programmes. Also, their study revealed that, when quality control of the facility equipment was adequate, problems associated with images of diagnostic value was as a result of human errors. For example, when the equipment was well controlled, most of the poor quality rejected images was due to improper choice of technical factors, including underexposure, overexposure and positioning errors. The results of the film reject analysis indicated that these reasons accounted for 6.1%, 1.5% and 11.7% of the film rejects in the Teaching, Regional and Private Hospitals, respectively. This, in economic terms, implied a monetary loss of about ₵2.6 M (£830), ₵1.2 M (£380) and ₵1.8 M (£580) per year to the Teaching, Regional and Private hospitals respectively. Correct patient positioning played a major role in determining the success of any radiological examination. The large discrepancies observed for positioning errors between the Teaching Hospital (3.1%) and the Private Hospital (11.7%) were attributed to the absence of quality control checks by a supervising radiologist, unclear definition of the area of interest, inadequate training of operating staff on positioning, or a combination of the aforementioned factors (Schandorf & Tetteh, 1998).

Role of physician in justification of x-ray

Klah & Steeve (2012) indicated in their study that Thomas Edison who invented the fluoroscope had to stop his work when his assistant died of an X-ray overdose.

Pregnancy is often associated with reduced immunity and increased susceptibility to infections than the rest of the population. A study by Akintomide & Ikpme (2014) indicated that, most radiation dose in medical X-rays were below thresholds needed to induce congenital malformation in fetus (100mGy). However, there is no safe level for the risk of cancer because, cancer can occur at any dose. As a result, it is essential that the referring physician obtains information on the last menstrual cycle and in extreme situations conduct a pregnancy test to rule out pregnancies before referring women for radiographic examination. However, most female clients reporting to the physician are sometimes in critical conditions such that, the referring physician request for radiographic examinations without conducting a thorough assessment, thereby exposing them to radiations (Akintomide & Ikpme, 2014).

According to ICRP (2000), thousands of pregnant women are exposed to medical IR annually. However, the knowledge of the harmful effects to IR in patients and fetus at doses used for various imaging procedures has been widely researched and safety measures have been recommended. IAEA (2012) indicates that the process of optimization is necessary to reduce exposures to IR. This process involves regulating the practice of imaging specialists rather than the referring physician. This is achieved with quality assurance programs through regular analysis of repeated examinations using IR. IAEA (2012) reports that unnecessary exposures have been reported to be as high as 50% in some imaging centres. Also, this report indicates the lack of awareness on the part of the referring physician concerning the radiation dose involved, the possible hazards and the practice guidelines. The risk of radiation-induced cancer according to ICRP (2012) might be three times as high as for the average population.

The referring physicians play an important role in screening patients and in proper documentation (RPEC, 2001). They are also required to provide radiographers and radiologist with all relevant information as part of the examination request (RPI, 2010). This includes supply of the last menstrual period (Ratnapalan et al., 2004).

Patient's knowledge on medical x-ray

Patient's knowledge of X-ray is often insufficient. It alarming to note however that there is very little literature on the knowledge of the patient on medical X-rays. Yet, many studies have highlighted the deficiencies in knowledge of medical students, doctors, dentist and paramedics IR (Mubeen et al., 2008).

However, despite the low knowledge of patients in IR, several requests of inappropriate referrals made by physicians have been attributed to patients' demand (Medelson & Murray, 2007). A study by Carlsen & Norheim (2005) indicated that physicians in Norway were increasingly demanding for medical X-rays. Another study conducted in Turkey indicates that most patients were aware of the use of medical X-ray used in mammography, but very few of them knew about the harmful effects of these X-rays (Yucel et al., 1 2005). It is therefore necessary that patient's knowledge on the hazardous effect of X-rays are improved to enable them make informed decisions.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This section describes the methodology of this research. It includes the study design, study population, study sites and the procedures used in data collection.

3.2 Study site

The study was conducted at the Korle Bu Teaching Hospital and the Ridge Hospital in Accra, Ghana.

3.2.1 Korle-Bu Teaching Hospital

The Korle Bu Teaching Hospital (KBTH) was established on 9th October 1923 and currently has a bed-capacity of 2,000. Also, it is currently the third largest hospital in Africa and the leading national referral Centre in Ghana. It has an average daily attendance of 1,500 patients and about 250 patients' admission. Also, about 3,879 patients visit the radiology department annually for various radiographic examinations. Geographically the KBTH is located latitude 5.5374° N and longitude 0.2274° W and stretches over a 4-square kilometer space.

The radiology department at the KBTH has been constructed with lead shielding materials necessary to offer protection against radiation exposure for people outside the facility. The radiology department also has concrete floors that contain frames made out of steel, wood and stones, further to reduce the risk of exposure to individuals. The Department of Radiology provides radiography services for both inpatient and outpatients. These services include general radiography, Trauma radiography, Ward radiography, Theater radiography,

Interventional radiography, Computerized Tomography scanning, Magnetic resonance Imaging and mammography. Aside the main Radiology block which houses five (5) different machines, there are satellite X-ray facilities at the Accident and Emergency Centre, the Korle Bu Polyclinic, The Child Health Department, The Chest Clinic, The MRI/CT Scan Centre, the Surgical Theater and a Mobile X-ray equipment. In all, the KBTH has 13 X-ray machines.

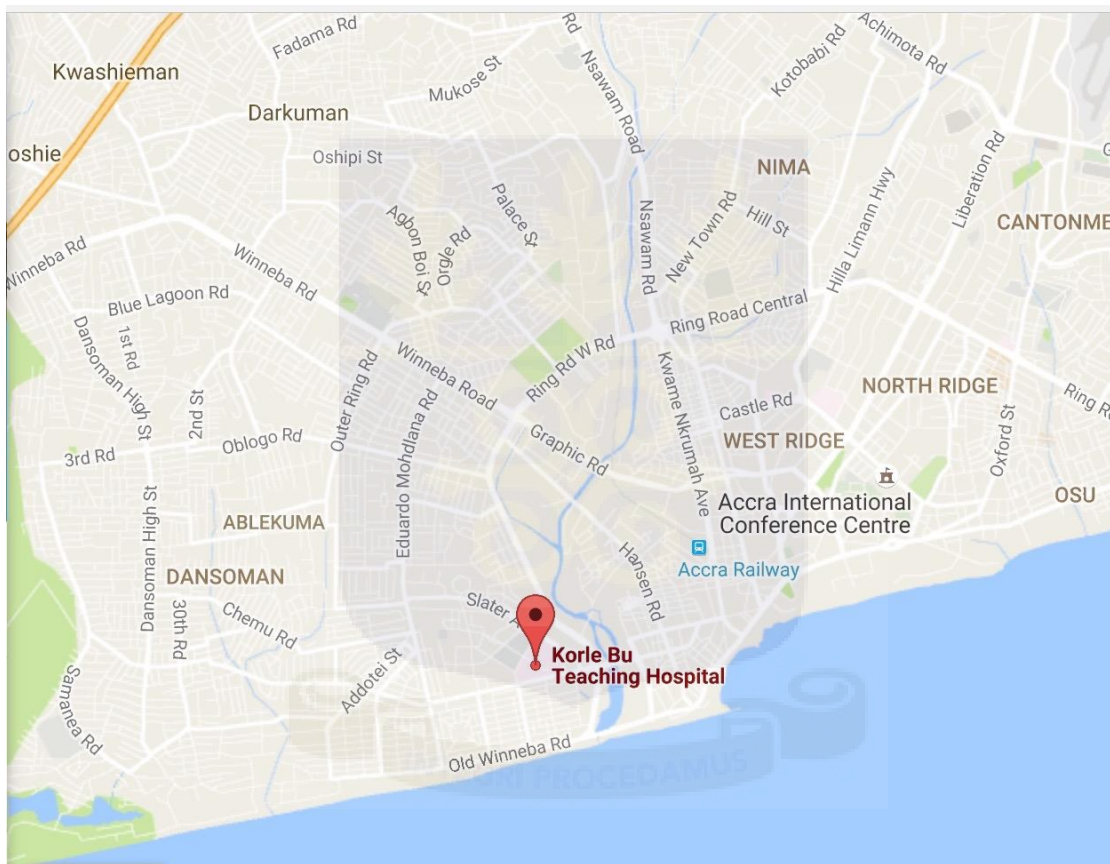


Figure 3: A Sectional Map of Accra locating Korle-Bu Teaching Hospital

Source: Ghana Survey Department, Accra

3.2.2 Ridge Hospital

Ridge regional hospital is located in the Accra Metropolis of the Osu Klottey Sub-Metropolitan. Geographically, the Ridge hospital is located on latitude 5.5627° N and longitude 0.1990° W. It was built by the Europeans in 1928 and was mainly used by them until independence. The name was then changed to the women's hospital after independence. It was upgraded to a district hospital in 1974 and then upgraded further to the regional hospital in 1996. It is a 191-bedded hospital with various departments such as pediatrics, medical, surgical among others. Ridge hospital is among the most renowned referring centers in Ghana, offering quality healthcare services to all. It has two-fixed X-ray machines, one CT scan and one mammogram. About 1,237 clients patronise the X-ray facility of the Ridge hospital annually.

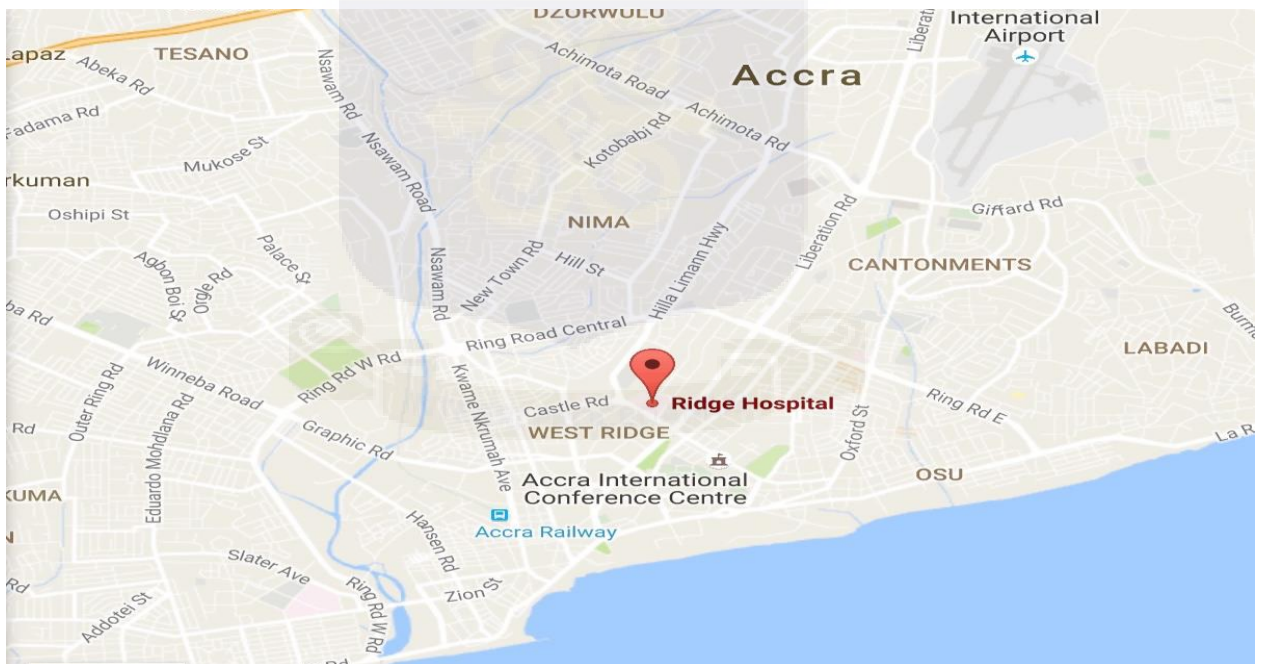


Figure 4: A Sectional Map of Accra locating Ridge Hospital

Source: Ghana Survey Department, Accra

3.3 Study variables

3.3.1 Outcome variable

The outcome variable is the reduction in exposure of patients to unsafe/excessive dose of IR during simple radiological examinations.

