ASSESSMENT OF AWARENESS AND KNOWLEDGE OF RADIATION PROTECTION AMONG NON-MEDICAL STUDENTS IN THE UNIVERSITY OF BENIN

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BEING A PROJECT SUBMITTED TO THE DEPARTMENT OF RADIOGRAPHY IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF B.SC.(RAD) DEGREE, UNIVERSITY OF BENIN, BENIN CITY, NIGERIA.

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CERTIFICATION

This is to certify that this project work, Assessment Of Awareness And Knowledge Of Radiation Protection Among Non-Medical Students In The University Of Benin, was carried out by **OMOKHIBORIA VICTORY OSEWE** with matriculation number **BMS1906979** under the guidance and supervision of **RAD. EMMANUEL CHUKWUJINDU** in partial fulfilment for the award of Bachelor of Radiography (B.Rad) degree in the department of Radiography, School of Basic Medical Sciences, University of Benin.

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APPROVAL

This project title ASSESSMENT OF AWARENESS AND KNOWLEDGE OF RADIATION PROTECTION AMONG NON-MEDICAL STUDENTS IN THE UNIVERSITY OF BENIN carried out and submitted by OMOKHIBORIA VICTORY OSEWE with matriculation number BMS1906979 in partial fulfillment of the Bachelor of Radiography (B.Rad) degree in the Department of Radiography, School of Basic Medical Sciences, University of Benin, has been examined, accepted and approved and is hereby recommended for final oral defense.

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EXTERNAL SUPERVISOR	**DATE**

DEDICATION

This project work is dedicated to Almighty God for granting me his wisdom and giving me the strength to finish complete this academic Journey.

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I wholeheartedly thank God for being with me throughout my days in the University and granting me the grace to succeed in carrying out this project Work.

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ABSTRACT

Modern technologies that emit radiation are being produced and used in medical, industrial and environmental sectors; this emphasizes the importance of public awareness and knowledge of radiation protection. Awareness is important, to minimize its risks to health and foster a culture of safety. Knowledge and Understanding is likewise important, to prevent unnecessary anxiety and unsafe practices. Non-medical students in the University are future professionals and leaders, Therefore they represent a key demographic whose willingness to listen and learn can significantly influence public health outcomes. The objective of this research was to assess the level of awareness and knowledge of radiation protection among non-medical students in the University of Benin, Benin city, Nigeria.

Data for this research were collected through an online questionnaire from a total of 395 respondents. The data of the research work was analyzed using descriptive statistics and Chi-Square tests.

The results show that 88.9% of students are aware of devices that emit radiation but only 8.1% have sufficient knowledge of the main principles of radiation protection. It was found out that the knowledge and awareness of students are significantly affected by their faculty and level of study. Both Awareness and knowledge are not solely dependent on general education but influenced by one’s academic discipline and demographic factors.

Keywords: Radiation Protection, Awareness, Knowledge, Non-Medical Students, University of Benin, Radiation Safety.

CHAPTER 1

INTRODUCTION

1.1 Background of the Study

Radiation, particularly ionizing radiation, plays a vital role in our daily life, with applications ranging from medicine, industry, agriculture and research (Ibáñez, 2024). Though has several health benefits, exposure to ionizing radiation carries potential health risks like tissue damage, carcinogenesis and genetic mutations (ICRP Publ., 2008; Akleyev et al., 2021). To reduce these risks, the international commission on Radiological protection (ICRP) has established fundamental principles of radiation protection, which include justification, optimization and dose limitation.

Despite the extreme importance of radiation safety, Studies have continuously shown the poor level of awareness and knowledge of radiation protection, even among medical professionals. A study that was used to assess the knowledge of radiation protection among medical students revealed that their understanding of radiation doses and the risks associated with radiation was generally poor (Albusair et al., 2020). Likewise, A research which was conducted among non-radiology healthcare personnel indicated low levels of awareness about radiation safety measures. The issue is even more concerning among non-medical individuals, who may lack basic education on the hazards associated with radiation and radiation protection measures (Wally et al., 2024). As the dependence on technologies that emit ionizing radiation such as diagnostic imaging and industrial equipment increases, the risk of exposure of the general public to radiation increases. Therefore, Awareness and knowledge among non-medical populations, including university students, is essential for developing effective educational interventions.

The knowledge and understanding of students about the hazards associated with Radiation and measures to take to prevent unnecessary exposure can be greatly enhanced with even a small amount of intervention in the form of quick training sessions (Elzaki et al., 2024). This emphasizes how deliberate education may be applied to reduce knowledge gaps. The Nigerian Nuclear Regulatory Authority (NNRA) is in charge of ensuring that radiation safety regulations are followed in Nigeria, however many people are still ignorant of this fact or how it affects their day-to-day lives (NNRA, 2023).

Furthermore, Students may gradually be unintentionally exposed to low quantities of electromagnetic radiation as a result of the growing use of technology like smartboards, wireless communications (Wi-Fi, Bluetooth) and lab equipment (Naren et al., 2020). Despite the fact that these devices release non-ionizing radiation, non-medical individuals may become confused and anxious, due to their lack of ability to differentiate between ionizing and non-ionizing radiation (Stein et al., 2021). This knowledge gap is frequently reflected in misconceptions about 5G towers, microwave ovens and cell phones, despite confirmation from bodies of Authority that non-ionizing radiation does not carry enough energy to damage DNA (WHO, 2021; National Cancer Institute, 2020).

Despite the lack of conclusive epidemiological evidence that proves that non-ionizing radiation (like microwaves and radio waves) have negative health effects, studies have shown that a significant amount of practitioners and students still think that there are risks associated with the devices we use everyday and believe that they are harmful (Stein et al., 2021; WHO, 2021).

In the University of Benin, non-medical students represent a significant portion of the University and general public. Assessing their awareness and understanding of radiation protection is crucial, not only for their personal benefit but also for fostering a culture of informed decision-making regarding radiation exposure. The aim of this study is to evaluate the current level of awareness and knowledge of radiation protection among non-medical students at the university of Benin, which will in turn help to identify gaps and inform future educational strategies.

1.2 Statement of the problem

The growing increase in modern technologies that emit ionizing radiation in various sectors has led to increase in the risks of exposure beyond the borders of medical settings. Though it is essential to educate those who specialize in medical and applied health about radiation protection, non-medical individuals who often lack formal training in this area shouldn't be left out (ICRP Publ., 2008). This lack of knowledge is concerning because of the potential health risks that is associated with ionizing radiation, which includes tissues damage, carcinogenesis and genetic mutations.

Several Studies have pointed out lack of awareness of radiation protection among medical students and professionals (Yousef et al., 2025). In a research conducted at Nara Medical University in Japan, the study showed that medical students had little awareness and knowledge about ionizing radiation and radiation protection. However, after attending a lecture on radiation for 20 minutes, their understanding greatly improved, pinpointing the impact of targeted educational interventions (Yamauchi et al., 2025). Similarly, A study was used to evaluate the radiation protection practices and knowledge of Moroccan nurses who worked in operating rooms, the overall knowledge was still very poor. A total of 91.7% of the nurses who had participated in the study had received no formal training on radiation protection. (Harbaj et al., 2024).

The absence of basic radiation safety principles in the general curriculum of universities, especially in faculties that are not science-based increases this awareness gap. Many students are not aware that they are exposed to trace amounts of radiation during everyday treatments like dental X-rays or airport body scanners. Though this daily exposure is generally given in safe limits, it can accumulate and affect the body in the long run, especially when It is not done with adequate safety measures in place (Streffer et al., 2007).

Furthermore, The presence of equipment that emit radiation in engineering departments, research labs or university health centers poses a risk to Students in the University and pinpoints the need for more awareness about Radiation and Radiation Protection. Students may take actions that are risky or fail to respond appropriately in situations involving radiation leaks or equipment malfunctions, as a result of lacking basic understanding of radiation safety (West et al., 2016).

Although several studies have conducted research on awareness of radiation protection among medical students and healthcare professionals, very few research have been done to assess the level of awareness and knowledge of non-medical students. Insufficient attention has been directed toward non-medical undergraduates, who constitute a substantial and largely untrained segment of the university community. This creates a significant gap in understanding how well students comprehend the risks and safety measures associated with exposure to radiation. This study therefore fills that gap by assessing the awareness and knowledge of radiation protection among non-medical students in the University of Benin, identifying specific misconceptions and providing data that can guide educational interventions and public health initiatives.

Addressing this gap is very important, as it aligns with global efforts to enhance the understanding of the general public about the risks associated with radiation and safety measures. By bringing this lack of knowledge to light, the university can implement strategies to foster a culture of safety and informed decision-making among students in the University.

1.3 Research Questions

1. What is the level of awareness of non-medical students at the University of

Benin?

2. What is the level of knowledge of Radiation Protection among non-medical students?
3. What are the common sources of information on radiation protection among Non-Medical Students?
4. What is the perception of Non-Medical Students regarding radiation and its associated risks?

1.4 Hypothesis

The study will test the following Hypothesis:

a. Null Hypothesis (H0): There is no significant difference in the level of knowledge of radiation protection among Non-Medical Students across different faculties.

b. Alternative Hypothesis (H1): There is a significant difference in the level of knowledge of radiation protection among non-medical students across different faculties.

1.5 Aim and Objectives of the study

The aim of this study is to assess the level of awareness and knowledge of radiation protection among Non-Medical Students at the University of Benin and to examine how demographic factors influence their understanding of the risks associated with radiation and safety measures. The study seeks to promote informed decision-making, identify knowledge gaps, and contribute to the development of targeted educational strategies, aimed at enhancing radiation safety awareness across Non-Medical faculties in the University of Benin.

The Objectives of the Study:

1. to assess the level of awareness of radiation protection among Non-Medical Students.
2. to evaluate their level of knowledge of Radiation Protection principles.

3. to determine how demographic factors (faculty, Level of study, gender) influence awareness and knowledge.
4. to identify major sources of information on radiation protection.
5. to highlight common misconceptions about radiation among Students.

