KNOWLEDGE AND AWARENESS OF RADIATION HAZARDS AMONG COMPUTED TOMOGRAPHY SCAN PATIENTS IN SELECTED DIAGNOSTIC FACILITIES IN BENIN CITY.

BY

DORCAS IDIARU

BMS2001100

DEPARTMENT OF RADIOGRAPHY

SCHOOL OF BASIC MEDICAL SCIENCES

COLLEGE OF MEDICAL SCIENCES

UNIVERSITY OF BENIN CITY

BENIN CITY

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SUPERVISOR: MR. C. V. MBIAKU

OCTOBER, 2025.

CERTIFICATION

This is to certify the project on **KNOWLEDGE AND AWARENESS OF RADIATION HAZARDS AMONG COMPUTED TOMOGRAPHY SCAN PATIENTS IN SELECTED DIAGNOSTIC FACILITIES IN BENIN CITY** written by **DORCAS IDIARU** with matriculation number **BMS2001100** in partial fulfillment of the Bachelor of Radiography Degree (B.Rad) in the **DEPARTMENT OF RADIOGRAPHY, SCHOOL OF BASIC MEDICAL SCIENCES, UNIVERSITY OF BENIN.**

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MR. C. V. MBIAKU ……………………

(Supervisor) Date

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MRS. F. O. IGBINEDION …………………….

(Head of Department) Date

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EXTERNAL EXAMINER Date

DEDICATION

This work is dedicated to God Almighty for the grace, help, favor and strength he gave me throughout my years in school and for the successful completion of this project work. I also would love to dedicate this work to individuals who became patients due to the biological effects radiation.

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ABSTRACT

Computed Tomography (CT) has become indispensable in modern diagnostics, yet it exposes patients to relatively high doses of ionizing radiation that may pose long-term health risks. This study assessed the level of knowledge and awareness of radiation hazards among patients undergoing CT examinations in selected diagnostic facilities within Benin City, Nigeria. A descriptive cross-sectional survey design was adopted, and data were collected from 200 respondents using a structured, self-administered questionnaire. The instrument contained sections on demographic characteristics, knowledge of CT radiation, and awareness of radiation-related health risks. Data were analyzed using descriptive statistics and Chi-square tests at a significance level of $p < 0.05$. Findings revealed generally poor knowledge of CT-related radiation among patients. Only 28.5% correctly identified that CT employs ionizing radiation, while 32% recognized that CT delivers higher doses than conventional X-rays. Awareness of the ALARA principle was particularly low (14%). Although 42% of respondents acknowledged that radiation could have internal health effects, many were uncertain about cumulative exposure risks and the vulnerability of pregnant women and children. Chi-square analysis showed significant associations between knowledge and demographic factors such as age ($p = 0.014$), educational level ($p = 0.001$), and occupation ($p = 0.034$), while gender showed no significant relationship ($p = 0.072$). The study concludes that most CT patients in Benin City possess inadequate knowledge and limited awareness of radiation hazards, which could hinder informed decision-making and safe imaging practices. It recommends that radiographers and radiologists provide structured pre-examination counseling, strengthen patient-education programs, and adopt policy-based communication standards to improve radiation literacy.

Keywords: Awareness, Computed Tomography, Ionizing Radiation, Patient Education, Radiation Hazards, Radiation Safety.

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Computed Tomography (CT) scans have become extremely useful in modern diagnostic medicine by offering detailed cross-sectional images that aid in the accurate diagnosis and management of various medical conditions (Michelle et al., 2013). Their quick acquisition time and high-resolution imaging capabilities have led to an increase in their utilization worldwide. However, this surge in CT scan usage has raised concerns about the potential health risks associated with ionizing radiation exposure, particularly the increased lifetime risk of cancer.

The development of computed tomography (CT) revolutionized medical imaging, beginning with Allan Cormack's pioneering work in the 1950s or 60’s on reconstructing attenuation coefficients from x-ray measurements, though his findings initially went unnoticed (Schulz et al., 2021). Godfrey Hounsfield went on to conceive the idea of cross-sectional imaging in 1967. Without prior knowledge of Cormack’s work, Hounsfield developed a practical CT reconstruction method using iterative computations. Despite funding challenges, his 1968 proposal outlined CT’s potential, including high sensitivity to tissue contrast and 3D imaging. The first live-patient CT scan in 1971 confirmed a brain tumor, marking a breakthrough (Schulz et al., 2021). Hounsfield and Cormack later shared the Nobel Prize for their contributions.

The growing use of medical imaging has raised concerns about radiation exposure risks, particularly from repeated CT scans. While immediate tissue damage (deterministic effects) is rare at diagnostic doses, long-term cancer risks (stochastic effects) may increase with cumulative exposure (Michelle et al., 2013). Exposure to ionizing radiation can have biological effects on the human body, ranging from mild cellular changes to severe health conditions, depending on the dose and frequency of exposure. Repeated exposure on patients undergoing multiple CT scans, fluoroscopic procedures, or radiation therapy are susceptible to radiation effects generally divided into deterministic and stochastic effects (Schulz et al., 2021). Deterministic effects occur when the radiation dose exceeds a certain threshold, leading to immediate or short-term damage.

On the other hand, stochastic effects are probabilistic and do not have a threshold. Even low doses carry some risk, and this risk increases cumulatively. Children are particularly vulnerable due to their developing tissues and longer life expectancy. For instance, a child undergoing repeated CT imaging for chronic conditions may face a higher lifetime risk of leukemia or thyroid cancer compared to adults. Additionally, radiation exposure can sometimes cause teratogenic effects and is particularly dangerous when imaging is done during pregnancy. The fetus is highly sensitive, especially in the first trimester, and exposure during this period can lead to developmental abnormalities or even miscarriage (Schulz et al., 2021).

Ionizing radiation, used in CT imaging can damage DNA and potentially lead to carcinogenesis. The risk is cumulative, meaning that repeated exposures can increase the likelihood of adverse effects. Children and young adults are more likely to develop cancer and related radiation induced hazards due to their developing tissues and longer post-exposure lifespan, which allows a more extended period for potential radiation-induced effects to manifest (Michelle et al., 2013).

Though radiation is a powerful diagnostic tool, its risks demand careful and informed use. A well-balanced approach ensures patients receive the benefits of modern imaging while minimizing potential harm. By applying the ALARA principle “As Low As Reasonably

Achievable” clinicians can be able to ensure the diagnostic benefits against the potential harm before recommending procedures involving radiation, and they take extra precautions when dealing with children or pregnant women.

1.2 Statement of Problem

The increasing reliance on CT imaging has raised significant concerns regarding patient exposure to ionizing radiation and the associated health risks. The increasing availability and use of CT imaging necessitates an urgent assessment of the current level of patient awareness. As the use of CT exponentially grows, leading to an increase use among patients yearly, it is important that patients are properly educated or at least have an idea of radiation hazards that could befall them after CT procedure is done in the long run. Unfortunately, there is a paucity of data particularly in regions like Benin City, Nigeria, on the knowledge and awareness of radiation induced hazards among patients and how demographic factors such as age, education level and gender affect patient’s knowledge and awareness. This gap limits knowledge in areas such as targeted educational interventions aimed at enhancing patient understanding and promoting the judicious use of CT imaging.

1.3 Research Questions

This study answers the following questions;

1. What is the current level of knowledge among patients regarding radiation used in CT scans?
2. How aware are patients of the potential health risks associated with CT radiation exposure?
3. Is there a significant relationship between patients' demographic characteristics and their knowledge and awareness of CT radiation risks?

1.4 Hypothesis of the Study

The hypothesis of this study is;

Null Hypothesis (H_0): There is no significant relationship between patients' demographic characteristics and their knowledge and awareness of radiation-induced hazards associated with CT scans.

Alternative Hypothesis (H_1): There is a significant relationship between patients' demographic characteristics and their knowledge and awareness of radiation-induced hazards associated with CT scans.

1.5. Aim of the Study

The aim of this study is to assess the current level of knowledge and awareness of radiation hazards among computed tomography (CT) scan patient in selected diagnostic facilities in Benin City.

1.6 Objectives of the Study

The objective of this study is to;

1. Evaluate patients' knowledge of the radiation involved in CT scans.
2. Assess patients' awareness of potential health risks associated with CT radiation exposure.
3. Examine the relationship between patients' demographic factors (e.g., age, education level, gender) and their knowledge and awareness of CT radiation risks.

1.7 Significance of the Study

1. To understand how patients' knowledge and awareness levels can lead to improved educational interventions, ensuring that patients make informed decisions about their healthcare and are aware of the potential risks associated with CT scans.

2. To radiographers as some findings from this study can highlight areas where radiographers may need to enhance communication with patients regarding radiation risks, leading to better patient care and adherence to safety protocols.
3. In medical field as this study can inform policy development and training programs aimed at improving patient education on radiation risks, ultimately contributing to safer imaging practices.
4. To contribute to body of knowledge as this research adds to the existing literature on patient awareness of medical imaging risks, particularly in the Nigerian context, and can serve as a reference for future studies and interventions.

1.8 Scope of Study

This study focuses on patients undergoing CT scans in selected diagnostic centers in Benin City, Nigeria. The study does not cover other imaging modalities or extend beyond the specified geographic location. This study is carried out within a span of two months from July 2025 to September 2025 to enable vast data collection.

1.8 Operational Definition of Terms

1. Computed Tomography (CT): A medical imaging technique that uses computer-processed combinations of multiple X-ray measurements taken from different angles to produce cross-sectional images of specific areas of the body.
2. Ionizing radiation: This is a type of radiation that possesses sufficient energy to remove electrons from an atom.
3. Radiation Hazards: Potential adverse health effects, such as cancer, that may result from exposure to ionizing radiation during medical imaging procedures.

4. Patient Awareness: The extent to which patients are informed about and understand the meaning and use of radiation and associated risks of CT scans.
5. Patient Knowledge: The factual information that patients possess regarding radiation exposure, including understanding of ionizing radiation, potential health risks, and safety measures associated with CT scans.
6. Diagnostic Facilities: Medical facilities equipped with imaging technologies, including CT scanners, where diagnostic procedures are performed.

CHAPTER TWO

LITERATURE REVIEW

2.1 Conceptual Review

2.1.1 History of Computed Tomography

Fig 2.1. A Modern CT Scan Machine (Al-Ameen & Sulong, 2016).