3.3.2 Independent variables

The variables that could affect the outcome of the study include the rules and regulations set by facility managers, level of qualification and knowledge of radiographers, poor record keeping systems, patients knowledge in X-ray, protective features at the X-ray departments, justification of radiological examinations by physicians, regular maintenance of X-ray equipment, availability of monitors/dosimeters, recalibration of dosimeters, availability of safety protocols and adherence to protocols.

3.4 Study population

The study population comprises all physicians, radiographers, hospital managers and conveniently selected individuals visiting the X-ray departments at Ridge and Korle Bu Teaching Hospitals in Accra for simple radiographic examination.

3.5 Study sample

A total of 175 individuals were recruited in this research. Thirty (30) of the recruited participants were radiographers, twenty (20) were physicians, one hundred and twenty (120) were patients and five (5) individuals were in the managerial sector.

3.6 Inclusion Criteria

1. All individuals who consented to the study
2. Physicians at the Korle-Bu Teaching hospital and Ridge Hospital
3. Radiographers at the Korle Bu Teaching Hospital and Ridge Hospital
4. Legal Owners of X-ray equipment at the Korle Bu Teaching Hospital and Ridge Hospital
5. Clients at the X-ray departments who were willing to participate in the study.

3.6.1 Exclusion Criteria

1. Individuals who did not consent to participate in the study
2. Clients who were in critical condition
3. Individuals below 18 years.

3.7 Study design

This research was a descriptive cross-sectional study involving X-ray machine operators, physicians, facility authorities and some patients undergoing X-ray examinations. It had three main components, which were:

1. Interviewing facility authorities, physicians and X-ray machine operators.
2. Interviewing some clients undergoing radiographic examinations.
3. Checking documented safety records of facilities.

The study also employed the use of a pre-designed questionnaire to collect key demographic data among participants.

3.8 Sample size calculation

The sample size was calculated using the formula provided by Yamane (1967). The formula is based on the assumption that a simple random sampling gives every patient an equal chance of being selected with a probability of 0.5 and a confidence interval of 95%.

The sample size was therefore calculated using the formulae:

$$n = \frac{N}{1 + N(e)^2}$$

Where n= sample size

N= sample population

e = level of precision= 0.05

According to the 2011 annual report of the Korle Bu Teaching hospital, 3,879 clients patronised the X-ray facilities for simple radiographic examination in the year 2011. Also, records from the Radiation Protection Authority of Ghana Atomic Energy Commission indicated that about 1,237 clients patronised the X-ray facilities at the Ridge Hospital in the year 2011. Substituting the two sample population indices into the Yamane equation for sample size calculation, a total of 370 participants, 103 from KTH and 72 from the Ridge Hospital were recruited for the study.

3.9 Sampling technique

The convenience sampling technique was used to select the one hundred and seventy-five (175) participants who were used in the study. This technique made it easy to choose readily available participants. It also allowed individuals who met the inclusion criteria to be recruited. The consent of all the recruited participants was sought before the experiment was started.

3.10 Data Collection Tools

3.10.1 Questionnaire

A structured questionnaire was used to collect data from the participants (APPENDIX B).

The structured questionnaire was largely closed-ended with a few open-ended questions.

3.10.2 Multi-purpose Detector (MPD)

The RTI Electronics Multi-purpose detector manufactured in Sweden in 2012 was placed 100cm from the X-ray tube at a voltage range of 55-90kV and was connected to a laptop computer to measure the entrance surface dose (ESD) of IR in 40 patients taking skull, abdominal, chest, spine and pelvic X-rays.

3.11 Data collection procedure

Trained research assistants were employed in data collection. A questionnaire was employed to investigate the radiation protection of patients undergoing simple radiographic procedures at Korle-Bu Teaching Hospital and Ridge Hospital. The questionnaire also collected information on the following:

- Provision of protective measures by management for the staff and patients
- Safety operations and knowledge of hospital management
- Safety operations and knowledge of radiographers in the conduct of their duty
- Patient safety and knowledge on radiation and its effects on human beings
- Investigations into incidents/accidents
- Quality assurance programme implementation by the hospital, local rules development and supervision for the full implementation of the rules and clinical dosimetry to reduce doses to patients

- Measurement of IR to which patients are actually exposed.

The field study was carried out in three (3) phases:

- Stakeholder's meeting
- Selection and enrolment of study participants
- Data collection

Enrolment of Study Participants: Participants were considered to be eligible when their consent was given.

Data collection: Responses from the participants were coded. One represented “no”, Two represented “yes” and zero represented “don't know” response. Each category of the questionnaire was assessed using the Performance Indicators (PI). The PI's for each category was evaluated according to the formula provided by Yamene (1967).

$$PI = \frac{1}{N} \sum_{i=1}^N w_i$$

Where PI=Performance indicator,

N= number of questionnaires

w=weighing factor assigned to each questionnaire.

The percentage (%) of obtained PI of the results from the questionnaire was also calculated using the equation below.

$$\% \text{ of } \textit{Obtained PI} = (\textit{Obtained PI} | \textit{Expected PI}) \times 100\%$$

3.12 Quality control

Research assistants (RAs) with requisite background knowledge were recruited and trained.

Data was checked daily to ensure that all information were properly collected and filed.

Double data checks were done to ensure that the right information was entered from the questionnaires.

3.13 Pre-testing of questionnaire

The questionnaire was pre-tested at the Achimota hospital, because the participants had similar characteristics as that of the Korle-Bu teaching hospital and Ridge regional hospital. Pretesting was done to evaluate the research questions and to determine if respondents clearly understood the questions and could provide answers. Necessary modifications were effected before the actual study.

3.14 Data processing and analysis

Information from the study were evaluated using STATA (Version 13). Appropriate measures of centrality (mean or median) and dispersion (Standard deviation, range) were calculated and summarized in a tabular form. Categorical data were summarized as frequency distribution tables. Test of associations and correlation between explanatory variables and the outcomes of interest were done using regression [coefficient of determination (R^2)].

3.15 Ethical considerations

Permission to carry out the research was obtained from the Ghana Health Service Ethics Review committee with reference number GHS-ERC 77/12/15. Approval was also obtained from the Radiation Protection Authority of the Ghana Atomic Energy Commission (GAEC). In addition, approval was sought from the collaborating X-ray facilities involved. Participation was voluntary and participants consented before they were included in the study. All procedures were thoroughly explained and confidentiality of all information was assured.

CHAPTER FOUR

RESULTS

4.1 Introduction

The study aimed at investigating the radiation protection for patients visiting the Korle-Bu Teaching Hospital and Ridge Hospital in Greater Accra for radiographic examination.

4.2 Socio-demographic data

Table 3 below summarizes the socio-demographic characteristics of the respondents of the study. A total of 175 participants were recruited in the study. Ninety-nine (56.7%) of the participants were from Korle Bu Teaching hospital while 76 (43.3%) were from Ridge hospital. Amongst all the respondents, 138 (78.9%) were Christians while 37 (21.1%) were Muslims. There were more female patients 80 (66.7%) than males 40 (33.3%). Majority of the radiographers were males (93.3%). Fourteen of the physicians who were interviewed were males (70%) and 6 (30%) were females. The study also showed that, majority, 4 (80%) of the hospital managers were males. Furthermore 25 (83.3%) of the 30 radiographers interviewed had a first degree while 5 (16.7%) had a master's degree education. Also, a majority (90%) of the 30 radiographers interviewed had more than 5 years of working experience, with 2 (6.7) of them having worked for more than 20 years. Majority 49 (40.8%) of the 120 patients interviewed, had primary education, 40 (33.3%) had secondary education, 16 (13.3%) had a tertiary education, while 15 (12.5%) did not have any formal education. The studies also revealed that, majority (65%) of the 20 physicians interviewed were general practioners while 3/20 (15%) were specialists. In addition, 6/20 (30%) of the physicians had between 5-10 years of work experience and 2 (10%) had 16-20 years of work experience.

Table 3: Socio-demographic information (n=175)

<u>Characteristics</u>	<u>Frequency (n)</u>	<u>Percentage (%)</u>
Sex		
<u>Patients n=120</u>		
Male	40	33.3
Female	80	66.7
Subtotal	120	100
<u>Radiographers n=30</u>		
Male	28	93.3
Female	2	6.7
Subtotal	30	100
<u>Physicians n=20</u>		
Male	14	70
Female	6	30
Subtotal	20	100
<u>Managers n=5</u>		
Male	4	80
Female	1	20
Subtotal	5	100
<u>Religion n=175</u>		
Christian	138	78.9
Muslim	37	21.1
Subtotal	175	100
<u>Level of education (Radiographers)</u>		
First degree	25	83.3
Masters	5	16.7
Subtotal	30	100
<u>Years of practice as a radiographer</u>		
<5 years	3	10
6-10 years	9	30
11-15 years	11	36.7
16-20 years	5	16.6
>20 years	2	6.7
Subtotal	30	100
<u>Level of education of patients n=120</u>		
No formal education	15	12.5
Primary	49	40.8
Secondary	40	33.3
Tertiary	16	13.3
Subtotal	120	100
<u>Specialty of physician n=20</u>		
General practice	13	65
Surgery	4	20
Internal Medicine	3	15
Obstetrics and Gynaecology	0	0
Subtotal	20	100

Years of experience of physician (n=20)

< 5 years	4	20
6-10 years	6	30
11-15 years	4	20
16-20 years	2	10
>20 years	4	20
Subtotal	2	100

4.3 Protection measures available at the facilities.

In figure 4.3 below, none of the facilities inspected, had a radiation survey meter. However, eighty percent had gonadal shields that were in good condition. Also, all the facilities, which were inspected, had exposure signals with posted explanation on the walls.