1.6 Significance of the study

- **Radiation safety awareness**: This study will provide valuable insight into the current level of awareness and understanding of radiation protection among Non-Medical Students, a group that is often overlooked in radiation safety education. The findings can inform strategies to broaden the reach of education on radiation beyond medical and allied health disciplines in the University.
- **Educational Development**: by identifying gaps in knowledge and sources of misinformation, this study will support the design and implementation of targeted awareness campaigns and academic Contents aimed at Non-Medical Students, creating a more informed academic environment that is conscious about radiation safety.
- **Proactive Public Health Plan**: Creating more awareness about radiation among the wider student population contributes to better public health outcomes, especially now that we are in a technology-driven world in which there is daily increase in usage and production of radiation-emitting devices.
- **Demographic insight**: The study will point out how demographic factors like faculty, academic level, and gender influence radiation knowledge, thereby enabling customized and effective educational interventions within the university.
- **Support for Policy Advocacy**: This study may also serve as a foundation for suggestions about university-level policy modifications. The results could be used to support the

inclusion of a Radiation safety seminar or general studies course, guaranteeing that all students, regardless of discipline, obtain fundamental knowledge.

- **Long-Term Risk Mitigation**: Non-medical students who possess radiation awareness can help avoid unintentional exposures in their personal and professional life as future leaders, engineers, educators, legislators, etc. This is in line with international objectives to advance safety and health in a variety of interdisciplinary fields. (Mengnjo et al., 2019)

1.7 Scope of the Study

This study will be conducted within the University of Benin, Benin city, Edo State. It will consist of Non-Medical Students across different faculties in the University.

1.8 Operational definition of terms

Awareness: In this study, It refers to the basic consciousness or recognition of radiation and radiation protection concepts among non-medical students, such as knowing what radiation is and understanding that exposure can be harmful.

Knowledge: It refers to the accurate information and understanding that students possess about radiation protection principles, sources of radiation, health risks and safety measures based on established guidelines (e.g. ALARA principle).

Radiation: The emission of energy as electromagnetic waves or moving subatomic particles. In this Study, it mainly refers to ionizing radiation, which has enough radiation to remove tightly bound electrons from atoms and molecules.

Radiation Protection: Involves measures and practices aimed at safeguarding people from the harmful effects of exposure to ionizing radiation, based on principles such as justification, optimization and dose limitation as recommended by the international corporation on radiological protection (ICRP).

Non-Medical Students: Refer to undergraduate students enrolled in faculties outside Medical Sciences discipline such as Agriculture, Arts, Engineering, Law, Life sciences, Social sciences, Education, Environmental sciences, Management Sciences, Physical sciences, etc.

Cross-Sectional Study: An observational study that analyzes data from a population at a specific point in time. In this context, it is used to assess the level of knowledge and Awareness of students without following them over time.

CHAPTER 2

LITERATURE REVIEW

2.1 Conceptual Review

2.1.1 Definition and Types of Radiation

According to the United Nations Scientific Committee on the Effects of Radiation [UNSCEAR], Radiation is the emission or transmission of energy in the form of waves or particles through space or a material medium (Chen et al., 2024). It can be produced artificially for a variety of applications in industry, research, medicine and communication technologies or can occur naturally in the environment. To put it simple way, Radiation is the movement of energy from one place to another and depending on the type and energy level of the radiation involved, its interaction with matter can result in ionization, excitation or other physical or chemical changes [International Atomic Energy Agency (IAEA), 2021].

Based on its capacity to ionize atoms, radiation can be roughly divided into two types:

1. **Ionizing Radiation:** Ionizing radiation contains sufficient energy to liberate firmly bonded electrons of atoms, forming ions in the process. This kind of radiation can affect living tissues biologically, which makes it both beneficial for medical uses (such cancer treatment and diagnostic imaging) and potentially dangerous if not properly managed. (WHO, 2023)

The following are the primary forms of ionizing radiation:

- **Alpha particles (α):** Being made up of two protons and two neutrons, these particles are heavy and positively charged. They are dangerous if consumed or inhaled, however they have a minimal penetrating power and can be stopped by a piece of paper or the outermost layer of human skin (World Nuclear Association, 2024)
- **Beta particles (β):** High-energy, fast-moving electrons or positrons released by radioactive nuclei are known as beta particles (β). Although they can penetrate more easily than alpha particles, they can still be shielded by materials like glass or plastic with comparable ease (ICRP Publ., 2008).
- **Gamma rays (γ) and X-rays:** These electromagnetic waves are incredibly strong and have a deep penetration range. Despite being widely used in medical imaging and cancer treatment, They require protection from thick shielding materials such as lead (Liang et al., 2024). Neutrons are uncharged particles that are usually released during nuclear processes. Neutron radiation can profoundly penetrate human cells and materials, hence particular shielding such as water or concrete is necessary for protection (Ebtsam et al., 2023).

2. Non-Ionizing Radiation: Atoms and molecules cannot be ionized by the energy contained in non-ionizing radiation. Instead, it could cause heat or excite electrons to become more energetic. Excessive exposure to certain types of non-ionizing radiation can nevertheless pose health risks like thermal injury or photochemical damage, even though they are generally thought to be less dangerous than ionizing radiation (IAEA, 2021).

Types of Non-ionizing radiation include:

- **Ultraviolet (UV) radiation:** Despite being classified as non-ionizing, the high-energy components of UV radiation (UV-C and parts of UV-B) can nevertheless have significant biological effects such skin cancer and eye impairment (Omer et al., 2021).
- **Visible Light:** The part of the electromagnetic spectrum that is visible to the human eye is known as visible light. It is necessary for vision but can be harmful in high intensity exposures such as lasers. (Haigh, 2020)
- **Infrared radiation (IR):** Burns can result from exposure to excessive levels of infrared radiation (IR), which is linked to heat. (Ciottone, 2023)
- **Microwaves:** Used in cooking and communication devices; prolonged exposure can cause tissues to heat up.
- **Radiofrequency (RF) radiation:** Current research focuses on the potential long-term health impacts of radiofrequency (RF) radiation, which is released by broadcast antennas, wireless networks and cell phones (Miller et al., 2019).

Implementing suitable safety measures and guaranteeing radiation protection require an understanding of the different types of radiation and their characteristics, particularly as modern civilization grows more dependent on radiation-emitting devices. Teaching non-medical students about these categories will foster appropriate use of devices that emit radiation and lays the groundwork for a larger awareness of radiation protection.

2.1.2 History of Radiation Protection

After Wilhelm Roentgen discovered X-rays in 1895 and Henri Becquerel discovered radioactivity in 1896, The use of shielding to protect oneself from Radiation began to take shape in the early 1900s. Many early pioneers experienced radiation burns, amputations and even death from overexposure because the detrimental effects of exposure to radiation were not yet known. For example, It has been alleged that Marie Curie, a pioneer in the field of radiation research carried radioactive chemicals (plutonium and radium) in her pocket without wearing protective shielding and this led to long-term health issues. She died from aplastic anemia in 1934, which is a condition linked to high levels of exposure to radiation (Rentetzi et al., 2017).

As the effects of radiation on health became more obvious by the 1920s, early protective guidelines were established. One of the earliest efforts put in place to control exposure was the International X-ray and Radium Protection Committee (IXRPC) which was established in 1928. The International Commission on Radiological Protection (ICRP) which is still a major global authority on radiation protection, was subsequently formed from this. Radiation Protection evolved over time from simply being avoided to the foundation of contemporary radiological safety: justification, optimization (ALARA) and dose limitation.

2.1.3 Principles of Radiation Protection

According to International Atomic Energy Agency [IAEA], Radiation protection also known as radiological protection refers to keeping people and the environment safe against the negative effects of exposure to ionizing radiation while allowing its useful applications to continue.

The main goals of radiation protection are to reduce the likelihood of stochastic effects like cancer and genetic mutations, which happen at random with increasing dose without a threshold and to prevent deterministic effects, which have a threshold dose and severity that increases with dose (Mack et al., 2020)

International guidelines and standards serve as the foundation for radiation protection. The following are the ICRP and IAEA's accepted principles:

1. **Justification**: This means that the examination being carried out must be one that is medically indicated and useful (Do et al., 2016). Any choice that modifies the circumstances around

radiation exposure ought to be more beneficial than detrimental. According to this principle, radiation exposure practices should only be implemented if they result in a net positive benefit (ICRP, 2021). For instance, the advantages of gathering vital medical data outweigh the slight radiation risk, making the use of X-rays in medical diagnostics legitimate.

2. **Optimization (ALARA Principle):** Radiation exposure should be kept as low as reasonably achievable (ALARA), while accounting for social and economic issues. Even after a technique has been justified, every effort should be taken to reduce exposures through equipment design, operating practices and protective measures (Huei et al., 2020). Optimization means that the imaging should be carried out using doses that are as low as reasonably achievable (ALARA) and consistent with the diagnostic task (Harrison et al., 2021).
3. **Dose Limitation:** The total dose given to any person from regulated sources in planned exposure scenarios cannot be greater than the suitable thresholds advised by regulatory bodies. The purpose of dose limits is to shield people from serious health risks. For instance, occupational exposure limits are designed to bring stochastic risks down to acceptable levels, although they are set significantly lower than thresholds for deterministic effects (ICRP, 2021).

Three fundamental safety precautions are used while putting these principles into practice:

Time: Reducing the duration of exposure to a radiation source directly reduces the dose.

Distance: Because the intensity of radiation decreases with the square of distance (inverse square law), exposure is greatly reduced by increasing the distance from a radiation source.

Shielding: Radiation can be absorbed or attenuated by using suitable materials (such as lead, concrete or water) positioned between the source and the person to prevent exposure.

These measures are critical in diverse settings, including medical imaging departments, nuclear facilities, research laboratories, and even in everyday life where natural and artificial radiation sources exist. (Kim et al., 2018)

Radiation protection also extends to different exposure scenarios, They are classified as:

Occupational Exposure: Radiation exposure from the workplace, mostly experienced by researchers, radiographers, and employees at nuclear power plants.

Public Exposure: radiation exposure that the general public experiences, such as from medical operations or ambient radiation.

