ASSESMENT OF THE RADIATION SAFETY STANDARD IN YOBE STATE UNIVERSITY TEACHING HOSPITAL DAMATURU.

BY

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NSU/PGD/RMP/0006/17/18

A PROJECT SUBMITTED TO THE SCHOOL OF POST GRADUATE STUDIES, NASARAWA STATE UNIVERSITTY KEFFI, IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF DEGREE OF POST GRADUATE DIPLOMA IN PHYSICS (RADIATION AND MEDICAL)

DEPARTMENT OF PHYSICS

FACULTY OF NATURAL AND APPLIED SCIENCES

NASARAWA STATE UNIVERSITY, KEFFI

NIGERIA

SEPTEMBER 2018

DECLARATION

I hereby declare that this project has been written by me and it is a report of my research work. It has not been presented in any previous application for post graduate diploma. All quotations are indicated and sources of information specifically acknowledged by means of references.

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CERTIFICATION

The project assessment of the radiation safety standard in yobe state university teaching hospital damaturu meets the regulations governing the award of postgraduate diploma of the school of post graduate studies Nasarawa state university, keffi and is approved for its contribution to knowledge.

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AKNOWLEDGEMENT

Appreciation is considered as an epitome of courtesy especially to those that contribute to ones success. In view of this my happiness and profound gratitude goes to Almighty Allah who give me the wisdom, knowledge, strength and opportunity to carry out this research successfully. I also acknowledged the effort of my supervisor Dr. S. D. Yusuf who greatly contributed to the success of this work through his un tireless effort. My lecturers and the entire department of physics staff who assisted me in my education carrier, for their courage and orientation in other to achieve success in my carrier.

I must express a profound appreciation to my parents, Alh. Bukar Abba Yusufari and Haj. Gajiram Bukar for their un ending support to my success. I also appreciate the efforts of my family members, friends and colleagues for their support.

ABSTRACT

The use of radiation has become very common in diagnosis and treatment of disease in the field of medicine since its discovery more than a century ago. Radiation protection and safety has been a major concern of many national and international bodies because of the potential hazardous effects associated with ionizing radiation if not properly controlled. Radiographers, who are the major dispenser of ionizing radiation, need proper monitoring for safe practice. In Nigeria, Nigerian Nuclear Regulatory Authority (NNRA) is saddled with the responsibility to regulate and monitor the use of ionizing radiation in the country. International Commission on radiation Protection (ICRP) in conjunction with International Atomic Energy Agency (IAEA) had been providing series of documents on radiation safety standards. Twenty personnel of radiology department from Yobe state university teaching hospital Damaturu were administered a self structured questionnaires on compliance to radiation safety standard. The result reveals high compliance rate in the hospital. Conclusively, this showed that radiographers working in public establishments in Yobe state were been monitored and they strictly followed the radiation protection and safety standard rules to be within radiation workers dose limits. That is principles of radiation protection are observed.

Key words: Compliance, Radiographer, Radiation, Protection, Safety, Standard.

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CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

The discovery of X- rays by Roentgen in 1895 was a great achievement for the medical field. The medical application of x-rays developed and increased dramatically across all medical fields namely, application in dentistry, orthopeadics, surgery and paediatrics for producing body images for diagnostic purpose. X-Radiation is dangerous and yet it is used extensively in medicine. Its use is regulated and monitored to protect staff, patients and general public from the dangers associated with the application of x-rays (Bushong, 2001).

Radiation is the emission and propagation of energy in the form of waves, rays or particles, there are three main types of radiation which include ionizing radiation, non ionizing radiation and neutrons (Shika, 2012). Radiation safety is the protection of personnel against harmful effects of ionizing radiation by taking steps to ensure that people will not receive excessive doses of radiation and by monitoring all sources of radiation to which they may be exposed, they are measures taken when working with radioactive substances (International Atomic Energy Agency, 2014). Radiation safety provides more effective diagnosis and treatment, improves patient and personnel safety and reduces radiation exposure risk (Agapi & Efstathios, 2016). Radiation safety rules must be strictly adhered to otherwise it results in so many hazards including environmental contamination, increasing cancer risk and damaging of living organs to both personnel and patients (Dance *et al*., 2014).

Radiation Safety standards are standards, regulations, rules or codes of practice established to protect man and the environment against ionizing radiation and to minimize danger to life and property (IAEA, 2014). The standards goal is not only to give lowest dose but to provide correct dose to enable personnel to make beneficial diagnosis and avoid exposures that could cause deterministic effect from non compliance to safety standard. This may also result in closure of radiology centre, revocation of licenses and some legal penalties until standards are fully implemented (Ola, Renate & Fred, 2010).

The Nuclear Safety and Radiation Protection Act 19 of 1995, and the Radiation Safety Regulations 2006, Regulates all listed electronic products (radiation sources). And any person who intends to utilise radiation source for medical purposes shall notify the authority of his intention and shall apply for authorization and give information necessary to demonstrate the safety of the practice. The license authorizes institutions to procure, install and use x-ray machines. The license is issued with the conditions and guidelines that have to be satisfied in order to continue using the x-ray machines. Compliance is enforced by inspectors from the Nigerian Nuclear Regulatory Authority (NNRA) through periodic inspections. Failure to meet these requirements during inspections constitutes a danger to the public and justifies an action of sealing equipment (NNRA, 2006).

The main objective of the Nuclear Safety and Radiation Protection Act, 19 of 1995 is to provide health and safety to employees in the workplace and the people in a community who are affected by the activities around them. The employer is responsible for ensuring that appropriate protective measures are set up and implemented such as safe working environment, protective clothing and radiation monitoring devices. The employees should comply with safety rules and procedures specified by the employer. The employees must adhere to appropriate use of protective clothing and radiation monitoring devices ensuring protection for themselves, the clients and general public from exposure to radiation (NNRA, 2006).

The Nigerian Nuclear Regulatory Authority (NNRA), under the professional code of conduct requires radiographers to protect themselves, the patients, co-workers and the general public from radiation exposure. The Council also expects Radiographers to be involved in continuous professional development to update themselves with professional developments and maintain their skills (NNRA, 2018).

The definition of radiation safety for this study will relate to licensing of listed electronic products, availability and use of lead protective clothing and radiation monitoring device, implementation of quality assurance program and proper management of radiation records. The implication of the definition will indicate how radiographers conduct themselves in the workplace, their knowledge, attitudes, perceptions and performance (Triantopoulou, Tsalafoutas & Maniatis, 2004). The radiation protection studies that were conducted overseas by Adam and Smith (2003) did not explore the challenges faced by radiographers in implementing radiation protection measures. Therefore this study is aimed at investigating compliance to Radiation safety standards in Radiography departments, and evaluates the level of compliance and challenges radiographers face in the implementation of radiation safety standards. Insufficient research in radiography and the fact that the study was never done in Yobe state motivated the conduct of the study.

1.2 Statement of the Problem

There is an indication that some Radiology departments in public hospitals are not complying with radiation safety standards. The Radiation Control inspectors visit some hospitals and confirmed that some hospitals do not comply with the licensing conditions of x-ray equipments. A number of radiology departments received warning notices and some x-ray machines were sealed until they comply with the licensing conditions. The availability of adequate protective clothing such as lead aprons, thyroid collars, lead gloves, gonad shields, written protocols and quality assurance were also a concern (NNRA, 2018).

The increasing use of radiation has stimulated a concern for potential harmful radiation effects. The complexity of radiography procedures, lack of quality control programme and specific training on radiation protection may result in an occurrence of deterministic effects. The potential for increased stochastic effects is a major public safety concern (Shika, 2012).

There are rapid developments with regard to radiation safety measures that radiographers are expected to comply with. Radiographers are challenged to keep abreast with these developments. The NNRA and IAEA are enforcing compulsory continuing professional development for radiographers ensuring that they are updated with new developments in their profession to remain competent (NNRA, 2018).

1.3 Research Question

What is the current status of compliance to radiation safety standard at public hospitals in Yobe State of Nigeria?

1.4 Aim of the Study

The aim of the study is to assess the level of compliance to Radiation Safety and standard by Radiographers and radiation workers at public hospitals in Yobe State.

1.5 Objectives of the Study

The specific objectives of the study are to:

1. Generate demographic profile of public service radiographers in Yobe state university teaching hospital.

2. Evaluate the level of compliance to the implementation of radiation safety standards of public service radiographers using a self structured questionnaire
3. Investigate the challenges faced by radiographers in the implementation of radiation safety standards.

