ASSESSMENT OF THE USE OF LEAD APRONS AND GONAD SHIELDS IN ROUTINE X-RAY EXAMINATIONS AT UNIVERSITY OF BENIN TEACHING HOSPITAL AND RAYTOUCH DIAGNOSTICS

BY

EVBUOMWAN EMMANUELLA IWINOSA

BMS2101814

DEPARTMENT OF RADIOGRAPHY

SCHOOL OF BASIC MEDICAL SCIENCES

COLLEGE OF MEDICAL SCIENCES

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OCTOBER, 2025

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A PROJECT SUBMITTED TO THE DEPARTMENT OF RADIOGRAPHY IN PARTIAL FULFILLMENT FOR THE REQUIREMENT OF THE AWARD OF BACHELOR DEGREE IN RADIOGRAPHY (B.RAD)

UNIVERSITY OF BENIN, BENIN CITY, NIGERIA

SUPERVISOR: MR. VICTOR .C. EGBUKICHI

OCTOBER, 2025.

CERTIFICATION

This is to certify the project on ASSESSMENT OF THE USE OF LEAD APRONS AND GONAD SHIELDS IN ROUTINE X-RAY EXAMINATIONS AT UNIVERSITY OF BENIN TEACHING HOSPITAL AND RAYTOUCH DIAGNOSTICS written by EVBUOMWAN EMMANUELLA IWINOSA with matriculation numberBMS2101814 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. Victor .C. Egbukichi ……………………

(Supervisor) Date

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MRS. F. O. IGBINEDION …………………….

(Head of Department) Date

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EXTERNAL EXAMINER Date

DEDICATION

This research project is dedicated to God almighty whom by his love and Mercy has brought me thus far in this academic journey.

I'll also love to dedicate this work to my wonderful parents for their constant love and support Your belief in me gives me the drive to strife for greatness, I love you always. To my entire family, thank you for your constant love and support. I am grateful.

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It is with utmost joy that I return all Glory to my Heavenly Father for his never-ending love and support towards me in the course of this Academic Journey for it has pleased him to bring me thus far.

To my Head of Department, Dr. Mrs Fanny Igbinedion, you are a Mother indeed. Thank you Ma for your constant encouragement and push in the right direction, it gave me the focus and drive needed for this program.

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I must give my heart-felt thanks to my wonderful parents, Mr and Mrs Evbuomwan for their constant love and support and to siblings and ever supportive aunty faith as well, Thank you for all you do.

I'm immensely grateful for the gifts of good friends their impact in this journey has been tremendous. I love and appreciate y'all so much.

To my coursemate, it was really nice going through this journey with you all.

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ABSTRACT

The increasing reliance on diagnostic radiography in modern medicine has made patient safety a critical component of healthcare delivery. Among the essential radiation protection measures employed during X-ray procedures are lead aprons and gonad shields, which serve to limit exposure to ionizing radiation, particularly to radiosensitive organs. The study aimed to assess the use of lead aprons and gonad shields during routine X-ray examinations at the University of Benin Teaching Hospital (UBTH) and Raytouch diagnostics with emphasis on frequency, knowledge, attitudes, and influencing factors. A descriptive cross sectional survey was adopted, census sampling technique was used to select a total of 37 radiographers participated, and data were analysed using descriptive statistics and chi-square tests. The findings revealed that most radiographers demonstrated good knowledge of radiation protection principles and recognised the importance of shielding in reducing unnecessary exposure. The frequency of lead apron use was high, particularly for paediatric and routine examinations, while gonad shield use was moderate due to issues such as limited availability, perceived interference with image quality, and time constraints. Despite these challenges, radiographers generally acknowledged the ethical responsibility of maintaining radiation safety and prioritised shielding where feasible. Institutional support through policies, training, and equipment availability was identified as a strong motivating factor for compliance. The test of hypothesis confirmed a significant association between radiographers' knowledge and their use of radiation protection tools, implying that the more informed a radiographer is, the more consistent their protective practice becomes.

Keywords: Ionizing, Radiation, time constraints

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

The increasing reliance on diagnostic radiography in modern medicine has made patient safety a critical component of healthcare delivery (Frantzen et al., 2012). Among the essential radiation protection measures employed during X-ray procedures are lead aprons and gonad shields, which serve to limit exposure to ionizing radiation, particularly to radiosensitive organs (Jeukens et al., 2020). These protective devices are designed to mitigate both stochastic and deterministic effects associated with radiation exposure, especially in sensitive populations such as children and reproductive-age adults (Freeman, 2022). Despite the availability of such safety tools, evidence from recent studies suggests a discrepancy in their consistent application across various healthcare settings (Frantzen et al., 2012).

Ionizing radiation, which is commonly used in routine diagnostic imaging, carries inherent risks including DNA damage, carcinogenesis, and hereditary effects (Ho et al., 2022). This has led to the establishment of radiation protection principles justification, optimization, and dose limitation—as articulated by international regulatory bodies such as the International Commission on Radiological Protection (ICRP) (Jeukens et al., 2020). Gonad shields and lead aprons are integral to the optimization principle, aimed at keeping radiation doses as low as reasonably achievable (ALARA) (Ho et al., 2022). However, evolving technology and increasing scrutiny of conventional practices have sparked renewed debates regarding the efficacy and necessity of these protective devices (Freeman, 2022).

The use of gonad shielding, in particular, has come under increased scientific review. According to Freeman (2022), a systematic review and meta-analysis revealed that gonad shields were frequently mispositioned, covering the intended anatomical area in only 15% of female and 48% of male pediatric pelvic radiographs. This improper placement not only reduces shielding efficacy but may also necessitate image retakes, thereby increasing overall radiation exposure (Frantzen et al., 2012). Similar findings were echoed by Frantzen et al. (2012), who concluded that the disadvantages of gonad shielding such as the potential for diagnostic obstruction and workflow disruption often outweigh the perceived benefits (Jeukens et al., 2020).

Moreover, advancements in imaging technology, including digital radiography and automated exposure controls, have significantly reduced the radiation dose from modern X-ray systems (Jeukens et al., 2020). Jeukens et al. (2020) argue that such improvements, when paired with optimized protocols, may render routine gonad shielding obsolete. Their findings emphasize that in many cases, especially where shields are inaccurately placed, discontinuing their use could actually lower patient risk (Freeman, 2022).

Despite these advancements, radiation protection practices remain unevenly implemented, particularly in developing healthcare environments (Ho et al., 2022). Jeukens et al., (2020) examined the effectiveness of surface shielding in scenarios where gonads lie outside the primary beam and found minimal protective advantage, especially when lead shields were poorly positioned. This variability in shielding practices may be attributed to a lack of standardized institutional protocols, insufficient radiographer training, or logistical challenges in equipment maintenance and availability (Jeukens et al., 2020).

Radiographers, who are the primary operators of X-ray equipment, play a pivotal role in ensuring radiation safety (Ho et al., 2022). However, studies have revealed gaps in knowledge, compliance, and attitudes toward the use of shielding devices (Jeukens et al., 2020). Ho et al. (2022) emphasized the need for updated training and policy frameworks to address discrepancies in radiographic practice. Their review showed that while many radiographers acknowledged the importance of shielding, actual compliance rates were suboptimal, largely due to perceived inconvenience and time constraints (Frantzen et al., 2012).