Medical Exposure: Exposure of volunteers, patients, and caregivers in scientific or medical research settings.

Non-medical students may come into contact with radiation via a variety of academic, research and environmental sources even when they are not directly involved in radiation work. Thus, establishing a culture of safety, encouraging responsible behavior, and guaranteeing compliance with international radiation protection requirements all depend on an awareness of these principles. (Do et al., 2016)

2.1.4 Sources of Radiation in Everyday life

Exposure to radiation is inevitably bound to occur in our day-to-day life. Radiation comes from a wide range of natural and artificial sources, many of which individuals come into contact with on a daily basis. Recognizing the significance of radiation protection and awareness, particularly among non-medical individuals, requires an understanding of these sources.

1. Natural Sources of Radiation

Natural background radiation accounts for the bulk of the average individual's annual exposure. It can be categorized into:

a) **Cosmic Radiation:** The Earth is continuously bombarded by cosmic rays that come from the sun and distant space. People who live at higher elevations or who fly frequently (like airline crews) receive higher doses because their intensity rises with altitude and latitude (Baatout, 2023).

b) **Terrestrial Radiation:** Soils, rocks, and construction materials include naturally occurring radioactive elements like uranium, thorium, and potassium-40. These substances contribute to external exposure by releasing gamma radiation (IAEA, 2021).

c) **Radon Gas:** Inhaling radon and its decay products is the leading cause of natural exposure to radiation and associated with an increased risk of lung cancer (World Health Organization [WHO], 2021). Radon-222 is a radioactive gas that can build up in homes, especially in areas with inadequate ventilation. Radon-222 is a byproduct of uranium, which is found in rocks and soil. **(**Bulut et al., 2024)

d) **Internal Radiation:** Small amounts of radioactive isotopes like potassium-40 and carbon-14 are naturally consumed or inhaled by humans through food, water and air. They all play a part in ongoing internal exposure.

2. Artificial (Man-Made) Sources of Radiation

Artificial sources nonetheless contribute significantly to radiation exposure, especially in industrial and medical settings, even though they typically contribute less than natural sources.

a) Medical Radiation:

Medical applications such as diagnostic X-rays, CT scans, fluoroscopy and radiation therapy are the most significant sources of artificial exposure. While these procedures are medically justified, they significantly contribute to collective radiation doses in the population (Chen et al., 2023).

b) Consumer Products:

Certain commonplace objects such as luminous watches, smoke detectors (containing americium-241), some older television sets and specific ceramics and glassware contain radioactive elements or emit little amounts of radiation (EPA, 2023).

c) Industrial and Research Use:

Industries employ radioactive materials for things like scientific research, gauging devices, sterilizing and radiography (weld inspection). Individuals in close proximity or in unfavorable regulatory environments may be at risk, even though exposure to the general public from these sources is typically minimal due to safety regulations. (Engineering National Academies of Sciences, 2021)

d) Fallout and Environmental Contamination

Relics from previous nuclear weapons testing and accidents (such as Chernobyl and Fukushima) contribute to long-term, low-level environmental pollution in impacted areas, but they are less frequent now.

Importance of Awareness

Non-medical students frequently don't know enough about radiation and its effects, even though they are constantly surrounded by these sources. When exposed to radiation-related situations, this ignorance gap could cause unwarranted anxiety or dangerous conduct. Particularly in establishments where radiation is utilized for practical or academic reasons. knowledge of the common sources of radiation enables people to support safe practices, identify possible hazards, and make educated judgments.

2.1.5 Radiation Mishaps and Acquired Knowledge

Global knowledge and legislation about radiological protection have been influenced by a number of radiation-related incidents throughout history. Large amounts of radioactive material were spilled into the environment during the 1986 Chernobyl accident in Ukraine, which was brought on by a reactor explosion. Children exposed to radioactive iodine had a rise in thyroid cancer cases as a result of the incident, while plant workers experienced acute radiation sickness [ARS] (Zaletel et al., 2024)

Similarly, the 2011 Fukushima Daiichi nuclear accident in Japan illustrated the dangers of nuclear installations being disrupted by natural disasters. Mass evacuations and extensive nuclear contamination resulted from the disaster. These incidents highlighted the need for stringent safety procedures, continuous observation and public education initiatives to inform the local community. (National Academies of Sciences, 2016)

Although Large-scale radiation accidents are not very common in Nigeria, the NNRA has tightened its control due to a few isolated cases of wrong handling of industrial radiography equipment and unlawful possession of radioactive materials. These incidents highlight the significance of extensive radiation education, particularly in communities close to facilities that use radioactive equipment. (Stulberg et al., 2013)

2.1.6 Health Risks Associated with Radiation exposure

Ionizing radiation has enough energy to liberate tightly bonded electrons from atoms, forming ions in the process. This process may cause molecular alterations in cells, which could have a range of negative health effects. The dose, duration and kind of radiation, as well as the age and health status of the individual, all affect the degree and kind of health concerns connected to exposure to radiation. (Alomairy et al., 2025)

1. Acute Health Effects

Acute Radiation Syndrome (ARS) is the collective term for the immediate health effects of high doses of ionizing radiation over a brief period of time. ARS can appear in a variety of ways depending on the degree of exposure:

Hematopoietic Syndrome: affects bone marrow and lowers blood cell counts, raising the risk of bleeding and infections. It occurs at doses >2–3 Gy.

Gastrointestinal Syndrome: Damage to the lining of the gastrointestinal tract at doses ranging from 5–12 Gy can result in severe dehydration, nausea, vomiting and diarrhea.

Neurovascular Syndrome: Neurological symptoms such headaches, lightheadedness, unconsciousness at doses of between 10–20 Gy and death after doses >10–12 Gy.

Early signs of ARS may include nausea, vomiting, tiredness and skin burning. Without urgent medical assistance, these illnesses can be lethal. (Lopez et al., 2011)

2. Chronic Health Effects

Chronic health issues are more likely to develop after prolonged exposure to lower doses of radiation. These include:

Cancer: One known carcinogen is ionizing radiation. Repeated or prolonged exposure can cause harm to one's DNA, causing mutations that can lead to a number of malignancies in the thyroid, breast, lung and leukemia.

Cardiovascular Diseases: Although the precise mechanisms are still being investigated, certain studies indicate a connection between radiation exposure and an increased risk of cardiac disorders.

Cataracts: Radiation can damage the lens of the eye, leading to the formation of cataracts over time. (Kamiya et al., 2015)

3. Genetic and Reproductive Effects

Additionally, Radiation exposure may have genetic effects:

Hereditary Effects: Radiation may produce germ cell mutations that can be passed on to children, although research on atomic bomb survivors has not definitively demonstrated hereditary consequences. (Ayan et al., 2017)

Reproductive Health: Excessive radiation exposure can reduce fertility and raise the chance of miscarriage or birth defects. (Arun et al., 2025)

4. Psychological and Social Impacts

Beyond physical health, Radiation exposure can contribute to psychological stress, worry and social stigma, particularly in populations affected by nuclear accidents or contamination. Fear of possible negative health impacts can have a significant impact on mental health, which highlights the importance of support networks and public education. (Collett et al., 2021)

Exposure to ionizing radiation, especially in high doses or over long periods of time can pose significant health risks. These risks are generally categorized into:

Deterministic Effects: These have a threshold dose and increase in severity with increasing dose. Examples include skin burns, cataracts and radiation sickness.

Stochastic Effects: These occur by chance and typically have no threshold dose. The primary concern is the increased risk of cancer and genetic mutations (Pacelli & Mansi, 2007). Understanding these effects is crucial for encouraging safe practices, especially in medical imaging where patients may be exposed to repeated doses. (Kadhim et al., 2013)

2.1.7 Radiation Protection Guidelines and Safety Standards

The science and practice of shielding humans and the environment from the damaging effects of ionizing radiation is known as radiation protection. It is governed by worldwide standards and guidelines created by national regulatory agencies, International Atomic Energy Agency (IAEA) and the International Commission on Radiological Protection (ICRP).

Principles of Radiation protection

According to the ICRP, radiation protection is based on three fundamental ideas (ICRP Publ., 2008)

- **Justification of Practice**

Any choice that modifies radiation exposure ought to be more beneficial than detrimental. This implies that unless a practice that involves radiation exposure results in a net benefit to people or the society, it should not be implemented. (Ebdon-jackson et al., 2021)

- **Optimization of Protection (ALARA)**

Radiation doses should be kept As Low As Reasonably Achievable (ALARA), taking into account economic and societal factors. This principle encourages continuous efforts to minimize unnecessary exposure through good design, procedural controls, and education. (Dudhe et al., 2024)

• **Dose Limitation**

Exposure to people should not exceed the advised limits in order to prevent deterministic effects and reduce the risk of stochastic outcomes like cancer.

The ICRP recommends the following dose limits for exposure in the workplace and general public:

Occupational workers: 20 mSv annually on average over five years (no single year > 50 mSv)

Public exposure: 1 mSv per year (ICRP., 2007)

Protective Measures and Safety Practices

- **Time, Distance and Shielding:** An Essential measure include minimizing time spent close to a radiation source, increasing distance between the patient and radiation source and ensuring proper shielding (such as the use of lead aprons and shields).
- **Monitoring and Personal Dosimetry:** To monitor exposure levels, employees wear tools like TLDs (Thermoluminescent Dosimeters) or film badges.
- **Training and Awareness:** Particularly for those who might not be regularly exposed but are nonetheless at risk, education regarding radiation hazards and safety precautions is essential.
- **Engineering Controls:** Use of interlocks, warning signs and protective barriers in workplaces and medical facilities. (AbuAlRoos et al., 2019)

Patient Protection

Radiographers follow a code of ethics that entails the duty and responsibility to take proper care of all patients assigned to them. The following must be done to reduce exposure of patients to radiation:

1. Repeat radiographs should be minimized
2. Filtration should be accurate
3. Correct collimation to the area of interest
4. Appropriate shielding such as gonadal and female breast shielding
5. If the patient is pregnant, the fetus should be properly protected and ionizing radiation should be completely avoided.
6. There should be optimum imaging system speed
7. The appropriate projections and exposure factors needed for the Examination should be selected by using high kV and low mAs, using Postero-Anterior instead of Antero-Posterior projections to lessen the dose the to anterior upper thoracic region (thyroid and female breasts), making use of techniques that are in line with digital radiography system speed as determined by exposure indicator values. (Bontrager, 2018)

Figure 2.1: A female ovarian shield

(Bontrager, 2018)

Figure 2.2: Male gonadal shield

(Bontrager, 2018)

Figure 2.3: Thyroid shields with regular neck cutout apron.