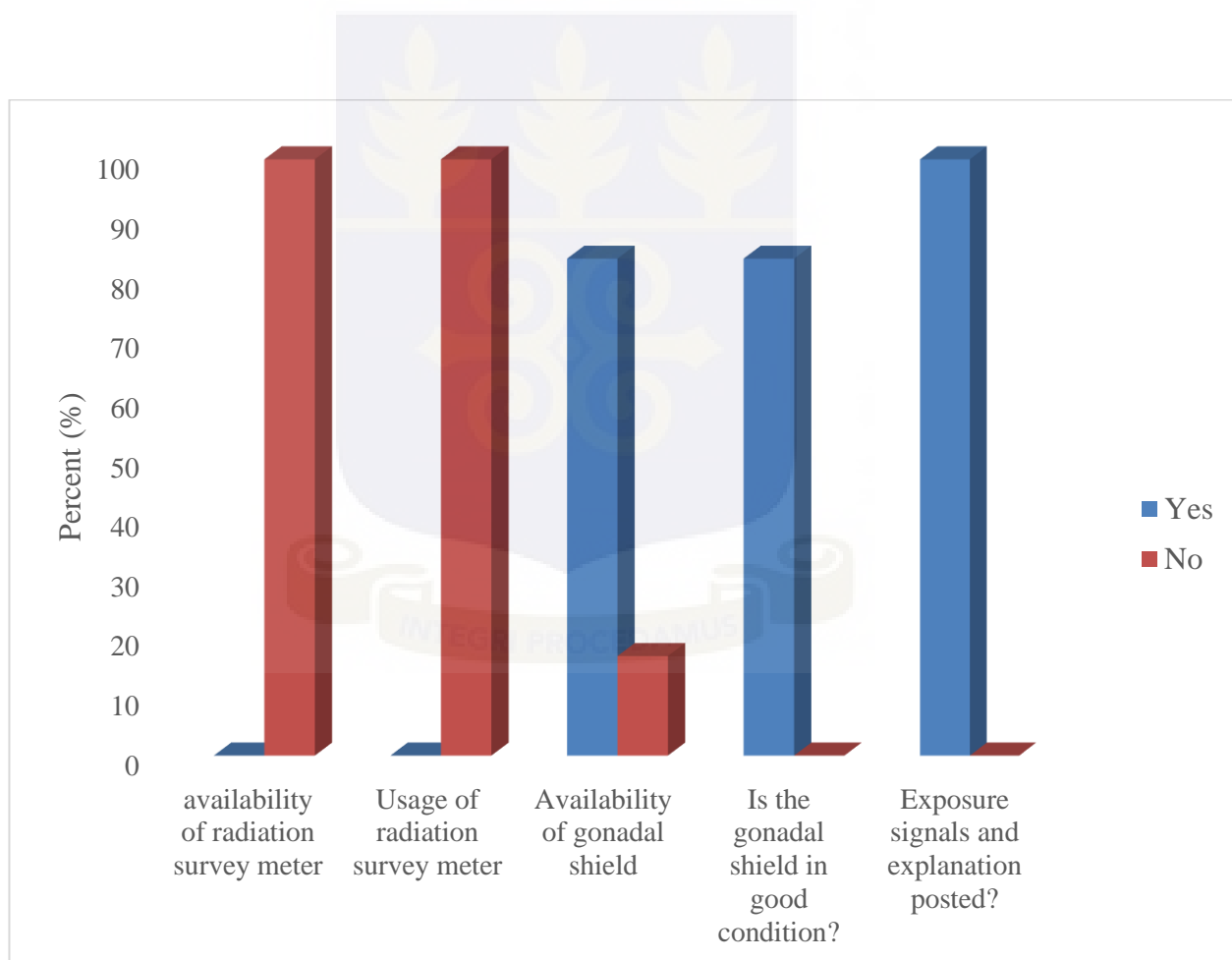


Figure 5: Protection measures available at the facilities.

4.4: Safety Operations at the facilities by the Management

Figure 6 below summarizes the safety operations by management of the Korle-Bu and Ridge Hospitals. From the graph, 17% of the managers were not knowledgeable in the terms and conditions of certification while thirty percent (33%) were conversant with these conditions. Also 33% of the respondents did not have adequate staff level. The study also showed that, 33% of the respondents were not provided with adequate monitoring equipment. Furthermore, 33% of the respondents were not provided with adequate monitoring equipment. Furthermore, 33% of the study participants indicated that, there was no mechanism for periodic programme reviews, feedback and recommendations.

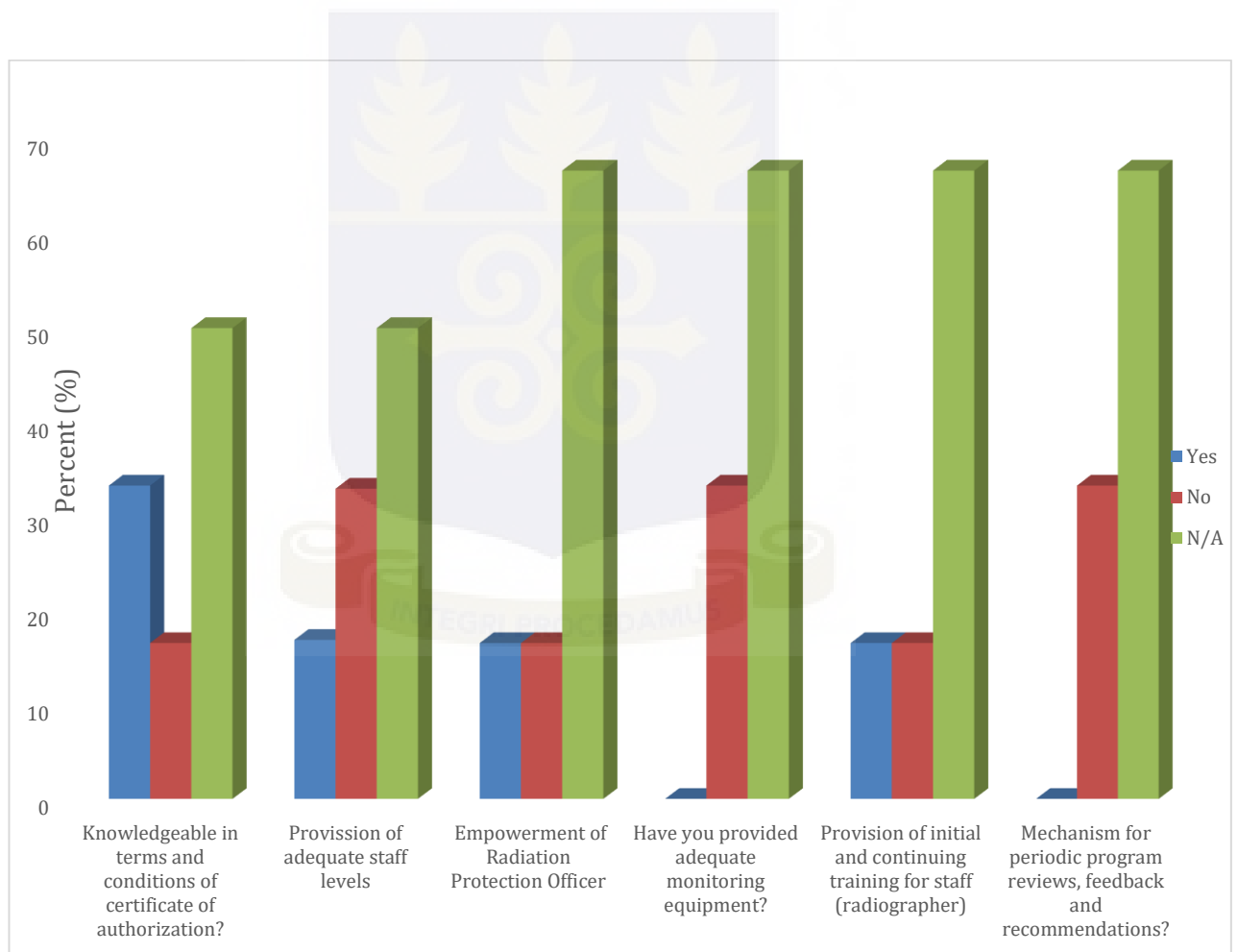


Figure 6: Safety operations by management

4.5 Safety operations by radiographer at the facilities

Figure 7 below shows the safety operations by the radiographers in the various facilities. All the radiographers had adequate knowledge in radiation. About sixty six percent (66%) of the respondents were conversant with the terms of authorization and also had sufficient time to give priority to radiation. All the radiographers claimed they asked the patients of their last menstrual period. However, in taking the X-rays, only 80% used the patient exposure chart.