In addition to the clinical and professional dimensions, patient awareness of radiation safety remains a critical yet underexplored area (Freeman, 2022). Educated patients are more likely to request protective measures and participate actively in safety protocols (Ho et al., 2022). However, in many healthcare systems especially in resource-limited settings patients are rarely informed about the risks of radiation or the existence of protective devices such as lead aprons and gonad shields (Ho et al., 2022). This information gap may contribute to the continued underutilization of safety equipment (Jeukens et al., 2020).

The University of Benin Teaching Hospital (UBTH), being a major referral center in Nigeria, handles a high volume of routine radiographic procedures (Ho et al., 2022). The frequency and diversity of cases make it an ideal environment to assess the current state of radiation protection practices (Freeman, 2022). An evaluation of the use of lead aprons and gonad shields at UBTH and at Raytouch will not only provide insight into existing gaps in compliance and knowledge but also inform targeted interventions aimed at improving patient and occupational safety (Frantzen et al., 2012).

This study, therefore, seeks to critically examine the application of lead aprons and gonad shields during routine X-ray procedures at UBTH and Raytouch (Jeukens et al., 2020). It will assess the frequency of use, the level of awareness among patients, the knowledge and attitudes of radiographers, and the systemic factors that influence protective practices (Ho et al., 2022). By integrating evidence from contemporary research with local realities, the study aims to contribute meaningfully to the global discourse on radiation safety and support the implementation of best practices in diagnostic radiography (Freeman, 2022).

1.2 Statement of the Problem

The use of lead aprons and gonad shields is a well-established practice in diagnostic radiography for minimizing patient exposure to ionizing radiation, especially to radiosensitive organs such as the gonads (Frantzen et al., 2012). According to the International Commission on Radiological Protection (ICRP), shielding measures form a core part of the optimization principle, which aims to keep radiation doses “As Low As Reasonably Achievable” (ALARA) (Jeukens et al., 2020). When correctly applied, these protective devices help reduce both stochastic risks (like cancer) and hereditary effects in patients undergoing X-ray procedures.

However, despite clear international recommendations and proven benefits, studies have shown that these shielding devices are inconsistently used in clinical settings. Freeman (2022) found that gonad shields were correctly positioned in only 15% of female and 48% of male pediatric pelvic radiographs, with many shields either misaligned or omitted entirely. In many developing healthcare systems, including Nigeria, factors such as lack of training, inadequate equipment, poor awareness, and institutional oversight contribute to low compliance rates with radiation protection protocols (Ho et al., 2022). At the University of Benin Teaching Hospital (UBTH), where a high volume of routine radiographic procedures is conducted daily, the extent to which these protective measures are consistently applied remains unclear.

This study, therefore, aims to assess the use of lead aprons and gonad shields during routine X-ray examinations at UBTH and Raytouch Diagnostics. It seeks to determine their frequency of use, evaluate the knowledge and attitudes of radiographers, and identify factors that influence compliance with safety guidelines. The findings from this study will help bridge existing gaps in practice and support the implementation of evidence-based recommendations to improve radiation safety standards at UBTH and Raytouch Diagnostics.

1.3 Research Questions

1. How frequently are lead aprons and gonad shields used during routine X-ray examinations at UBTH and Raytouch diagnostics?

2. What is the level of knowledge of radiographers toward the use of lead aprons and gonad shields?

3. What is the level of attitude of radiographers toward the use of lead aprons and gonad shields?

4. What factors influence the use or non-use of lead aprons and gonad shields in UBTH and Raytouch diagnostics?

1.4 Research Hypotheses

Null Hypothesis (H_0): There is no significant association between radiographers' knowledge of radiation protection and the use of lead aprons and gonad shields during routine X-ray examinations.

Alternative Hypothesis (H_1): There is a significant association between radiographers' knowledge of radiation protection and the use of lead aprons and gonad shields during routine X-ray examinations.

1.5 Aim of the Study

The aim of this study is to assess the use of lead aprons and gonad shields during routine X-ray examinations at the University of Benin Teaching Hospital (UBTH) and Raytouch diagnostics with emphasis on frequency, knowledge, attitudes, and influencing factors.

1.6 Research Objectives

1. To determine the frequency of use of lead aprons and gonad shields during routine X-ray examinations at UBTH and Raytouch diagnostics.

2. To assess radiographers’ knowledge towards the use of lead aprons and gonad shields.

3. To identify factors influencing the use or non-use of lead aprons and gonad shields in the radiology department of UBTH and Raytouch diagnostics.

1.7 Significance of the Study

To Health: This study is significant to patient and occupational health because it highlights the importance of using radiation protective devices specifically lead aprons and gonad shields during routine X-ray examinations. Consistent use of these shields reduces unnecessary exposure to ionizing radiation, especially to radiosensitive organs and tissues. The findings can help reinforce safety practices that minimize both immediate and long-term radiation risks, such as infertility, genetic mutation, and cancer.

To the Profession: For the radiography profession, this study provides insight into the level of compliance with standard radiation protection protocols among practicing radiographers at UBTH and Raytouch Diagnstics. It can serve as a foundation for continued professional development by identifying gaps in knowledge, attitude, or practice. Additionally, the study can inform curriculum updates, internal training, and policy reforms aimed at strengthening radiographers' roles as frontline advocates of radiation safety.

To Society: At the societal level, the study promotes awareness about radiation protection and the value of informed consent. By emphasizing the role of shielding devices, it can help empower patients to be more involved in their own healthcare decisions. Furthermore, the findings may guide policymakers and healthcare administrators in enforcing radiation safety standards that safeguard public health and build trust in diagnostic imaging services.

1.8 Scope of the Study

This study is limited to the assessment of the use of lead aprons and gonad shields during routine X-ray examinations at the University of Benin Teaching Hospital (UBTH) and Raytouch diagnostics, Benin City. It specifically focuses on general radiographic procedures conducted within the hospital's radiology department. The study targets radiographers, to evaluate their knowledge, attitudes, and practices. The research does not extend to specialized imaging procedures such as CT scans, fluoroscopy, or interventional radiology. It also excludes the use of other radiation protective devices like thyroid shields or mobile barriers. The findings are contextual to UBTH and Raytouch and may not be directly generalized to other institutions without similar settings.

1.9 Operational Definitions of Terms

Lead Apron: A protective garment worn by patients or radiographers during X-ray procedures, designed to shield vital organs and tissues from exposure to scatter radiation. In this study, it refers to the standard 0.5 mm lead-equivalent apron used in UBTH's and Raytouch's radiology department.

Gonad Shield: A lead-based or lead-equivalent protective device specifically designed to protect the testes or ovaries from ionizing radiation during radiographic procedures. This term in the study refers to the physical use and correct placement of such shields during routine X-ray exams.

Routine X-Ray Examination: Refers to standard, non-specialized radiographic procedures such as chest, limb, pelvis, and abdomen X-rays that are performed as part of daily clinical diagnostic services at UBTH and Raytouch diagnostics.