The invention of computed tomography (CT) marked a revolutionary leap in medical imaging, beginning with Allan Cormack's foundational work in the 1950s–60s on reconstructing tissue attenuation from x-ray measurements, though his findings were initially overlooked (Schulz et al., 2021). Simultaneously, Godfrey Hounsfield, inspired by pattern recognition and a chance conversation with a physician, independently developed the concept of cross-sectional imaging in 1967. Without formal training in medicine or advanced mathematics, Hounsfield devised an iterative reconstruction method using basic computations, later scaling it to an 8×8 matrix with colleague Stephen Bates. Despite limited funding, initially just £2,500 from the UK Department of Health, Hounsfield built a prototype scanner using repurposed parts, achieving the first CT image of a cadaveric brain in 1969 (Schulz et al., 2021). Collaborating with radiologist James Ambrose, he demonstrated the system's potential, revealing brain lesions with unprecedented clarity. The first live-patient scan in 1971 confirmed a brain tumor, validating CT's clinical value.

However, early skepticism from radiologists, who prioritized spatial resolution over CT's superior soft-tissue contrast and 3D imaging, nearly stalled its adoption. Hounsfield's persistence and engineering ingenuity overcame these challenges, leading to rapid advancements. By the mid-1970s, CT had replaced invasive procedures like pneumoencephalography, transforming diagnostics. Hounsfield and Cormack shared the 1979 Nobel Prize for their contributions, though their paths never crossed. Early CT systems evolved through generations from slow, head-only scanners to faster whole-body systems with spiral, multi-slice, and cone-beam designs each improving speed, resolution, and patient comfort. Despite initial doubts, CT's impact was profound, laying the groundwork for modern digital imaging and inspiring future modalities like MRI. It is therefore safe to say that the history of CT stems from collaborative efforts. The story of CT highlights the interplay of innovation, persistence, and interdisciplinary collaboration in advancing medical technology. (Schulz et al., 2021).

2.1.2 Generations of Computed Tomography

The development of whole-body CT scanning represented a major milestone in medical imaging, expanding the technology beyond brain examinations. In 1974, Robert Ledley introduced the first full-body scanner, the Automatic Computerized Transverse Axial scanner, at Georgetown University. This began the first generation of CT. This early system, similar to EMI’s initial design, used a narrow x-ray beam and required slow, incremental rotations. Despite its limitations, it demonstrated CT’s potential for diagnosing conditions throughout the body. To address motion artifacts caused by breathing and internal organ movement, faster scanning methods became essential (Schulz et al., 2021).

The second-generation CT scanners emerged, replacing single pencil beams with a fan-shaped x-ray beam and a detector array covering a 30-degree arc. This innovation reduced scan times to just 20 seconds per slice by minimizing the number of required rotations. Clinicians quickly recognized its value, as CT scans provided such precise diagnostic information that many patients could avoid unnecessary surgeries (McCollogh et al., 2023).

Further advancements led to third-generation CT systems, where both the x-ray tube and detectors rotated continuously around the patient. This "rotate-rotate" design significantly accelerated imaging but initially suffered from ring artifacts due to detector inconsistencies. To mitigate this, fourth-generation scanners were developed, featuring a stationary ring of detectors with only the x-ray tube rotating. While this eliminated ring artifacts, it introduced challenges with scatter radiation and higher costs, making third-generation designs more practical in the long run (McCollogh et al., 2023).

A breakthrough came with fifth-generation electron beam CT (EBCT), which used a stationary tungsten anode and a rapidly deflected electron beam to generate x-rays. Capable of capturing images in as little as 50 milliseconds, EBCT revolutionized cardiac imaging, enabling coronary artery calcium scoring and pulmonary artery assessments. However, despite its speed, EBCT saw limited adoption due to high costs and competition from evolving spiral CT technology (McCollogh et al., 2023).

Radiation dose reduction also became a priority, with early cardiac CT doses of 20 mSv now reduced to below 1 mSv through optimized protocols. Retrospective ECG gating allowed 4D cardiac imaging, capturing heart function over time, while computational fluid dynamics enabled non-invasive fractional flow reserve measurements to assess blood flow blockages.

Wide-detector systems further expanded CT’s capabilities, permitting perfusion studies for stroke evaluation, myocardial ischemia detection, and tumor therapy monitoring. Today, CT continues to evolve, balancing speed, resolution, and dose efficiency to meet ever-growing clinical demands. From its humble beginnings as a brain-imaging tool, CT has become an indispensable, versatile modality in modern medicine (McCollogh et al., 2023).

2.1.3 Principles and Production of Computed Tomography (CT) Image

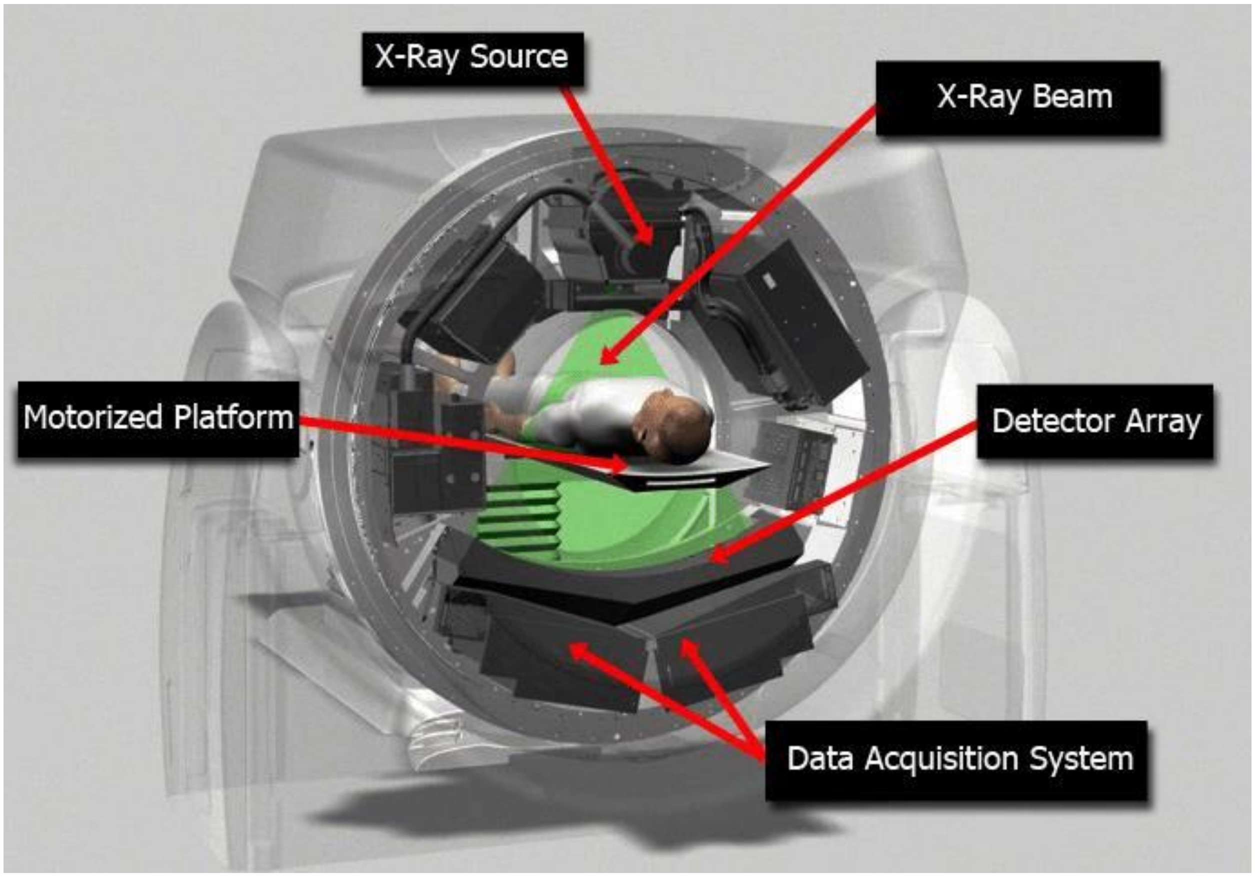


Fig 2.2. An Illustrative Diagram of a CT System going into Details (Al-Ameen & Sulong, 2016).

Generally, the production of CT images involves the generation of two-dimensional (2D) slices which are later reconstructed to three-dimensional (3D) anatomical structures. The process involves emitting X-ray photons through the body, measuring their absorption, and converting this data into digital images. Denser tissues (like bone) absorb more X-rays, appearing brighter, while less dense tissues (like lungs) appear darker. However, to better understand these principles it is important that important hardware elements such as x-ray tube and generator, gantry, detector, collimator, shielding, patient table and pitch are briefly discussed (Schulz et al., 2021).

The generator supplies electrical power to the x-ray tube, which produces x-rays via thermionic emission. A high-voltage current (80–140 kV) accelerates electrons from the cathode (negatively charged filament) to the anode (positively charged target) (Hermena &Young, 2023). When electrons strike the anode, they produce x-rays through two mechanisms, firstly characteristic radiation which is produced from inner shell electron ejection and bremsstrahlung radiation which is produced from electron deceleration. Only 1% of energy converts to x-rays, while 99% becomes heat, requiring cooling systems. Overall CT basically follows the normal production of x-rays. The gantry houses the x-ray tube and detectors and it rotates 360 degrees around the patient. The detectors capture transmitted x-rays and convert them to electrical signals.

The detectors consist of a scintillator layer which converts x-rays into visible light and photodiode layer converts light to digital data. The collimator not only shapes the x-ray beam but also reduces scatter radiation, improving image clarity. The motorized table moves the patient through the gantry. Table pitch, which is defined as movement per rotation, affects scan speed and resolution. This is because a high pitch means a faster scan, lower radiation and reduced detail while a low pitch is the vice-versa (McCollogh et al., 2023).

CT images are generally produced from x-rays passing through the body at multiple angles, with detectors measuring attenuation (absorption). Each measurement creates an attenuation profile, forming a sonogram (raw data set). Now images are produced dependent on the density of the tissue in question and also what is called the Hounsfield Units (HU). Hounsfield Units (HU) is quantitative measurement for the density of tissues in computed tomography. Some common units include air, water, bone, fat and muscle which are -1000 HU, 0 HU, +400 to +1000 HU, -40 to -100 HU and 40–80 HU respectively. After this, image are reconstructed either through Filtered Back Projection (FBP) which is a traditional method that sharpens images by filtering raw data, Iterative Reconstruction which uses advanced algorithm reducing noise and radiation dose and AI-Based Reconstruction which used deep-learning techniques for ultra-high-resolution imaging (Hermena &Young, 2023). The images are reformatted to give 3D representation of anatomical structures. There are various reformatting techniques according to Hermena &Young, 2023.

Firstly, Multiplanar Reformation (MPR) which reconstructs images in axial, sagittal, and coronal planes. 3D Volume Rendering (VR) creates lifelike models for surgical planning (e.g., fractures, vascular studies). Maximum Intensity Projection (MIP) highlights dense structures (e.g., bones, contrast-filled vessels). Minimum Intensity Projection (MinIP) emphasizes low-density areas (e.g., lungs, airways).