1.6 Significance of the Study

Findings of the proposed study will establish level of compliance to radiation safety standards and challenges faced by radiographers in Yobe state public hospitals. Solutions will be suggested and, inputs will be made to assist policy makers of the Department of radiology in public hospitals.

1.7 Scope of the Study

The emphasis on this research is the importance of radiation safety and standards compliance in public hospitals. This means that the research will assess the level of compliance to safety standards with the availability of personnel protection and safety equipments, principles and techniques employed. The research focused on Yobe state university teaching hospital Damaturu.

1.8 Definition of Terms

Radiation

Radiation can be described as energy or particles from a source that travel through space or other mediums (Dance *et al.*, 2014).

Ionising Radiation

Any radiation emanating from listed electronic product, capable of producing ions directly or indirectly in its passage through matter (Shika, 2012).

Listed Electronic Products

Refers to any manufactured product which and when in operation contains or act as part of electronic circuit and emits radiation which may cause injury, ill health or death to human beings (Shika, 2012).

License

Refers to a legal document issued by the regulatory body granting permission to perform specified activities using listed electronic product in a regulated area (NNRA, 2006).

Quality Assurance Program

It is a system of plans, tests, reviews, reports, records and actions of which the purpose is to protect the public and radiation workers from unnecessary exposure to radiation and to reduce the occurrence of misdiagnosis caused by faulty equipment and operator error (NNRA, 2006).

International Commission on Radiological Protection (ICRP)

Is an international body consisting of experts in the fields of radiology, physics, radiation protection, biology, genetics, biochemistry and biophysics functioning to prepare, review and publish recommendations for the promotion of effective radiation protection (IAEA, 2014).

Medical Exposure

Exposure received by patients as part of their treatment or diagnosis (NNRA, 2006).

Occupational Exposure

All exposures workers receive as a direct and necessary condition of their occupation, business or employment (NNRA, 2006).

Radiation Dose

The amount of radiation absorbed per unit mass of matter. It provides a measure to gauge the potential for biological effects (Shika, 2012).

Dose limitation

Refers to the use of radiation protective clothing as an effective way of reducing radiation dose to the patients (NNRA, 2006).

Optimisation

Means that all exposures should be kept As Low As Reasonable and Achievable (NNRA, 2006).

CHAPTER TWO

LITERATURE REVIEW

2.1 Radiation

Radiation can be described as the energy or particles from a source that travel through space or other mediums. Visible light, heat, microwaves and wireless communications are all forms of radiation (Podgorsak, 2005). Radiation can broadly be defined as the entire spectrum of electromagnetic waves, radio waves, microwaves, infrared, visible light, ultraviolet, x-rays and atomic particles. Radiation is the transport of energy by electromagnetic waves or atomic particles which can be classified into two main categories ionising or non-ionising depending on its ability to ionize matter. The ionization potential of atoms, i.e. the minimum energy required to ionize an atom, ranges from a few electron volts for alkali elements to 24.6 eV for helium which is in the group of noble gases. Ionization potentials for all other atoms are between the two extremes (Dance *et al.*, 2014). Although the term "ionizing radiation" is in this case more precise, common usage often omits "ionizing" and this is what is done here, there are four major types of radiation which include gamma (γ) radiation, beta (β) radiation, alpha (α) particles and Auger electrons (Thormod, 2013).

Radioactive substances and radiations are used for diagnosis, treatments, and research. x-rays for instance pass through muscles and other soft tissue but are stopped by dense materials. This property of x-rays enables doctors to locate fractured bones and to locate cancers that might be growing in the body. Certain diseases are also found by injecting a radioactive substance and monitoring the radiation given off as the substance moves through the body. Radiation used for cancer treatment is called ionizing radiation because it forms ions in the cells of the tissues it passes through as it dislodges electrons from atoms. This can kill cells or change genes so the cells cannot grow (Dance *et al.,* 2014). Modern communication systems use some forms of electromagnetic radiation, variations in the intensity of the radiation represent changes in the sound, pictures, or other information being transmitted. For example a human voice can be sent as a radio wave or microwave by making the wave vary to correspond variations in the voice. Musicians have also experimented with gamma sonification, or using nuclear radiation, to produce sound and music (Shika, 2012).

The increasing use of radiation has stimulated a concern for potential harmful radiation effects**.** The effects of radiation are classified into stochastic and non-stochastic. Stochastic effects occur where a cell exposed to radiation is modified and over a long period may develop into cancer or genetic mutations. Non stochastic effects occur when a tissue is exposed to high dose of radiation within a short period of time resulting in death of a cell and delayed cell division, for example skin changes, and gonodal cell damage leading to infertility (Dewey, George & Gray, 2005).

2.1.1 Types of Radiation

In nuclear medicine, there are four types of radiation which play a relevant role in tumour and normal tissue effects: gamma (γ) radiation, beta (β) radiation, alpha (α) particles and Auger electrons (Dance *et al.,* 2014).

Gamma radiation

Gamma radiation is an electromagnetic radiation of high energy (usually above 25 keV) and is produced by subatomic particle interactions. Electromagnetic radiation is often considered to be made up of a stream of wave-like particle bundles (photons) which move at the speed of light and whose interaction properties are governed mainly by their associated wavelength. Although the collective ionization behavior of large numbers of photons can be predicted with great accuracy, individual photon interactions occur at random and, in passing through any type of matter, a photon may interact one or more times, or never. In each interaction (which will normally involve a photoelectric event, a Compton event or a pair production event), secondary particles are produced, usually electrons (which are directly ionizing) or another photon of reduced energy which itself can undergo further interactions. The electrons undergo many ionizing events relatively close to the site of their creation and, therefore, contribute mostly to the locally absorbed dose. Any secondary photons which may be created carry energy further away from the initial interaction site and, following subsequent electron-producing interactions, are responsible for the dose deposition occurring at sites which are more distant from the original interaction (Podgorsak, 2005).

Beta radiation

Beta radiation is electrons emitted as a consequence of β radionuclide decay. A β decay process can occur whenever there is a relative excess of neutrons (β^-) or protons (β^+). One of the excess neutrons is converted into a proton, with the subsequent excess energy being released and shared between an emitted electron and an anti-neutrino. Many radionuclides exhibit β decay and, in all cases, the emitted particle follows a spectrum of possible energies rather than being emitted with a fixed, discrete energy. In general, the average β energy is around one third of the maximum energy. Most β emitting radionuclides also emit γ photons as a consequence of the initial β decay, leaving the daughter nucleus in an excited, metastable state. Since β particles are electrons, once ejected from the host atom, they behave exactly as do the electrons created following the passage of a γ ray, giving up their energy (usually of the order of several hundred kilo electronvolts) to other atoms and molecules through a series of collisions. For radionuclides which emit both β particles and γ photons, it is usually the particulate radiation which delivers the greatest fraction of the radiation dose to the organ which has taken up the activity. For example, about 90% of the dose delivered to the thyroid gland by ^{131}I arises from the β component. On the other hand, the γ emissions contribute more significantly to the overall whole body dose (Podgorsak, 2005).

Alpha particles

Alpha radiation is emitted when heavy, unstable nuclides undergo decay. Alpha particles consist of a helium nucleus (two protons combined with two neutrons) emitted in the process of nuclear decay. The α particles possess approximately 7000 times the mass of a β particle and twice the electronic charge, and give up their energy over a very short range (<100 μm). Alpha particles usually possess energies in the mega electronvolt range, and because they lose this energy in such a short range are biologically very efficacious, i.e. they possess a high linear energy transfer and are associated with high relative biological effectiveness (Podgorsak, 2005).

Auger electrons

Radionuclides which decay by electron capture or internal conversion leave the atom in a highly excited state with a vacancy in one of the inner shell electron orbitals. This vacancy is rapidly filled by either a fluorescent transition (characteristic x-ray) or non-radiative (Auger) transition, in which the energy gained by the electron transition to the deeper orbital is used to eject another electron from the same atom. Auger electrons are very short range, low energy particles that are often emitted in cascades, a consequence of the inner shell atomic vacancy that traverses up through the atom to the outermost orbital, ejecting additional electrons at each step. This cluster of very low energy electrons can produce ionization densities comparable to those produced by an α particle track. Thus, radionuclides which decay by electron capture and/or internal conversion can exhibit high LET-like behaviour close (within 2 nm) to the site of the decay (Podgorsak, 2005).