(Bontrager, 2018)

Figure 2.4: Gonad shields with sheet of lead rubber for gonad protection.

(Clarks, 2016)

Figure 2.5: Entrance to a controlled area showing warning signs and lights.

(Clarks, 2016)

Figure 2.6: A Technologist wearing a TLD/personnel monitor/film badge

(Bontrager, 2018)

Legal and Regulatory Framework

In Nigeria, the Nigerian Nuclear Regulatory Authority (NNRA) regulates radiation safety and conformity with international norms. All Facilities that make use of equipment that emit radiation must be licensed and are to undergo routine checkups to verify that they comply to safety measures (Bhatt et al., 2018; Wilds et al., 2013).

2.1.8 Importance of Radiation Protection Awareness Among Non-Medical Students

Even if they are not actively involved in the medical or industrial use of radiation, They need to be aware about radiation protection, which will play an essential part in guaranteeing their safety and the safety of others when they come in contact with ionizing radiation. Non-medical students (such as those studying engineering, science courses or other disciplines) rarely receive sufficient lectures on radiation safety, despite the fact that healthcare professionals (such as radiographers, doctors and nuclear medicine technologists) receive substantial training in this area (Harbaj et al., 2024; Whitney et al., 2019). These people may be exposed to the dangers of radiation by secondary exposure during fieldwork, research or working in settings where equipment that emit radiation is being used, even though they are not actively involved in radiation exposure.

- **Protection of Health and Safety**

Non-medical students may unknowingly be exposed to the dangers of radiation, especially when they are carrying out engineering project works, conducting science-based research or staying in settings that are prone to radiation. They might not be able to identify the risks associated with radiation or take the right safety measures to minimize or prevent exposure, as a result of lacking sufficient information about Radiation. For example, if appropriate safety precautions are not taken, students who are employed in manufacturing facilities, research labs or other businesses that make use of X-rays, radioactive isotopes or other radiation-emitting devices may be in danger of acute or long-term impacts of radiation (Harbaj et al., 2024).

Institutions can greatly lower the risk and negative health impacts of radiation exposure by ensuring that non-medical students have a solid understanding of radiation protection. This entails teaching the students about radiation safety measures like time, distance, shielding and the significance of keeping an eye on exposure levels, wearing protective shield and following legal requirements (Alamoudi, 2025).

- **Role in Promoting a Safety Culture**

In addition to protecting people, radiation protection awareness helps create a culture that values safety. Non-medical students who receive radiation safety education become more aware of the dangers and are better equipped to push for safer procedures in their communities and places of employment. This kind of awareness can spread outside the walls of the university and into professional settings, promoting safer radiation usage across a range of sectors, including mining, construction, environmental monitoring and research (Whitney et al., 2019). Furthermore, whether in their future professional settings, companies or personal networks, students who possess knowledge about radiation safety can contribute to educate others.

- **Public Health Implications**

Non-medical students who are knowledgeable about radiation protection can assist in preventing public health emergencies that could be as a result of inappropriate handling of radiation, as they will be future leaders in a variety of businesses and sectors. For example, communities can lower their risk of radiation-related incidents by being aware of and comprehending radiation protective principles. The design and implementation of radiation-related systems, such as waste disposal or building radiation shielding may involve non-medical students, particularly those pursuing disciplines like environmental science, engineering or urban planning. Understanding radiation protection guarantees that these designs adhere to safety regulations and lower the hazards of exposure for the general public (Baatout, 2023).

- **Enhancing Interdisciplinary Collaboration**

Radiation protection is a multi-disciplinary field and awareness among students from science and non-science disciplines enhances collaboration across various sectors. Training programs like NIH-funded Educational course: Integration of Biology and Physics into Radiation Oncology (IBPRO) have been developed and is designed to enable interaction among Radiation oncologists, Medical physicists and radiobiologists. This have resulted in long-lasting protocols of research, changes in practice, etc. This shows how interdisciplinary knowledge builds communication, innovation and safety practices in radiation protection. (Burmeister et al., 2018)

- **Ethical Responsibility**

Non-medical students have an ethical obligation to understand potential risks and the significance of safety procedures in their chosen industries since they will soon be working as professionals. These students will be more inclined to uphold moral standards pertaining to the environment, public health and the security of their coworkers and communities if they have sufficient knowledge about radiation protection, making sure that the dangers of radiation are reduced by appropriate preventive measures becomes part of their moral obligation.

2.2 Empirical Review

The empirical review concentrates on earlier studies on radiation safety awareness and knowledge, especially among students who are not in the medical field. Although a lot of study has been done on radiation protection for medical professionals, relatively little has been done on non-medical students' knowledge and comprehension of radiation protection. The following studies demonstrate the significance of radiation protection education for students and the gap that currently exists.

The Knowledge and risk perception of radiation among Japanese nursing students was examined in a study. More than 50% of the students according to the study lacked sufficient knowledge about radiation hazards and the precautions that must be taken in areas that are prone to radiation. Majority of the students did not receive official training on radiation safety during their time in the university, even though they were sometimes close to radiation sources. (Yoshida et al., 2020). The study made it clear how important it is for medical students to get training in Radiation protection and the need to include a course that teaches about Radiation protection in the curriculum of all medical students (Yamauchi et al., 2025).

A research study was carried out at Shandong University of China, to evaluate the impact of Novel General Education Courses on Radiation Protection for Undergraduates. The course called ‘The Basis of Radiation Protection’ was introduced into the curriculum. This led to significant improvements in their basic radiation safety cognition and increased their level of knowledge. This indicates how short educational interventions can improve the awareness of radiation safety, reduce knowledge gaps among Non-Medical students and support their preparedness for interdisciplinary applications (Liang et al., 2024).

A comparable study by Alamoudi et al., 2025 focused on Radiation Protection and Safety Among Undergraduate and Intern Radiologic Technologists who perform X-ray procedures in diverse settings and work with medical teams to provide quality patient care. Although many interns and undergraduate students in their third and fourth year were aware and knowledgeable about radiation to an extent, Students in their second year had little or no prior knowledge. The study recommends integrating a formal radiation safety module into undergraduate curricula across universities.

Hankin et al. & Jones et al. (2020) revealed that educational interventions are effective in increasing participants’ knowledge levels of radiation protection. The study evaluated the efficiency of a radiation protection training module using a pre-intervention and post-intervention approach. The findings demonstrated increase in the knowledge of participants on radiation protection. Over half of the participants stated that the education they had received would impact their imaging requesting practice in the future. The ideal outcome of the study was to limit requests of unnecessary examinations and ensure that patients are protected from too much exposure to radiation. This study emphasizes how crucial structured training initiatives are, for raising the awareness and safety knowledge of both medical and non-medical individuals.

Mellis et al. (2024) assessed the knowledge of radiation doses and risks among medical students and referrers in northern Scotland. The study found widespread gaps in awareness of radiation doses among medical students and brief educational interventions showed significant improvements. These students were more qualified to handle potential radiation threats and actively supported safety precautions. The study indicated that radiation protection awareness could greatly minimize the risk of occupational exposure and help students contribute to a safety oriented professional culture.

The findings of an intervention study showed how Medical and Applied Medical Sciences Students at the Majmaah University, Majmaah, Saudi Arabia demonstrated low levels of radiation protection awareness. Applied medical students were more aware about radiation protection than medical students. Overall, the knowledge and awareness of Medical and Applied Medical students about ionizing radiation dose and the health risks associated with it, was reportedly low. Students that felt scared about the risks associated with medical imaging were greater in number than those who felt comfortable and less concern about the risks associated with it. The report revealed the urgent need for targeted educational initiatives within Medical, Applied Medical and non-medical departments on campus. (Alali et al., 2024)

A study conducted by Albusair et al., 2020 evaluated the awareness and knowledge of radiation in common radiological investigation and the risks associated with it among medical students in Saudi Arabia and found that although most of the students were aware risks associated with radiation, they were not confident about their knowledge of ionizing radiation. This calls for the need to introduce radiation protection course into the curriculum of Undergraduates.

Similarly, Harbaj et al., 2024 did a study on the knowledge, attitudes and practices regarding the justification of radiological examinations among general practitioners in Morocco. It revealed they had moderate knowledge and practices. It emphasizes the need to introduce a program into the curriculum that focuses on practical cases and real-life scenarios and continuous training and local support tools should be developed.

Another study assessed the awareness of Radiation Hazards and Knowledge About Radiation Protection Among Medical Students at the Northern Border University, Arar and found that the students had significantly low awareness and knowledge score. It emphasized the importance of radiation education to improve awareness and knowledge of radiation (Shafiq et al., 2024).

In a study, Dilek et al. (2025) compared the Awareness of Radiation Protection among University students before and after Hospital Internship. The study concluded that most medical students were unaware of basic radiation protection concepts during their time in the University and majority became aware and more knowledgeable after their internship. This suggests a strong need for curriculum integration and practical training sessions should likewise be organized to demonstrate how the radiation safety protocols are implemented in the hospital. These training sessions can be done with modern technologies like virtual reality or augmented reality.

2.2.1 Summary of Review

Despite these findings, There are significant gaps in the literature. These empirical findings underscore the necessity for targeted educational interventions among not just medical students but also non-medical students.

This study seeks to fill this gap by evaluating the level of awareness and knowledge about radiation protection among Non-medical students in the University of Benin, with the aim of promoting informed decisions about their health and encouraging a safety-conscious culture across all disciplines in the university.

According to a research by Alamoudi et al. (2025)., Structured education on radiation drastically improves the knowledge of students on radiation physics, protection and safety guidelines.