2.1.4 Artifact and Contrast Media Used in Computed Tomography

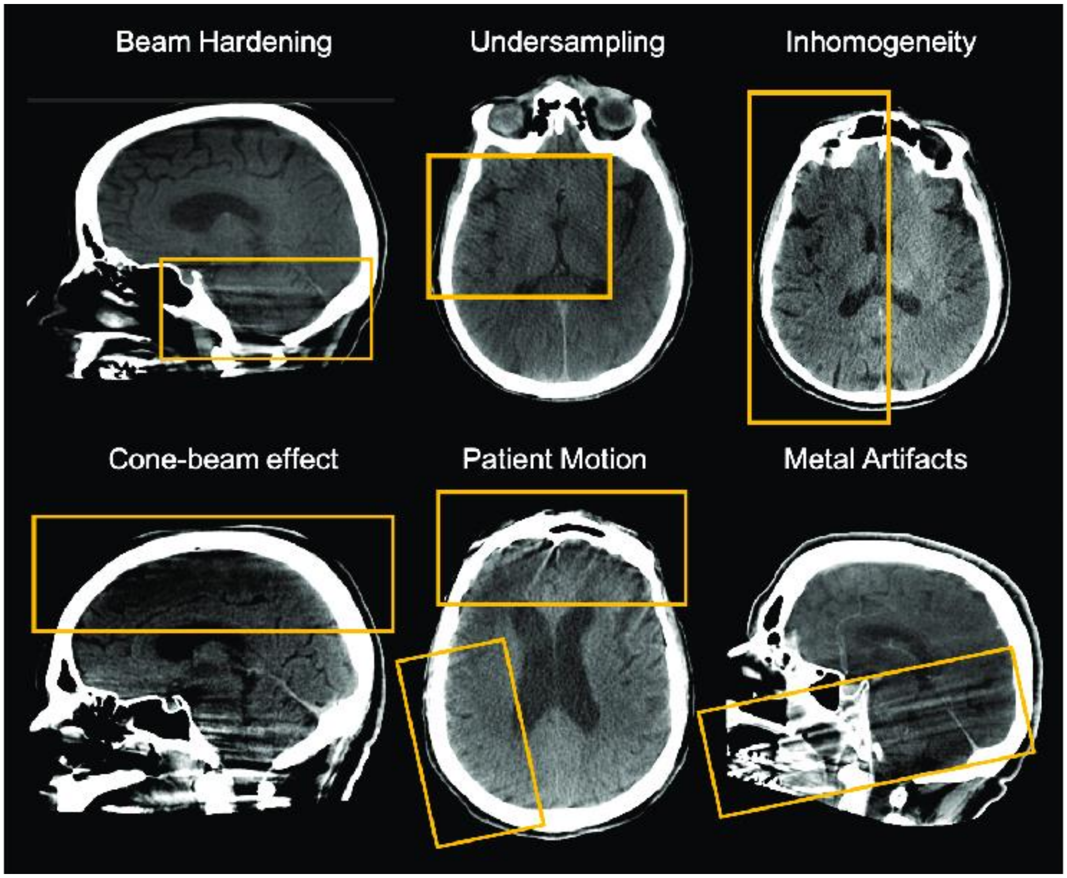


Fig 2.3. Some CT Image Artifact (Cancelliere et al., 2022)

Artifact

CT artifacts are errors found between the reconstructed image and the actual attenuation coefficients of the object which can either result from the physical limitations of the imaging system or patient related factors. (Seeram et al., 2016). Artifacts in clinical CT can obscure or mimic pathology. Common types of artifacts include:

1. Ring Artifact is caused by mis-calibrated or defective detector elements, ring artifacts appear as bright/dark rings centered on the rotation axis. Recalibration or detector replacement typically resolves the issue (Boas & Fleischmann, 2012).
2. Noise arises from low photon counts, creating random streaks. Noise reduction strategies include increasing mAs or use tube current modulation, adjust slice thickness and iterative reconstruction to improve image quality at lower doses (Boas & Fleischmann, 2012).
3. Beam Hardening and Scatter both cause dark streaks between high-attenuation objects (e.g., metal, bone). To reduce this, we use higher kV scans and iterative reconstruction with custom corrections (Boas & Fleischmann, 2012).
4. Pseudo-enhancement causes artificial dense pathologies post-contrast such as renal cyst, due to beam hardening/scatter. Smaller cysts show greater pseudo-enhancement. Dual-energy CT reduces but does not eliminate this effect (Boas & Fleischmann, 2012).
5. Motion Artifact appear as blurring, double images and streaks as a result of patient/cardiac/respiratory motion. Faster scanners, ECG gating, or motion correction algorithms mitigate these artifacts (Boas & Fleischmann, 2012).
6. Cone-Beam & Windmill Artifacts is caused by Helical CT. Helical CT introduces windmill artifacts (periodic streaks) and stair-step artifacts on reformats. Cone-beam reconstruction or AMPR reduces these effects (Boas & Fleischmann, 2012).
7. Metal Artifact arises from beam hardening, scatter, and under-sampling. Reduction methods include iterative technique to increase image quality and high kV (Boas & Fleischmann, 2012).

Contrast Media

Contrast media are substances used to highlight areas of the body in radiographic contrast to their surrounding tissues. In CT contrast media not only improves image quality but it also highlights blood vessels, tumors etc. iodinated contrast media are mostly used intravenously in CT imaging. They highlight blood vessels, tumors and inflammation. Iodinated contrast agents enhance tissue differentiation by increasing X-ray absorption. Intravenous contrast media has an arterial phase (20 sec post-injection) which is best for arteries (e.g., CT angiography) and a venous phase (70 sec post-injection) which evaluates organ perfusion. Oral contrast is also given to improve visualization of gastrointestinal system. Example of contrast media used in CT include, ioversol, iopamidol,barium sulphate etc.

2.1.5 Application of CT Scans in Modern Medicine

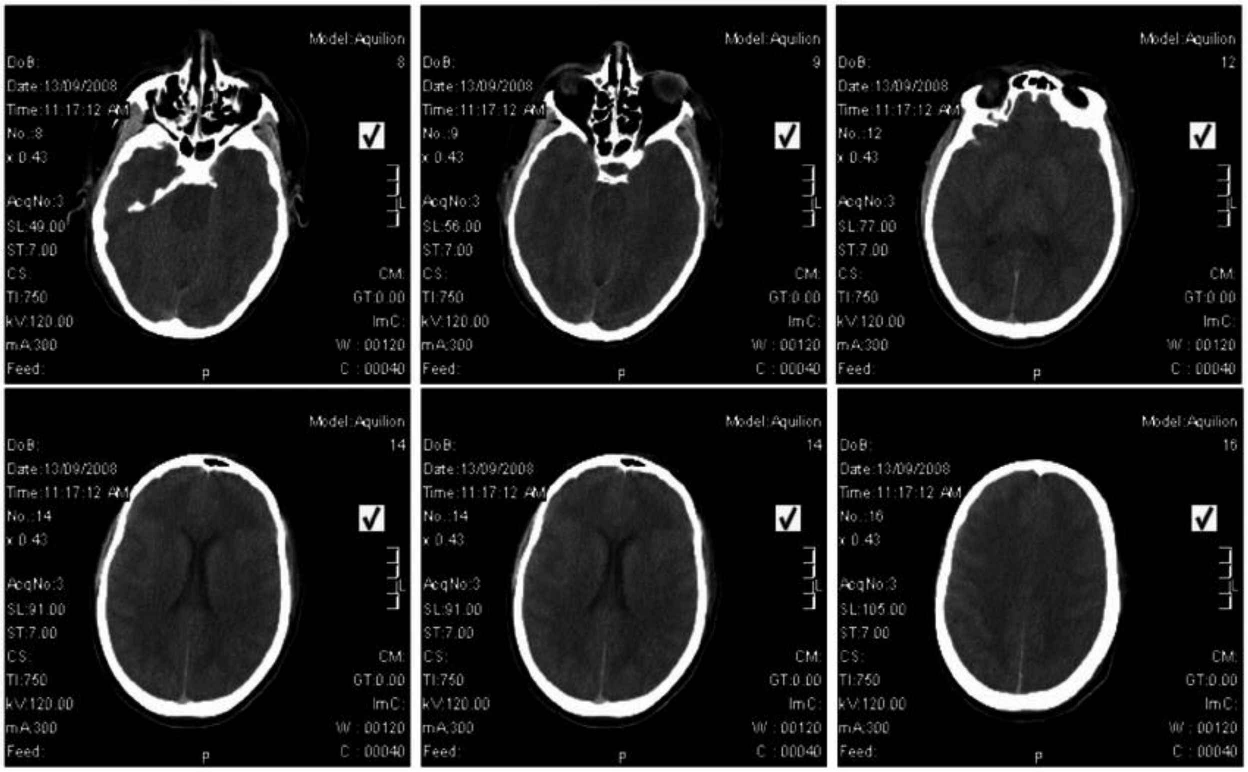


Fig 2.4. CT Scan of the Brain of Patient 5 showing Cerebral Edema On Illness Day 12 (Sewlall et al., 2014)

Computed Tomography (CT) has transformed medical diagnostics by providing high-resolution cross-sectional images of the body (Noor, 2023). This imaging modality is indispensable for detecting and monitoring numerous medical conditions, including:

1. Cancer Detection & Monitoring: CT scans can identify tumors in organs like the lungs, liver, and kidneys. It is also useful in the staging of cancer and assessing treatment response.

2. Trauma & Emergency Medicine: CT rapidly diagnoses head injuries (brain bleeds, fractures). It also assesses spinal cord damage, internal bleeding, and organ trauma. It is used in polytrauma cases (car accidents, falls).

3. Cardiovascular & Pulmonary Conditions: CT Angiography (CTA) visualizes coronary artery disease, aneurysms, and clots. It also detects pulmonary embolism (PE) and aortic dissections. Finally, it evaluates heart function and structural abnormalities.

4. Infectious & Inflammatory Diseases: Identifies abscesses, pneumonia, and osteomyelitis (bone infections). It also monitors inflammatory conditions like Crohn’s disease.

5. Musculoskeletal Disorders: CT diagnoses fractures, joint degeneration, and spinal abnormalities. It also assesses soft tissue injuries (tendons, ligaments).

6. Therapeutic & Surgical Applications: Beyond diagnosis, CT plays a crucial role in treatment planning and intervention through radiation therapy planning to precisely target tumors

while sparing healthy tissue and image guided surgery to help surgeons navigate complex procedure like tumor removal.

2.1.6 Radiation Induced Hazards on Patients

Radiation consists of energy transmitted through matter or space as either waves or particles. It can be categorized into two main types: non-ionizing radiation, which lacks sufficient energy to alter atomic structure, and ionizing radiation, which can displace electrons and modify chemical properties. Ionizing radiation includes four distinct forms: alpha particles, beta particles, photons (such as X-rays and gamma rays), and neutrons. While 82% of radiation exposure comes from natural sources, the remaining 18% originates from artificial sources, with medical imaging accounting for approximately 15% of man-made radiation exposure (Asefa et al., 2016). Unlike natural background radiation, medical radiation can be managed through proper safety protocols (Asefa et al 2016).