2.1.2 Classification of Radiation

Radiation is classified into two main classes base on their energy and ionization potentials, these are non ionizing radiation and ionizing radiation respectively. Ionizing radiation is further divided into directly ionizing and indirectly ionizing radiation based on the particles charge as indicated in Figure 2.1 (Podgorsak, 2005).

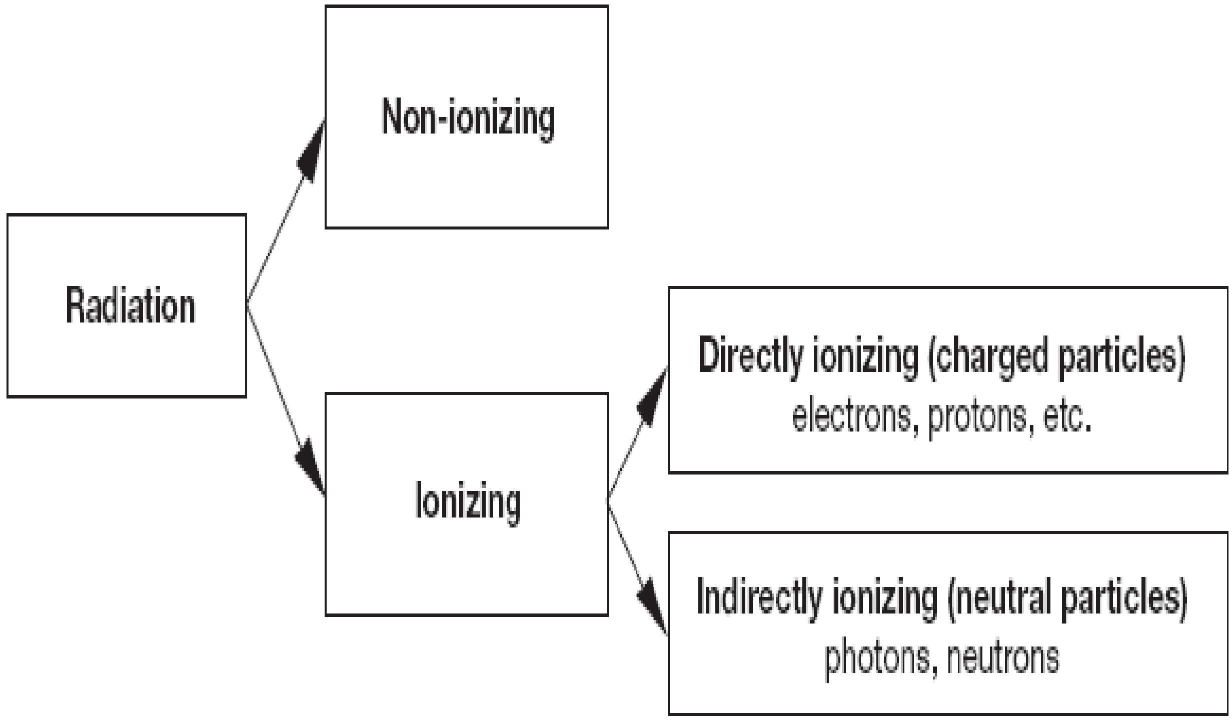

Figure 2.1: Classification of radiation (Podgorsak, 2005).

Non-Ionizing Radiation: these cannot ionize matter because its energy per quantum is below the ionization potential of atoms. Near ultraviolet radiation, visible light, infrared photons, microwaves and radio waves are examples of non-ionizing radiation (Podgorsak, 2005).

The particles of non-ionizing radiation have small kinetic energy to produce charged ions as they passing through matter. For non-ionizing electromagnetic radiation the associated particles (photons) have only sufficient energy to change the rotational, vibrational or electronic valence configurations of molecules and atoms. Some effects of non-ionizing forms of radiation on living tissue have recently been studied and different biological effects are observed (Thormod, 2013).

Non-ionizing radiation is capable of causing thermal ionization if it deposits enough heat to raise temperatures to ionization energy level. These reactions occur at far higher energies than with ionization radiation, which requires only single particles to cause ionization. Similarly thermal ionization occurs in the flame ionization of a common fire and the browning reactions in the food items induced by infrared radiation during broiling type cooking (Podgorsak, 2005).

The non-ionizing portion of electromagnetic radiation consists of electromagnetic waves that are not energetic enough to attract electrons from atoms or molecules and leads to their ionization. These include radio waves, microwaves, infrared, and (sometimes) visible light. The lower frequencies of ultraviolet light may cause chemical changes and molecular damage similar to ionization, but is technically not ionizing. The highest frequencies of ultraviolet light, as well as all X-rays and gamma-rays are ionizing (Thormod, 2013).

The occurrence of ionization depends on the energy of the individual particles or waves, and not on their number. An intense flood of particles or waves will not cause ionization if these particles or waves do not carry enough energy to be ionizing, unless they raise the temperature of a body to a point high enough to ionize small fractions of atoms or molecules by the process of thermal-ionization (this, however, requires relatively extreme radiation intensities) (Thormod, 2013).

Ionizing Radiation: this can ionize matter either directly or indirectly because its quantum energy exceeds the ionization potential of atoms. X rays, γ rays, energetic neutrons, electrons, protons and heavier particles are examples of ionizing radiation (Podgorsak, 2005).

Radiations with high energy can ionize atoms that is to say it can knock electrons out of an atom creating ions. Ionization occurs when an electron is stripped out from an electron shell of the atom, which leaves the atom with a net positive charge. Because living cells and importantly the DNA in those cells can be damaged by this ionization, exposure to ionizing radiation is considered to increase the risk of cancer. Thus "ionizing radiation" is somewhat artificially separated from particle radiation and electromagnetic radiation, simply due to its great potential for biological damage (Thormod, 2013). While an individual cell is made of trillions of atoms, only a small fraction of those will be ionized at low to moderate radiation powers. The probability of ionizing radiation causing cancer is dependent upon the absorbed dose of the radiation and is a function of the damaging tendency of the type of radiation (equivalent dose) and the sensitivity of the irradiated organism or tissue (effective dose) (Podgorsak, 2005).

If the source of the ionizing radiation is a radioactive material or a nuclear process such as fission or fusion there are particle radiation to be considered. Particle radiation is subatomic particles accelerated to relativistic speeds by nuclear reactions. Because of their energy they are quite capable of knocking out electrons and ionizing materials but since most have an electrical charge they don't have the penetrating power of ionizing radiation. The exception is neutron particles. There are several different kinds of these particles but the majority are alpha particles, beta particles, neutrons, and protons. Roughly speaking, photons and particles with energies above 10 electronvolts (eV) are ionizing (some authorities use 33 eV, the ionization energy for water). Particle radiation from radioactive material or cosmic rays almost invariably carries enough energy to be ionizing (Thormod, 2013).

Most ionizing radiation originates from radioactive materials and space (cosmic rays), and as such is naturally present in the environment, since most rock and soil has small concentrations of radioactive materials. The radiation is invisible and not directly detectable by human senses as a result instruments such as Geiger counters are usually required to detect its presence. In some cases it may lead to secondary emission of visible light upon its interaction with matter, as in the case of Cherenkov radiation and radio luminescence (Thormod, 2013). This research focuses on radiation having energies high enough to ionize matter. Examples are x-rays, cosmic rays, and the emissions from radioactive elements.

Ionizing radiation has many practical uses in medicine, research and constructions, but presents a health hazard if used improperly (Shika, 2012). Exposure to radiation causes damage to living tissue with high doses resulting in Acute radiation syndrome (ARS), with skin burns, hair loss, internal organ failure and death, while any dose may result in an increased chance of cancer and genetic damage. A particular form of cancer, the thyroid cancer often occurs when nuclear weapons and reactors are the radiation source because of the biological proclivities of the radioactive iodine fission product. However calculating the exact risk of cancer forming in cells caused by ionizing radiation is still not well understood and currently estimates are loosely determined by population based on data from the atomic bombing in Japan and from reactor accident follow up such as with the Chernobyl disaster (Thormod, 2013). The International Commission on Radiological Protection states that, The Commission is aware of uncertainties and lack of precision of the models and parameter values, Collective effective dose is not intended as a tool for epidemiological risk assessment and it is inappropriate to use it in risk projections and in particular, the calculation of the number of cancer deaths based on collective effective doses from trivial individual doses should be avoided (Podgorsak, 2005).