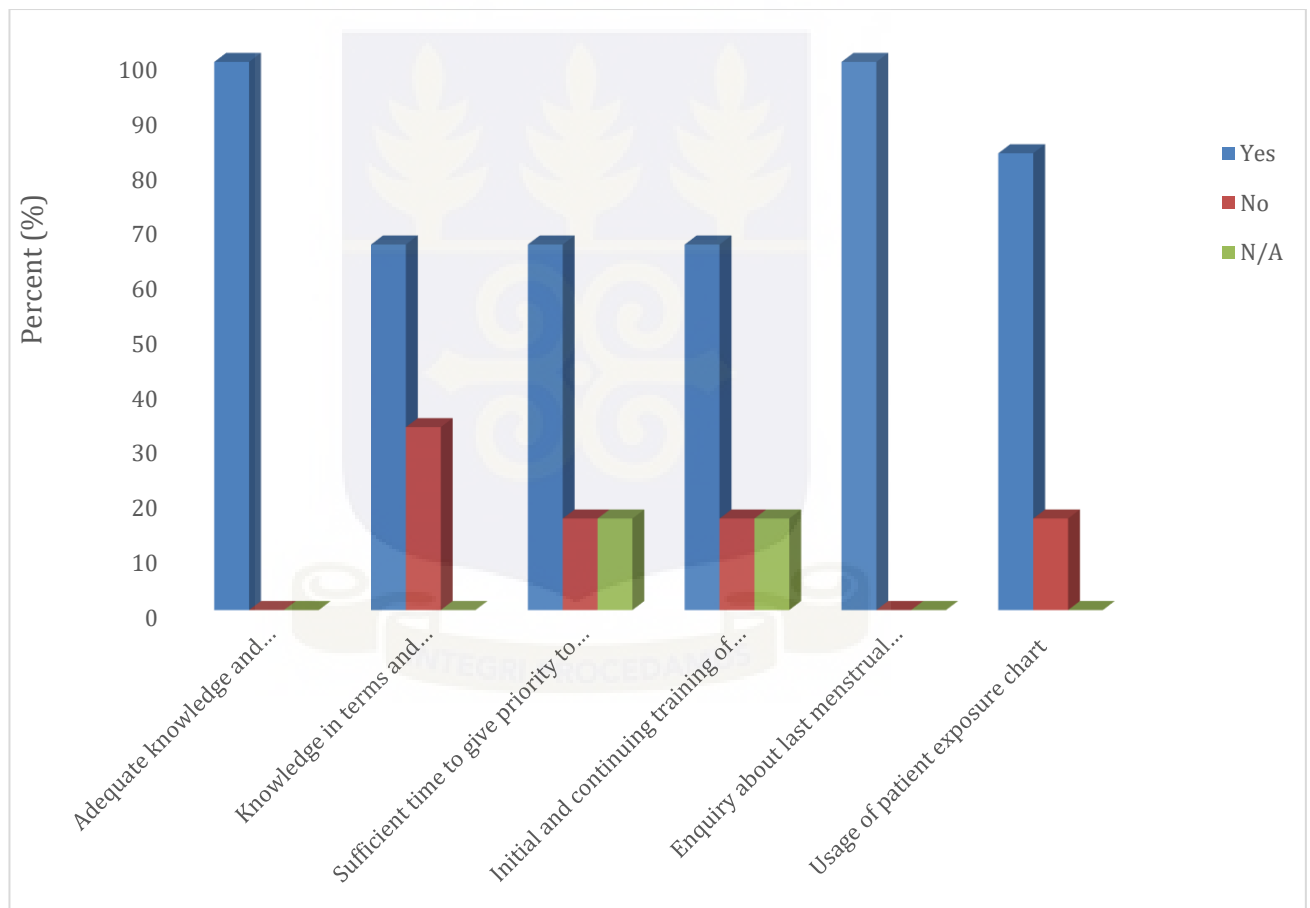


Figure 7: Safety Operations at the facilities by Radiographers

4.6 Radiographers enquiry and patient's knowledge on X-rays

In figure 8 below, summarizes the results of the assessment of female patients' menstrual cycle and knowledge of x-ray before radiological exposure as determined by questionnaire. 17% of the female patients indicated that the radiographers did not inquire about their last menstrual period. Thirty-three (33%) percent also indicated that the radiographers asked of their previous X-ray examination. However, a majority of the patients (83%) indicated that, they did not have any idea about the bad effects of X-rays.

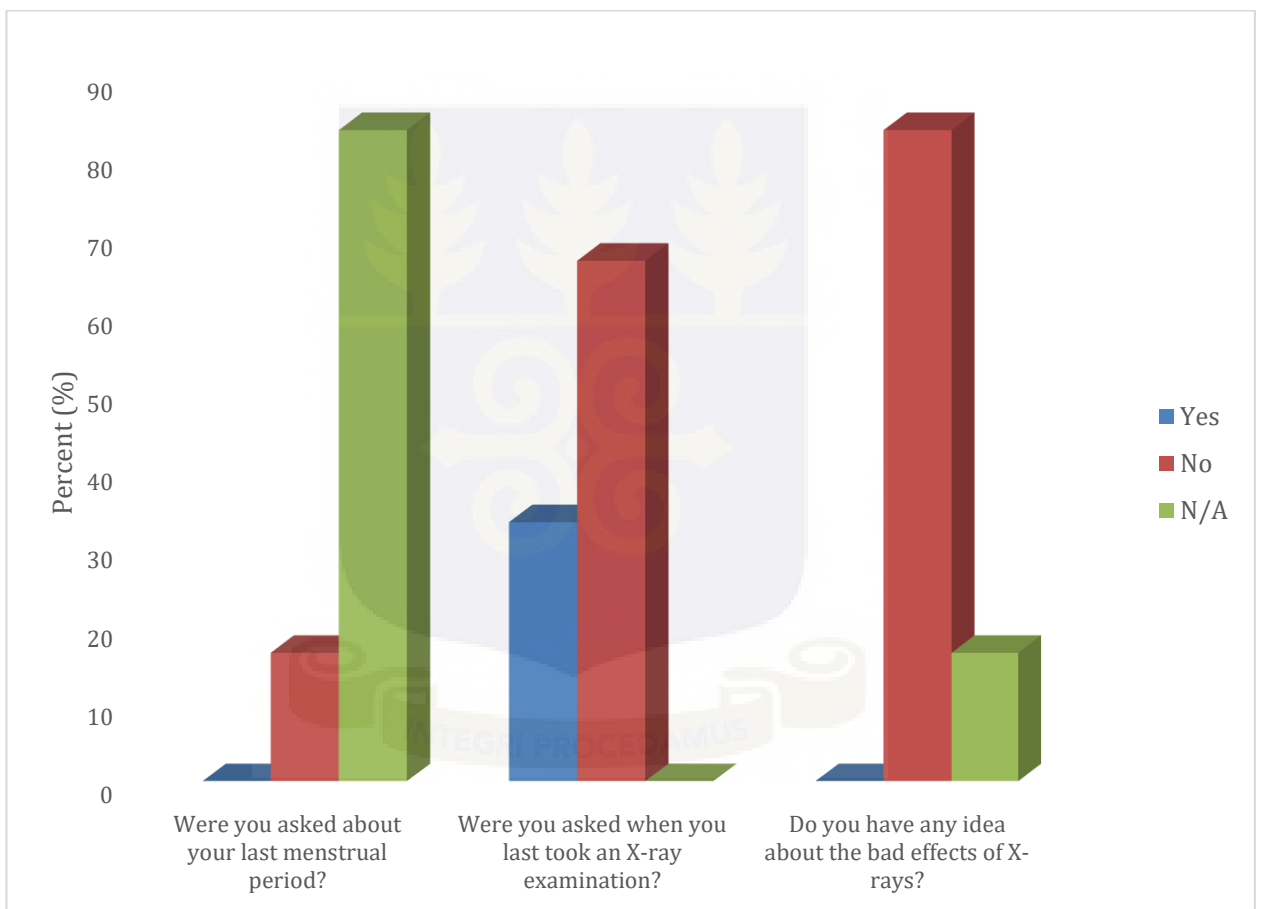


Figure 8: Radiographers enquiry and patient's knowledge on X-ray

Figure 9 below shows the results of assessment of the respondents for knowledge of accident occurrence, safety and quality assurance procedures in the x-ray facilities. As shown, sixty-seven percent (67%) of the respondents said there had been incidents and accidents at the X-ray departments. However, only 17% of these were reported. There was safety assessment review in 67% of these reported cases. Also, eighty-three percent (83%) of the respondents agreed that quality assurance procedures were performed.

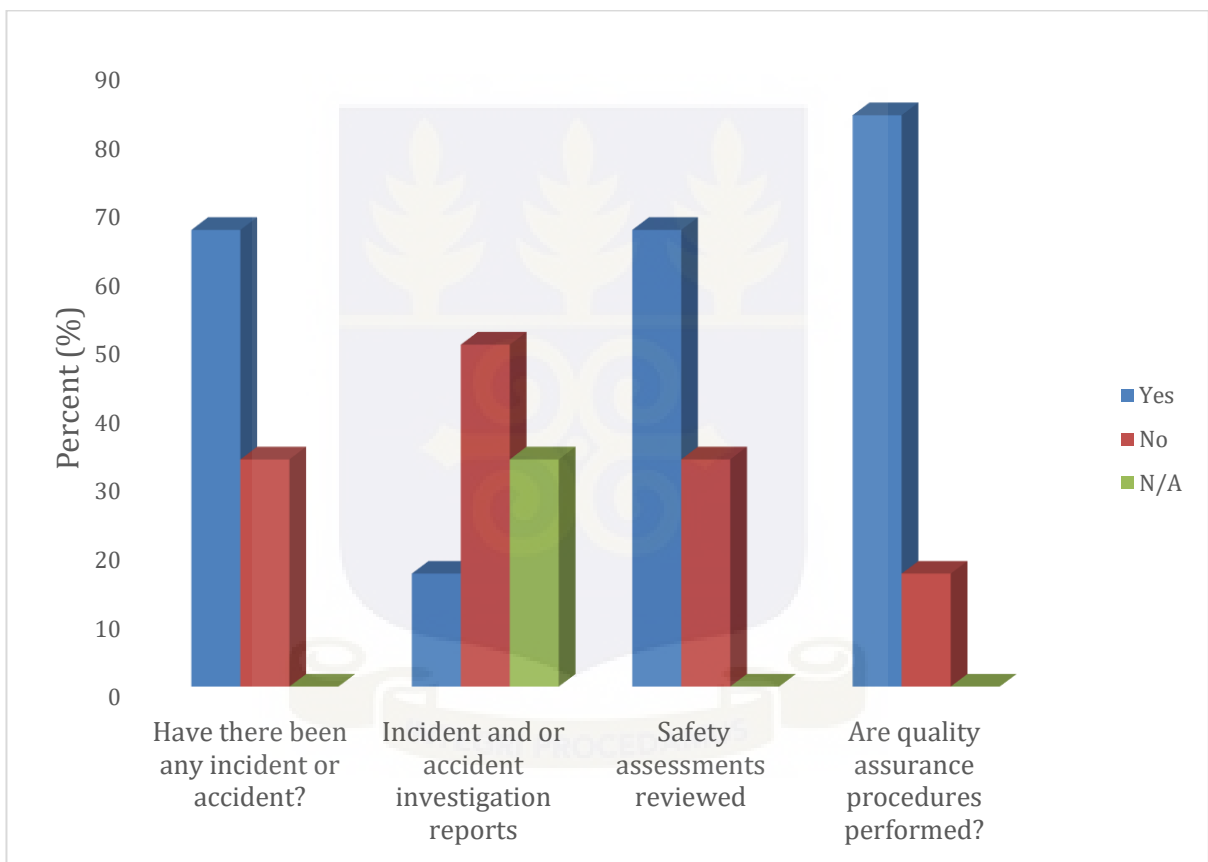


Figure 9: Investigation and Quality Assurance at the Facilities.

Figure 10 below summarized the local rules and supervision in the X-ray departments. As shown, 17% of the radiographers indicated that the local rules were in writings. Thirty-three percent (33%) said that they were adequately supervised to ensure adherence to these protection and safety measures.