Radiation Protection: A set of practices aimed at minimizing unnecessary exposure to ionizing radiation for both patients and healthcare workers. In this context, it includes the use of lead aprons and gonad shields as per safety guidelines.

Compliance: The extent to which radiographers adhere to established protocols and guidelines regarding the use of radiation protective equipment during imaging procedures.

CHAPTER TWO

LITERATURE REVIEW

2.1 Conceptual Review

2.1.1 Routine X-Ray Examinations

Routine X-ray examinations are among the most commonly performed diagnostic procedures in clinical medicine. They are typically the first-line imaging tests requested by physicians due to their speed, accessibility, and ability to provide valuable insights into a wide range of conditions. These examinations are considered "routine" not because they are trivial, but because they are regularly employed in evaluating various systems of the body such as the chest, abdomen, bones, and joints, with standard protocols and techniques that have been refined over decades (Bushberg et al., 2012).

At the heart of every routine X-ray exam is the fundamental principle of differential absorption. When an X-ray beam is directed toward the body, the tissues it encounters absorb or scatter the radiation to varying degrees based on their density, atomic number, and thickness. Dense materials like bone absorb more radiation and appear white or light on the final image, while less dense tissues, like lungs filled with air, allow more X-rays to pass through and thus appear darker. This contrast in absorption patterns enables clinicians to identify abnormalities, fractures, infections, degenerative changes, or even early signs of malignancy.

Chest X-rays, for example, are among the most frequently ordered radiographic studies (Bushberg et al., 2012). They are crucial for assessing the lungs, heart, and bony thoracic structures. Indications range from routine health screenings to the evaluation of cough, shortness of breath, chest pain, or fever. A standard chest radiograph includes posteroanterior (PA) and lateral views, which together provide a comprehensive image of the thoracic cavity. Radiologists assess parameters such as lung expansion, cardiac silhouette, mediastinal contours, and the presence of any opacities, effusions, or abnormal calcifications. Skeletal X-rays also fall under the category of routine examinations. They are indispensable in trauma settings for identifying fractures or dislocations, but are equally useful in non-traumatic scenarios like evaluating chronic joint pain, monitoring bone healing, or diagnosing conditions such as osteoarthritis, osteoporosis, or bone tumors. These studies are usually focused on the specific body part of interest, be it the hand, wrist, knee, or spine, and often include multiple projections to better localize any abnormalities (Bushberg et al., 2012).

The process of undergoing a routine X-ray exam is relatively quick and straightforward. The patient is positioned by a radiographer, who ensures the correct anatomical alignment and exposure parameters. Lead shielding may be used to protect non-target areas, particularly the reproductive organs, from unnecessary radiation. The exposure itself lasts only a fraction of a second. Digital radiography systems, now widely adopted, provide immediate images that can be reviewed on-screen, allowing for rapid diagnosis and minimizing the need for repeat exposures.

Though routine, these exams are not without considerations. Radiation exposure, albeit low in diagnostic radiology, must always be justified by clinical need. The principle of ALARA (As Low As Reasonably Achievable) is central to radiographic practice, ensuring that the benefits of the exam outweigh the risks (Bushberg et al., 2012). Proper technique and standardized protocols also help to avoid repeat imaging, which can increase cumulative dose.

In modern healthcare, routine X-rays serve as a gateway to more advanced imaging when necessary. While they may not provide the fine detail of CT or MRI scans, they are highly efficient in triaging patients and guiding further management. For instance, a suspicious chest X-ray may prompt a CT scan to further characterize a lesion, while a normal film might spare the patient from additional testing. Their cost-effectiveness and minimal invasiveness contribute to their continued relevance in everyday clinical practice. In conclusion, routine X-ray examinations are a cornerstone of diagnostic radiology. They play a vital role in initial assessments, ongoing monitoring, and even preventative screening. Their value lies in their ability to rapidly capture structural changes in the body with minimal discomfort and relatively low risk to the patient. As technology continues to evolve, the quality and safety of these examinations only improve, but their core utility remains as indispensable today as it was when X-rays were first introduced into medicine more than a century ago (Bushberg et al., 2012).

2.1.2 The Discovery of X-Rays

Fig 1. First X-ray Picture Made Public by Roetgen (Roy, 2023)

Wilhelm Conrad Röntgen made a groundbreaking observation in 1894 during experiments involving gas discharges under high voltage at low pressure (Prabhu et al., 2020). He noticed that a special type of radiation was generated when electrodes interacted inside an evacuated glass tube. This radiation had the unique ability to pass through solid objects such as the human hand, casting shadows on fluorescent screens provided the applied voltage exceeded 30 kilovolts. He later termed this new kind of radiation "X-rays." As investigations progressed, it became clear that this phenomenon was a form of electromagnetic radiation emitted when high-speed electrons collided either with the tube's anode or the glass envelope itself. This happened due to the acceleration of electrons from the negatively charged cathode under the influence of high voltage. Röntgen's discovery had far-reaching consequences in the field of physics. It expanded on earlier findings made by Hertz, who had previously detected electromagnetic radiation with wavelengths a million times longer than visible light. In contrast, Röntgen revealed that electromagnetic waves could also be produced with wavelengths much shorter about ten times shorter than the wavelength of visible light approaching the scale of atoms themselves. This revelation opened the door to using X-rays as a scientific tool for exploring atomic and molecular structures. They became vital for studying the biochemical composition of substances at the atomic level.

As X-ray technology evolved, it was further revolutionized by the development of the Coolidge tube, a significant milestone in the advancement of medical imaging. This modern X-ray tube used the principle of thermionic emission and served as the blueprint for most of today's X-ray systems. The cathode component of the tube was made of tungsten and formed into a filament. When electrical current passed through it, the filament heated up to a point of incandescence, prompting it to emit electrons. These electrons were then accelerated across a high-voltage gap toward the anode. Upon striking the anode surface, the sudden deceleration of these electrons led to the generation of heat and electromagnetic radiation—i.e., X-rays.

To prevent random scattering due to mutual electron repulsion, the tungsten filament was surrounded by a metal focusing cup carrying a strong negative charge. This structure helped concentrate the electron stream into a small, defined area on the anode. Before the Coolidge tube's invention, X-ray tubes often called gas tubes depended on the presence of residual gas inside them to facilitate electron production. Ionization of these gas molecules led to a cascade of electron release, known as an "avalanche effect." However, this method was inherently unstable due to its reliance on gas pressure, which was hard to regulate. Consequently, these early tubes produced relatively weak X-rays and required lengthy exposure times.

The introduction of the Coolidge tube brought about a fundamental shift. It eliminated the dependence on gas pressure and enabled precise control over both the number and energy of electrons being produced. Thermionic emission offered a consistent and scalable electron source. The number of electrons could now be adjusted independently of the tube voltage by simply varying the filament current. This led to the generation of a much denser electron stream and, consequently, more intense X-ray output. This technological leap significantly reduced exposure times and improved image quality, laying the foundation for modern radiographic practice (Prabhu et al., 2020).