The kind of radiation discussed in this research is ionising radiation because it can produce charged particles (ions) in matter. Ionising radiation is emitted by a large range of natural materials, can be produced by everyday devices such as X-ray machines, and can also be emitted by unstable atoms. Atoms become unstable when they have the wrong amount of mass required to keep them stable, an excess of energy, or both. Unstable atoms are said to be radioactive (Shika, 2012).

2.1.3 Classification of Ionizing Radiation

Ionizing radiation is radiation that carries enough energy per quantum to remove an electron from an atom or a molecule, thus introducing a reactive and potentially damaging ion into the environment of the irradiated medium. Ionizing radiation can be categorized into two types: (i) directly ionizing radiation and (ii) indirectly ionizing radiation. Both directly and indirectly ionizing radiation can traverse human tissue, thereby enabling the use of ionizing radiation in medicine for both imaging and therapeutic procedures (Dewey *et al.*, 2005).

i. Directly ionizing radiation consists of charged particles, such as electrons, protons, α particles and heavy ions. It deposits energy in the medium through direct Coulomb interactions between the charged particle and orbital electrons of atoms in the absorber.

ii. Indirectly ionizing radiation consists of uncharged particles which deposit energy in the absorber through a two-step process. In the first step, the neutral particle releases or produces a charged particle in the absorber which, in the second step, deposits at least part of its kinetic energy in the absorber through Coulomb interactions with orbital electrons of the absorber in the manner discussed for directly ionizing charged particles.

Ionising radiation is one of the few cancer- causing agents for which substantial data is available to estimate risk. The epidemiological studies of populations exposed to radiation such as the survivors of the Second World War atomic explosions demonstrated that exposure to radiation has delayed induction of malignancies (Dewey *et al.*, 2005).

2.1.4 Radiation Quantities and Units

Accurate measurement of radiation is very important in all medical uses of radiation, be it for diagnosis or treatment of disease. In diagnostic imaging procedures, image quality must be optimized, so as to obtain the best possible image with the lowest possible radiation dose to the patient to minimize the risk of morbidity. In radiotherapy, the prescribed dose must be delivered accurately and precisely to maximize the tumour control probability (TCP) and to minimize the normal tissue complication probability (NTCP). In both instances, the risk of morbidity includes acute radiation effects (radiation injury) as well as late radiation-induced effects, such as induction of cancer and genetic damage. Several quantities and units were introduced for the purpose of quantifying radiation and the most important of these are listed in Table 2.1. Also listed are the definitions for the various quantities and the relationships between the old units and the SI units for these quantities (Dance *et al.,* 2014).The definitions of radiation related physical quantities are;

i. Exposure X is related to the ability of photons to ionize air. Its unit, roentgen (R), is defined as a charge of 2.58×10^{-4} coulombs produced per kilogram of air.

ii. Kerma K (acronym for kinetic energy released in matter) is defined for indirectly ionizing radiation (photons and neutrons) as energy transferred to charged particles per unit mass of the absorber.

iii. Dose (also referred to as absorbed dose) is defined as energy absorbed per unit mass of medium. Its SI unit, gray (Gy), is defined as 1 joule of energy absorbed per kilogram of medium.

iv. Equivalent dose H_T is defined as the dose multiplied by a radiation weighting factor W_R. When different types of radiation are present, H_T is defined as the sum of all of the individual weighted contributions. The SI unit of equivalent dose is the sievert (Sv).

v. Effective dose E of radiation is defined as the equivalent dose H_T multiplied by a tissue weighting factor W_T. The SI unit of effective dose is also the sievert (Sv).

vi. Activity A of a radioactive substance is defined as the number of nuclear decays per time. Its SI unit, becquerel (Bq), corresponds to one decay per second.

In addition to the physical quantities, other dose related quantities have been introduced to account not only for the physical effects but also for the biological effects of radiation upon tissues. These quantities are organ dose, equivalent dose, effective dose, committed dose and collective dose (Podgorsak, 2005).

Organ dose

The organ dose is defined as the mean dose D_T in a specified tissue or organ T of the human body, given by:

$$D_T = \frac{1}{m_T} \int_{m_T} D \ dm = \frac{\varepsilon_T}{m_T} \qquad (2.1)$$

Where: m_T is the mass of the organ or tissue under consideration;

ε_T is the total energy imparted by radiation to that tissue or organ.

Equivalent dose

The biological detriment (harm) to an organ depends not only on the physical average dose received by the organ but also on the pattern of the dose distribution that results from the radiation type and energy. For the same dose to the organ, a neutron radiation will cause greater harm compared with grays or electrons. This is because the ionization events produced by a neutron radiation will be much more closely spaced (densely ionizing radiations) and so there is a higher probability of irreversible damage to the chromosomes and less chance of tissue repair. Consequently, the organ dose is multiplied by a radiation weighting factor w_R to account for the effectiveness of the given radiation in inducing health effects; the resulting quantity is called the equivalent dose H_T (Podgorsak, 2005). The equivalent dose *H*T is defined as:

$$H_T = w_R D_{T,R} \tag{2.2}$$

Where: $D_{T,R}$ is the absorbed dose delivered by radiation type R averaged over a tissue or organ T

w_R is the radiation weighting factor for radiation type R.

For X rays, g rays and electrons w_R = 1; for protons w_R = 5; for particles w_R = 20; and for neutrons w_R ranges from 5 to 20, depending on the neutron energy (Podgorsak, 2005).

The SI unit of equivalent dose is J/kg and its name is the sievert (Sv); the old unit is the rem and the relationship between the two units is 1 Sv = 100 rem; for example, for 1 Gy of photon dose to an organ, the equivalent dose is 1 Sv. However, for the same dose of 20 keV neutrons, the equivalent dose is 10 Sv, since the detriment is ten times larger (i.e. w_R = 10 for 20 keV neutrons). The organ dose $D_{T,R}$ is a measure of the energy absorption per unit mass averaged over the organ, while the equivalent dose H_T is a measure of the consequent biological harm (detriment) to the organ or tissue T (Dance, *et al.*, 2014). If an organ is irradiated by more than one type of radiation, the equivalent dose is given by the sum:

$$H_{T=} \sum w_R D_{T,R} \tag{2.3}$$

In earlier ICRP recommendations, weighting factors related to the quality of radiation were applied to the absorbed dose to a point, and the radiation weighted absorbed dose was called the dose equivalent *H* (not referred to an organ, but to a point) (Podgorsak, 2005).

Effective dose

The relationship between the probability of stochastic effects and equivalent dose is also found to depend on the organ or tissue irradiated. This implies that for the same equivalent dose the detriments from the exposure of different organs or tissues are different. To take account of these differences, tissue weighting factors are needed. Tissue weighting factors w_T should represent the relative contribution of an organ or tissue to the total detriment due to the effects resulting from a uniform irradiation of the whole body. For low doses, individual organ or tissue detriments can be treated as additive and the total detriment to the whole body is the summation of individual detriments. The relative contribution to the total detriment is therefore given by the quotient between the individual detriment and the total detriment resulting from a uniform irradiation of the whole body (Podgorsak, 2005).

Since the sum of relative contributions is normalized to unity, the sum Sw_T = 1. The effective dose *E* is defined as the summation of tissue equivalent doses, each multiplied by the appropriate tissue weighting factor w_T, to indicate the combination of different doses to several different tissues in a way that correlates well with all stochastic effects combined

$$E = \sum w_T H_T \tag{2.4}$$

Tissue weighting factors w_T despite depending on the sex and age of the person, for the purposes of radiation protection the values for tissue weighting factors are taken as constants and are applicable to the average population; for example, w_T = 0.20 for gonads, w_T = 0.12 for lung or red bone marrow and w_T = 0.01 for skin. Thus for the same equivalent dose, the risk of a stochastic effect at low doses is higher for gonads than for the lungs or red bone marrow.

The unit of effective dose is J/kg and its name is the sievert (Sv) (Podgorsak, 2005).

A uniform equivalent dose over the whole body gives an effective dose that is numerically equal to the uniform equivalent dose. The weighing factors w_T and w_R are mutually independent; that is, the tissue risk factors w_T are independent of radiation type and the radiation weighting factors w_R are independent of tissue type, allowing us to write:

$$E = \sum_T w_T \sum_R w_R D_{T,R} = \sum_R w_R \sum_T w_T D_{T,R} \quad (2.5)$$

$$E = \sum w_T D_{T,R} \quad (2.6)$$

The effective dose is a measure of dose designated to reflect the amount of radiation detriment likely to result from the dose. Effective doses from various radiation types and exposure modes may be compared directly. Annual dose limits for occupational and public exposure are given in

terms of the annual effective dose; in the case of exposure of an organ or of hands or feet they are given in terms of equivalent dose (Podgorsak, 2005).