In addition to directly endangering one's health, lack of knowledge about radiation protection also compromises public health readiness for situations that involve radiation.

This study adds to the growing body of research aimed at broadening radiation safety knowledge across disciplines by assessing the awareness and knowledge of radiation protection among non-medical students in the University of Benin.

Furthermore, prior empirical research indicates that the way radiation safety education is delivered and its structure have a big impact on how effective it is. It has been demonstrated that interactive sessions, simulations, and multimedia tools perform better than conventional lecture-based approaches (Burmeister et al., 2018). Therefore, in addition to evaluating awareness, this study might provide recommendations for successful teaching methods that can be used at the University level.

CHAPTER 3

RESEARCH METHODOLOGY

3.0 Introduction

This study aims to assess awareness and knowledge of Radiation Protection Among Non-Medical Students in the University of Benin and promote better safety protocols in the medical setting.

3.1 Research setting

This research will be conducted within the University of Benin, Edo state, Nigeria. The university environment provides a diverse range of non-medical Students across various faculties.

3.2 Study Design

This study is a descriptive cross-sectional survey design. This method was chosen to allow the collection of data in one place from a broad student population, to assess their current level of knowledge and awareness about Radiation Protection.

3.3 Target population

The target Population for this study consists of undergraduate non-medical students from selected faculties in the University of Benin. This group was selected because they represent students who may have little or no basic knowledge on Radiation and Radiation Protection but are likely to have encounter with imaging modalities that make use of Radiation in the near future.

The population size is approximately 30,000.

3.4 Sampling technique/Sample size

A simple random sampling technique was used to ensure that all non-medical students had an equal chance of being selected. While efforts were made to include students from various faculties to ensure diversity of responses, the sample size was determined using Taro Yamane's formula for known populations, resulting in a total of 395 participants. This method was chosen because it allows accurate estimation of proportions in large populations with minimal sampling bias. However, since data collection was conducted online, participation was limited to students with internet access, which may have introduced a form of sampling limitation.

The Taro Yamane's formula was used to determine the sample size:

$n = (N/1+Ne^2)$

n = sample size

N = population size = 30,000

e = 0.05 margin error

Using this technique, the sample size gotten is 395.

Yamane's method will be used to guarantee statistical adequacy and dependability, enabling the findings to be generalized within the chosen population. Given the resources available for this undergraduate study, a margin of error of 5% was selected to strike a balance between feasibility and precision.

To ensure a balanced representation across different fields of study, the research study includes students from different faculties. This signifies that although it is not formally applied, stratified random sampling is also being considered for this survey, involving the inclusion of both science and non-science disciplines, to understand if a student's faculty can influence their level of awareness and knowledge about radiation protection.

3.5 Instrument for data collection

The main instrument for data collection will be a well structured questionnaire. The questionnaire will be designed to assess the awareness and knowledge levels of students about radiation and radiation protection practices. It will consist of both closed and open-ended questions divided into sections like demographic data, general awareness questions, knowledge based questions, attitude/perception questions and sources of information/misconceptions. The questionnaire will be distributed through Google forms for easier access and wider distribution. (See appendix I)

The questionnaire will be one that is easy to use, brief and include terms that is easy to understand.

It will be divided into five sections and consist of between 25 to 30 items in total:

Section A: Data on Demographics

Section B: General Awareness of Radiation

Section C: Knowledge of the principles of Radiation Protection

Section D: Attitudes And Perceptions

Section E: Sources Of Information & Misconceptions

To assess attitudes and views, Questions will be created using both straightforward multiple-choice forms and scaled Likert-type statements (such as Strongly Agree to Strongly Disagree).

The questionnaire will be in words that are easy to understand, to avoid confusing non-medical students.

3.6 Validity of the instrument and Pilot study

The questionnaire will be reviewed by my project Supervisor, an expert in Radiography, to make sure the content is clear, logical and relevant to the objectives of the study. His feedback will be used to refine and improve the Questionnaire before distribution. It will then be piloted with 6 non-medical students to identify and revise any unclear or confusing questions.

3.7 Reliability of the instrument

Reliability will be measured using the test-retest method, and a Cronbach's alpha coefficient of 0.7 or higher will be targeted, which will indicate acceptable internal consistency (Bolarinwa, 2015). A Cronbach's alpha of 0.70 and above is typically regarded as appropriate in social science research, according to Bolarinwa et al. (2015). The test will ensure that the questions are related to radiation protection and assess awareness, knowledge and perception in a consistent and cohesive way.

3.8 Method of Data collection

Data in this study will be collected through an online google form questionnaire. The link to the form will be distributed in person, via emails, WhatsApp groups and other social media platforms that University of Benin Students are part of. Participation will be voluntary and anonymous and informed consent will be obtained at the beginning of the form.

Demographic data (such as age, sex, etc.) will also be collected.

3.9 Method of Data analysis

The collected data will be exported from Google forms and analyzed using Statistical

Package for the Social Sciences (SPSS) version 22. Descriptive statistics such as frequency, percentage, mean and standard deviation will be used to summarize the data. Inferential Statistics, including chi-square tests will be used to test associations between demographic variables and awareness levels. Results will be presented in both tables and charts.

3.10 Ethical consideration

Ethical approval will be obtained from the research ethics committee at the school of Basic Medical Sciences in the University of Benin. Respondents will be informed about the purpose of the study and their participation will be completely voluntary. Anonymity and confidentiality of the information provided will be strictly maintained. (see appendix II).

No names or matriculation numbers will be obtained when carrying out the study, in order to further protect participants. Reference number will be used to gain ethical permission. Participants will be informed that their data would not be used for any other purpose apart from this study and that they are free to withdraw at any time if they become uncomfortable with the study. By taking these steps, the research is guaranteed to adhere to the Belmont Report on the principles of respect for persons, beneficence and fairness.

CHAPTER 4

DATA PRESENTATION, ANALYSIS AND INTERPRETATION

4.1 Introduction

The analysis was conducted on responses from a total of **395 participants**, **with no missing data** recorded across the selected variables. The variables analyzed focused on radiation awareness and understanding among respondents. Specifically, the study examined participants' awareness of machines or devices that emit radiation (e.g., X-ray machines), knowledge of radiation protection principles, recognition of natural radiation sources, understanding of ionizing versus non-ionizing radiation, and perceptions of exposure risks from sources like microwaves and telecommunication masts.

The completeness of responses (N = 395 for each variable) Indicates high participant engagement and data reliability. These variables provide essential insights into the general awareness, perception, and understanding of radiation exposure and safety among the respondents, forming a solid foundation for subsequent inferential analysis and discussion.

Table 4.1: The completeness of responses (N = 395 for each variable) for awareness levels

		Are you aware that certain machines or devices emit radiation (e.g., X-ray machines)	Which of the following are principles of radiation protection?	Which of the following is a natural source of radiation?	I understand the difference between ionizing radiation and non-ionizing radiation.	Do you think standing near a microwave or telecommunication mast exposes you to harmful radiation?
N	Valid	395	395	395	395	395
	Missing	0	0	0	0	0

Interpretation: All questionnaires were complete, with no missing data for any variable. This ensures that the subsequent analyses are based on the full sample of 395 respondents, increasing the reliability of the findings.

Table 4.2: Frequency and Percentage Table

Are you aware that certain machines or devices emit radiation (e.g., X-ray machines)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	30	7.6	7.6	7.6
	Not sure	14	3.5	3.5	11.1

	Yes	351	88.9	88.9	100.0
	Total	395	100.0	100.0	

Interpretation: The result shows that most **respondents (88.9%) are aware** that certain machines or devices emit radiation, while **7.6% are not aware** and **3.5% are unsure**, indicating a generally **high level of awareness** among participants.

This high rate of awareness suggests that most students have encountered devices that emit radiation, likely through medical exposure or technologies but it doesn’t guarantee deep understanding of the principles of radiation protection.

Table 4.3: Frequency and Percentage Table

Which of the following are principles of radiation protection?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Dose Limitation	114	28.9	28.9	28.9
	Energy Boosting	20	5.1	5.1	33.9
	Justification	3	.8	.8	34.7
	Justification, Dose Limitation	6	1.5	1.5	36.2
	Justification, Dose Limitation, Radiation Maximization	5	1.3	1.3	37.5

Justification, Optimization, Dose Limitation	32	8.1	8.1	45.6
Justification, Optimization, Dose Limitation, Radiation Maximization	5	1.3	1.3	46.8
Justification, Optimization, Dose Limitation, Radiation Maximization, Energy Boosting	2	.5	.5	47.3
Optimization	61	15.4	15.4	62.8
Optimization, Dose Limitation	5	1.3	1.3	64.1
Optimization, Dose Limitation, Radiation Maximization	9	2.3	2.3	66.3
Optimization, Radiation Maximization	2	.5	.5	66.8
Optimization, Radiation Maximization, Energy Boosting	2	.5	.5	67.3
Radiation Maximization	124	31.4	31.4	98.7
Radiation Maximization, Energy Boosting	5	1.3	1.3	100.0
Total	395	100.0	100.0	

Interpretation: The data indicates that **Radiation Maximization (31.4%)** and **Dose Limitation (28.9%)** were the most selected responses, while only **8.1%** correctly identified **Justification, Optimization, and Dose Limitation** the three core principles of radiation protection. This suggests that although respondents recognize some aspects, **comprehensive understanding of the principles of radiation protection is very limited.** Misconceptions, such as selecting

‘Radiation Maximization’ reveal gaps in formal education about the principles of radiation protection.

Table 4.4: Frequency and Percentage Table

Which of the following is a natural source of radiation?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Cigarettes	8	2.0	2.0	2.0
	Cigarettes, Mobile phone	7	1.8	1.8	3.8
	LED light	114	28.9	28.9	32.7
	LED light, Mobile phone	4	1.0	1.0	33.7
	Mobile phone	123	31.1	31.1	64.8
	Radon gas	127	32.2	32.2	97.0
	Radon gas, LED light	6	1.5	1.5	98.5
	Radon gas, LED light, Mobile phone	2	.5	.5	99.0
	Radon gas, Mobile phone	4	1.0	1.0	100.0
	Total	395	100.0	100.0	

Interpretation: The results show that **Radon gas (32.2%)** and **Mobile phones (31.1%)** were the most commonly identified sources of radiation, While Radon gas is indeed a natural source, mobile phones and LED lights are non-ionizing and generally not harmful in normal exposure. This demonstrates **misconceptions among respondents**, some cannot differentiate between natural and man-made or non-ionizing sources, highlighting the need for education to clarify the radiation that is safe and harmful.