Healthcare facilities utilize various imaging technologies, including ionizing modalities like X-rays, CT scans, fluoroscopy, and mammography, as well as non-ionizing alternatives such as ultrasound and MRI. The biological effects of ionizing radiation occur through two primary mechanisms: deterministic effects, which involve direct cell damage at high exposure levels, and stochastic effects, which may lead to cancer development due to random cellular mutations.

To mitigate these risks, the International Commission on Radiological Protection (ICRP) recommends three key principles: justification of all imaging procedures to ensure necessity, optimization of radiation doses to minimize exposure, and strict dose limitations to protect patients. These guidelines aim to reduce the potential for radiation-induced harm while maintaining the diagnostic value of medical imaging (Asefa et al., 2016).

Radiation-induced risks fall into two main categories: immediate tissue damage at extremely high doses (deterministic effects) and long-term, probabilistic risks like cancer development (stochastic effects) (Michelle et al., 2013). Deterministic effects occur when the radiation dose exceeds a certain threshold, leading to immediate or short-term damage. Examples include skin burns, radiation dermatitis, and, in high-dose cases, organ damage. These effects are dose-dependent and predictable.

On the other hand, stochastic effects are probabilistic and do not have a threshold. The most concerning of these is radiation-induced cancer. Even low doses carry some risk, and this risk increases cumulatively. A patient who has had several diagnostic scans over time might not experience immediate symptoms, but their long-term cancer risk subtly increases. Example includes cancer, genetic mutation and radiation induced cardiovascular disease. Also noteworthy are teratogenic effects of radiation which occur during pregnancy especially at early stages in the first trimester. The severity and nature of these effects are closely linked to both the radiation dose and the gestational age at the time of exposure. High-dose radiation exposure during this period has been associated with an increased incidence of congenital anomalies such as microcephaly, developmental delays, growth restrictions and even death.

2.1.7 Computed Tomography Related Radiation Induced Hazard

The radiation dose from a CT scan is significantly higher than that from conventional radiography. For instance, a single abdominal CT scan can deliver a dose of approximately 10 millisieverts (mSv), compared to 0.02 mSv from a chest X-ray (Al Ewaidat et al., 2018). Repeated exposure to such doses can accumulate over time, potentially increasing the risk of radiation-induced health effects. The use of ionizing radiation in medical imaging, particularly computed tomography (CT) scans, has become increasingly prevalent in modern healthcare. While these diagnostic tools are invaluable, they are not without risks. Ionizing radiation can damage DNA, potentially leading to mutations and the development of cancer over time.

JAMA Internal Medicine published a study that estimated that the 93 million CT scans performed in the United States in 2023 could result in approximately 103,000 future cancer cases (Schulz et al., 2021). This projection suggests that CT scan-related cancers may account for up to 5% of all new cancer diagnoses annually. The study highlighted that, abdominal and pelvic scans were responsible for the highest number of projected cancers, with lung, colon, leukemia, and bladder cancers being the most common in adults (Schulz et al., 2021). Children are particularly vulnerable due to their developing tissues and longer life expectancy, increasing the window for radiation-induced malignancies to develop. Further emphasizing this concern, research by the Institute of Cancer Research in London reported that the rising use of CT scans contributes to about 103,000 new cancer cases annually in the U.S., including 10,000 in children. This accounts for approximately 5% of all annual cancer cases. The study underscores the importance of judicious use of CT imaging to minimize unnecessary radiation exposure (Michelle et al., 2013). These findings underscore the need for healthcare providers to balance the diagnostic benefits of CT scans against the potential long-term risks of radiation exposure. Implementing stricter guidelines and exploring alternative imaging methods when appropriate can help mitigate these hazards.

2.1.8 Patients' Knowledge and Awareness of Radiation Risks

Several studies have highlighted a general lack of awareness among patients regarding the risks associated with ionizing radiation from medical imaging. Al Ewaidat et al. (2018) found that a significant proportion of patients in Jordanian hospitals had limited knowledge about the radiation doses and associated risks of CT scans. Similarly, a study conducted in Saudi Arabia revealed that while most patients preferred to be informed about radiation risks, the majority were not provided with such information by healthcare professionals (Al-Mallah et al., 2023). These findings suggest a global trend of inadequate patient education concerning radiation hazards.

Several factors influence patients' knowledge and awareness of radiation risks. Higher educational attainment is associated with better understanding of radiation risks (Al-Mallah et al., 2023). Also, Patients with prior CT scan experiences tend to have greater awareness of associated risks (Al Ewaidat et al., 2018). Furthermore, effective communication from healthcare providers significantly enhances patient understanding (Al-Mallah et al., 2023). Finally, studies indicate variations in awareness levels across different regions, emphasizing the need for localized educational interventions (Neossi Guena et al., 2017).

To enhance patients' knowledge and awareness of radiation-induced hazards dissemination of brochures, videos, and other educational resources in waiting areas can inform patients about radiation risks. Also, regular training sessions can equip healthcare professionals with the necessary knowledge to educate patients effectively. Developing standardized protocols for discussing radiation risks can ensure consistency and comprehensiveness in patient education.

Finally, implementing decision aids can facilitate shared decision-making between patients and healthcare providers.

2.2 Empirical Review

2.2.1 Patients' Knowledge of the Radiation Doses Involved in CT Scans.

Ewaidat et al., 2023’s research aimed to evaluate patients' understanding of radiation exposure and associated risks during CT scans. A questionnaire-based study was conducted across six major hospitals in Jordan from September 2014 to March 2015, involving 600 participants (52.33% female, 47.6% male). Findings indicated no notable gender-based differences in knowledge (P = 0.596), but employment and professional background significantly impacted awareness (P = 0.000). The study concluded that patients generally lacked sufficient knowledge about ionizin*g* radiation, emphasizing the need for radiologists and imaging staff to enhance patient education.

Alsubaie & Abujamea, 2023 assessed emergency department patients' awareness of radiation risks linked to CT scans. A survey of 357 adults (44% male, 56% female) revealed that 58.5% were not informed about potential risks by their physician, and 58.1% expressed anxiety regarding radiation exposure. Despite concerns, 84.9% proceeded with the scan. The results highlighted insufficient patient-provider communication about radiation hazards, suggesting a need for better risk disclosure before imaging procedures.

Raja et al., 2021 assessed patients’ knowledge and involvement in decision-making regarding CT radiation risks. This cross-sectional study examined 500 patients undergoing CT scans, focusing on their awareness of radiation dangers and participation in decision-making. Most (64%) had never been informed about ionizing radiation, and only 45% were involved in the decision to undergo scanning. Knowledge levels were higher among males, younger individuals (<25 years), those with advanced education, and higher-income groups ($P < 0.0001$). A majority (91%) prioritized diagnosis over radiation concerns, trusting their doctor's judgment (98%).

Alashban & Alghamdi, 2024 assessed patients' perspectives on ionizing radiation exposure from CT scans in Saudi Arabia. A survey of 412 Saudi outpatients assessed their understanding of CT-related radiation risks. Only 56.8% correctly identified CT as using ionizing radiation, while 75.2% knew radiation doses varied by exam type. Just 21.4% had discussed risks with their physician. Awareness varied by gender, age, and employment status. The study concluded that patients had limited knowledge of radiation hazards, calling for improved education to ensure informed consent.

Alrasheed & Alammar, 2024's study investigated how often doctors informed patients about radiation risks before ordering CT scans. Among 387 Saudi patients, 58% knew CT involved harmful radiation, with awareness linked to higher education and prior scan experience. While 88.9% were told why they needed a CT, only 7.2% received dose-related information, and 19.1% were informed of risks. Nearly all (96.9%) preferred being educated about scan necessity, indicating a gap in risk communication.

2.2.2 Patients' Awareness of Potential Health Risks Associated with CT Radiation Exposure

Odhiambo et al., 2019 did a study on the awareness of ionizing radiation risks among CT patients in Kenya. A Kenyan study of 120 CT patients (60% male, 40% female) found low awareness only 14% knew CT used ionizing radiation, and just 2% understood its higher dose compared to X-rays. While 65% recognized risks for pregnant women, only 10% linked radiation to cancer. The study concluded that most patients lacked fundamental knowledge of ionizing radiation and its long-term effects.

Singh et al., 2017 did a study on patient's awareness of radiation dose and risks in an Australian radiology clinic. A survey of 242 patients (59.8% male) in Melbourne revealed limited awareness only 34.2% knew CT had higher radiation than X-rays, and few identified mammography or PET scans as radiation-based. Most (85.6%) were not informed about risks by their referring doctor, highlighting a systemic lack of patient education.

Almad & Jamea, 2021 did a study on patient awareness and anxiety regarding medical radiation exposure. A study of 418 patients (48% male, 52% female) found that less than 32% were informed about radiation risks before imaging. While 59% felt anxious, only 25% reconsidered the procedure due to risks. The findings indicated insufficient pre-scan discussions about radiation exposure.

Ewaidat et al., 2023 study aimed at assessing the level of patients' awareness and knowledge regarding radiation and dosage along with the associated risks from computed tomography (CT) scan. This cross-sectional study used questionnaires, which were distributed to the diagnostic imaging departments of six large local hospitals in Jordan between September 2014 and March 2015. A total of 600 patients completed the questionnaire, out of which, 52.33% of respondents were female and 47.6% male. The findings show insignificant effects of gender on patient's knowledge (*P* = .596) and significant effect of employment and profession on positive scores (*P* = .000). Similarly, no statistical differences were found between gender and correct answers (*P* = .707). This cohort of patients demonstrated a lack of awareness and knowledge about the use of ionizing radiation for diagnostic imaging. Thus, there may exist a similar lack of information that will require imaging professionals to raise patients’ awareness and offer them the appropriate information.

2.2.3 Relationship between Patients' Demographic Factors and Their Knowledge and Awareness Of CT Radiation Risks

Alsubaie & Abujamea, 2023 assessed emergency department patients' awareness of radiation risks linked to CT scans. A survey of 357 adults (44% male, 56% female) revealed that 58.5% were not informed about potential risks by their physician, and 58.1% expressed anxiety regarding radiation exposure. Younger patients (<60 years) displayed greater awareness of radiation-cancer links ($P < 0.001$) and infertility risks ($P = 0.004$). Pregnancy risk awareness was lower in young patients (47%) than young adults (89%). Middle-aged patients received more risk explanations ($P = 0.038$), suggesting age-related disparities in communication.

Al-Mallah et al., 2017 carried out a Bahraini study of 416 patients and found no significant age, gender, or education effects on radiation knowledge. However, physician-referred patients were better informed than self-referred ones, likely due to pre-scan discussions.