Committed dose

When radionuclides are taken into the body, the resulting dose is received throughout the period of time during which they remain in the body. The total dose delivered during this period of time is referred to as the committed dose and is calculated as a specified time integral of the rate of receipt of the dose. Any relevant dose restriction is applied to the committed dose from the intake. The committed dose may refer to the committed effective dose and the committed equivalent dose (Dance *et al.*, 2014).

Collective dose

The radiation protection quantities discussed above relate to the exposure of an individual. The collective dose relates to exposed groups or populations and is defined as the summation of the products of the mean dose in the various groups of exposed people and the number of individuals in each group. The unit of collective dose is the man-sievert (man-Sv) (Podgorsak, 2005).

Table 2.1: Radiation quantities, units and conversion between old and SI units

Quantity	Definition	SI unit	Old unit	Conversion
Exposure X	$X = \frac{\Delta Q}{\Delta m_{air}}$	$2.58 \times \frac{10^{-4}\,\mathrm{C}}{\mathrm{kg\ air}}$	$1\ \mathrm{R} = \frac{1\ \mathrm{esu}}{\mathrm{cm}^3\ \mathrm{air}_{STP}}$	$1\ \mathrm{R} = 2.58 \times \frac{10^{-4}\,\mathrm{C}}{\mathrm{kg\ air}}$
Kerma K	$K = \frac{\Delta E_{tr}}{\Delta m}$	$1\ \mathrm{Gy} = 1 \frac{\mathrm{J}}{\mathrm{kg}}$	—	—
Dose D	$D = \frac{\Delta E_{ab}}{\Delta m}$	$1\ \mathrm{Gy} = 1 \frac{\mathrm{J}}{\mathrm{kg}}$	$1\ \mathrm{rad} = 100\ \frac{\mathrm{erg}}{\mathrm{g}}$	1 Gy = 100 rad
Equivalent dose H_T	$H_T = D w_R$	1 Sv	1 rem	1 Sv = 100 rem
Effective dose E	$E = H_T w_T$	1 Sv	1 rem	1 Sv = 100 rem
Activity $\mathcal{A}$	$\mathcal{A} = \lambda N$	$1\ \mathrm{Bq} = 1\ \mathrm{s}^{-1}$	$1\ \mathrm{Ci} = 3.7 \times 10^{10}\ \mathrm{s}^{-1}$	$1\ \mathrm{Bq} = \frac{1\ \mathrm{Ci}}{3.7 \times 10^{10}}$

(Podgorsak, 2005).

2.2 Radiation Protection and Safety

Radiation protection and safety is based on the principles of justification, optimization and dose limitation. Justification involves the responsibility of the referring doctor to conduct correct assessment and collection of the clinical indications for the requested examination, communicate knowledge of the expected results and the way the results are expected to influence diagnosis and subsequent patient management (Dewey *et al.*, 2005).

Medical exposure to radiation should follow a principle that no practice involving exposure to radiation should be adopted unless it produces a net benefit to the individual. The risk benefit equation is hard for somatic effects and even harder for hereditary effects. Parents who receive the benefit of being diagnosed and treated properly are at risk of giving birth to children who inherit damaged genes. The manifestations of abnormal genes will be visible in future generations (Dewey *et al.*, 2005).

Optimisation involves keeping radiation exposure to the patient and radiation workers to minimum by using appropriate exposure factors and limiting number of repeat exposures. The radiation control of radiation workers is more structured and controlled than in the case of patients where rules and regulations are difficult to standardise. Justifying x-ray requests results in effective management of patients ensuring optimisation of the cost to the benefit ratio (Triantopoulou *et al.*, 2004).

Dose limitation requires the use of protective clothing and shields to limit radiation exposure to body parts. The dose equivalent to individuals shall not exceed the limits recommended for the appropriate circumstances. The exposure of individuals should be subjected to dose limits. The annual whole body Dose Equivalent for occupationally exposed persons is 20msv/year averaged over five consecutive years and 50mSv in any single year and for members of the public is 1msv/year (NNRA, 2006).

Radiation protection of the patient involves medical and technical decisions. Technical decisions (dose limitation and optimisation) involve the actions taken by the radiographer to ensure the selection of appropriate technique, equipment, following a strict administrative procedure, training and efficient storage and retrieval of previous x-ray images to avoid repeat investigations. Quality assurance program needs to be in place to govern and control the administration with respect to radiation dose to the patient. The use of radiation should be regulated and monitored (Dance *et al.,* 2014).

Medical decisions (justification) involves the actions taken by the clinician to collect data around clinical information and previous x-ray examinations already done and communicate the information to assist radiology staff to decide as to whether or not an examination is necessary and which examination will be the most appropriate (Shika, 2012).

2.3 Radiation Protection and Risk

Radiation protection is defined as the science and practice of limiting harm to human bein gs from radiation. In every activity of our daily lives humans are exposed to hazards. For example every time you cross the road there is a possibility that you may be hit by a car, and each time a person smokes a cigarette there is an increased chance of that person con tracting lung cancer. Although we are all aware of the possible consequences, people still cross roads and still smoke cigarettes. This apparent disregard for our own safety may be because we have some appreciation of the probability and size of the consequence of eac h action; that is, we have an idea of the risk of crossing the road or smoking a cigarette.

This also applies in the field of radiation protection; in all radiological activities it is impo rtant to have some idea of the risk associated with the use of ionizing radiation. In simple terms, risk is defined as a combination of the probability that a harmful consequence ma y occur and the size of that consequence (Agapi & Efstathios, 2016).

The information used to estimate the risk of ionizing radiation is derived from detailed ac cident investigations and long-term epidemiological studies of populations exposed to ra diation, such as the survivors of the atomic bombing of Hiroshima and Nagasaki in Japan in 1945. Two main organizations (the United Nations Scientific Committee on the Effe cts of Atomic Radiation (UNSCEAR) and the Advisory Committee on the Biological Eff ects of Ionizing Radiation (BEIR)) are responsible for collecting and summarizing the rel evant data, and for producing detailed reports on their findings. These reports are then co llated to establish risk estimates on which a system of radiological protection can be base d. The organization responsible for making recommendations based on these risk estimat es is known as the International Commission on Radiation Protection (IACRS, 1990).

2.4 Implementing a System of Radiation Protection

The most important principle of radiation protection is to keep all doses as low as possible while still allowing the beneficial use of ionizing radiation. The recommendation of the ICRP can be applied at several levels in order to control the hazards from radiation . These levels are as: regulatory, management and operational (IAEA, 2014).

Regulatory Requirements

The formulation and implementation of regulations and legislation varies from country to country. Regulations provide a link between the ICRP recommendations and their imple mentation in the workplace. The country's regulators (an agency or government departm ent) should be responsible for assessing whether a practice is justified, and for prohibiting it if there is no justification. The regulations should set a satisfactory standard of protecti on, which can be applied to all justified practices (Dance *et al.,* 2014).

In Nigeria, the regulatory body is the Nigerian Nuclear Regulatory Authority (NNRA). Its regulatory functions are defined in legislative framework of the Nuclear and Radiological Safety Act No. 19 of 1995. The regulatory standards are defined in the Nigerian Basic Ionizing Radiation Regulations 2001 (NiBIRR) and other practice specific codes and guidance documents. The NNRA documents have defined system of authorization for practices and enforcement of standards based on international best practices (NNRA, 2006).

Management Requirements

It is not possible for workers to implement satisfactory standards of safety without the support and direct involvement of management. Hence, a formal management structure s hould be introduced to deal specifically with the issues of radiation protection. One of main responsibilities of this management is to encourage a good attitude to safety and rec ognition that safety is a personal responsibility. In addition, the management should optimize protection by defining responsibilities clearly and providing clear and simple operation instructions. It should also consider potential exposures and provide a system for safety analysis to identify possible causes of accidents and limit the probability and effect of such accidents (IAEA, 2014).