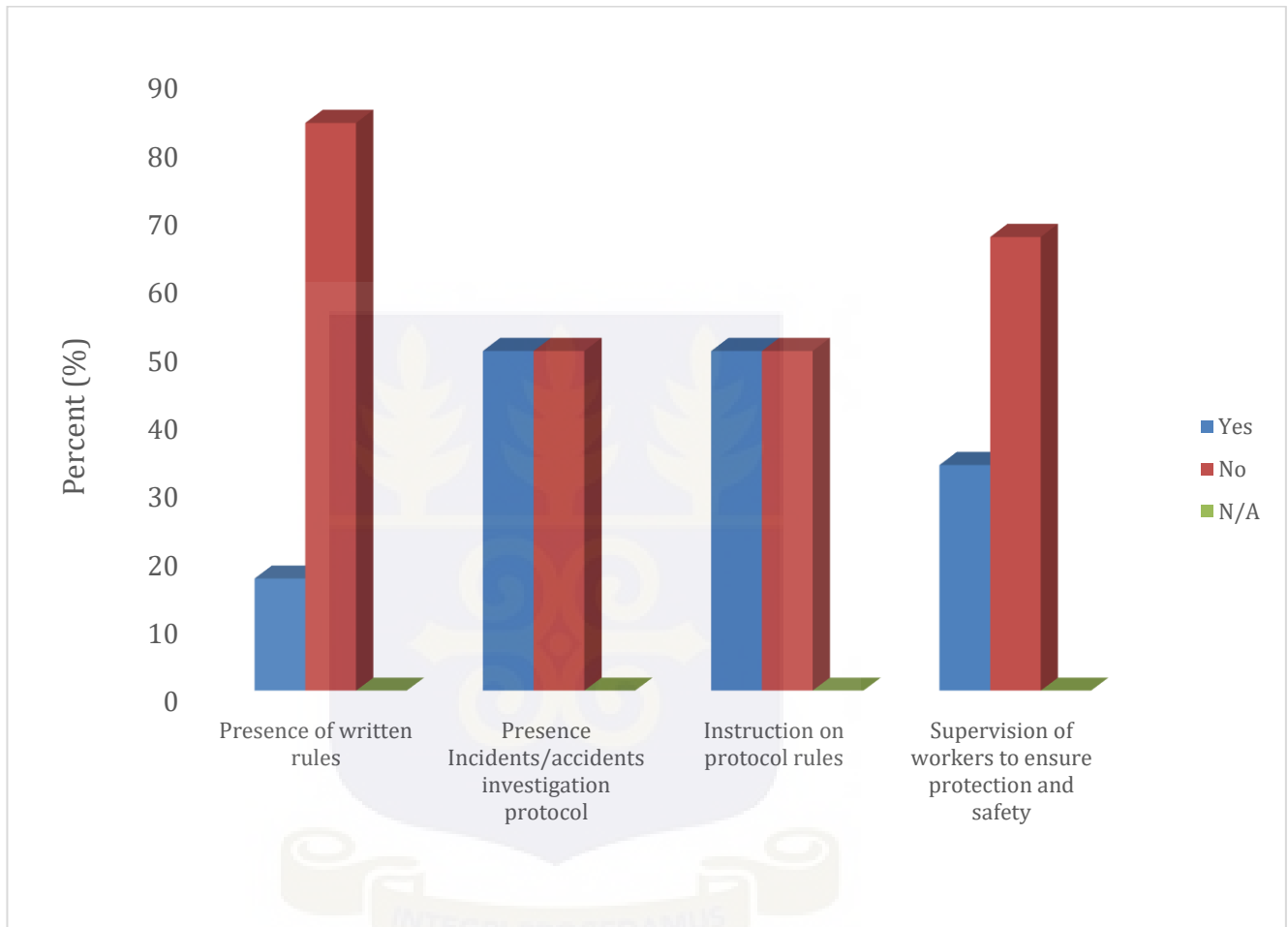


Figure 10: Local Rules and Supervision at the Facilities

Figure 11 below summarises the results of clinical dosimetry at the X-ray facilities. As shown, 83% of the respondents indicated that there were no representation values of the patients' doses for most procedures while 50% indicated that there were equipment failures. Also, the results show that 50% of patients/doctors had no knowledge on incidents/accidents that occurred at the X-ray departments.

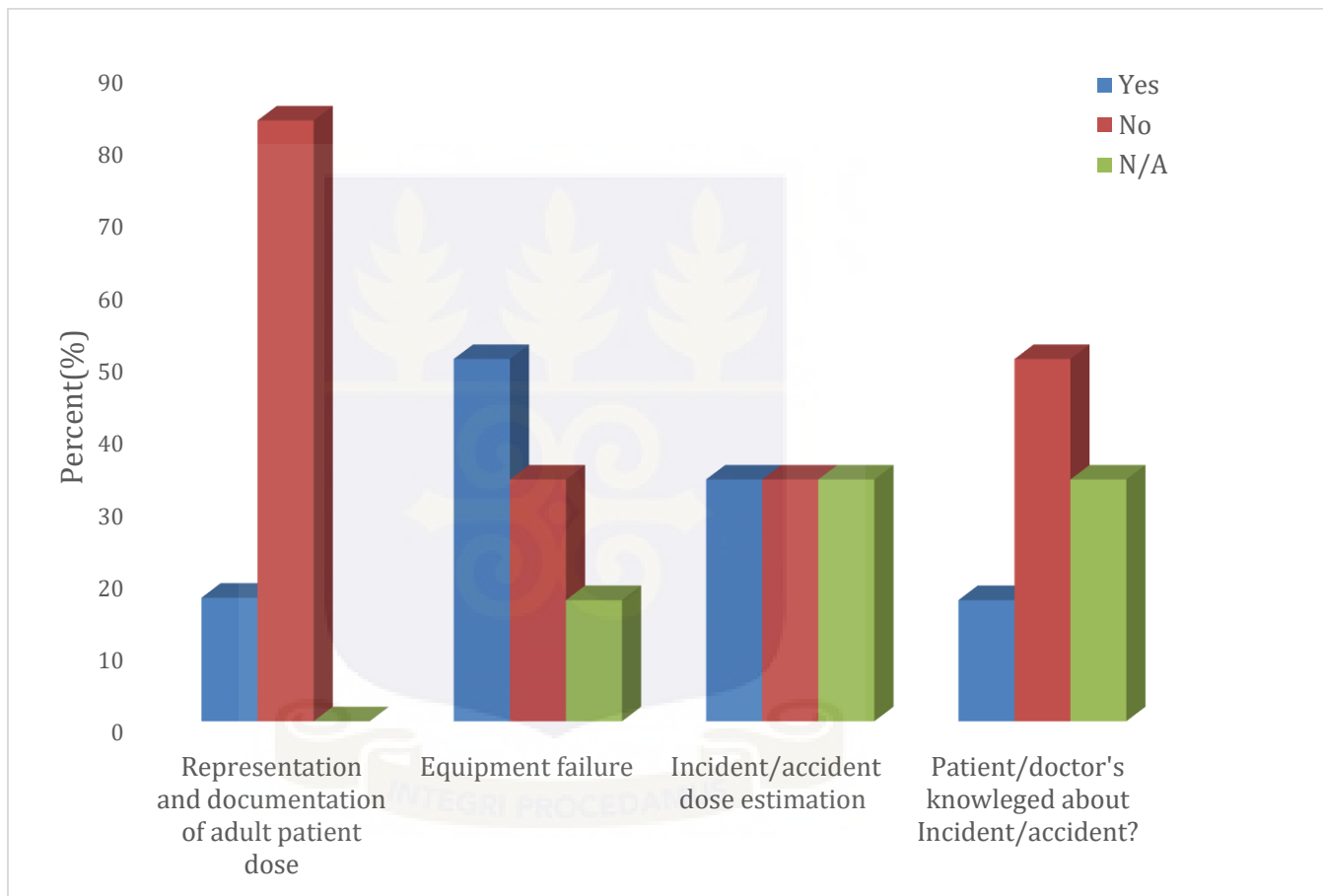


Figure 11: Clinical Dosimetry at the Facility

Table 4 below summarizes the performance indicators for all the categories investigated as determined by the equation $PI = \frac{1}{N} \sum_{i=1}^N w_i$. The table showed that Radiographers had the highest 1.79 (89.5%) expected PI in safety operations needed in patient's protection.

Table 4: Performance indicators of the considered radiation safety categories

Category	Expected PI	Obtained PI	% Obtained PI
1. Protection Measures	2	1.6	80.0
2. Safety Operations - Management	2	1.06	53.0
3. Safety Operations -Radiographer	2	1.79	89.5
4. Patient Safety and Knowledge - (to be answered by Patient)	2	0.89	44.5
5. Investigation and Quality Assurance - (to be answered by Radiographers)	2	1.6	80.0
6. Local Rules and Supervision - (to be answered by Radiographers/Management)	2	1.29	64.5
7. Clinical Dosimetry - (to be answered by Radiographers)	2	1.00	50.0

4.7 Role of physicians

Figure 4.12 shows a summary of the various health conditions for which physicians requested for X-ray examinations. As shown, majority (34%) of the X-ray examinations requested were chest X-rays for diagnosis of respiratory infections. The least (8%) prevalent reason, however, were X-ray for routine medical examinations.

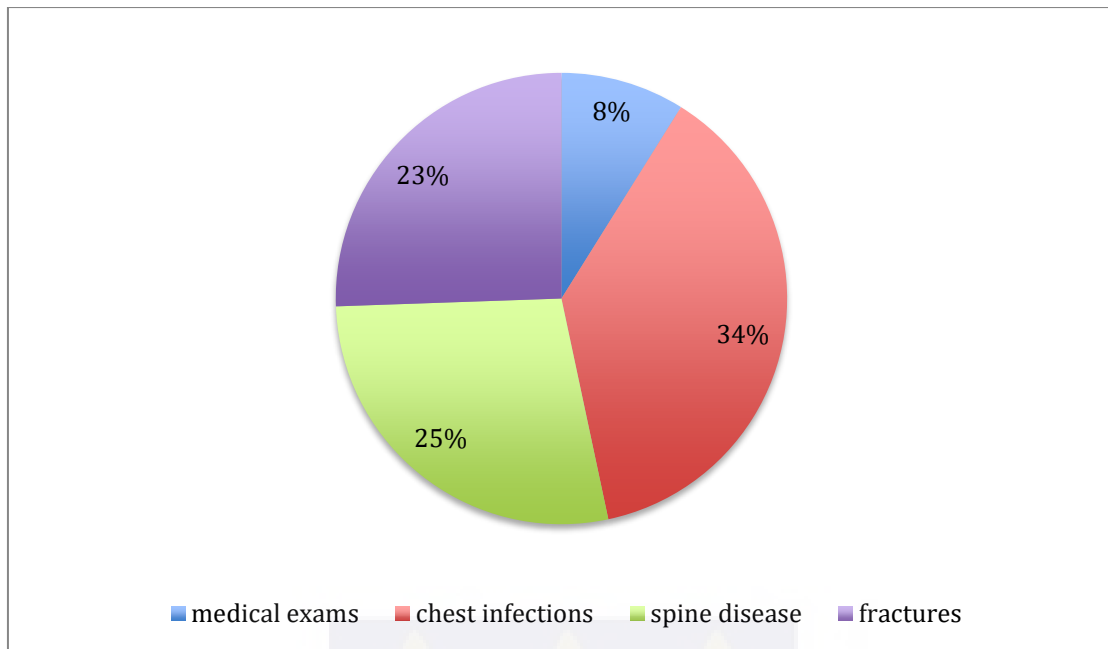


Figure 12: Reasons for X-ray request by physicians

Figure 4.13 summarizes the results of the assessment of physicians of safe dose of X-ray that patients could be exposed to ensure safety of the foetus/conceptus. As shown, a majority (80%) of the physicians did not enquire about the last menstrual period (LMP) of their female patients when requesting for X-ray examinations. Also, only 10% of physicians had knowledge of the safe X-ray dose that patients can be exposed to during examination. Majority (98%) were however knowledgeable on the hazards of x-ray radiations.