2.1.3 Production of X-Rays

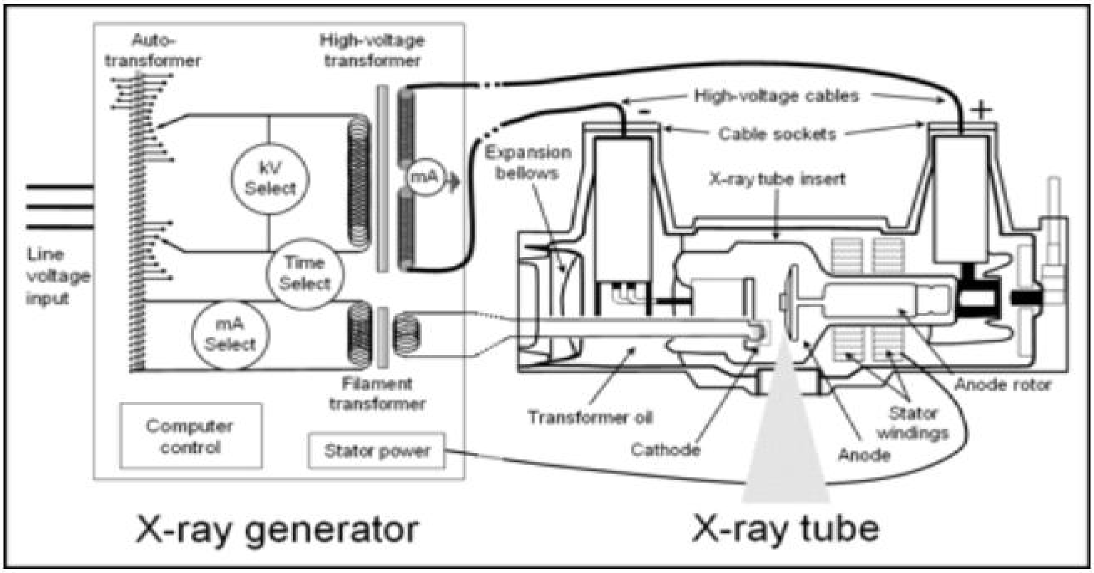

Fig 2. X-ray Generator and X-ray Tube Illustrated (Seibert, 2004)

X-rays are a category of electromagnetic radiation with wavelengths typically ranging from 0.01 to 10 nanometers (Tafti & Maani, 2023). These waves have been foundational in diagnostic radiology, allowing for detailed imaging of human tissues and aiding clinicians in identifying various diseases. In simple terms, X-rays are created when electrons are sped up by a potential difference and then transformed into electromagnetic energy. The basic X-ray generation system comprises two core components: the X-ray tube and the generator. The X-ray tube itself contains several critical elements, including a negatively charged cathode and a positively charged anode positioned close to each other within a sealed vacuum. The generator connects to these two electrodes via high-voltage cables, enabling the necessary electrical flow to initiate X-ray production.

The production process begins when the cathode filament, housed inside a focusing cup, is electrically heated to a high temperature. This heat causes the filament to emit electrons, a phenomenon referred to as thermionic emission. The emitted electrons form a dense cloud near the surface of the filament, and due to their like charges, they naturally repel one another. To initiate their acceleration, a high voltage is applied between the cathode and anode. This voltage difference propels the electrons across the vacuum toward the anode target. The focusing cup, shaped and charged to direct the electrons precisely, ensures that the electron stream follows a straight path. The rate of electron flow is measured in milliamperes (mA), with 1 mA corresponding to about 6.24 x 10^15 electrons per second. The kinetic energy of these electrons is measured in kiloelectron volts (keV) and is directly tied to the voltage applied across the tube.

When these high-energy electrons collide with the anode target, usually made of tungsten due to its high melting point and atomic number, X-ray production takes place. The electrons approach the nuclei of tungsten atoms and are abruptly decelerated, causing their kinetic energy to be released as electromagnetic waves. This specific mechanism is called bremsstrahlung or "braking radiation." The result is a broad spectrum of X-ray energies. Alternatively, some incoming electrons may knock inner-shell electrons out of their orbits within the tungsten atoms. When outer-shell electrons fall inward to fill these vacancies, they release energy in the form of characteristic X-rays. These have discrete energy levels that are unique to the atomic structure of the target material, making them useful for identifying specific elements. However, bremsstrahlung radiation still accounts for the majority of the X-rays produced in typical diagnostic settings (Tafti & Maani, 2023).

Understanding how X-rays interact with human tissue is crucial to comprehending how images are formed. There are three main types of interactions: coherent (or classical) scattering, Compton scattering, and photoelectric absorption. Coherent scattering involves low-energy X-rays that bounce off orbital electrons without causing ionization, slightly altering their direction and contributing marginally to the patient's dose. Compton scattering occurs when higher-energy X-rays eject outer-shell electrons, leading to ionization and scattered rays, which degrade image quality and increase radiation exposure. Photoelectric absorption, on the other hand, happens when X-rays strike inner-shell electrons, dislodging them and prompting a chain reaction of electron shifts that emit secondary X-rays. This process plays a vital role in image contrast (Tafti & Maani, 2023).

Image formation is influenced by how much X-ray energy is absorbed or transmitted by different tissues. Factors such as tissue density, atomic number, and the energy of the X-ray beam all determine the level of attenuation. The more X-rays are absorbed by a tissue, the brighter it appears on the final image. Detection systems can either be analog (film-based) or digital. Traditional analog systems are limited in their ability to capture a wide range of exposure levels accurately. This often necessitates multiple images for proper diagnosis, inadvertently increasing the patient's radiation exposure. Digital detectors, in contrast, offer the ability to adjust contrast and brightness post-acquisition and provide greater flexibility in image analysis and enhancement (Tafti & Maani, 2023).

2.1.4 Radiation Protection: History and Evolution of Shielding Practices

The story of radiation protection is as old as the discovery of X-rays themselves. When Wilhelm Röntgen unveiled this mysterious new form of energy in 1895, the initial fascination with its diagnostic potential quickly turned into concern, as reports of injuries, skin burns, hair loss, and delayed tissue damage, began to emerge among early experimenters and radiologists. At the time, however, the biological risks of ionizing radiation were poorly understood. There were no formal protocols, no protective gear, and no regulatory oversight. Protection, if considered at all, was a matter of personal improvisation.

In the early decades of radiology, shielding practices were virtually non-existent. Radiologists and technicians often exposed themselves to large doses of radiation while performing fluoroscopy with their hands placed directly in the beam to position patients. It wasn't uncommon for practitioners to develop chronic dermatitis or even amputate fingers due to prolonged radiation exposure. This lack of awareness persisted until accumulating evidence of harm forced the medical community to reconsider its casual approach to radiation use.

The turning point came as researchers began documenting the biological effects of radiation, leading to the formation of early regulatory bodies. One of the most significant steps in organized radiation protection was the establishment of exposure limits. As awareness grew, simple but crucial protective measures were introduced such as lead aprons, thyroid collars, and leaded glass barriers. The focus was primarily on external shielding to protect the operator from scattered and direct radiation. Walls of radiology rooms were lined with lead, and portable shields became standard in most diagnostic areas.