Operational Requirements

In addition to regulatory and management requirements, control is necessary at the operat ional level to ensure safe practices in the workplace. These practical considerations should include such aspects as recommended by NNRA (2006) and IAEA (2014) such as

i. Safe storage of radioactive materials
ii. Safe transport of radioactive materials
iii. use of time, distance and shielding to reduce radiation fields
iv. Use of containment to limit the spread of radioactive materials into workplaces and the public environment
v. Adequate maintenance of plant and equipment to reduce the probability of failure, and
vi. Safe management of radioactive wastes.

In addition, there is a requirement on individual workers that they accept responsibility for their own safety. They must use all protective equipment supplied and work according to safety procedures.

2.5 Basic Safety Standards

In 1990, the Inter-Agency Committee on Radiation Safety (IACRS) was established to further promote consistency in the practical application of radiation protection. This com mittee consisted of a group of international organizations with a common interest in radiation protection. As a result, a detailed document (called the International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources) was prepared. This document, commonly known as the Basic Safety Standards (BSS), is intended to serve as a practical guide for the design and implementation of an effective radiation protection program. It contains standards which are primarily based on the principles of radiation protection recommended by the ICRP. It also takes into account nuclear safety principles as recommended by the International Nuclear Safety Ad visory Group (INSAG), a group, which has been producing Nuclear Safety Standards (NUSS) specifically for nuclear installations since 1985. Many of the principles recomm ended by INSAG are relevant to other radiation sources and installations (Dance *et al.*, 2014).

The Development of the Basic Safety Standards

Like the ICRP recommendations, the Basic Safety Standards are intended for guidance only and not as legal text. The standards are designed such that they may be incorporated into the legislation of individual countries as required to form a practical basis for the specific radiation protection needs of that country (IACRS, 1990).

2.6 IAEA Safety Standards

The IAEA's Statute authorizes the Agency to "establish or adopt standards of safety for protection of health and minimization of danger to life and property" standards that the IAEA must use in its own operations, and which States can apply by means of their regulatory provisions for nuclear and radiation safety. The IAEA does this in consultation with the competent organs of the United Nations and with the specialized agencies concerned. A comprehensive set of high quality standards under regular review is a key element of a stable and sustainable global safety regime, as is the IAEA's assistance in their application. The IAEA commenced its safety standards programme in 1958. The emphasis placed on quality, fitness for purpose and continuous improvement has led to the widespread use of the IAEA standards throughout the world. The Safety Standards Series now includes unified Fundamental Safety Principles, which represent an international consensus on what must constitute a high level of protection and safety. With the strong support of the Commission on Safety Standards, the IAEA is working to promote the global acceptance and use of its standards. Standards are only effective if they are properly applied in practice (Amano, 2014).

The IAEA's safety services encompass design, siting and engineering safety, operational safety, radiation safety, safe transport of radioactive material and safe management of radioactive waste, as well as governmental organization, regulatory matters and safety culture in organizations. These safety services assist Member States in the application of the standards and enable valuable experience and insights to be shared.

Regulating safety is a national responsibility, and many States have decided to adopt the IAEA's standards for use in their national regulations. For parties to the various international safety conventions, IAEA standards provide a consistent, reliable means of ensuring the effective fulfillment of obligations under the conventions. The standards are also applied by regulatory bodies and operators around the world to enhance safety in nuclear power generation and in nuclear applications in medicine, industry, agriculture and research (Amano, 2014)

With a view to ensuring the protection of people and the environment from harmful effects of ionizing radiation, the IAEA safety standards establish fundamental safety principles, requirements and measures to control the radiation exposure of people and the release of radioactive material to the environment, to restrict the likelihood of events that might lead to a loss of control over a nuclear reactor core, nuclear chain reaction, radioactive source or any other source of radiation, and to mitigate the consequences of such events if they were to occur. The standards apply to facilities and activities that give rise to radiation risks, including nuclear installations, the use of radiation and radioactive sources, the transport of radioactive material and the management of radioactive waste (IAEA, 2014).

2.7 Responsibilities for Protection and Safety

The person or organization responsible for any facility or activity that gives rise to radiation risks shall have the prime responsibility for protection and safety, which cannot be delegated. The principal parties responsible for protection and safety are (NNRA, 2006; IAEA, 2014).

(a) Registrants or licensees, or the person or organization responsible for facilities and activities for which notification only is required.

(b) Employers, in relation to occupational exposure.

(c) Radiological medical practitioners, in relation to medical exposure;

(d) Those persons or organizations designated to deal with emergency exposure situations or existing exposure situations.

Other parties shall have specified responsibilities in relation to protection and safety. These other parties include:

(a) Suppliers of sources, providers of equipment and software, and providers of consumer products.

(b) Radiation protection officers.

(c) Referring medical practitioners.

(d) Medical physicists.

(e) Medical radiation technologists.

(f) Qualified experts or any other party to whom a principal party has assigned specific responsibilities.

2.8 Previous Research

A study by Dewey, George and Gray (2005) confirmed that the use of x-radiation without appropriate radiation protection measures cause cancer. In their study, they monitored the orthopedic surgeons participation in the use of x- radiation during surgical procedures. The use of x-rays in orthopedic surgical practices without appropriate thyroid lead protection resulted in them developing thyroid cancer.

A radiation control study conducted by Horner (1995) to evaluate the implementation of radiation protection and safety measures such as quality assurance program and methods of dose limitation. The findings were that there was generally poor implementation of quality assurance program resulting in poor processing conditions of x-ray films which resulted in poor quality radiographs. The researcher concluded that radiation protection measures were not adhered to in radiography workplaces.

In a retrospective study conducted to evaluate the availability and utilisation of gonad shielding during x-ray examination of the pelvis. The gonodal shielding during x-ray procedures is an effective way of reducing radiation exposure to reproductive organs. Doolan *et al.* (2004) examined Pelvic radiographs of both males and females were examined in four hospitals. Their findings were that radiographs with gonodal protection were malpositioned with bony structures obscured or gonads insufficiently protected. Some hospitals surveyed had inadequate supplies of gonodal shields in the general radiography rooms. The investigation concluded that patients in the hospitals under study received avoidable radiation to the gonads due to malpositioning or omissions during pelvic examinations.

A survey of one hundred radiographers conducted by Adejua *et al.* (2012) from public and private radiodiagnostic centres administered questionnaires on compliance rate of safety standard as described by national and international commission on ionizing radiation such as IAEA and NNRA. The result reveals high compliance rate in majority of radiodiagnostic centres located in south west Nigeria. Conclusively, this study showed that radiographers working in both private and public establishments in south west, Nigeria were been monitored and they strictly followed the radiation protection standard rules to be within radiation workers dose limits.

CHAPTER THREE

MATERIALS AND METHOD

3.1 Materials

Material used in the collection of data for this research is a self structured questionnaire comprising of three sections: the demographic information, level of compliance to the implementation of radiation safety standard and the challenges faced by the radio radiographers. Frequency and percentage is used as a tool for the data presentation and analysis.

3.2 Method

The method used for this research focus on the study design, area of study, population of the study, sample of the study, sampling technique, instrument for data collection, validity of the instrument, reliability of the instrument, procedure for data collection and method for data analysis.

3.2.1 Study Design

The research design that is adopted for this research is the survey method. This is adopted because it allows for collection and analysis of all data, it also tries to study all the facts of the population and it is considered most suitable for this work because human being are involved who have different view to answer questions. A qualitative descriptive survey research design is used for this study. Qualitative approach provides standardized information in form of quality assurance and will assist in making analysis and measuring compliance to radiation safety standards.

In addition the study sought to examine tools and techniques already available and to recommend ways of improving on the status quo owing to the importance of radiation safety and standard.

3.2.2 Area of the Study

This study is conducted in radiology department of Yobe State university teaching hospital Damaturu. Yobe is one of the 36 states of Nigeria, with a population of about 3.1 million people (National population Commission, 2015). It shares borders with Borno, Bauchi, Jigawa, Gombe and Adamawa states and international border with Niger Republic. The capital city of Yobe is Damaturu which has 3 public hospitals with Radiation facility and 3 private hospitals and diagnostic centres.

Yobe state have a number of primary health care facility, specialist hospitals and 2 tertiary health facilities in Damaturu and Nguru towns. X-ray facilities are found in all the two tertiary health facility and specialist hospitals in Damaturu, Gashua, Geidam and Potiskum.

3.2.3 Population of the Study

The population of this study as tabulated in Tables 3.1 includes all the staff of the radiology department of Yobe State University Teaching Hospital, Yobe State Specialists Hospital and Maryam Abacha Hospital all in Damaturu. That is all the hospitals that have radiology department in Damaturu local Government.