Ewaidat et al., 2023 study aimed at assessing the level of patients’ awareness and knowledge regarding radiation and dosage along with the associated risks from computed tomography (CT) scan. This cross-sectional study used questionnaires, which were distributed to the diagnostic imaging departments of six large local hospitals in Jordan between September 2014 and March 2015. A total of 600 patients completed the questionnaire, out of which, 52.33% of respondents were female and 47.6% male. Higher education levels correlated with better radiation awareness

(P = 0.000), with healthcare workers scoring highest (mean 52.94). Gender had no significant impact (P = 0.596), but profession did (P = 0.00).

2.3 Theoretical Framework

2.3.1 Health Belief Model (HBM)

The Health Belief Model is a psychological framework developed by Rosenstock 1974 to explain and predict health-related behaviors by focusing on individual beliefs and attitudes. It comprises several key constructs:

Perceived Susceptibility: This refers to an individual's assessment of their risk of experiencing a health issue. In the context of CT scans, patients' belief about their vulnerability to radiation-induced hazards influences their engagement in protective behaviors.

Perceived Severity: This involves the belief about the seriousness of contracting an illness or leaving it untreated. Patients who perceive radiation exposure as having severe health consequences are more likely to seek information and take preventive actions.

Perceived Benefits: This construct assesses the belief in the efficacy of the advised action to reduce risk or seriousness of impact. If patients believe that understanding radiation risks leads to better health outcomes, they are more inclined to acquire knowledge and adhere to safety protocols.

Perceived Barriers: This pertains to the individual's evaluation of the obstacles to behavior change. Barriers such as lack of information, fear, or misconceptions can hinder patients from seeking knowledge about radiation risks.

Cues to Action: These are triggers that prompt individuals to take action. For patients, cues can include advice from healthcare providers, educational materials, or media reports highlighting radiation hazards.

Self-Efficacy: This involves the confidence in one's ability to take action. Patients with higher self-efficacy are more likely to seek information and engage in behaviors that mitigate radiation risks.

2.3.2 Theory of Planned Behavior (TPB)

The Theory of Planned Behavior by Ajzen 1985 posits that an individual's behavioral intentions are influenced by their attitudes toward the behavior, subjective norms, and perceived behavioral control. In the context of CT scan patients:

Attitude Toward the Behavior: Patients' positive or negative evaluations of acquiring knowledge about radiation risks can affect their intention to engage in such behavior. A positive attitude towards learning about radiation hazards is likely to increase information-seeking actions.

Subjective Norms: These refer to the perceived social pressure to perform or not perform a behavior. If patients believe that important others (e.g., family, healthcare providers) expect them to be informed about radiation risks, they are more likely to comply.

Perceived Behavioral Control: This involves the perceived ease or difficulty of performing the behavior. Patients who feel confident in their ability to access and understand information about radiation risks are more likely to engage in knowledge-seeking behaviors.

2.3.3 Application to the Study

In Nigeria, studies have indicated a general lack of awareness among patients regarding radiation exposure during medical imaging procedures. Applying the HBM and TPB in this context can provide a structured approach to identify the factors influencing patients' knowledge and awareness. By addressing perceived barriers, enhancing self-efficacy, and leveraging subjective norms, healthcare providers can develop targeted educational interventions to improve patients' understanding and promote safer practices in diagnostic imaging.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Research Setting

This study was conducted across three healthcare facilities in Benin City, Edo State, Nigeria: the University of Benin Teaching Hospital (UBTH), Raytouch Diagnostics, and Benin Medical Center (BMC). These institutions were purposefully selected due to their relevance in diagnostic service delivery and accessibility to the target population.

The University of Benin Teaching Hospital (UBTH), established on May 12, 1973, is a federal tertiary institution located in Ugbowo, Benin City. It functions as a multi-specialist referral center with an estimated bed capacity of over 900. As a teaching hospital, UBTH is involved in training, research, and the provision of secondary and tertiary healthcare services. It also houses diagnostic departments, including radiology, with modern imaging modalities and a growing emphasis on oncology, evidenced by the commissioning of a Cancer Centre with a TrueBeam Linear Accelerator in 2025. The hospital serves a diverse patient population across the South-South region and beyond.

Raytouch Diagnostics is a privately owned, multi-disciplinary diagnostic center situated in Dawson, Benin City. Although its official date of establishment is not publicly documented, the facility has been actively providing services since at least 2022. It is known for its state-of-the-art radiological and laboratory equipment, offering services such as computed tomography (CT), electrocardiography (ECG), echocardiography, and advanced pathology testing. Raytouch

Diagnostics is recognized for its timely, patient-centered diagnostic approach and partnerships with healthcare providers in the region.

Benin Medical Center (BMC) is a relatively recent addition to the healthcare landscape in Edo State. It is a state-of-the-art private hospital offering a wide range of diagnostic and therapeutic services, including radiological imaging, emergency care, surgical interventions, and specialist consultations. BMC is known for its luxurious environment, modern infrastructure, and integration of technology in patient care. It aims to deliver international-standard medical services and caters to both local and expatriate populations.

Collectively, these facilities provided an appropriate environment for assessing the diagnostic practices and experiences relevant to this study. Their differences in structure, ownership, and service delivery enabled a comparative and comprehensive evaluation of the variables under investigation.

3.2 Research Design

This research adopted a descriptive cross-sectional survey design. This design is suitable for gathering data from a sample population at a single point in time to examine the prevalence and distribution of certain characteristics in this case, knowledge and awareness of radiation-induced hazards. A quantitative approach was employed to facilitate the systematic collection, analysis, and interpretation of numerical data obtained through the use of structured questionnaires. This design also allowed for the exploration of relationships between patients' demographic variables and their knowledge and awareness levels.

3.3 Target Population

The target population for this study comprised of patients undergoing computed tomography scans in selected diagnostic centers in Benin City during the period of the study. These individuals represent various age groups, educational levels, and socio-economic backgrounds. Inclusion criteria include patients who are 18 years and above, those who are mentally and physically capable of providing informed consent, and those who are willing to participate in the study. Exclusion criteria include critically ill patients, individuals below the age of 18, and patients who decline consent.

3.4 Sample Technique and Sample Size

A purposive sampling technique was used to select diagnostic centers based on availability, accessibility, and volume of patients. Within these centers, a convenience sampling method was employed to recruit participants who meet the inclusion criteria and are available during the data collection period.

The sample size was determined using cochrans formular as follows

$n = (z^2 \text{ x } p \text{ x } (1-p))/e^2$

where,

$z = 1.96$ (95% confidence level)

$p = 0.15$ (assumed proportion)

$e = 0.05$ (margin of error)

$n = (1.96^2 \text{ x } 0.15 (1-0.15)/ 0.05^2 = 195.9$

Thus, the sample size rounded up to 200 to account for possible non responses.

3.5 Instrument of Data Collection

The primary instrument for data collection was a structured, self-administered questionnaire designed by the researcher. The questionnaire consisted of close ended questions and was divided into three sections;

Section A: Socio demographic information

Section B: Knowledge of radiation and CT scan risks

Section C: Awareness of radiation induced health hazards

The questions were designed in simple, clear English to ensure understanding by all participants regardless of educational background.

3.6 Validity of Instrument

To ensure content validity, the questionnaire was reviewed by experts in radiography. Their feedback were incorporated to refine the items to ensure relevance, clarity, and appropriateness to the study objectives. A pilot test involving 20 patients undergoing CT scans in a diagnostic center not included in the main study was also conducted. The feedback from this pretest was used to make necessary modifications to the questionnaire.

3.7 Reliability of Instrument

The reliability of the instrument was assessed using the test-retest method, where the same questionnaire was administered to a group of 20 respondents twice at an interval of two weeks. The responses were analyzed using Cronbach’s alpha to measure internal consistency. A reliability coefficient of 0.7 was considered acceptable for the instrument.

3.8 Method of Data Collection

Data collection spanned a period of two months (July to September 2025). During this period, eligible participants was approached in waiting areas of the diagnostic centers before or after their CT examinations. The purpose of the study was explained to them, and informed consent was obtained. Those who agree to participate were provided with the questionnaire to fill on-site, with assistance available where needed. The data collection process was supervised by trained research assistants to ensure compliance and completeness.

3.9 Method of Data Analysis

Data collected was coded and entered into the Statistical Package for Social Sciences (SPSS) version 26 for analysis. Descriptive statistics such as frequencies, and percentages were used to summarize the data. Inferential statistics, specifically Chi-square tests, was used to examine the hypothesis. A p-value of <0.05 will be considered statistically significant.

3.10 Ethical Considerations

Ethical approval for this study was obtained from the Research and Ethics Committee of the University of Benin Teaching Hospital and the management of the participating diagnostic centers. All participants were informed about the purpose, procedures, and voluntary nature of the study. Written informed consent was obtained from each participant. Confidentiality and anonymity was maintained by ensuring that no personal identifiers are included in the questionnaire or analysis. Participants were assured of their right to withdraw from the study at any stage without any repercussions. The study strictly adhered to the principles of beneficence, non-maleficence, autonomy, and justice.

CHAPTER FOUR

DATA PRESENTATION, AND DISCUSSION OF FINDINGS

4.1 Data Presentation

Table 4.1: Age Distribution of Respondents

Age Group	Frequency	Percentage (%)
18–25	52	26.0
26–35	53	26.5
36–45	33	16.5
46–60	29	14.5
61+	33	16.5
Total	200	100.0

According to Table 4.1, the majority of respondents were within the age group 26–35 years (26.5%), followed closely by those aged 18–25 years (26%). The least represented group was 46–60 years (14.5%). This indicates a fairly youthful population.

Table 4.2 Gender Distribution of Respondents

Gender	**Frequency**	**Percentage (%)**
Male	95	47.5
Female	105	52.5
Total	200	100.0

As shown in Table 4.2, there were more female respondents (52.5%) compared to males (47.5%). This shows a near balance in gender distribution, though females were slightly more represented.

Table 4.3 Educational Level of Respondents

Education	**Frequency**	**Percentage (%)**
No formal education	25	12.5
Primary	50	25.0
Secondary	45	22.5
Tertiary	60	30.0
Postgraduate	20	10.0
Total	200	100.0

According to Table 4.3, most respondents had tertiary education (30%), while 12.5% had no formal education. This suggests that the sample comprised participants from diverse educational backgrounds.

Table 4.4: Occupational Status of Respondents

Occupation	**Frequency**	**Percentage (%)**
Student	45	22.5
Employed	35	17.5
Self-employed	89	44.5
Unemployed	16	8.0
Retired	15	7.5
Total	200	100.0

From Table 4.4, the majority of respondents were self-employed (44.5%), while the least represented group were retirees (7.5%). This highlights that most participants were economically active.