By the mid-20th century, institutions began to take formal responsibility for the safety of their medical personnel. Radiations monitoring badges, or dosimeters, were introduced, allowing workers to track their cumulative exposure. Over time, this enabled more precise control over occupational doses, which were steadily brought down in accordance with the evolving limits proposed by international regulatory bodies. The philosophy of radiation protection also matured during this period. What started as crude barrier methods evolved into a more structured framework guided by principles such as time, distance, and shielding. These principles emphasized minimizing exposure time, maximizing distance from radiation sources, and using adequate physical barriers. This framework became the backbone of occupational safety protocols in medical imaging departments. Fast-forward to the 21st century, and the emphasis on worker protection has deepened. Technological advances have allowed for more efficient imaging techniques that use significantly lower doses, while shielding equipment has become lighter and more effective. Moreover, the development of digital imaging and automatic exposure control systems further reduced the need for repeat examinations, minimizing unnecessary radiation exposure. There has also been a cultural shift from passive compliance to proactive safety where radiologic technologists, physicists, and administrators are more involved in radiation safety planning (Boice et al., 2020).

Interestingly, the most recent discussions in the evolution of shielding practices are focusing not only on protecting workers but also on re-evaluating whether certain patient shielding practices such as the routine use of lead aprons are still necessary in all circumstances. Some experts argue that shielding may not be as beneficial for patients in digital radiography as once believed and might even interfere with automatic exposure systems, potentially increasing the dose (Boice et al., 2020). These debates underscore how dynamic the field remains and how contemporary radiation protection is as much about critical thinking as it is about physical barriers.

In conclusion, radiation protection has undergone a remarkable transformation from the early days of complete unawareness to today's refined practices backed by scientific evidence and regulatory oversight. The evolution has not only saved lives but has also professionalized the field of medical imaging, embedding safety as a central pillar of practice. It reflects a journey of scientific learning, institutional responsibility, and a steadfast commitment to the well-being of medical workers and patients alike (Boice et al., 2020).

2.1.5 Lead Aprons

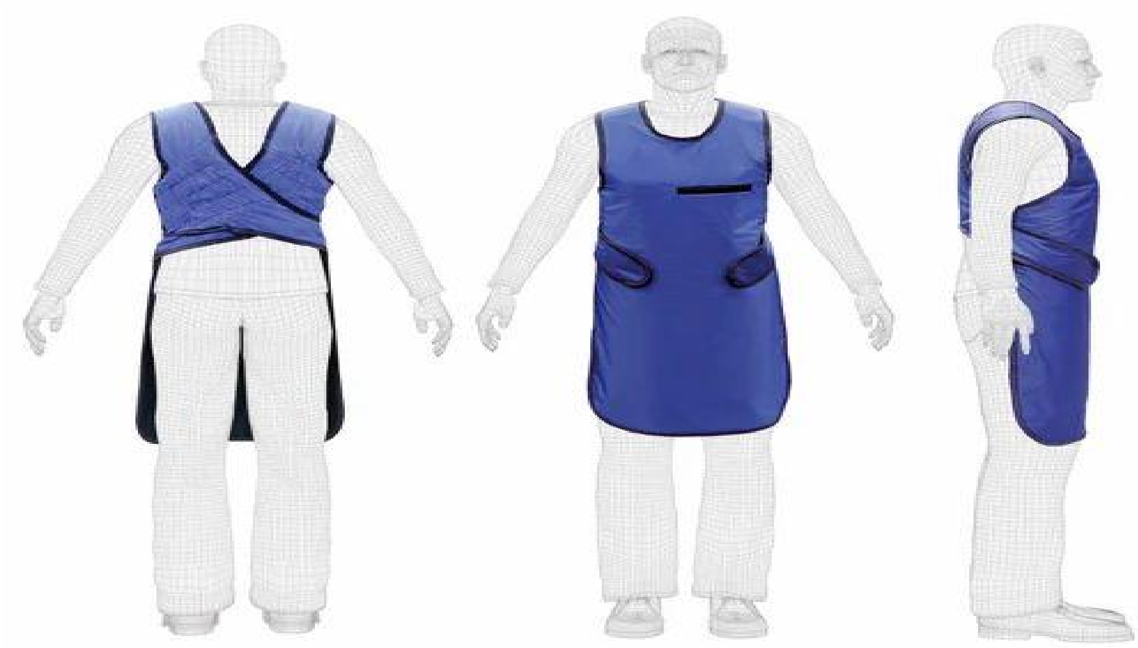

Fig 3. Lead Aprons (Dauer et al., 2007)

Lead aprons have long stood as a frontline defense in medical environments where ionizing radiation is routinely used, especially in diagnostic radiology and interventional procedures. These protective garments, typically embedded with lead or lead-equivalent materials, serve a singular yet crucial purpose: to shield radiosensitive organs from scatter radiation and reduce overall exposure, both for patients and healthcare workers.

The history of lead apron use in radiological practice dates back nearly to the early days of X-ray discovery, when the harmful biological effects of ionizing radiation started to become apparent. As medical imaging advanced and exposure increased, so did the need for protective measures. Lead aprons quickly became standard attire for radiographers and clinicians who had to remain in close proximity to active radiation sources. Over time, with growing awareness and regulatory guidance, their use was institutionalized, forming a core component of personal radiation protection protocols (Periyasamy & Kaginelli, 2023). At the core of their protective function lies lead, a dense, malleable metal that efficiently attenuates X-ray photons. By absorbing and scattering secondary ionizing radiation, lead aprons drastically reduce the dose that penetrates to underlying tissues. The extent of this attenuation depends on the thickness and uniformity of the lead-embedded material.

Traditionally, aprons contain a lead equivalence of 0.25 to 0.5 mm, which offers substantial protection, especially in lower-energy diagnostic applications. In modern practice, lead-free or composite alternatives are also being explored to reduce weight without compromising safety (Hyun et al., 2016). The importance of ensuring the structural integrity of these aprons cannot be overstated. Damaged or cracked aprons compromise their protective efficacy, allowing radiation to pass through weakened points. In a quality assurance assessment carried out across five hospitals in Abuja, Nigeria, it was revealed that many lead aprons in clinical use had tears, cracks, or visible signs of degradation most of which were not readily detectable by visual inspection alone (Ilupeju et al., 2023). These defects can result in unintentional exposure, particularly when vulnerable body areas such as the gonads, thyroid, or bone marrow are involved. Routine radiographic evaluations and fluoroscopic inspections of lead aprons are therefore recommended to detect such structural compromises early.

The real-world effectiveness of lead aprons has also been examined in several experimental and clinical contexts. A study by Hayre et al., 2020 tested the protective value of lead-rubber aprons in shielding radiosensitive organs. Their findings underscored that, while the aprons significantly reduced radiation dose, their shielding capacity varied across organ sites and exposure scenarios. For instance, while the gonads and thyroid benefitted from substantial dose reduction, the breast and other peripheral organs received less protection, particularly when not directly shielded or when scatter geometry was complex. This highlights the importance of appropriate apron positioning, patient posture, and the use of supplementary shielding when necessary.