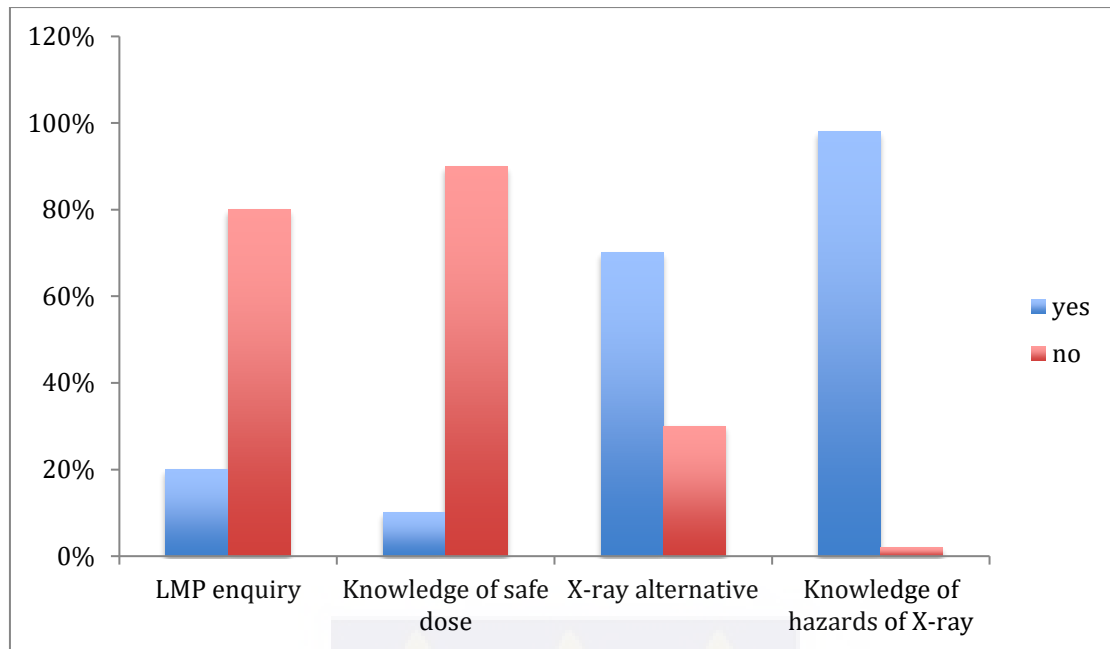


Figure 13: Physicians knowledge of safe x-ray dose that patients could be exposed to and measures taken to ensure safety of foetus/conceptus.

4.8 Patients Dosimetry

The dose to patients in the Ridge Hospital and Korle-Bu Teaching Hospital undergoing skull PA, chest PA, lumbar spine AP, abdomen AP, pelvis AP and thoracic AP examination has been shown in Table 4.3. The entrance surface dose to patients' due to lumbar spine AP was found to be the highest of all the examinations considered in both hospitals with the least dose being chest PA. The study also showed that, patient doses at Ridge Hospital were always higher than that of Korle-Bu Teaching Hospital by a maximum factor of 2.6.

Table 5: Entrance Surface Dose to patients at Ridge Hospital and Korle-Bu Teaching Hospital

Examination	Entrance surface dose (mGy)		
	DRL for Ghana	Ridge Hospital	Korle-Bu Teaching Hospital
*Skull PA	3.4	2.45	1.25
*Chest PA	0.50	0.65	0.25
#Lumbar spine AP	6.3	12.05	7.29
#Abdomen AP	6.6	3.63	1.40
#Pelvis AP	6.0	4.25	2.47
#Thoracic spine AP	3.1	6.60	5.60

*PA-Postero-anterior #AP-Antero-posterior

In figure 4.14 below, the dose to patients in the two hospitals for the considered radiology examinations has been compared with the proposed diagnostic reference level (DL) and DRL for Ghana and Germany respectively. The doses in the two hospitals were found to be lower than the DRL from Germany, except for the lumbar spine and chest examinations at Ridge Hospital. Again, the doses in both hospitals were also found to be lower than the DRL for Ghana, for the skull PA, abdomen PA and pelvis AP radiology examinations. However, the doses in the two hospitals were found to be higher than the DRL for Ghana, for thoracic and lumbar spine AP radiology examination. It was also observed that, the proposed DRL for Ghana, for chest PA was more in the Korle-Bu Teaching Hospital but less in Ridge hospital. Generally, optimisation of the radiology procedures by radiographers at the hospitals was observed to reduce the doses that patients were exposed to especially for chest PA, thoracic and lumbar spine AP examinations.

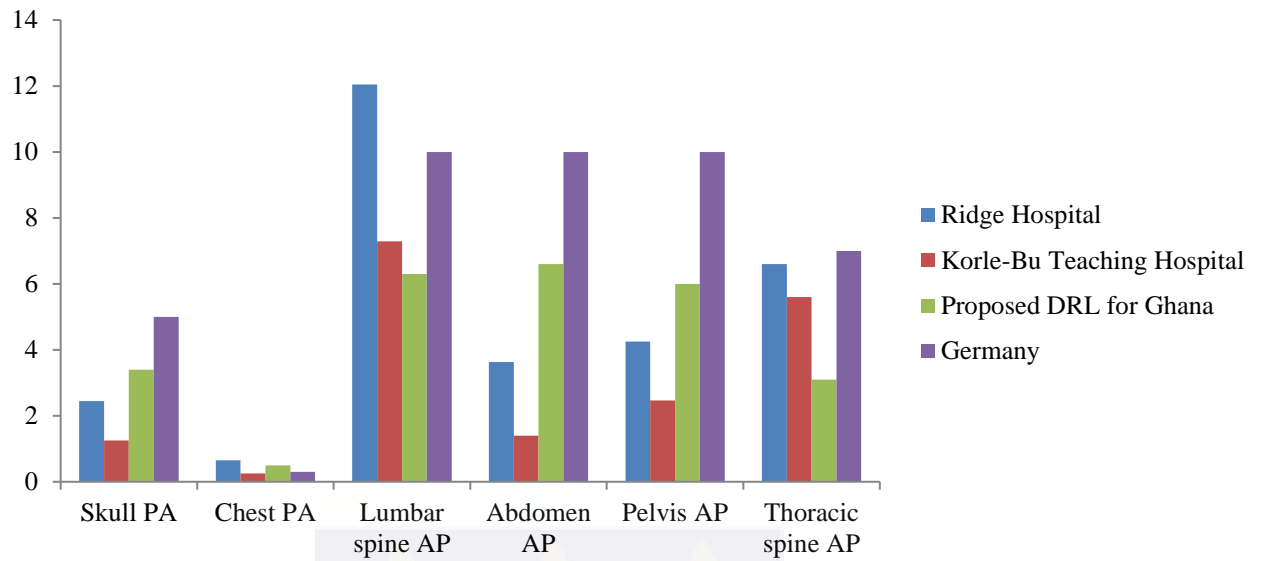
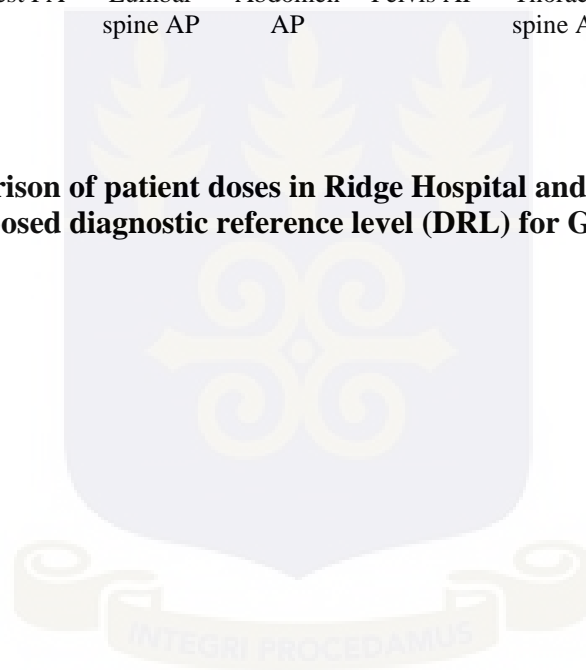


Figure 14: Comparison of patient doses in Ridge Hospital and Korle-Bu Teaching Hospital with proposed diagnostic reference level (DRL) for Ghana and DRL for Germany.



CHAPTER FIVE

DISCUSSION

5.1 Introductory statement

Radiation protection for patients undergoing radiological examinations has been a major concern for both the industrialized and developing countries. In the past, medical exposures to ionizing radiations were minimal but in recent times, increasing diagnostic technology has led to an increase in medical exposure to ionizing radiations (Inkoom, 2010). Even though there are various safety measures in place to protect radiographers against unsafe dose of ionizing radiations, there is none to protect patients. To provide data necessary for formulation of measures to protect patients against harmful consequences of unsafe radiation therefore, this study set out to determine the Safety standards/procedures and the level of protection for patients against ionizing radiation at the radiology departments in the Korle Bu Teaching Hospital and Ridge Hospital in Accra. A total of 370 participants were calculated by the Yamane (1967) formula to be recruited for the study, however, due to logistic constraints, only 175 of them actually participated in the study. In this study, 175 recruited individuals were investigated and their level of education, knowledge, role and the availability of facilities necessary to protect the patients from ionizing radiations were determined using a structured questionnaire.

5.2 Socio-demographic characteristics of radiographers

The study showed that majority of the radiographers were educated with at least 85% of them having a Bachelor of Science degree. This was in agreement with a study conducted by Kyei et al (2015) that showed that, most practicing radiographers were university graduates with first degree education. It was also observed that, majority of the radiographers had worked for 11-15 years.

5.3 Safety measures available at the facilities

The study also showed that, majority of the respondents used both Automatic Exposure Control (AEC) and manual selection of exposure parameters. The respondents indicated that, during the use of manual selection of parameters and patient exposure chart, the weight and height of the patient were estimated by visual observation and years of experience of the radiographers. This could be attributed to the absence of weighing scales and height estimators in the study facilities that were considered. The absence of these measuring tools had the potential to lead to over or under exposure of patients to ionizing radiation or a retake of a radiograph which may be harmful to the patient. This finding was in line with a study by Eze et al (2012), which acknowledged that, most radiographers, because of over reliance on their training, job experience and continuous professional development were concerned with optimal exposure factors rather than safety of the patients.

The results also showed that warning notices and exposure signals with explanation were present in the various facilities. However, these signals and warnings signs were not transcribed into local dialects. The International best radiation protection practises require that, such signals and warning should be presented in a language that is understood by the technicians in order to make them effective.

The presence of protective apparatus and signage at the X-ray departments are necessary for patients and public protection. In view of this, when the availability, knowledge and use of gonadal for patients' protection were assessed from the radiographers, a majority (83) of them indicated that these equipment were available, in good condition and were used for patients protection. These findings, however, is in contrast to that from the study by Eze et al. (2012) among radiographers in Lagos which showed that, although radiographers had

excellent knowledge in patient protection during X-ray examinations, protective devices such as gonad shields were deliberately and inadvertently ignored in government hospitals. Also, though all the radiographers who participated in this present study wore TLG badges for detection of radiation, radiation survey meters were absent from the facility and therefore, one could not detect the amount of radiation that was leaking from the X-ray tube and doors. Also, with the absence of the survey meters, it was impossible to monitor the doses of radiation that patients were exposed to in order to minimise them if necessary. For this reason, the multi-purpose detector had to be introduced into the X-ray room to enable this study to be conducted.