Table 4.5: Respondents' Knowledge of Radiation in CT Scans

Item	Correct Response	Incorrect/Don't Know
Type of radiation (Ionizing)	57 (28.5%)	143 (71.5%)
CT vs. X-ray dose (Higher)	64 (32.0%)	136 (68.0%)
Radiation accumulates in body (Yes)	67 (33.5%)	133 (66.5%)
Long-term risk (Cancer)	70 (35.0%)	130 (65.0%)
More sensitive group (Children)	63 (31.5%)	137 (68.5%)
ALARA principle	28 (14.0%)	172 (86.0%)
Dose differs by body part (Yes)	62 (31.0%)	138 (69.0%)

According to Table 4.5, the overall knowledge of CT radiation among respondents was low. For instance, only 35% identified cancer as a long-term risk of CT radiation, while a very small proportion (14%) were aware of the ALARA principle. This indicates gaps in patient knowledge.

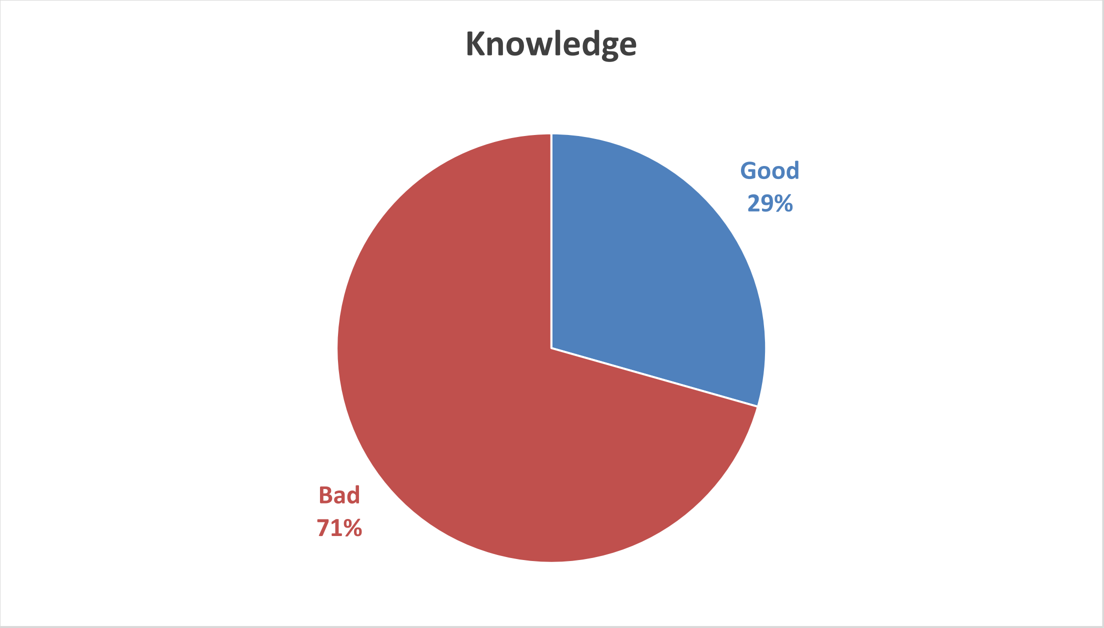


Fig 4.1 Level of Knowledge among respondents

Table 4.6: Awareness of Radiation Risks

Question	**Yes (%)**	**No (%)**	**Not Sure (%)**
Heard about radiation before CT	60 (30.0)	70 (35.0)	70 (35.0)
Told multiple CT increases exposure	74 (37.0)	55 (27.5)	71 (35.5)
Radiation effects inside body	84 (42.0)	42 (21.0)	74 (37.0)
Who should be cautious			
All patients	106 (53.0)		

As shown in Table 4.6, awareness was moderate. While 42% agreed radiation has internal effects, 37% were not sure. A majority (53%) believed all patients should be cautious of CT radiation, but fewer respondents specifically recognized vulnerable groups such as pregnant women and children.

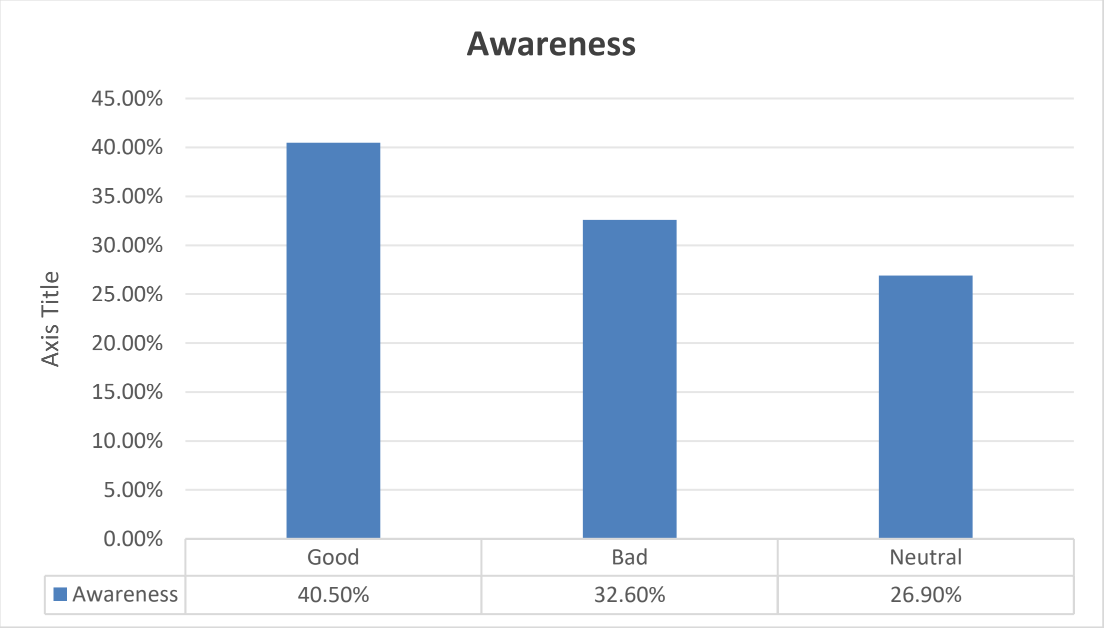


Fig 4.2 Level of awareness among respondents

4.2 Hypothesis Testing

Hypothesis Restated

Null Hypothesis (H_0): No significant relationship between demographics and knowledge of CT radiation risks.

Alternative Hypothesis (H_1): Significant relationship exists between demographics and knowledge of CT radiation risks.

Table 4.7: Chi-square Test of Relationship Between Demographic Variables and Knowledge

Variable	**χ^2 Value**	**df**	**p-value**	**Decision**
Age vs Knowledge	12.45	4	0.014	Reject H_0
Gender vs Knowledge	3.22	1	0.072	Accept H_0
Education vs Knowledge	18.62	4	0.001	Reject H_0
Occupation vs Knowledge	10.38	4	0.034	Reject H_0

According to Table 4.7, there is a significant relationship between age, education, and occupation and patients' knowledge/awareness of CT radiation risks, since $p < 0.05$ in these cases. However, gender showed no significant association ($p = 0.072$), meaning male and female respondents demonstrated similar levels of knowledge.

4.3 Discussion of Findings

According to Table 4.5, patients demonstrated generally poor knowledge of the radiation involved in CT scans. Only 28.5% correctly identified that CT scans use ionizing radiation, while 56% admitted they did not know the type of radiation used. Similarly, just 32% knew that

CT has a higher radiation dose than X-rays, and 33.5% recognized that radiation can accumulate in the body. Awareness of long-term risks was also low, as only 35% associated CT radiation with cancer, and only 14% knew about the ALARA principle for minimizing dose. These results indicate that the majority of patients lacked accurate knowledge of radiation in CT scans.

The findings reveal significant gaps in patients' understanding of CT radiation, which is concerning given that CT examinations contribute the highest radiation dose among diagnostic imaging modalities. The fact that less than one-third of respondents could identify the correct type of radiation underscores a lack of basic knowledge. Additionally, the minimal awareness of ALARA reflects poor communication about radiation protection practices. This knowledge deficit can compromise informed consent, as patients may agree to scans without fully appreciating the risks or the importance of dose optimization. It also raises ethical concerns since patient education is a critical part of radiological practice.

This result agrees with Ewaidat et al. (2023), who found that most patients in Jordan lacked sufficient knowledge about ionizing radiation, with education and employment significantly influencing awareness. Similarly, Raja et al. (2021) reported that 64% of patients had never been informed about ionizing radiation, and only 45% were actively involved in decision-making, reflecting knowledge gaps. In contrast, Alashban & Alghamdi (2024) observed a comparatively higher knowledge rate in Saudi Arabia, where 56.8% of patients correctly identified CT as using ionizing radiation and 75.2% recognized that radiation doses varied by exam type. The difference may be attributed to better hospital communication structures and more frequent patient-provider discussions in that setting.

The implication of this finding is that inadequate knowledge among CT patients undermines informed decision-making and may foster misconceptions about radiation safety. For clinical practice, radiographers and radiologists must actively integrate patient education into the imaging workflow, particularly before consent. Policies should mandate standardized counseling that explains ionizing radiation, cumulative exposure risks, and protective measures such as ALARA. Strengthening this practice would empower patients, reduce anxiety, and promote safer utilization of CT services.

As presented in Table 4.6, awareness of radiation-induced health risks was limited among respondents. While 42% acknowledged that CT radiation could have effects inside the body, 21% disagreed and 37% were unsure. Regarding cumulative risk, only 37% agreed that undergoing multiple CT scans could increase radiation exposure, while 27.5% disagreed and 35.5% remained unsure. When asked who should be most cautious, 53% believed all patients should be cautious, but only 25.5% specifically identified pregnant women, 3% children, and 3.5% the elderly. These results demonstrate fragmented awareness, with many patients either uncertain or holding incomplete perceptions of health risks associated with CT scans.

This result indicates that although some patients recognize that CT radiation can have biological effects, their awareness is neither comprehensive nor specific. The fact that only one-third of respondents identified the cumulative risks of repeated scans shows a significant gap in understanding long-term health implications such as cancer risk, genetic mutations, and tissue sensitivity. The low proportion identifying vulnerable groups like pregnant women and children further underscores limited awareness of differential susceptibility. This suggests that most patients view CT radiation as a generalized concern, rather than appreciating nuanced risks tied to specific groups and exposure histories.

The present findings are in line with Odhiambo et al. (2019), who reported that only 10% of Kenyan patients associated CT radiation with cancer and just 2% understood its higher dose compared to X-rays. Similarly, Almad & Jamea (2021) found that fewer than 32% of patients were informed about radiation risks before imaging, reflecting insufficient awareness and communication. On the other hand, the results contrast with Singh et al. (2017), where 34.2% of Australian patients knew CT scans had higher radiation than X-rays, indicating a relatively better level of awareness compared to this study's population. The differences may reflect stronger radiation awareness campaigns and stricter informed consent policies in developed healthcare systems.