Similarly, Hyun et al., 2016 explored the actual efficiency of lead aprons in blocking radiation, concluding that although lead aprons offer measurable protection, their shielding effect is not absolute. The study found variability in radiation reduction depending on the apron's make, lead equivalence, and the angle of exposure. Radiation that entered the body from lateral or oblique angles was more likely to bypass apron shielding, especially if the garment was poorly fitted or not worn correctly. These findings reaffirm that lead aprons, while critical, must be used in tandem with other protective strategies such as proper beam collimation, distance maintenance, and minimal exposure time.

As these garments are handled daily, their frequent use inevitably leads to mechanical wear and tear. Periyasamy &Kaginelli, 2023 emphasized the necessity for periodic quality assurance tests, noting that a surprising number of aprons in clinical circulation failed basic integrity checks. The authors advocate for implementing mandatory routine inspections, ideally every six to twelve months, using fluoroscopy or X-ray imaging to identify defects that could compromise protection. They also stressed the need for adequate storage practices, such as hanging aprons vertically when not in use, to avoid creases and internal fractures.

In summary, lead aprons remain an indispensable tool in radiation safety practice. Their ability to attenuate secondary radiation and protect vulnerable organs has been well-documented across decades of clinical application and research. However, their effectiveness is not merely a function of material but also of maintenance, proper usage, and integration with broader radiation protection protocols. When treated as part of a holistic safety strategy alongside time, distance, shielding, and regular quality checks lead aprons can continue to serve their role in safeguarding both healthcare workers and patients from the latent risks of ionizing radiation (Periyasamy & Kaginelli, 2023).

2.1.6 Gonad Shielding

Fig 4. Gonad Shields (Dauer et al., 2007)

Gonad shielding has long been regarded as a fundamental protective strategy in diagnostic radiology, particularly when imaging the pelvic and abdominal regions. At its core, the practice involves placing a lead or lead-equivalent barrier over the reproductive organs to reduce exposure to ionizing radiation. Given the radiosensitivity of gonadal tissues and the associated risk of heritable mutations, shielding these organs has been historically seen as non-negotiable especially in pediatric and young adult patients.

The origins of gonad shielding date back to the mid-20th century, a time when radiation doses from diagnostic imaging were significantly higher than they are today. Early research and radiological safety campaigns emphasized minimizing the potential genetic risks of radiation, which prompted global guidelines recommending routine use of contact shielding for patients undergoing radiographic examinations of the pelvis and lower abdomen (Ho et al., 2022). Over the decades, gonad shields became widely available in various shapes and designs, ranging from flat shields and contour-fit cups to pelvic drapes and their use were often seen as a hallmark of radiation-conscious practice.

However, despite its longstanding presence in radiology departments, gonad shielding has become a subject of re-evaluation in recent years. Advances in imaging technology particularly with the advent of digital radiography have dramatically reduced the radiation dose per examination. In fact, modern X-ray systems now offer optimized exposure settings, better image processing, and improved beam collimation, all of which significantly minimize the scatter radiation that originally justified the use of shields. As a result, some researchers and clinical authorities have begun to question whether routine gonad shielding still offers any meaningful benefit (Ho et al., 2022).

The study by Ho et al., 2022 provides a comprehensive review of this evolving debate. They found that while traditional guidelines continue to advocate for shielding in specific cases, a growing number of professional bodies including the American Association of Physicists in Medicine (AAPM) have updated their recommendations to discourage routine gonad shielding. Their argument is based not only on the lower dose profiles of modern imaging but also on the risks posed by shielding itself. Shields can interfere with automatic exposure control systems, leading to higher doses if the system compensates for attenuated areas. Furthermore, improperly placed shields may obscure diagnostic information or require repeat exposures ironically increasing the radiation burden.

This tension between tradition and technology is further explored in the recent study by Cardoso et al., 2023 who conducted a questionnaire survey to assess current practices surrounding gonad shielding in digital radiography. Their findings revealed a fragmented landscape: while some institutions have begun phasing out the practice in line with updated recommendations, others continue to rely on shielding due to institutional policy, habit, or patient expectations. Technologists, in particular, expressed concern about changing long-standing protocols without sufficient public education, fearing that patients might equate the removal of shields with decreased safety. The study also highlighted a need for clear, evidence-based national guidelines to ensure consistency and protect radiographers from legal or ethical ambiguity in clinical settings.

The ethical and scientific implications of gonad shielding are further unpacked in the work by Karami et al., 2016. Their article investigates not just the technical effectiveness of gonad shields but also the practical challenges in their application. They noted that incorrect shield placement is a common issue, especially among less experienced personnel. Mispositioned shields can either fail to protect the gonads or compromise image quality requiring repeat exposures and inadvertently increasing the radiation dose. Additionally, in certain anatomical variations or mobile patients (e.g., children), achieving proper shield alignment can be particularly difficult. The authors ultimately call for individualized approaches, emphasizing that shielding should never compromise diagnostic accuracy. While gonad shielding was once a symbol of patient care and radiation responsibility, today it occupies a more nuanced position in clinical radiology. Its use must be weighed against the capabilities of modern equipment, the nature of the examination, the reliability of shield placement, and the diagnostic objectives. Rather than adhering blindly to tradition, professionals are now encouraged to evaluate the risks and benefits in context recognizing that shielding may not be the best or only way to achieve radiation safety in every case (Cardoso et al., 2023).

2.1.7 Reassessing Patient Shielding in Modern X-Ray Imaging.

The concept of radiation protection has long been central to the practice of diagnostic radiology. It represents both a technical safeguard and an ethical obligation ensuring that while the benefits of imaging are utilized, the potential risks of ionizing radiation are kept to a minimum. One of the most visible and longstanding methods of protection has been patient shielding, traditionally using lead to reduce unnecessary exposure. However, with major advances in imaging technology and dose management, the benefits of such shielding are now being carefully re-examined.

In a comprehensive literature review, Samara et al., 2022 explored the role and relevance of patient shielding in the context of modern medical X-ray imaging. Their analysis synthesized evidence from various clinical studies and technical reports, seeking to evaluate whether the protective advantages of shielding remain significant enough to justify its continued routine use.

Historically, the rationale for using shielding particularly for radiosensitive organs like the gonads, thyroid, and breast was straightforward. Shields served to block scatter radiation, providing an additional layer of protection when imaging fields extended beyond the area of clinical interest. This was especially important during an era when dose control mechanisms were limited and image quality often required higher exposures. In that context, shielding clearly contributed to dose reduction and was widely regarded as essential.

However, the review by Samara et al., 2022 highlights a significant paradigm shift. With today's digital radiography systems, dose management has become highly optimized. Features such as automatic exposure control (AEC), improved beam collimation, and better detector efficiency have drastically reduced the amount of radiation used during imaging. In light of these changes, the study finds that the marginal benefit of patient shielding has diminished, especially when imaging protocols are properly followed and the beam is tightly collimated to the region of interest.