Table 4.5: Frequency and Percentage Table

I understand the difference between ionizing radiation and non-ionizing radiation.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	159	40.3	40.3	40.3
	2	56	14.2	14.2	54.4
	3	105	26.6	26.6	81.0
	4	36	9.1	9.1	90.1
	5	39	9.9	9.9	100.0
	Total	395	100.0	100.0	

Interpretation: The results indicate that 40**.3% of respondents strongly disagreed or had very low understanding (rating 1)** of the difference between ionizing and non-ionizing radiation, while **only 9.9% rated their understanding highest (rating 5)**. This suggests that **a significant proportion of respondents lack clear knowledge** on the difference between ionizing and Non-ionizing Radiation, highlighting a major educational gap and the need for **greater awareness and education on radiation concepts.** Such knowledge is essential for informed perception and safe practices in their everyday lives.

Table 4.6: Frequency and Percentage Table

Do you think standing near a microwave or telecommunication mast exposes you to harmful radiation?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	65	16.5	16.5	16.5
	Not sure	73	18.5	18.5	34.9
	Yes	257	65.1	65.1	100.0

Total	395	100.0	100.0	

Interpretation: The findings show that **65.1% of respondents believe standing near a microwave or telecommunication mast exposes them to harmful radiation**, while **18.5% were uncertain** and **16.5% disagreed**. This indicates that **most respondents hold misconceptions or heightened concern about everyday radiation sources**, which could lead to unnecessary anxiety, emphasizing the need for **public education on safe and unsafe radiation exposures**. Only 16.5% correctly disagreed, which shows that public education on safe radiation practices is highly needed.

4.2 Pie Chart Visualization of the above frequency and percentage table.

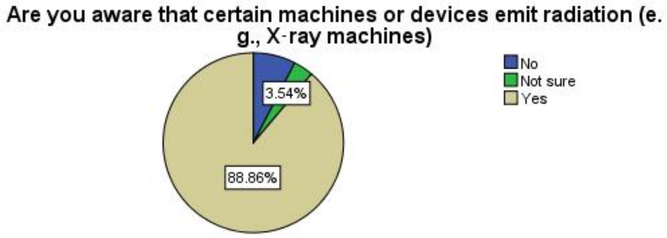

Figure 4.1

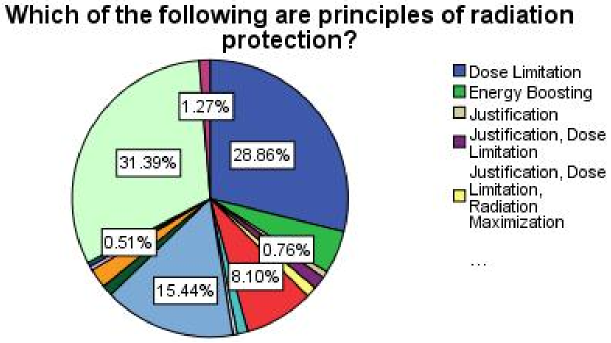

Figure 4.2

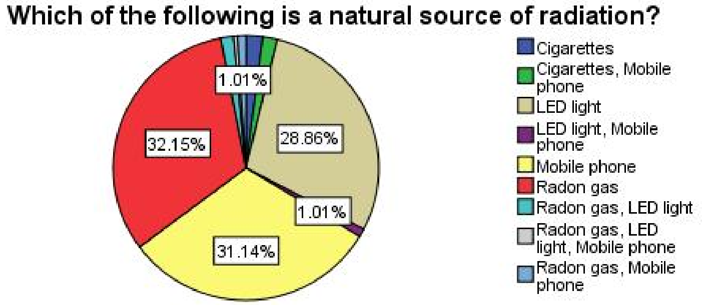

Figure 4.3

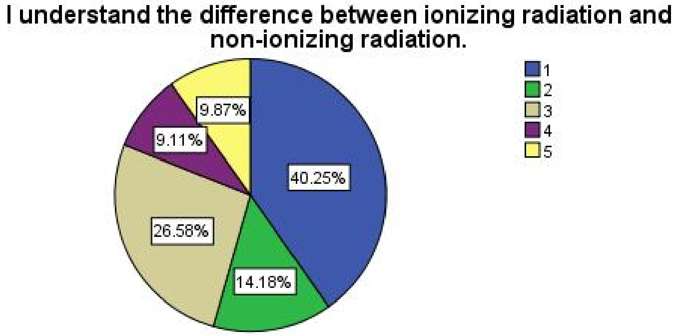

Figure 4.4

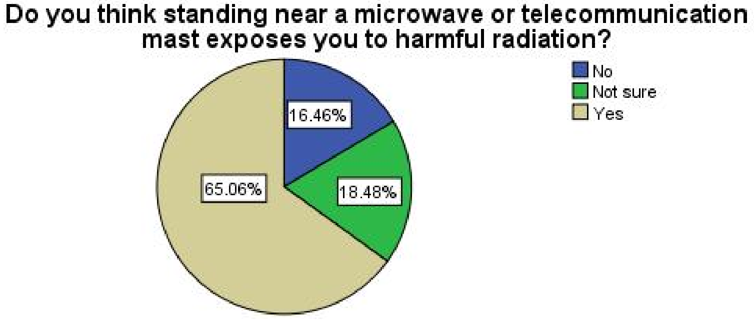

Figure 4.5

Table 4.7: Descriptive Statistics

Descriptive Statistics

	N	Mean	Std. Deviation
I feel staying in a room where Radiation is being used is safe, as long as I don’t stay there for too long.	395	2.76	1.245
I would be okay holding a friend during their X-ray exam if I’m given a lead apron to wear.	395	3.23	1.385
Radiation exposure only becomes dangerous after repeated or very long-term contact.	395	3.52	1.525
I understand the difference between ionizing radiation and non-ionizing radiation.	395	2.34	1.345
I feel confident that I can protect myself in environments where Radiation is used.	395	2.50	1.326
Even though I’m not in the medical field, I think learning about radiation protection is still relevant to my everyday life.	395	4.34	1.083
Valid N (listwise)	395		

Interpretation: The table presents the mean and standard deviation of respondents' perceptions about radiation safety. The **highest mean (4.34)** indicates strong agreement that learning about radiation protection is relevant to everyday life.

Moderate agreement (mean = 3.52) was observed for the belief that radiation becomes dangerous after long-term exposure. Low means for understanding differences (2.34) and confidence to protect oneself (2.50), show **practical knowledge gaps**. Awareness of relevance is high but **practical understanding and confidence remain relatively low**, suggesting the need for educational and training interventions.

4.3 Inferential Statistics

Chi-square test between Demographic Variables and Awareness Levels

A **Chi-square test** between **demographic variables and awareness levels** examines whether there is a **statistically significant association** between participants' background characteristics (such as faculty, level of study, gender, and age) and their awareness about radiation-related issues.

Table 4.8: Are you aware that certain machines or devices emit radiation (e.g., X-ray machines)

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	111.390[a]	20	.000
Likelihood Ratio	101.281	20	.000

N of Valid Cases	395		

a. 21 cells (63.6%) have expected count less than 5. The minimum expected count is .21.

Interpretation: The Chi-square test result ($\chi^2 = 111.39$, df = 20, $p < 0.001$) indicates a significant association between demographic variables and awareness of X-ray machines. This suggests that awareness and knowledge of radiation protection **significantly vary by demographic factors**. Students from science-based faculties had higher knowledge, while non-science students demonstrated more misconceptions. These results indicate that educational background strongly influences understanding of radiation safety.

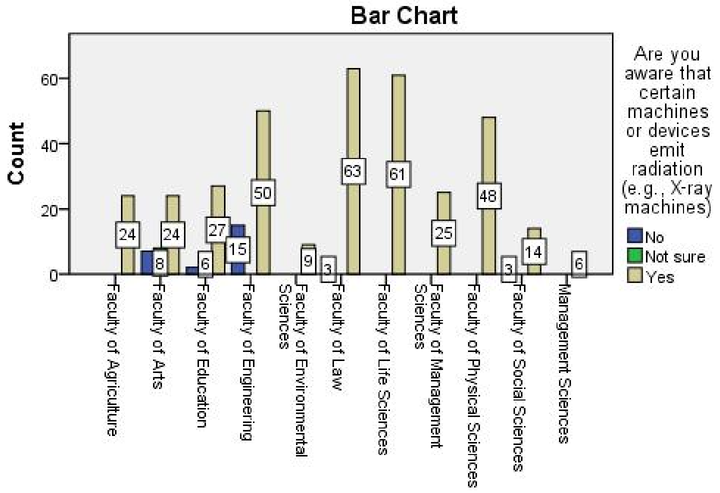

Figure 4.6

Table 4.9: What is your level of study and Are you aware that certain machines or devices emit radiation (e.g., X-ray machines)

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	35.502[a]	8	.000

Likelihood Ratio	39.860	8	.000
N of Valid Cases	395		

a. 8 cells (53.3%) have expected count less than 5. The minimum expected count is 1.95.

Interpretation:

- Chi-Square Test Results:
  - Pearson Chi-Square: 35.502 (df=8), p=0.000
  - Likelihood Ratio: 39.860 (df=8), p=0.000

Significant association between variables ($p < 0.05$)

Valid Cases: 395

Note: 53.3% of cells have expected counts < 5 (potential reliability issue)

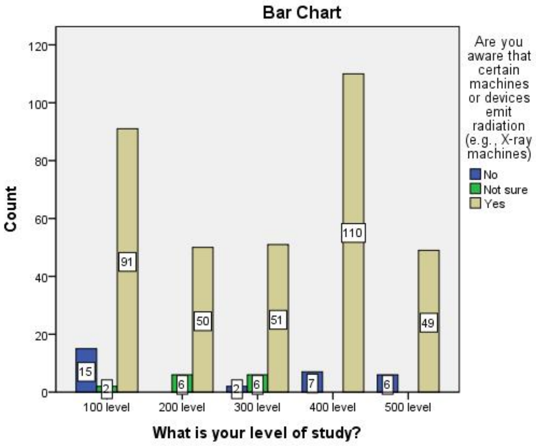

Figure 4.7

Table 4.9.1 Which of the following are principles of radiation protection?