The implication of this result is that patients' partial awareness may limit their ability to actively participate in decision-making regarding CT scans. Without adequate risk knowledge, patients are less likely to question unnecessary imaging, potentially increasing their lifetime radiation burden. This highlights the urgent need for structured patient education and risk communication strategies within diagnostic facilities. Radiographers and physicians should not only disclose risks but also tailor messages to emphasize vulnerable populations and the dangers of repeated exposure. Enhancing this communication could improve patient trust, reduce unnecessary scans, and ensure more informed healthcare choices.

According to Table 4.7, the Chi-square analysis revealed significant relationships between certain demographic factors and patients' knowledge/awareness of CT radiation. Age was significantly associated with knowledge ($\chi^2 = 12.45$, $p = 0.014$), education was strongly associated with knowledge ($\chi^2 = 18.62$, $p = 0.001$), and occupation was associated with awareness ($\chi^2 = 10.38$, $p = 0.034$). However, gender was not significantly related to knowledge ($\chi^2 = 3.22$, $p = 0.072$). These results suggest that educational attainment, age, and occupational background influence knowledge and awareness levels, while gender differences do not.

This finding highlights that, demographic variables play a critical role in shaping patients' understanding of CT radiation. Education is especially important, as individuals with higher qualifications are more likely to access, interpret, and apply information about radiation risks. Similarly, occupation may influence awareness since those in professional or health-related fields are exposed to relevant knowledge sources. The lack of gender-based differences suggests that men and women in this population have equal access to, or lack of, radiation-related information. These outcomes underscore the importance of considering demographic disparities when designing public health campaigns or patient education interventions.

This result is consistent with Ewaidat et al. (2023), who also reported that higher education and professional background significantly influenced patients' awareness of radiation risks, while gender differences were not statistically significant ($p = 0.596$). Likewise, Alsubaie & Abujamea (2023) found that younger patients displayed greater awareness of radiation–cancer links and infertility risks, supporting the finding that age plays a role in awareness levels. However, the result contrasts with Al-Mallah et al. (2017), who reported no significant effects of age, gender, or education on radiation knowledge among Bahraini patients, suggesting that demographic influences may vary across cultural and healthcare contexts.

The implication of this result is that radiation education strategies must be tailored to demographic subgroups. Patients with lower educational attainment and those outside professional occupations may require simplified, targeted information about radiation hazards. Since gender was not significant, interventions can be gender-neutral but should prioritize age and education-specific strategies. This evidence calls for healthcare providers and policymakers to integrate demographic-sensitive approaches into awareness campaigns, ensuring that vulnerable groups do not remain uninformed about CT radiation risks.

CHAPTER FIVE

SUMMARY, CONCLUSION AND SUGGESTIONS FOR FURTHER STUDIES

5.1 Summary of Findings

This study assessed patients' knowledge and awareness of radiation hazards associated with CT scans in selected diagnostic facilities in Benin City. The results showed that most patients lacked adequate knowledge of the radiation hazards involved in CT scans. Specifically, less than one-third correctly identified CT as using ionizing radiation, while awareness of the ALARA principle and cumulative risks was very low. In terms of awareness of health risks, many respondents were uncertain about the long-term effects of CT radiation, and only a few recognized vulnerable groups such as pregnant women and children. Chi-square analysis demonstrated that age, education, and occupation significantly influenced knowledge and awareness, while gender had no significant effect.

5.2 Conclusion

The findings indicate that patients undergoing CT scans in Benin City possess insufficient knowledge and partial awareness of radiation risks. Although some understood that CT radiation could have health effects, the majority lacked comprehensive awareness, particularly regarding cumulative risks and specific vulnerable groups. Demographic factors such as education and occupation were strong predictors of knowledge and awareness, underscoring the need for targeted interventions. Overall, the study concludes that there is a critical need to strengthen patient education and communication strategies to improve informed consent and promote radiation safety.

5.3 Recommendations

Based on the findings, the following recommendations are made:

1. Enhanced Patient Education: Radiographers and radiologists should prioritize structured counseling sessions before CT scans, explaining radiation risks, cumulative exposure, and protective principles such as ALARA.
2. Awareness Campaigns: Hospitals and diagnostic centers should implement health talks, posters, and brochures on radiation safety to improve public awareness, especially in waiting areas.
3. Policy Integration: Hospital policies should mandate that physicians and radiographers provide information on radiation risks as part of informed consent before scans are conducted.
4. Demographic-sensitive Strategies: Tailored education programs should be developed for groups with low educational attainment and non-professional occupations, ensuring that vulnerable populations are adequately informed.
5. Continuous Professional Development: Radiology staff should undergo periodic training to strengthen communication skills and improve patient engagement on radiation safety.

5.4 Suggestions for Further Studies

Future research could:

1. Assess the effectiveness of specific patient education interventions, such as audiovisual tools or mobile-based awareness programs, on improving knowledge.
2. Investigate the role of healthcare providers' communication practices in shaping patients' understanding of radiation risks.
3. Examine long-term patient outcomes in relation to knowledge and awareness of radiation safety.

5.5 Limitations of the Study

1. The data relied on self-reported responses, which may be subject to recall bias or social desirability bias.

2. Time and resource constraints limited the ability to conduct a longitudinal assessment of changes in knowledge after educational interventions.

REFERENCES

Adejumo, A. A., Enebeli, U., & Bilewu, O. O. (2020). Assessment of Patients’ Knowledge of Radiation Exposure during Medical Imaging Procedures at Private Medical Radiography Centers in Ogun State, Nigeria. *Asian Journal of Medicine and Health*, 18(10), 99–109.

Al Ewaidat, H., Zheng, X., Khader, Y., Spuur, K., Abdelrahman, M., Alhasan, M. K. M., & Al-Hourani, Z. A. (2018). Knowledge and Awareness of CT Radiation Dose and Risk Among Patients. *Journal of Diagnostic Medical Sonography*, 34(5), 374–380.

Alashban, Y., & Alghamdi, S. A. (2024). Patient perspectives on ionizing radiation exposure from computed tomography in Saudi Arabia: a knowledge and perception study. *Radiation protection dosimetry*, *200*(7), 687–692.

Alawad, S., & Abu Jamea, A. (2021). Awareness of radiation hazards in patients attending radiology departments. Radiation and Environmental Biophysics, 60(3).

Al-Mallah A, Vaithinathan AG, Al-Sehlawi M, (2017). Awareness and knowledge of ionizing radiation risks between prescribed and self-presenting patients for common diagnostic radiological procedures in Bahrain. *Oman Med Journal*. 2017;32(5):371.

Alrasheed, A. A., & Alammar, A. M. (2024). Exploring patient preferences for information about CT radiation exposure: Bridging the gap between patient preference and physician practice. *Patient Preference and Adherence*, 18, 1929–1938.

Alsubaie, F. H., & Abujamea, A. H. (2024). Knowledge and Perception of Radiation Risk From Computed Tomography Scans Among Patients Attending an Emergency Department. *Cureus*, *16*(1), e52687.

American Academy of Family Physicians. (2010). Health effects of prenatal radiation exposure. *American Family Physician*, 82(5), 488–493.

Asefa, G., Getnet, W., & Tewelde, T. (2016). Knowledge about Radiation Related Health Hazards and Protective Measures among Patients Waiting for Radiologic Imaging in Jimma University Hospital, Southwest Ethiopia. *Ethiopian journal of health sciences*, *26*(3), 227–236.

Boas EF, Fleischmann D. CT artifacts: causes and reduction techniques. *Imaging Med.* 2012;4:229–240

Cancelliere, Nicole & Hummel, Eric & Nijnatten, Fred & Haar, Peter & Withagen, Paul & Vlimmeren, Marijke & Hallacoglu, Bertan & Agid, Ronit & Nicholson, Patrick & Pereira, Vitor. (2022). The butterfly effect: Improving brain cone-beam CT image artifacts for stroke assessment using a novel dual-axis trajectory. *Journal of neurointerventional surgery.* 15. 10.1136/neurintsurg-2021-018553.

Ewaidat, H. A., Zheng, X., Khader, Y., Spuur, K., Abdelrahman, M., Khaled, M., Alhasan, M., & Al-Hourani, Z. A. (2018). Knowledge and awareness of CT radiation dose and risk among patients. *Journal of Diagnostic Medical Sonography,* 34(5).

Hermena, S., & Young, M. (2023, August 8). CT-scan image production procedures. *In StatPearls. StatPearls Publishing.*

Institute of Cancer Research. (2025). Rise in CT scans causing thousands of cancer cases, experts warn. *The Times*

Mainprize, J. G., Yaffe, M. J., Chawla, T., & Glanc, P. (2023). Effects of ionizing radiation exposure during pregnancy. Abdominal Radiology, 48(5), 1564–1578.

McCollough, C. H., & Rajiah, P. S. (2023). Milestones in CT: Past, Present, and Future. *Radiology*, *309*(1), e230803.

Michelle L. Ricketts, Mark O. Baerlocher, Murray R. Asch, Andy Myers, Perception of Radiation Exposure and Risk Among Patients, Medical Students, and Referring Physicians at a Tertiary Care Community Hospital, *Canadian Association of Radiologists Journal*, Volume 64, Issue 3, 2013, Pages 208-212,

Neossi Guena, M., Nguemeleu, D. N., Ndzana Ndah, T., & Moifo, B. (2017). An Assessment of Both Patients and Medical Staff Awareness of the Risks of Ionizing Radiation from CT Scan in Cameroon. *Open Journal of Radiology*, 7(3), 199–208.

Noor, M. (2023). An overview of computed tomography: What it is and how it works? Applications of computed tomography. **Imaging in Medicine, 15**(5), 39–94.

Odhiambo, Ogowe & Abuya, Joseph & Khakai, Mukabi & Nyamwange, Caleb & Isiaho, Minayo & Mwangi, Njeru & Omenta, Ong’era. (2019). Awareness of patients on ionizing radiation exposure and the risks associated with it in CT scan examination at Moi teaching and referral hospital, Kenya. *Journal of Scientific and Innovative Research*. 8. 94-97. 10.31254/jsir.2019.8306.

Raja, R., Khalil, M., Mahmood, H., & Raza, S. M. (2021). Evaluation of knowledge of patients undergoing CT examination regarding radiation risks and their involvement in decision making. **Pakistan Journal of Public Health*, 11*(1).

Sewlall, Nivesh & Richards, Guy & Duse, Adriano & Swanepoel, Robert & Blumberg, Lucille & Dinh, Thu-Ha & Bausch, Daniel. (2014). Clinical Features and Patient Management of Lujo Hemorrhagic Fever. *PLoS neglected tropical diseases.* 8. e3233. 10.1371/journal.pntd.0003233.