In fact, the review uncovers an unintended consequence of shielding that challenges long-standing practices: when shielding is incorrectly placed, it can interfere with the automatic exposure settings, prompting the system to increase radiation output in order to compensate for the obstructed detector area. This paradoxical effect could lead to a higher overall radiation dose, thereby undermining the very safety shielding was meant to enhance (Samara et al., 2022). Despite these findings, the study does not entirely dismiss the value of shielding. For certain patient populations such as children, pregnant individuals, or those undergoing repeated imaging carefully applied shielding may still offer measurable protection, particularly when beam settings are not ideal or when equipment lacks modern optimization features. More importantly, patient reassurance remains a relevant factor. Samara et al., 2022 note that many patients feel more secure when shielding is used, suggest that its psychological benefit should also be taken into account in clinical decision-making.

Ultimately, the review urges a more individualized and evidence-based approach to radiation protection. Rather than applying shielding indiscriminately, practitioners are encouraged to consider the specific context of each imaging scenario factoring in patient age, body region, equipment capabilities, and potential interference with imaging parameters. The broader goal, as underscored by Samara et al., 2022 is to maintain high standards of safety while embracing the technological progress that allows for inherently lower doses and smarter imaging practices.

2.1.8 Current Policies and Guidelines on Lead Aprons and Gonadal Shields

Lead Aprons

Lead aprons remain a cornerstone of radiation safety practices, especially in fluoroscopic and orthopaedic procedures. These aprons often constructed with a lead equivalence of 0.25 mm or higher are designed to protect vital organs from scatter radiation during exposure. According to Lakhwani et al., 2019, the consistent use of lead aprons is essential in maintaining the three fundamental principles of radiation protection: justification, optimization, and dose limitation. Their utility is emphasized in interventional settings where prolonged exposure is common, and their integrity must be ensured through routine inspections for cracks or thinning and proper storage to maintain effectiveness. The International Commission on Radiological Protection (ICRP) reinforces the use of shielding, particularly for healthcare professionals who work close to radiation sources (ICRP, 2010). Aprons are advised in any procedure where scatter radiation is expected to exceed permissible levels, such as in fluoroscopy, CT-guided interventions, and mobile X-ray use. The ICRP further recommends complementing lead aprons with thyroid shields and protective eyewear depending on proximity to the beam and the nature of the procedure.

Gonadal Shields

Gonadal shielding has historically been employed in pelvic or abdominal X-ray examinations, particularly in children and young adults, to reduce potential heritable effects of ionizing radiation. This practice was once widely endorsed, especially when the gonads were within 5 cm of the primary beam (Lakhwani et al., 2019). However, in light of modern radiographic technology marked by dose-reducing advancements such as digital detectors and automatic exposure control the relevance of routine gonad shielding has significantly declined. Current guidance from international bodies such as the ICRP, the National Council on Radiation Protection and Measurements (NCRP), and the American Association of Physicists in Medicine (AAPM) strongly advises against the routine use of gonadal shields during pelvic and abdominal imaging (ICRP, 2010; NCRP, 2009). These organizations argue that such shields can obscure important diagnostic information, interfere with automatic exposure control systems, and ultimately result in increased radiation exposure due to compensatory dose adjustments.

Additionally, it is now widely recognized that the external shielding of gonads offers minimal protection from internal scatter radiation, which constitutes a significant portion of dose to reproductive organs during X-ray procedures (ICRP, 2010). As a result, recommendations have shifted toward removing gonadal shielding from standard imaging protocols unless specific clinical circumstances justify its use.

2.2 Theoritical Framework

2.2.1 Health Belief Model (HBM)

The Health Belief Model (HBM) is built around the idea that individuals make decisions about health practices based on perceived threats and the benefits of taking preventive action. It emphasizes components like perceived susceptibility, perceived severity, perceived benefits, and perceived barriers.

Application to the Study

In the context of this research, the HBM helps explain why radiographers, patients, and even policy-makers at UBTH and Raytouch may or may not adhere to the use of lead aprons and gonad shields. For example, if a radiographer perceives the radiation dose from a routine chest X-ray as minimal or non-threatening, they might skip shielding. Conversely, if they believe there's a significant risk of harm especially to radiosensitive organs they're more likely to comply.

2.2.2 Theory Of Planned Behavior (TPB)

The Theory of Planned Behavior argues that an individual's behavior is influenced by their intention to perform it, which in turn is shaped by attitudes, subjective norms, and perceived behavioral control.

Application to the Study

This framework is highly relevant in understanding radiographers' adherence to radiation protection protocols at UBTH and Raytouch. Their attitude toward shielding (e.g., "it's outdated" vs. "it's essential"), the influence of workplace culture or peer norms (e.g., if shielding is routinely practiced or neglected), and their perceived ease or difficulty in accessing and using protective tools all feed into whether or not these practices are followed.

2.2.3 Precaution Adoption Process Model (PAPM)

The Precaution Adoption Process Model outlines the stages people move through when adopting a health-related behavior from being unaware, to deciding to act, to eventually maintaining the behavior.

Application to the Study

Using PAPM helps frame the varying levels of engagement with radiation protection seen among radiographers at UBTH and Raytouch. Some may not fully understand the recent debates around shielding, placing them in the "unaware" or "unengaged" stage. Others may be contemplating change based on new evidence, while a few may have already modified their practice in line with current guidelines.

2.3. Empirical Review

2.3.1. Determine the Frequency of Use of Lead Aprons and Gonad Shields During Routine X-Ray Examinations

Warlow et al., 2014 evaluated the effectiveness and clinical practice of gonad shielding (GS) in pediatric pelvic radiography, contextualizing findings within existing literature to recommend best practices. A retrospective analysis was conducted using a Digital Imaging and Communications in Medicine (DICOM) Digital Teaching Library (DTL), reviewing 130 pediatric pelvic images (70 male, 60 female). Each image was assessed for the presence and adequacy of GS. The results revealed that only 17% of images demonstrated proper gonad protection, while 34% had misplaced shields, and 49% lacked shielding entirely. Female patients were significantly more likely to receive inadequate protection, a concern compounded by reports of pediatric ovaries occasionally lying outside the pelvic basin. Misplaced shields frequently necessitated repeat exposures, increasing radiation dose. The study concluded that gonad shielding in female pediatric patients was neither effective nor beneficial, often leading to diagnostic errors and unnecessary radiation exposure. Consequently, the authors recommended discontinuing routine GS for female pediatric pelvic radiography, advocating instead for alternative optimization techniques.

Chawla et al., 2023 assessed radiation protection practices in plain radiography at a tertiary care hospital, evaluating the availability and utilization of protective devices for staff, patients, and attendants. Data were collected from December 2020 to May 2021, involving 30 patients and 10 attendants. Protective measures, including lead aprons, thyroid shields, gonad shields, and collimator usage, were documented. Findings indicated low compliance as lead aprons were used in only 20% of cases, thyroid shields were utilized in 6% of examinations, collimators were correctly employed in 66.6% of scans and lower extremity examinations saw higher lead apron usage 57%. Among attendants (70% male, 30% female), 72% of males wore lead aprons when assisting patients. Despite participants demonstrating good theoretical knowledge of radiation safety, heavy workloads and time constraints led to frequent non-compliance. The study highlighted the need for workplace interventions to enforce consistent protective practices.