5.4 Assessment of safety standards at the facilities by Management

An assessment of the quality assurance of both facilities was designed to investigate the occurrence of incidents and how these were used to improve safety. Additionally, it was also to check how quality assurance programme incorporated the repair and maintenance of the X-ray machines. The study showed the availability of the aforementioned programme in all the facilities. These results were in contrast with findings by Muhogora et al (2010), who reported that, obsolete X-ray machines used in Tanzania did not have a record of quality assurance test. Respondents from the study indicated that, incidents (which included mix-up of names, exposure of wrong parts to radiation, retake of images etc.) were often not investigated and documented. Three (3) out of seven (7) respondents were of the opinion that, safety assessments did not take into consideration lessons learnt from the occurrence of such incidents.

5.5 Adherence to safety standards by radiographers at the facilities

The study again assessed the use of clinical dosimetry during common radiographic

procedures. It was recorded that, doses for adult patients were not measured for most of the common diagnostic procedures. Three (3) out of five (5) respondents indicated that, equipment failure, accidents and errors which occurred were not estimated. Patients were therefore not informed of such incidents and their adverse effects. The culture to assess patient doses should therefore be encouraged. Also, clearly laid down procedures to report and investigate incidents and accidents should be enforced by management to enhance optimum patient protection.

For radiographers, safety operations were designed to assess their knowledge and expertise on radiation and regulatory process. All the respondents who were interviewed had knowledge and expertise in radiation safety. A minority of the respondents however did not use the patient exposure chart and were not conversant with the terms and conditions of the authorization certificate from NRA. These factors might have contributed to the 0.21 loss of PI that was recorded.

5.6 Radiographers' enquiry and patient's knowledge on X-rays

From the study, none of the female respondents who went for radiographic examination from all the facilities were asked of their menstrual cycle before exposure to radiation. However, poor patient assessment and records by the physicians or radiographers' failure to capture such vital information could be detrimental. These findings were similar to those reported by William et al. (2014), which indicated that the patients were not enquired of their previous records before radiographic exposure. From these findings therefore, it is clear that intensive education coupled with other regulatory measures must be instituted by the radiation protection agency to ensure the protection of patients against unnecessary exposure to harmful radiations.

5.7 Role of physicians in patients' protection against harmful radiation

The physicians who were recruited in the study had adequate knowledge on the harmful effect of X-rays. They however were not aware of the accepted DRLs for the various body parts. Female respondents (20%) indicated that, physicians enquired about their last menstrual period. A study by Akintomide & Ikpeme (2014) further highlighted that, most physicians inadvertently exposed women who might be pregnant to X-ray radiations.

5.8 Assessment of patients' dosimetry

Generally, patients X-ray doses in Ridge Hospital were higher than that of Korle-Bu Teaching hospital by a maximum factor of 2.6. This could be attributed to the high radiation output from the X-ray machine installed at Ridge Hospital. Sharma et al (2012) also confirms that, patients' doses are affected by X-ray technology. The doses found in both hospitals were lower than that of DRL for Germany except for the lumbar spine and chest examinations in Ridge Hospital (Table 2). The doses in the two hospitals were all below the proposed DRL for Ghana for skull PA, abdomen PA and pelvis AP radiology examinations. However, for thoracic and lumbar spine AP radiology examinations, the doses were higher than the proposed DRL for Ghana. This might be due to the high tube voltage employed to penetrate these thick regions of the human body. The study also showed that, the proposed DRL for chest PA was high in Korle-Bu Teaching Hospital. Schandorf & Tetteh (1998) also in their study among radiographers and patients in Ghana showed that the radiation doses for most routine X-rays were above international standards.

CHAPTER SIX

CONCLUSION, RECOMMENDATIONS AND LIMITATIONS

6.1 Conclusion

Radiation protection of patients undergoing common radiographic procedures in Korle-Bu teaching hospital and Ridge hospital has been investigated using information collected from radiographers, physicians, patients and management. A self-structured questionnaire was designed to address the objectives of this study. The study showed that, none of the radiation safety categories achieved a full PI of 2. Radiographers had the highest PI (1.79) in safety operations while patient safety and knowledge recorded the lowest PI (0.89). There was no radiation monitoring equipment (survey meter) at all in the radiology departments of both facilities. Radiographers therefore were unable to detect radiation tube leakages or deterioration of shielding barriers that had been put in place. All the radiographers in these facilities had the academic qualification of a BSc degree. The study also showed that, radiographers had enough working experience thereby making them safety conscious. Majority of the radiographers at the study facilities employed the use of AEC and manual selection of exposure parameters. Safety protocols were available in all the departments. All the facilities considered for this study had authorization from the NRA to possess, use and handle X-ray for diagnostic purposes. This authorization was however granted on the basis that some corrective actions would be implemented. The physicians who were interviewed were knowledgeable about the hazardous effect of X-rays, however, their failure to query female patients particularly about their last menstrual cycle often led to the accidental exposure of foetuses to X-ray radiations. The Ghana Atomic Energy Commission has also recommended the actual dose of exposure of patients to radiation to be implemented by all radiographic institutions in the country.

6.2 Recommendation

Management in the hospitals are encouraged to provide staff with adequate, radiation-monitoring equipment, weighing scales and the necessary logistics to facilitate the operations of the radiographers in the radiology departments. Additionally, they should be committed to implementing all the corrective action provisions in the radiation authorization conditions issued by NRA. Lastly, management should provide a mechanism for feedback on operating experience, programme review and recommendations.

Physicians must take adequate history of all female clients of reproductive age to avoid the risk of exposing foetuses to harmful radiation in instances where such individuals may be pregnant.

Radiographers are to ensure adequate patient protection by using the approved procedures during manual selection of exposure parameters. Again, radiographers are to collaborate with management in order to draft a radiation safety procedures needed to ensure adequate protection of staff and clients. As part of optimising safety in the radiology unit, radiographers should investigate and report all accidents and incidents and perform periodic dosimetry.

6.3 Limitations of the study

1. Financial and time constraints did not allow for the recruitment of the calculated sample size.
2. The lack of consent by management resulted in the selection of very few individuals in this sector, as such findings from this study cannot be generalised.

3. The TLG badges of radiographers could not be collected and analysed as a result of time constraint. The MPD was however employed to measure the entrance surface dose.



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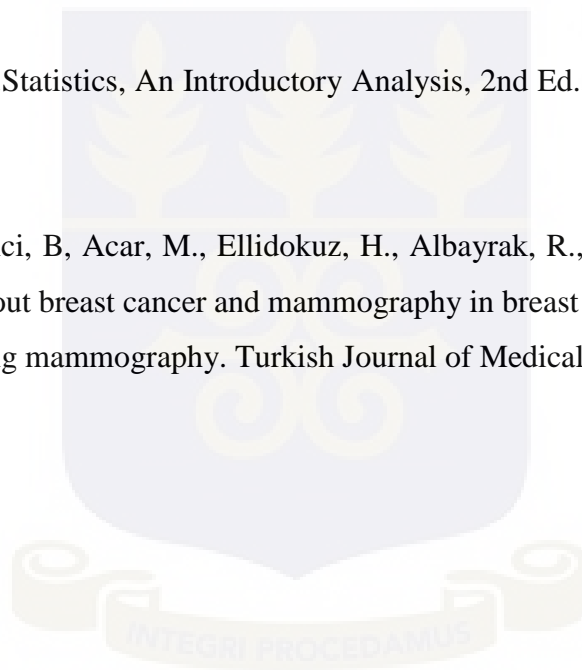
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APPENDICES

APPENDIX 1: CONSENT FORM FOR THE STUDY PARTICIPANTS

Identifying Number _____
Date _____

KORLE BU TEACHING HOSPITAL & RIDGE HOSPITAL

Information: to be read and translated to adults in their mother tongue if necessary

Adult's

Age:

Name:

Last name First name Middle initial

I am Samuel Teye from the School of Public Health, University of Ghana pursuing a Master's programme in Occupational Medicine. As part of the course programme and requirement for the award of a Master of Science degree in Occupational Medicine, I am conducting a research titled **“RADIATION PROTECTION FOR PATIENTS UNDERGOING SIMPLE RADIOGRAPHIC EXAMINATION IN SOME SELECTED HEALTH FACILITIES IN ACCRA”**.

The use of X-ray has increased in recent times. It has improved medical diagnosis of illnesses. X-ray devices use substances that produce ionizing radiation. Ionizing radiations are light particles that have enough energy to remove electrons from atoms or molecules to make these atoms or molecules charged. Medical X-ray accounts for the largest exposure to man-made ionizing radiation. Over exposure of patients to this ionizing radiation could

harm the patient in the short term or the long term. Short-term effects may include bruises or wounds whilst the long-term effect may include genetic defects such as leukemia. Most studies focus on the protection of the health worker.

This study aims at protecting the patient taking a simple radiological examination in some selected health facilities by looking at the safety facilities in these radiological departments.

The rationale behind this project is to determine the Safety standards and the level of protection of patients against ionizing radiation at the radiology department in some selected X-ray facilities in Accra.

It is important that you understand several general principles that apply to everyone who takes part in this study:

1. Participation in the study is entirely voluntary.
2. Personal benefit to you the individual is minimum, however the knowledge gained may benefit others.
3. You may withdraw from the study at any time.
4. Withdrawal from the study may not cause you to lose any services you are entitled to in this facility

The risk to you by participating is also very minimal. It is possible you may be frustrated by the questions that may be asked but be rest assured that, participation is completely voluntary. You are therefore free to opt out if you wish not to continue with this study. Your identity will be kept strictly confidential.

There will be no form of monetary compensation but for taking time off to participate in the study, you might be refreshed with water based on my discretion.

For any enquiries and explanation on the project, you are free to email me via (mesh10@hotmail.com) or 0244231533. You are also free to call Madam Hannah Frimpong on 0243235225. By completing and submitting this survey, you are giving your consent.

Thank you

APPENDIX 2: Consent form

CONSENT FORM

I..... have been thoroughly briefed on the entire methodology and significance of the on-going research which is being conducted by Samuel Teye (MSc Occupational Medicine)

On my own accord, I hereby consent to be part of the study based on my understanding of what the study entails.

I am doing this on condition that under no circumstances should any reference be made to my actual identity to other persons outside this study as promised by the researcher

Respondent's signature..... Date.....

Researcher's signature..... Date.....



APPENDIX 3: Questionnaire

Questionnaire

RADIATION PROTECTION FOR PATIENTS UNDERGOING SIMPLE RADIOGRAPHIC EXAMINATION IN SOME SELECTED HEALTH FACILITIES IN ACCRA.