Schulz, R. A., Stein, J. A., & Pelc, N. J. (2021). How CT happened: the early development of medical computed tomography. *Journal of medical imaging (Bellingham, Wash.)*, *8*(5), 052110.

Singh, N., Mohacsy, A., Connell, D. A., & Schneider, M. E. (2017). A snapshot of patients' awareness of radiation can and risks associated with medical imaging examinations at an Australian radiology clinic. *Radiography, 23*(2), 94–102

Smith-Bindman, R., Miglioretti, D. L., Johnson, E.,. (2025). Projected Lifetime Cancer Risks From Current Computed Tomography Examination Practices in the United States. *JAMA Internal Medicine, 185(5)*, 456–464.

Sweetman, S. J., & Bernard, J. (2019). Patient Knowledge and Perception of Radiation Risk in Diagnostic Imaging: A Cross-Sectional Study. *Journal of Patient Experience*, 7(1), 110–115.

The 2007 Recommendations of the International Commission on Radiological Protection. ICRP publication 103. (2007). *Annals of the ICRP*, *37*(2-4), 1–332.

APPENDIX I

QUESTIONNAIRE

INFORMED CONSENT
My name is **IDIARU DORCAS**, a final year student of the Department of Radiography, School of Basic Medical Science, College of Medical Sciences, University of Benin, Benin City, Edo State. I am carrying out a research title "**KNOWLEDGE AND AWARENESS OF RADIATION HAZARDS AMONG COMPUTED TOMOGRAPHY SCAN PATIENTS IN SELECTED DIAGNOSTIC FACILITIES IN BENIN CITY**". This research will be conducted as part of the requirements for the award of Bachelor of Radiography (B.RAD). Your participation is voluntary and you are free to ask question about the study and also withdraw at any time you wish. Your response will be strictly confidential and be used solely for the purpose of research. Please kindly include your signature and date if you are willing to participate.

Participant's signature **Researcher's**

Signature

SECTION A: Socio-Demographic Information

1. Age:

☐ 18–25 ☐ 26–35 ☐ 36–45 ☐ 46–60 ☐ 61 and above

2. Gender:

☐ Male ☐ Female

3. Educational Level:

☐ No formal education ☐ Primary ☐ Secondary ☐ Tertiary ☐ Postgraduate

4. Occupation:

☐ Student ☐ Employed ☐ Self-employed ☐ Unemployed ☐ Retired

5. Have you undergone a CT scan before?

☐ Yes ☐ No

6. If yes, how many times?

☐ Once ☐ 2–3 times ☐ More than 3 times

SECTION B: Knowledge of Radiation and CT Scan Risks

1. What kind of radiation does a CT scan use?

☐ Ionizing radiation ☐ Non-ionizing radiation ☐ I don’t know

2. How does CT scan radiation compare to regular X-rays?

☐ It is lower ☐ It is about the same ☐ It is higher ☐ I don’t know

3. Can radiation from CT scans accumulate in the body?

☐ Yes ☐ No ☐ I don’t know

4. Which of the following is a possible long-term risk of CT radiation?

☐ Muscle cramps ☐ Cancer ☐ Fever ☐ I don’t know

5. Who is more sensitive to CT radiation?

☐ Children ☐ Adults ☐ No difference ☐ I don’t know

6. Do CT scans use the ALARA principle to reduce radiation dose?

☐ Yes ☐ No ☐ I don’t know

7. Is there a difference in radiation dose depending on the body part being scanned?

☐ Yes ☐ No ☐ I don’t know

SECTION C: Awareness of Radiation-Induced Health Hazards

1. Before this CT scan, had you ever heard anything about radiation from medical imaging?

☐ Yes ☐ No ☐ Not Sure

2. Where did you first hear about radiation from CT scans?

☐ Doctor/Radiographer ☐ Family/Friends ☐ Internet/Social Media ☐ Posters/Brochures in hospital ☐ Other (please specify) __________

3. Have you ever been told that having many CT scans might increase radiation exposure?

☐ Yes ☐ No ☐ Not Sure

4. Do you think radiation from CT scans can have effects inside the body?

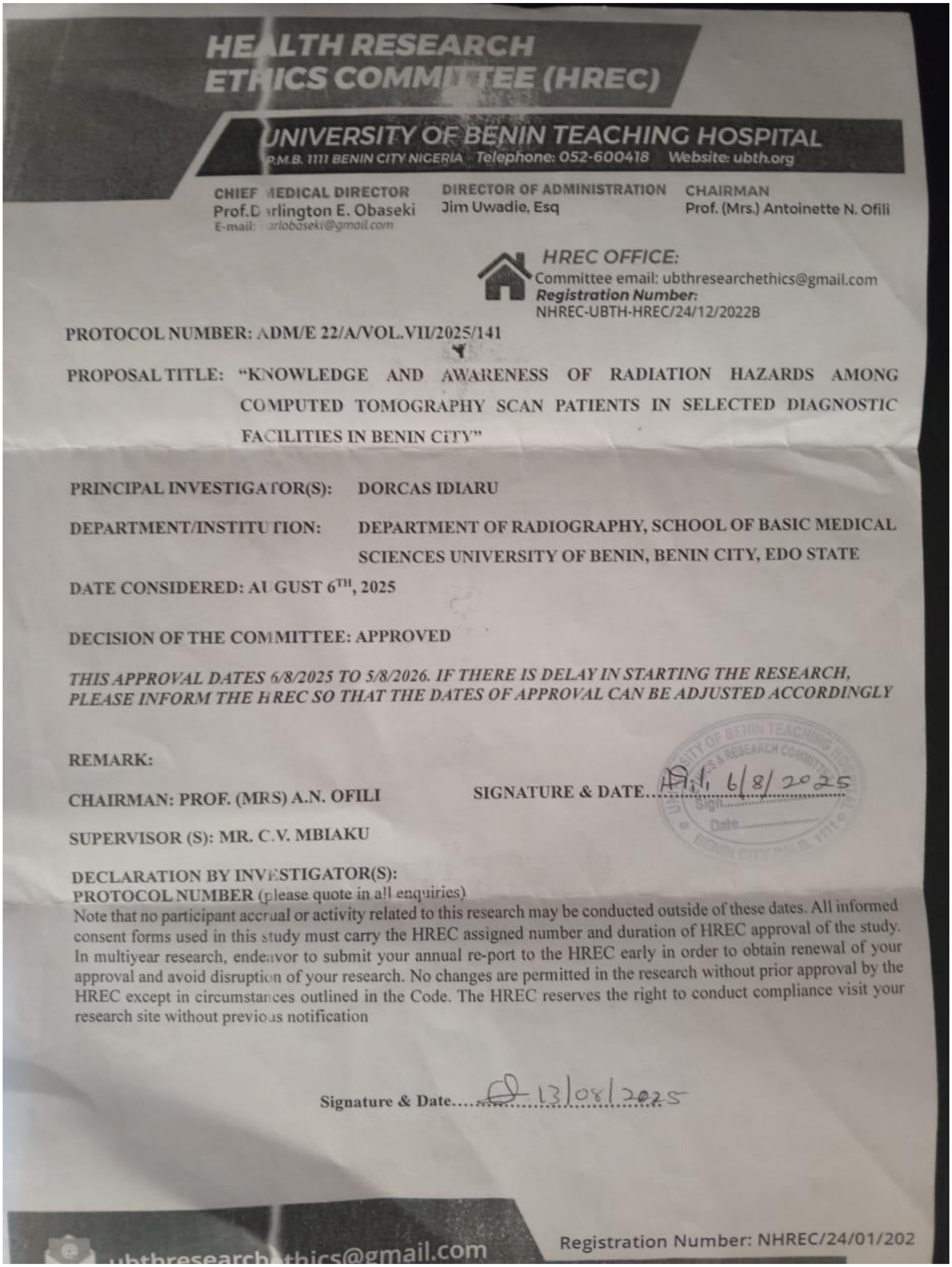
☐ Yes ☐ No ☐ Not Sure

5. In your opinion, who should be most cautious when it comes to CT scan radiation?

☐ Pregnant women ☐ Children ☐ Elderly ☐ All patients ☐ Not sure

APPENDIX II

ETHICAL APPROVAL



HEALTH RESEARCH ETHICS COMMITTEE (HREC)

UNIVERSITY OF BENIN TEACHING HOSPITAL

P.M.B. 1111 BENIN CITY NIGERIA Telephone: 052-600418 Website: ubth.org

CHIEF MEDICAL DIRECTOR	DIRECTOR OF ADMINISTRATION	CHAIRMAN
Prof.Darlington E. Obaseki E-mail: darlobaseki@gmail.com	Jim Uwadie, Esq	Prof. (Mrs.) Antoinette N. Ofili

HREC OFFICE:
Committee email: ubthresearchethics@gmail.com
Registration Number:
NHREC-UBTH-HREC/24/12/2022B

PROTOCOL NUMBER: ADM/E 22/A/VOL.VII/2025/141

PROPOSAL TITLE: "KNOWLEDGE AND AWARENESS OF RADIATION HAZARDS AMONG COMPUTED TOMOGRAPHY SCAN PATIENTS IN SELECTED DIAGNOSTIC FACILITIES IN BENIN CITY"

PRINCIPAL INVESTIGATOR(S): DORCAS IDIARU

DEPARTMENT/INSTITUTION: DEPARTMENT OF RADIOGRAPHY, SCHOOL OF BASIC MEDICAL SCIENCES UNIVERSITY OF BENIN, BENIN CITY, EDO STATE

DATE CONSIDERED: AUGUST 6TH, 2025

DECISION OF THE COMMITTEE: APPROVED

THIS APPROVAL DATES 6/8/2025 TO 5/8/2026. IF THERE IS DELAY IN STARTING THE RESEARCH, PLEASE INFORM THE HREC SO THAT THE DATES OF APPROVAL CAN BE ADJUSTED ACCORDINGLY

REMARK:

CHAIRMAN: PROF. (MRS) A.N. OFILI **SIGNATURE & DATE**………6/8/2025

SUPERVISOR (S): MR. C.V. MBIAKU

DECLARATION BY INVESTIGATOR(S):
PROTOCOL NUMBER (please quote in all enquiries)
Note that no participant accrual or activity related to this research may be conducted outside of these dates. All informed consent forms used in this study must carry the HREC assigned number and duration of HREC approval of the study. In multiyear research, endeavor to submit your annual re-port to the HREC early in order to obtain renewal of your approval and avoid disruption of your research. No changes are permitted in the research without prior approval by the HREC except in circumstances outlined in the Code. The HREC reserves the right to conduct compliance visit your research site without previous notification

Signature & Date………13/08/2025

ubthresearchethics@gmail.com Registration Number: NHREC/24/01/202