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	236.392[a]	56	.000
Likelihood Ratio	217.950	56	.000

N of Valid Cases	395		

a. 56 cells (74.7%) have expected count less than 5. The minimum expected count is .28.

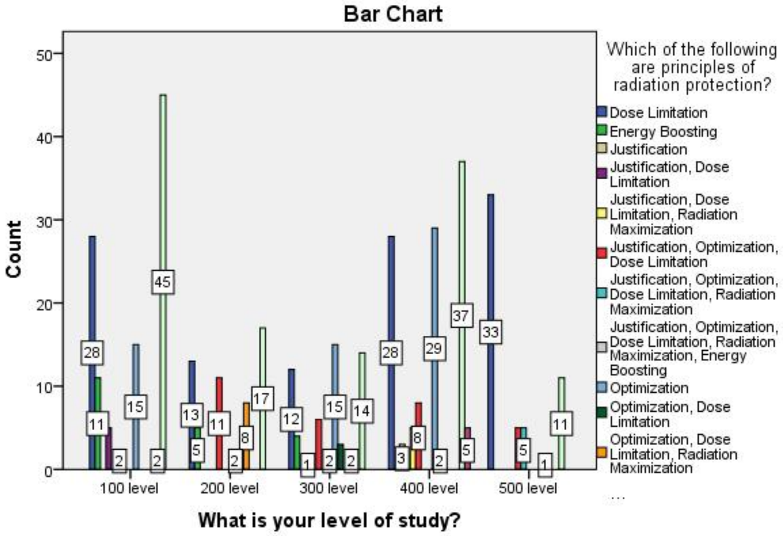

Figure 4.8

Interpretation:

- Significant association between variables (p=0.000)

- Pearson Chi-Square: 236.392 (df=56)

- Valid Cases: 395 (with potential reliability issue: 53.3% of cells have expected counts < 5)

Table 4.9.2 Are you aware that certain machines or devices emit radiation (e.g., X-ray machines)

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	6.621[a]	2	.036

Likelihood Ratio	10.142	2	.006
N of Valid Cases	395		

a. 1 cells (16.7%) have expected count less than 5. The minimum expected count is 3.76.

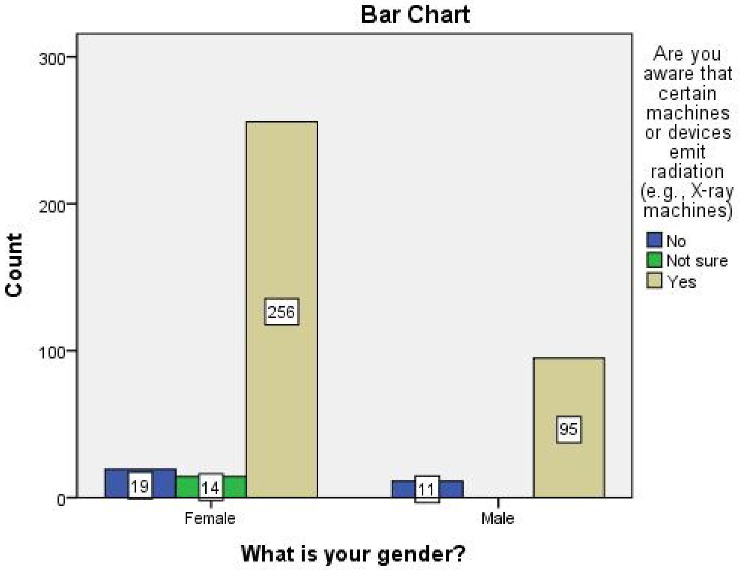

Figure 4.9

Interpretation:

- Significant association between variables (p=0.036)
- Pearson Chi-Square: 6.621 (df=2)
- Valid Cases: 395, indicating a statistically significant relationship

4.4 Test of Hypothesis

Hypothesis:

H0: There is no significant difference in the level of Knowledge of Radiation protection among non-medical students across different faculties.

H1:There is a significant difference in the level of knowledge of radiation protection among non-medical students across different faculties.

The hypothesis was tested using the **Chi-square test of independence** to examine the association between students' faculty and their knowledge of radiation protection principles. The knowledge was assessed based on the correct identification of the core principles: Justification, Optimization, and Dose Limitation.

The results revealed a statistically significant association between the faculty of study and knowledge levels ($\chi^2 = 236.39$, $df = 56$, $p < 0.001$).

Interpretation: The significant result ($p < 0.05$) indicates that the proportion of students with correct knowledge of the principles of radiation protection is not the same across all faculties. Therefore, the null hypothesis (H0) is rejected.

This shows that there is a statistically significant difference in the knowledge of radiation protection among students across faculties. Students who are in science faculties performed better than those in non-science faculties, confirming that curriculum exposure affects understanding. This supports the need for **customized educational programs** for students from different disciplines.

4.5 Discussion of Findings

The findings of this study provide a comprehensive overview of the Awareness and Knowledge of Radiation Protection among non-medical students in the University of Benin. The analysis reveals a critical disconnect between general awareness and specific, accurate knowledge, highlighting a substantial educational gap.

The study demonstrated that the level of general awareness was high, 88.9% of respondents recognized that devices like X-ray machines emit radiation. This suggests that students are not completely unfamiliar with the concept of Radiation in an environment that is filled with modern technology. However, this level of awareness was on a surface level, The study showed that They lacked deeper understanding. The knowledge of the principles of radiation protection was very low, Only 8.1% of students correctly picked Justification, Optimization, and Dose Limitation. A lot of respondents chose wrong options like “Radiation Maximization” (31.4%), This shows widespread misconceptions and a lack of formal education on the subject.

Additionally, the study uncovered significant misconceptions about radiation sources and risks. While 32.2% correctly identified Radon gas as a natural source, a similar proportion inaccurately selected Mobile phones (31.1%) and LED lights (28.9%). 65.1% of the students remarkably believed that standing near a microwave or telecommunication mast exposes them to harmful radiation. This indicates a common confusion between non-ionizing radiation (emitted by everyday electronics) and ionizing radiation (which carries higher health risks), leading to unnecessary anxiety.

These findings align with global studies [WHO (2021)], which shows how the general public is unable to differentiate the types of radiation.

The data on attitude widened this knowledge gap. The low mean score (2.34 on a 5-point scale) for understanding the difference between ionizing and non-ionizing radiation and a low confidence score (2.50) in the ability to protect oneself reveals that the significant part of the population don’t feel equipped to navigate situations involving radiation. Despite this, the predominantly positive response (mean score of 4.34) to the relevance of learning about radiation protection indicates a strong willingness and acceptance for educational interventions.

The inferential analysis confirmed that knowledge is not uniform across the university. The significant association ($p < 0.001$) between the faculty and levels of knowledge underscores the impact of exposure in the University. Students in faculties that study physics, environmental science, engineering or other science courses, are more likely to encounter and absorb science-based concepts, including those related to radiation. This finding is consistent with the empirical review, which noted that educational background is a key determinant of radiation safety awareness (Alamoudi et al., 2025; Liang et al., 2024).

The rejection of the null hypothesis strongly backs the conclusion that a one-size-fits-all approach to radiation safety education is not sufficient. Students from different faculties in the University have different levels of knowledge of radiation protection and this calls for customized educational approaches across various disciplines, to guarantee that every student gains the fundamental understanding needed for both their own safety and the welfare of the general public.

4.6 Limitations or Anomalies encountered during analysis.

1. Self-reported responses: Some students might have looked for the correct answers online or tried to guess the correct answers, instead of putting in what they actually know, which could make the results a bit unreliable.

2. Misunderstanding some questions: A few answers show that students confused things like mobile phones or LED lights as natural sources of radiation. This makes part of the knowledge data less accurate.

3. Small pilot study: The questionnaire was piloted with 6 students, which helped refine unclear questions, but such a small group may not have fully captured clarify and understanding before the main survey.

4. Low expected counts in Chi-square tests: Some cells in the Chi-square analyses had expected counts below 5, which can reduce the reliability of statistical conclusions in some cases.

5. Limited depth: The Questionnaire asked about awareness, knowledge and perceptions, but it didn’t explore why students had certain misconceptions, so we can’t fully explain all the reasons behind the results.

CHAPTER 5

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary of Findings

This study aimed to assess the **awareness, knowledge and perceptions of radiation protection among non-medical students at the University of Benin**, with specific focus on their understanding of radiation protection principles, the influence of demographic factors, sources of information and common misconceptions.

Data were collected from 395 non-medical students across various faculties using a well structured Google form questionnaire. The results were analyzed using descriptive statistics (frequencies, percentages, mean, standard deviation) and inferential statistics (Chi-square tests) representation.

The findings show that while **general awareness is high**, with 88.9% of students recognizing that devices like X-ray machines emit radiation, **in-depth knowledge remains very limited**. Only 8.1% correctly identified the core principles of radiation protection (Justification, Optimization, Dose Limitation), while misconceptions such as choosing 'Radiation Maximization' were common. Also, knowledge about natural and man-made sources of radiation was mostly inaccurate, many students wrongly identified mobile phones and LED lights as natural radiation sources.

The study also revealed gaps in **practical understanding and confidence**. A significant proportion of students could not distinguish between ionizing and non-ionizing radiation and many overcalculated the risks associated with everyday devices like microwaves or telecommunication masts. These misconceptions highlight **high awareness about the existence of radiation but lack of deep knowledge and understanding of it**, emphasizing the need for effective educational interventions.