Management: A, B3, C2,
Radiographers: A, B1, B3, B5, B6, B7
Patients: A, B4,

A. VERIFYING GENERAL INFORMATION PROVIDED

- 1 Name of the Institution:
- 2 Address of Facility:
- 3 Telephone/facsimile/email: Tel. #: Fax:
 Email:
- 5 Name, Position and Qualification Name:
 Position:
 Degree:
 Certification:
 Experience (Years):
 Age:
 Sex:
 Religion:

B VERIFICATION OF RADIATION SAFETY

B 1 Protection Measures - (to be answered by Radiographers)

i)	Is there a radiation survey meter on the facility?	Yes	No
ii)	Is the radiation survey meter being used?	Yes	No
iii)	Frequency of use of radiation survey meter?		
iv)	Do the facility own a gonadal shield?	Yes	No
v)	Is the gonadal shield in good condition?	Yes	No
vi)	When is the shield used?		
	Explain:		
		
vii)	Exposure signals and explanation posted?	Yes	No
vii)	Exposure signals and explanation posted	Provided?	No
		Working?	No

viii) Warning notices available	Provided? Working? Legible? In local language?	Yes Yes Yes	No No No
viii) Warning notices available?		Yes	No

B 2 Safety Operations - Management (to be answered by Management)

i) Are you knowledgeable about the terms and conditions of the certificate of authorization?	Yes	No
ii) Have you provided adequate staff levels?	Yes	No
iii) Have you provided adequate powers to the Radiation Protection Officer to stop unsafe operations?	Yes	No
iv) Have you provided adequate monitoring equipment? i.e. personnel monitors (TLDs) and radiation survey meter	Yes	No
iv) Have you made provision for initial and continuing training for staff (radiographer)?	Yes	No
vi) Have you provided a mechanism for periodic program reviews, feedback from operating experience and recommendations?	Yes	No
a) Date of last periodic program review		
b) Status of recommendations:		

B 3 Safety Operations – Technical (to be answered by Radiographers)

i) Do you have adequate knowledge and expertise in radiation?	Yes	No
ii) Are you conversant with the term and conditions of the authorization certificate	Yes	No
iii) Do you have sufficient time to give priority to attention on radiation safety?	Yes	No
iv) Do you conduct initial and continuing training of workers (other supporting staff)?	Yes	No
v) Are female patients asked of their menstrual cycle before exposure?	Yes	No
v) Do you use a patient exposure chart?	Yes	No
Vi) Which one do you use, automatic exposure control (AEC) or manual selection of exposure factors? a) AEC or b) Manual		
vii) What informs your selection of patient exposure parameters? Explain:		

B 4 Patient Safety and Knowledge - (to be answered by Patient)

i) Were you asked about your last menstrual period?	Yes	No
ii) Were you asked when you last took an X-ray examination?	Yes	No
iii) Do you have any idea about the bad effects of X-rays?	Yes	No
If 'Yes' Please explain:		
.....		
.....		
	Yes	No

B 5 Investigation and Quality Assurance - (to be answered by Radiographers)

i) Have there been any incident or accident? (incidents include mix-up of names, wrong body part exposure, retake of images etc)	Yes	No
ii) If so, were incident and or accident investigation reports prepared?	Yes	No
iii) Were safety assessments reviewed or made based upon lessons learned from any accident or accidents at similar facilities	Yes	No
iv) Are quality assurance procedures performed?	Yes	No
v) Is maintenance and repair work in accordance with manufacturers recommendations?	Scheduled? Performed?	Yes No Yes No
vii) Are maintenance/repair procedures	Scheduled? Performed?	Yes No Yes No
viii) Are there procedures for verifying patient identification?	Yes	No

B 6 Local Rules and Supervision - (to be answered by Radiographers/Management)

i) Are all rules in writing?	Yes	No
ii) Do the local rules include investigation and procedures to follow when an incident occurs?	Yes	No
iii) Have all workers in the facility been instructed on the rules to follow?	Yes	No
iv) Are all workers given adequate supervision to ensure rules, procedures, protection measures and safety provisions are followed?	Yes	No

B 7 Clinical Dosimetry - (to be answered by Radiographers)

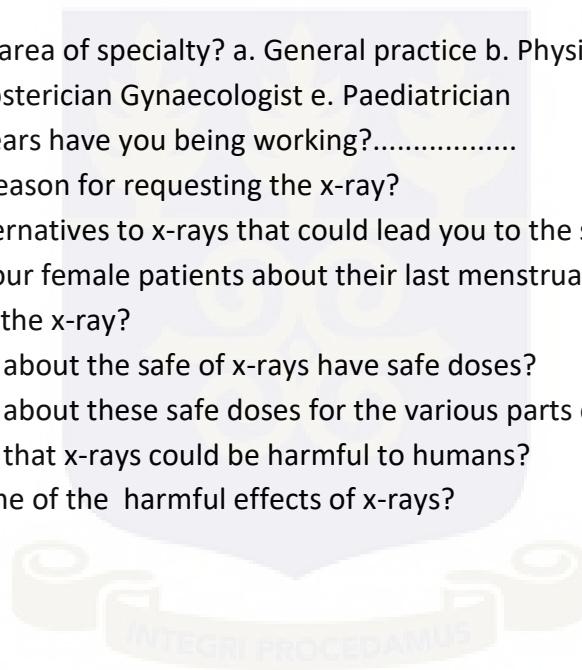
i) Are representative values of adult patient doses measured for the most common diagnostic procedures and documented?	Yes	No
ii) Did any equipment failure, accident, error, mishap or other unusual occurrence with potential for causing a patient exposure significantly different from that intended occur?	Yes	No
iii) If any incident/accident occur did the operator estimate the dose received by the patient?	Yes	No
iv) Was the patient informed about the incident/accident as well as his/her doctor?	Yes	No

Patients

1. Age:
2. Sex: a. male b. female
3. Religion a. Christian b. Muslim c. Traditionalist d. None
4. Educational level a. Primary b. Secondary c. Tertiary d. No formal education
5. Do you know about X-rays? A. yes b. No
6. If (4) above is yes, what are x-rays.....
7. Do you know about the harmful effect of x-ray a. yes b. no
8. If (6) above is yes, what are some of the harmful effect of x-ray?
Explain.....
9. Were you asked about your last menstrual period before the x-ray was taken?
a. yes b. no

Physicians

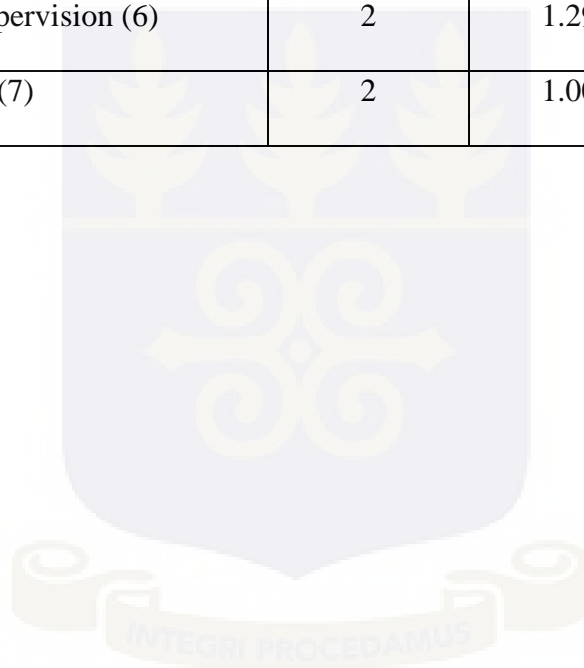
1. What is your area of specialty? a. General practice b. Physician specialist c. Surgeon d. Obsterician Gynaecologist e. Paediatrician
2. How many years have you being working?.....
3. What is the reason for requesting the x-ray?
4. Are there alternatives to x-rays that could lead you to the same diagnosis?
5. Do you ask your female patients about their last menstrual period before asking them to take the x-ray?
6. Do you know about the safe of x-rays have safe doses?
7. Do you know about these safe doses for the various parts of the human body?
8. Do you know that x-rays could be harmful to humans?
9. What are some of the harmful effects of x-rays?



APPENDIX 4:

Table 4.1: Performance indicators of the considered radiation safety categories

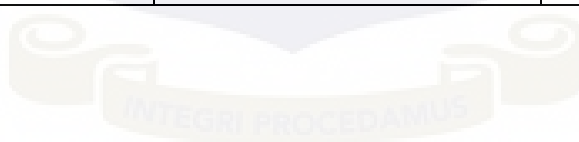
Category	Expected PI	Obtained PI	% Obtained PI
Protection Measures (1)	2	1.6	80.0
Safety Operations – Management (2)	2	1.06	53.0
Safety Operations –Radiographer (3)	2	1.79	89.5
Patient Safety and Knowledge (4)	2	0.89	44.5
Investigation and Quality Assurance (5)	2	1.6	80.0
Local Rules and Supervision (6)	2	1.29	64.5
Clinical Dosimetry (7)	2	1.00	50.0



APPENDIX 5:

Table 5.1: Identified variables and obtained coefficient of determination

Variables		Coefficient of determination (R ²)
A	B	
Experience of radiographer on the job	Protection measure category	0.35
Age of radiographer	Radiography experience	0.85
Experience of radiographer on the job	Safety operation category-radiographer	0.66
Experience of radiographer on the job	Investigations and quality assurance category	0.12
Experience of radiographer on the job	Local rules and supervision category	0.64
Experience of radiographer on the job	Clinical dosimetry category	0.27
Age of hospital management	Safety operation category-management	0.91
Age of patients	Patient safety and knowledge category	0.49



GHANA HEALTH SERVICE ETHICS REVIEW COMMITTEE

*In case of reply the
number and date of this
Letter should be quoted.*



Research & Development Division
Ghana Health Service
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Tel: +233-302-681109
Fax: + 233-302-685424
Email: Hannah.Frimpong@ghsmail.org

My Ref: GHS/RDD/ERC/Admin/App/16/90
Your Ref. No.

Samuel Teye
University of Ghana
School of Public Health
Legon, Accra

The Ghana Health Service Ethics Review Committee has reviewed and given approval for the implementation of your Study Protocol.

GHS-ERC Number	GHS-ERC 77/12/15
Project Title	“Radiation Protection of Patients Undergoing Simple Radiographic Examination in Selected Facilities in Accra”
Approval Date	14 th April, 2016
Expiry Date	13 th April, 2017
GHS-ERC Decision	Approved

This approval requires the following from the Principal Investigator

- Submission of yearly progress report of the study to the Ethics Review Committee (ERC)
- Renewal of ethical approval if the study lasts for more than 12 months,
- Reporting of all serious adverse events related to this study to the ERC within three days verbally and seven days in writing.
- Submission of a final report **after completion** of the study
- Informing ERC if study cannot be implemented or is discontinued and reasons why
- Informing the ERC and your sponsor (where applicable) before any publication of the research findings.

Please note that any modification of the study without ERC approval of the amendment is invalid.

The ERC may observe or cause to be observed procedures and records of the study during and after implementation.

Kindly quote the protocol identification number in all future correspondence in relation to this approved protocol

SIGNED.....
DR. CYNTHIA BANNERMAN
(GHS-ERC CHAIRPERSON)

Cc: The Director, Research & Development Division, Ghana Health Service, Accra