Table 3.1: Population of the study

Hospital	Personnel	frequency	Percentage
	Radiographers	12	23.07%
Yobe state university teaching hospital	Radiologist	6	11.54%
	Technicians	4	07.69%
	Other staff	6	11.54%
	Radiographers	3	05.77%
Yobe state specialist hospital Damaturu	Radiologist	5	09.62%
	Technicians	10	19.23%
	Other staff	2	03.85%
	Radiographers	0	00.0%
Maryam Abatcha hospital Damaturu	Radiologist	2	03.85%
	Technicians	0	00.0%
	Other staff	2	03.85%
	Total	**52**	**100%**

3.2.4 Sampling Technique

Yobe State University Teaching Hospital was selected for the study after a random sampling selection, using "My Random" software.

3.2.5 Sample Size of the Study

The sample size of the study consist of 28 personnel (respondents) as it covers all the medical staff of the radiology department of Yobe state university teaching hospital Damaturu, which consist of 10(35.71%) radiographers, 6(21.43%) radiologist, and 2(7.15%) technicians and 10(35.71%) other staff. The sample of the study is tabulated in Table 3.2.

Table 3.2: sample size of the study

Personnel	frequency	Percentage
Radiographers	10	35.71%
Radiologist	6	21.43%
Technicians	2	07.15%
Others staff	10	35.71%
Total	**28**	**100%**

3.2.6 Inclusion Criteria

The sample size of the study includes only the medical staff of the radiology department of the hospital who directly have access to the source of radiation. They include the radiographers, radiologist, technicians and other medical staff.

3.2.7 Exclusion Criteria

The sample size of the study excludes all staff of radiology department of the hospital whom do not have access to any source of radiation from the virtue of their engagement. They include clerical assistants and administrative staff of the department.

3.2.8 Instrument for Data Collection

A self-administered questionnaire was used in the study. Section A comprised of questions regarding demographic data and section B comprised of questions about radiation safety standards. The questionnaire uses close ended question with few open ended questions added at the end of group of questions.

The questionnaires were handed to radiographers and all medical staff (Radiologist and technicians) of the radiology department of the hospital. The completed questionnaires were collected and returned within a short period of time. Questionnaires were chosen for this study because they serve to find out what is already prevailing with a view of improving on the status quo, more so they are much reliable and feasible.

3.2.9 Validity of the Instrument

One of reasons behind exposing the instrument to a wide range of criticism and testing is for determining the face validity. Following the procedure, the suggestions and the criticisms made helped the outcome of the instrument. It was validated by senior lecturers with the Nasarawa state university keffi, two senior radiographers with the federal hospital nyan-nya and one measurement and evaluation expert from statistics department Nasarawa state university, keffi.

In the process certain adjustments including the reformation and outright rejections of some earlier items became necessary. To accommodate the various ideas chosen for the finding and attempt to process a good degree of content validity of the instrument appeared a bit concise. It was however administered carefully and skillfully without boring the respondents.

3.2.10 Reliability of the Instrument

Five (5) respondents were randomly sampled, from different level (radiographers and technicians) in a hospital were used for the reliability test (pre-test) of the instrument of the study. This was done as a pilot test to ascertain the reliability of the results.

3.2.11 Procedure for Data Collection

The procedure used for data collection was through the distribution of questionnaire. The questionnaires were distributed to all the medical staffs in radiology department of Yobe state university teaching hospital by the help of research assistants who were adequately instructed on what to do. In the process all the respondent who participate in the research where provided with a free pen as a reward for those who completed the questionnaire and return. This was done to encourage the respondent to participate actively in the research so as to improve the response rate.

3.2.12 Method of Data Analysis

The respondent score was analyzed using the relevant statistical procedures; the researcher employed the use of percentages and frequencies in analyzing the data.

CHAPTER FOUR

RESULT AND DISCUSSION

4.1 Result

The results of the data collected for the study were represented in tables containing frequency and percentages of the responses. The interpretation of data was based on the responses on the questionnaires collected from the medical staff of radiology department of Yobe state university teaching hospital Damaturu. 20 questionnaire were given out and 20 were filled and returned giving a responses rate of 100% (N = 20/20).

4.1.1 Data Presentation and Analysis

The data collected from the responses on the questionnaires received from medical staff of the radiology department of Yobe state university teaching hospital Damaturu was divided into three (3) sections.

Section A is the demographics of the respondent presented in Tables 4.1, 4.2 and 4.3, section B is the responses on the compliance to the implementation of radiation safety standard which is presented in Tables 4.4, 4.5 and 4.6. Finally section C is the response on the challenges faced by radiographers in the implementation of the radiation safety standard as presented in Table 4.7. The analysis of the result was done by using the simple frequency and percentage

4.1.1.1 Part A - Demographic of the Respondent

In this study demographic data includes gender of respondents, qualification of respondents and the age group of respondents as tabulated in Tables 4.1, 4.2, and 4.3 respectively,

Table 4.1: Gender of respondent

Gender	frequency	Percentage
Male	15	75%
Female	5	25%
Total	**20**	**100%**

Table 4.1 show the gender of the respondents which comprises of 15 male which is equivalent to (75%) and 5 females (25%) with age range between 20 years and 50 years. This shows the sum total of 20 (100%) of the respondents

Table 4.2: Age group of respondent

Demographic	Male	Female	Total	Percentage
Age range				
20-30	10	4	14	70%
31-40	4	1	5	25%
41-50	1	0	1	5%
Above 50	0	0	0	0%
Total	**15**	**5**	**20**	**100%**

Table 4.2 shows that the respondents both male and female are 14 respondents which is equivalent to (70%) are between the age range of 20 to 30 years, 5 (25%) are between the ages of 31 to 40years while 1 respondent (5%) is between the age of 41 to 50years and for above the age of 50years is 0 (0%)

Table 4.3: Qualification of the respondents

Qualifications	frequency	Percentage
National diploma	2	10%
B. Medical Radiography	10	50%
M.Sc Radiography	2	10%
Others	6	30%
Total	**20**	**100%**

Table 4.3 shows the frequency and percentage of personnel qualification are 2 (10%) of respondents having National diploma, 10 (50%) have Bachelors' of medical radiography, 2 (10%) are masters' of sciences in radiography and 6 (30%) with other qualifications (including radiologist).

4.1.1.2 Part B - Compliance to the Implementation of Radiation Safety Standard

In this study compliance to the implementation of radiation safety standard includes the protective equipment or devices available, the principles of radiation protection and safety employed and the radiation safety technique used in the hospital.

Table 4.4: Protective equipment available or in use

Protection Device	frequency	Percentage
Lead aprons full front and back	20	100%
Gonad shield	20	100%
Waist apron	20	100%
Lead gloves	11	55%
Thyroid shield	5	25%

Table 4.4 shows that the respondents indicates high level of the availability of protective equipments with an average of 100% lead aprons full front and back, 100% gonad shields, 100% waist apron, 55% lead gloves and 25% thyroid shield as provincial averages.

Table 4.5: Principle of radiation protection used

Principle	frequency	Percentage
Justification	20	100%
Optimization (ALARA Principle)	20	100%
Dose limitation	17	85%

Table 4.5 shows that the respondents indicates that the application of radiation protection principles were at 100% Justification, 100% Optimization (ALARA principle) and 85% Dose limitation.

Table 4.6: Radiation technique employed in the hospital

Technique	frequency	Percentage
Accurate collimation	20	100%
Effective communication	11	55%
High speed film screen combination	6	30%

Table 4.6 Shows that the respondents indicates that the application of radiation safety techniques such as accurate collimation is 100%, effective communication is 100% and High speed film screen combination which is 30%.

4.1.1.3 Part C- Challenges Faced by Radiographers in the Implementation of Radiation Safety Standard

This part shows the challenges faced by the radiographers in the implementation of radiation safety standard, that is having a practicing licenses, use of monitoring devices and continuous professional developments as tabulated;

Table 4.7: Challenges faced by radiographers

Challenges	frequency	Percentage
Radiographers with current practicing licenses	15	75%
Radiographers with monitoring devices	5	25%
Radiographers with continuous professional development certificate	7	35%

Table 4.7 shows that 75% of radiographers have current practicing licenses, 25% of the respondents have monitoring devices and 35% of the radiographers have continuous professional development certificate.

4.2 Discussion of Findings

Research findings are discussed and presented within the framework of the research objectives. The aim of the study was to assess compliance to Radiation Safety standards at yobe state university teaching hospital, Damaturu.