Demographic factors played a significant role. Students in science-based faculties or higher levels of study were more likely to correctly identify radiation protection principles, showing that academic background and exposure to scientific concepts strongly influence understanding. Despite these gaps, students showed a **positive attitude toward learning** about radiation protection. High mean scores for statements about the relevance of radiation education suggest strong willingness to engage with future learning opportunities. Overall, the study confirms that **awareness alone does not guarantee correct knowledge or safe practices** and educational interventions should be tailored to address the misconceptions and knowledge gaps identified.

5.2 Limitations of the Study

Though this study provides valuable insights, It still has some limitations:

1. Cross-Sectional Design: A cross-sectional design was used to carry out the study, which provides a snapshot of the situation at a single point in time. It cannot establish causality and changes in the awareness and knowledge of students cannot be tracked over time.

2. Sampling and Generalizability: Although the sample size was statistically adequate, the use of online questionnaires distributed through online means may have introduced a self-selection bias, thereby potentially over-representing students who are more proficient in technology or already have some interest in the topic. The findings mean that the results may not accurately reflect the views of all university students, especially those in non-medical fields.

3. Reliance on Self-Reported Data: The data were based entirely on students' self-reported responses to the questionnaire. This method is susceptible to social desirability bias, where respondents might provide answers they believe are expected or that will be viewed favourably by others, instead of providing answers based on their knowledge or perceptions.

4. Instrument Limitations: The knowledge assessment was limited to the questions written in the instrument. Although the validated questionnaire provided a reliable assessment, it was only able to measure what had been asked and might have missed some complicated details of the knowledge of students regarding radiation protection.

5.3 Conclusion

The findings of this study clearly shows that there is a obvious deficit in the basic knowledge and accurate understanding of radiation protection among non-medical students at the University of Benin. While a baseline awareness exists, it is often on a surface basis and coupled with a lot of misconceptions, particularly regarding the nature and risks of non-ionizing radiation from common devices.

The significant difference in knowledge across various faculties pinpoints that the University environment and exposure to science-based curriculum play a crucial role in shaping a student's understanding of radiation protection. The rejection of the null hypothesis confirms that knowledge is not uniform across the university.

Despite these gaps, the beneficial aspect of the relevance of radiation protection education is the most important point. It indicates that students are a receptive audience for targeted educational initiatives. This study therefore concludes that there is a critical and urgent need to implement structured, interdisciplinary educational programs to equip all students, regardless of their field of study, with the basic knowledge required to make informed decisions about radiation safety in their personal and professional lives.

5.4 Recommendations

Based on the findings of the study and the objectives of the research, the following recommendations are made to improve awareness, knowledge and correct misconceptions about radiation:

1. **Integration of a General Studies (GST) Module**: The University should develop and include a compulsory module on ‘Radiation and Everyday Life’ into the General Studies (GST) curriculum. This module should clearly distinguish between ionizing and non-ionizing radiation, explain basic protection principles (ALARA), and debunk any misconception/myth about radiation.

2. **Targeted Faculty-Specific Workshops**: For faculties that are highly likely to encounter radiation in labs or future careers (e.g., Engineering, Physical Sciences), the University should organize specialized workshops and seminars that address radiation safety that is specific to their disciplines.

3. **Campus-Wide Awareness Campaigns:** The Department of Radiography should launch annual awareness campaigns using flyers, social media and short videos to pass out accurate information about radiation sources, risks and safety measures, focusing on correcting identified misconceptions.

4. **Development of Digital Learning Resources:** Create and host online resources (such as a dedicated website or a series of short, animated videos) that students can access to learn about radiation protection from the comfort of their homes.

5. **Enhanced Collaboration Between Faculties:** Encourage interdisciplinary collaboration between the Department of Radiography and other non-medical faculties to share knowledge about radiation and relevant safety guidelines for students involved in research or projects that might involve equipment that emit radiation.

6. Policy Advocacy for University-Wide Safety Culture: The University management should be adopt a policy that promotes a culture of safety, which includes basic awareness of radiation protection as a component of student welfare.

5.5 Future Research

Based on the findings of this study, the following areas are suggested for further research:

1. **Effectiveness of educational interventions:** Investigate how different teaching methods like workshops, online courses or multimedia resources impact the knowledge and perceptions of radiation protection among students.
2. **Understanding the source of misconceptions:** Explore why misconceptions persist among non-medical students, including the influence of media, social networks and cultural beliefs.
3. **Comparative studies across universities:** Conduct similar studies at other universities to identify patterns, differences and best practices for improving radiation awareness and knowledge nationwide.
4. **Longitudinal impact**: Examine how awareness and knowledge of radiation protection evolve over time, particularly after exposure to educational programs or curriculum modules.

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APPENDIX I

QUESTIONNAIRE

DEPARTMENT OF RADIOGRAPHY

SCHOOL OF BASIC MEDICAL SCIENCE

UNIVERSITY OF BENIN

Project Title: **ASSESSMENT OF AWARENESS AND KNOWLEDGE OF RADIATION PROTECTION AMONG NON-MEDICAL STUDENTS IN THE UNIVERSITY OF BENIN**

Dear Respondents,

I, OMOKHIBORIA VICTORY OSEWE a final year student of the department of Radiography, School of Basic Medical sciences of the University of Benin solicits for your support.

I am currently writing a project on the above topic. This questionnaire is designed solely for academic purposes. All responses are anonymous and will be treated with complete confidentiality. You are kindly required to give your sincere opinion by ticking the answer that best fits.

SECTION A: DEMOGRAPHIC INFORMATION

1. What is your faculty? Faculty of Agriculture [ ] Faculty of Arts [ ] Faculty of Education [ ] Faculty of Engineering [ ] Faculty of Environmental Sciences [ ] Faculty of Law [ ] Faculty of Life Sciences [ ] Faculty of Management Sciences [ ] Faculty of Physical Sciences [ ] Faculty of Social Sciences [ ]
2. What is your level of study? 100 level [ ] 200 level [ ] 300 level [ ] 400 level [ ] 500 level [ ]
3. What is your gender? Male [ ] Female [ ]
4. What is your age? Below 18 years [ ] 18 years and above [ ]

SECTION B: GENERAL AWARENESS OF RADIATION

5. Are you aware that certain machines or devices emit radiation (e.g., X-ray machines) A. Yes [ ] B. No [ ]

6. Have you ever undergone any medical examination that involved radiation (e.g., X-ray, CT scan)? A. Yes [ ] B. No [ ]
7. Do you know that radiation can be harmful to human health?
    a. Yes [ ] B. No [ ]
8. Do you know non-medical individuals can also be exposed to radiation in daily life?
    a. Yes [ ] B. No [ ]

9. Have you ever seen a radiation warning sign?
    a. Yes [ ] B. No [ ]

SECTION C: KNOWLEDGE OF THE PRINCIPLES OF RADIATION PROTECTION

10. What does the acronym 'ALARA' stand for?
    a. As Low As Reasonably Achievable [ ]
    b. Legal Approach to Radiation Awareness [ ]
    c. Always Learn About Radiation Applications [ ]
    d. Not sure [ ]
11. Which of the following are principles of radiation protection?
    a. Justification [ ] B. Optimization [ ] C. Dose Limitation [ ] D. Radiation Maximization [ ] E. Energy Boosting [ ]

12. Which of these can protect a person from radiation exposure?

a. Wearing a lead apron [ ] B. Reducing time near radiation sources [ ] C. Standing farther from the source [ ] D. Increasing exposure to build tolerance [ ] E. Using appropriate shielding [ ]

13. Can ionizing radiation cause cancer or genetic mutations?

    a. Yes [ ] B. No [ ] C. Not sure [ ]

14. Which of the following is a natural source of radiation?

    a. Radon gas [ ] B. LED light [ ] C. Cigarettes [ ]
    b. D. Mobile phone [ ]

SECTION D: ATTITUDES AND PERCEPTIONS

Please indicate how well you agree with the following statements using Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree.

15. I feel staying in a room where Radiation is being used is safe, as long as I don't stay there for too long.

    a. Strongly Agree [ ] B. Agree [ ] C. Neutral [ ] D. Disagree [ ] E. Strongly Disagree [ ]

16. I would be okay holding a friend during their X-ray exam if I'm given a lead apron to wear.

    a. Strongly Agree [ ] B. Agree [ ] C. Neutral [ ] D. Disagree [ ] E. Strongly Disagree [ ]

17. Radiation exposure only becomes dangerous after repeated or very long-term contact.

a. Strongly Agree [ ] B. Agree [ ] C. Neutral [ ] D. Disagree [ ] E. Strongly Disagree [ ]

18. I understand the difference between ionizing radiation and non-ionizing radiation.

    a. Strongly Agree [ ] B. Agree [ ] C. Neutral [ ] D. Disagree [ ] E. Strongly Disagree [ ]

19. I feel confident that I can protect myself in environments where Radiation is used.

    a. Strongly Agree [ ] B. Agree [ ] C. Neutral [ ] D. Disagree [ ] E. Strongly Disagree [ ]

20. Even though I'm not in the medical field, I think learning about radiation protection is still relevant to my everyday life.

    a. Strongly Agree [ ] B. Agree [ ] C. Neutral [ ] D. Disagree [ ] E. Strongly Disagree [ ]

SECTION E: SOURCES OF INFORMATION & MISCONCEPTIONS

21. Where did you learn most of what you know about radiation?

    a. Social media [ ] B. School [ ] C. Television/radio [ ] D. Friends/family [ ] E. Online articles [ ] F. I have no idea [ ]

22. Do you believe that radiation is only used in hospitals?

    a. Yes [ ] B. No [ ] C. Not sure [ ]

23. Do you think standing near a microwave or telecommunication mast exposes you to harmful radiation?

    a. Yes [ ] B. No [ ] C. Not sure [ ]

24. Do you believe that only science students need to know about radiation?

a. Yes [ ] B. No [ ] C. Not sure [ ]

25. Would you like the university to provide short seminars or lectures on radiation safety?

a. Yes [ ] B. No [ ] C. Maybe [ ]

You have come to the end of the questionnaire. Thank you so much for taking your time to complete it.