4.2.1 Demographic Profile of Respondents

The demographic profile will assist the researcher to establish as to whether gender, age and qualification influences compliance to radiation safety standards.

4.2.2 Compliance to the Implementation of Radiation Safety Standard

4.2.2.1 Protective Equipment Available or in Use

Table 4.4 shows that the availability of protective equipments with an average of 100% lead aprons full front and back, 100% gonad shields, 100% waist apron, 55% lead gloves, 25% thyroid shield as provincial averages.

Radiographers have the ethical responsibility to make sure that lead protective garments are available and are used at all times to protect patients and public from primary radiation, especially sensitive parts of the body such as reproductive organs, thyroid glands and hands.

These findings are in agreement with the findings of other researchers (Doolan, 2004) where availability and use of gonad shielding were inadequate in a hospital in Dublin, lead gloves and thyroid collars (Dewey *et al.*, 2005) were often omitted and orthopaedic surgeons developed thyroid cancer due to exposure to radiation.

According to Radiation Control policy (2000) lead garments should be available and be used to protect patients, staff and public from radiation exposure. The most radio sensitive parts of the body to be protected at all times include reproductive organs, thyroid glands and hands.

4.2.2.2 Principle of Radiation Protection Used

Table 4.6 shows that the respondents indicated that the usage of radiation protection principles were at 100% Justification, 100% Optimization (ALARA principle) and 85% Dose limitation.

Justification of radiographic procedures provide assurance to the radiographer that the examination requested was the best for demonstrating the condition indicated on the clinical history provided. When x-ray examination requests are not justified means that some of the procedures that will be performed are not necessary and radiation optimisation and dose limitation is compromised.

Radiation safety principles such as ALARA, Ten day rule, Inverse square law, Justification and optimisation are recommended by ICRP in publication 26 and 60.

4.2.2.3 Radiation Technique Employed in the Hospital

The usage of accurate collimation, effective communication, high speed film screen combination and support, minimise radiation dose to the client, public and health workers

Table 4.6 Shows that the respondents indicated that the usage of radiation safety techniques such as accurate collimation 100%, effective communication 100%, High speed film screen combination 30%.

4.2.3 Challenges Faced by the Radiographers

Table 4.7 shows that 75% of radiographers have current practicing licenses, 25% have monitoring devices and 35% of the radiographers have continuous professional development certificate. This indicates that:

i. Not all radiographers have current practicing licenses
ii. Radiographers are not issued with radiation monitoring devices.
iii. Few personnel are with continuous professional development programs certificate.
iv. Total number of exposures given during radiography is not recorded.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATION

5.1 Summary

The summary of the findings was based on the analysis presented in chapter four. A survey method is used for the study and it was conducted based on the guided objectives of the study which is also the research question for the study. The data for the study was collected, presented and analyzed using frequency and percentage tables. The findings of the study are summarized as follows.

The respondents comprised of 20 medical personnel for the study from the radiology department of Yobe state university teaching hospital. The ages of respondents were between 20-50 years. From the result, 98% of respondents had good knowledge of radiation protection probably because of their academic qualifications to practice as qualified radiographer.

All the 20 medical personnel were satisfied with the level of safety devices provided for them because it met the standard of protection compared to the standard required. Assessing the safety devices, the hospital studied were able to provide the lead aprons, gonad shields, lead gloves, and thyroid shields.

The personnel need to undergo continuous professional development programs and training to attain new technology and procedures. And all radiographers need to be issued with monitoring devices so as to not exceed occupational limit of exposures.

5.2 Conclusion

The findings of compliance and non compliance to safety standard in certain elements of the Radiation Safety standards in the hospital shows high rate of literacy and compliance of personnel to radiation safety standards as stipulated by the national and international bodies (NNRA and IAEA). The radiation protection devices present in the hospital was impressive indicating the employer's willingness to abide by radiation safety and standards.

5.3 Recommendations

In a way to improve the safety standard and protection in the hospital the followings are some recommendations;

The management should provide a budget specifically for ensuring procurement of quality control tools and lead protective garments to improve compliance.

It should sponsor personnel to undergo continuous professional development programs.

Set up a team that will monitor, enforce and evaluate all areas of concern such as usage of lead protective garments, justification of x –ray examinations requested and other areas that require improvement.

5.4 Limitations of the Study

Limitations of the study are restrictions that result in negative effect on the generalizations of the findings.

The results of this study are limited to yobe state university teaching hospitals damaturu.

The findings are limited to the period in which the study was conducted

Some participants or respondent omitted some questions provided in the questionnaire.

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Appendix A

Department of physics,
Faculty of natural and applied science,
Nasarawa state university keffi,
Nasarawa state,
Nigeria.
13th June, 2018.

Dear respondent

Request to fill a questionnaire

I am a student of Nasarawa state university keffi, undergoing a post graduate studies in medical and radiation physics. Am conducting a research survey on the topic "Assessment of radiation safety standard in yobe state university teaching hospital Damaturu''

Am soliciting your assistance in answering the following questions, any information given will be treated as confidential in strict confidence for academic purpose. Attached is the questionnaire;

I will be grateful if my request is given due consideration.

Thank you

Yours faithfully

Idriss Bukar Abba

QUESTIONNAIRE

The researcher is soliciting your assistance in answering the following questions. Any information given will be treated in strict confidence for academic purpose.

SECTION A: DEMOGRAPHIC DATA

SELECT THE APPROPRIATE ANSWER AND TICK

1. What is your gender? Male ☐ Female ☐

2. What is your age range? 20-30☐ 31-40☐ 41-50☐ above 50☐

3. What is your highest qualification? National diploma ☐

B. Rad. Med. Radiography☐ Msc. Radiography ☐ others ☐

SECTION B: RADIATION SAFETY STANDARD AND IMPLEMENTATION

PLEASE TICK WHERE NECESSARY

1. Which of the following protective equipment are available or in use
    - Lead aprons full front and back ☐
    - Gonad shields ☐
    - Waist aprons ☐
    - Lead gloves ☐
    - Thyroid shields ☐
2. Which of the following principles of radiation protection is used in the hospital?
    - justification ☐
    - Optimization (ALARA Principle) ☐
    - Dose limitation ☐
3. Which of the following radiation protection technique do you employ in the hospital
    - Accurate collimation ☐
    - Effective communication ☐
    - High speed film screen combination ☐

4. Indicate the extend to which you agree or disagree with the following statement concerning practices

	Agree	Disagree	Don’t know
Screening time spent on a patient during fluoroscopic examination is always recorded.			
Staffs members present during fluoroscopy examination always wear lead aprons.			
Pregnant radiographers are allowed to perform procedures using fluoroscopy.			
All radiation workers in this hospital are registered with the radiation protection service (RRBN)			
Radiation workers are issued with the radiation monitoring devices monthly.			
Radiation records of staff are kept for a life time			
Continuous professional development program addresses quality control skills.			
Radiographers in this hospital have necessary skills to implement quality control measures.			
Patients are provided with lead protective clothing during radiography.			
The total number of exposures given during radiography is recorded on all request forms.			

5. Quality control test on general x-ray equipment in this hospital are done as follows

Visual inspection report is done monthly			
Light beam alignment test is done quarterly			
Quality assurance test are done annually			

Thank you for participating in this study.

Appendix B

YOBE STATE UNIVERSITY TEACHING HOSPITAL

KM 4 Near Dikkumari Village, Potiskum Road, Damaturu, Yobe State - Nigeria

Chief Medical Director:
Dr. Baba Waru Goni
MB:BS, FMCP, FWACP, MHPM, Msc (London), DTM&H (London)

Chairman Medical Advisory Committee
Dr. Yusuf Bukar Ngamdu
MB:BS, Msc Otology (London), FWACS

Director of Administration
Mallam Hassan Gana
BA (Ed) ABU; M. Ed (Unimaid)

13th June, 2018

Idriss Abubakar Abba
NSD/PGD/RMP/0006/17/18

RE: ETHICAL CLEARANCE

Your request for an ethical clearance to conduct a research on "Radiation safety standard at Yobe State University Teaching Hospital Damaturu in Yobe State" hereby refer.

You are hereby granted permission to conduct your research within the ambit of your proposal and in line with the ethical guidelines of human medical research.

Yours faithfully,

13/6/18

Dr. Yusuf Bukar Ngamdu
CMAC
For: CMD

All Correspondence Should be addressed to the Chief Medical Director