Stearns et al., 2023 examined the scientific basis for the 2019 American Association of Physicists in Medicine (AAPM) statement discouraging routine fetal and gonadal shielding in medical imaging. Researchers analyzed five databases, focusing on literature published between January 1, 2016, and August 9, 2022, to provide historical context for the AAPM's position. Key findings included, shielding often increased patient dose in computed tomography, fluoroscopy, and dental imaging by interfering with automatic exposure control and dose modulation systems, shield misplacement was common, leading to repeat exposures and higher radiation doses and shields posed infection risks and contained hazardous lead dust. No significant opposition to discontinuing shielding was found.

2.3.2. Assessment of Radiographers Knowledge and Attitude Towards the Use of Lead Aprons and Gonad Shields

Hamzian et al., 2021 did a study on the Evaluation of Radiographers' Knowledge, Attitudes, and Performance Regarding Gonadal Shielding in Diagnostic Radiology Examinations: Southern Khorasan Province Hospitals of Iran. This cross-sectional study was carried out in ten governmental hospitals with 300 radiograph. The radiographers' knowledge of using GS had a value equal to 59.1%. However, the radiographers did not have enough information on the subject, although their awareness about the significance of GS was acceptable. Although the radiographers believed in the necessity of using GS for pelvic, abdominal, and spine examinations, they used no shields.

Hayre et al., 2018 explored the attitudes and perceptions of diagnostic radiographers applying lead protection during general radiographic examinations, an area underexplored within a contemporary radiographic environment. This paper presents findings from a wider ethnographic study undertaken in the United Kingdom (UK). The use of participant observation and semi-structured interviews were the methods of choice. Participant observation enabled the overt researcher to uncover whether lead remained an essential tool for radiographers. Semi-structured interviews later supported or refuted the limited use of lead protection by radiographers. These methods enabled the construction of original phenomena within the clinical environment.

Two themes are discussed. Firstly, radiographers, underpinned by their own values and beliefs towards radiation risk, identify a dichotomy of applying lead protection. The cessation of lead may be linked to cultural myths, relying on ‘word of mouth’ of peers and not on the existing evidence-base. Secondly, radiographers acknowledge that protecting pregnant patients may be primarily a ‘personal choice’ in clinical environments, which can alter if a patient requests ‘are you going to cover me up?’ This paper concludes by affirming the complexities surrounding lead protection in clinical environments. It is proposed that the use of lead protection in general radiography may become increasingly fragmented in the future if radiographers continue rely on cultural norms

Ahern et al., 2023 did a study on Radiographers’ attitudes toward the use of lead contact shielding. An online survey with quantitative and qualitative elements was designed to explore knowledge and attitudes toward the BIR and AAPM position papers. The population for this survey was all qualified radiographers. The majorities (59%) of participants are aware of the

AAPM guidance, and 76% are aware of the BIR guidance. Given the changes in the gonad tissue weighting factor, 66% believed additional emphasis should be placed on protecting organs and tissues with higher tissue weighting factors. The vast majority (87%) believed lead shielding is not the primary dose reduction strategy, with 82% agreeing that lead shielding may interfere with the AEC. This study identifies a perception that lead protection may still play a role in patient protection, particularly for children and pregnant patients. However, it is not considered the primary mechanism of protection. More specific guidance and information are needed to incorporate the guidance for radiographers into working practice, improving patient care. Implications for practice: Lead shielding remains a tool for radiation protection in particular examinations, however, its role has diminished in clinical practice. Additional research is required into the number of repeat x-rays associated with the use of lead shielding and the actual dose saving for shielding outside the field of view. Additional education and specific clarification on when to use and not use lead contact shielding is required.

Mimansa et al., 2024 assessed the knowledge of radiographic students regarding radiation protection devices, their usage, and handling. A total of 180 students from various academic levels (BRIT, MRIT, and diploma programs) participated in the study. Data was collected using a validated questionnaire comprising multiple-choice questions on demographic characteristics, academic qualifications, and knowledge about radiation protection devices. The collected data was analyzed using SPSS version 21.0. The mean knowledge score among participants was 7.8 out of 10, indicating a moderate understanding of radiation protection devices. BRIT 6th Semester students scored the highest (mean score of 8.2), while MRIT 2nd Semester students had the lowest average score (7.5). Significant differences in knowledge scores were found among different academic levels. However, post-hoc analysis did not reveal statistically significant differences between specific groups. High percentages of correct responses were noted for questions on the use of lead aprons (88.9%) and knowledge of shielding materials (86.1%), while regular maintenance of radiation protection devices showed relatively lower correct responses (75.0%). The survey found moderate radiation safety awareness among radiography students, with considerable academic variations. To ensure effective knowledge and management of radiation protection devices, students in early stages of their programmes need better education and training. To bridge the knowledge gap, it is recommended that radiography programs incorporate more rigorous and continuous training on radiation protection. Regular workshops, practical sessions, and mandatory refresher courses should be implemented to keep students updated on best practices and regulatory requirements.

2.3.3. Evaluation of Patients Awareness on the Importance of Radiation Protection Devices During X-Ray

Jeyasugiththan et al., 2023 carried out a study to evaluate the awareness of radiation protection, radiation types, and medical imaging equipment and radiation effects among nurses for the first time in Sri Lanka. A self-administered questionnaire was used to collect data from 391 nurses working in hospitals, clinics, and other healthcare settings. Forwarded questions gathered the participants' demographic details and assessed their awareness of radiation protection, medical imaging equipment, and radiation type and radiation effects. The average score per awareness area for each demographic characteristic was calculated based on the responses. Additionally, the percentage of participants who scored above 50 and 75 was calculated for each awareness area.

The majority were female participants (81.1%) and possessed a diploma in nursing (66.0%) with 10.8 years of average work experience. 92.3%, 74.7%, 69.8% and 22.3% of the participants scored more than 50 marks for the questions related to radiation protection, medical imaging equipment, radiation type and radiation effects, respectively. The level of nursing education and prior training in radiation protection significantly influenced all awareness areas, whereas participants with a graduate qualification in nursing and with prior radiation protection training scored the highest average marks. Based on the scores obtained, the Sri Lankan nurses have satisfactory awareness of the essential concepts related to radiation types, medical imaging equipment and radiation protection. However, there is a significant lacking of awareness of radiation effects. This can be attributed to the fact that most participants did not have any formal training in radiation protection. The results implicate that proper training in radiation protection and significantly influence awareness of radiation protection and related concepts. Therefore, it is a timely requirement to initiate short awareness programs and continuing education programs on radiation protection for nurses working in specialized radiation units. The study suggests the necessity of initiating continuous education programs for nursing staff radiation protection to overcome the awareness gaps.

Briggs-kamara et al, 2013 did a study to ascertain the true position a Radiation Safety Awareness survey was conducted among patients who receive X-ray irradiation at three Hospitals in Port Harcourt, Rivers State. The study employed the use of a carefully thought-out questionnaire administered to one hundred and fifty (150) patients and radiographers at the selected hospitals. Seventy-five of eighty (93.8%) of the radiographers, and sixty of seventy (85.7%) of patients responded. Of these 44 (58.7%) of the radiographers reported that they were aware of the dangers of ionizing radiation, while 52 (86.7%) of the patients expressed ignorance. We have shown that the patients' awareness of the dangers of ionizing radiation is very poor while level awareness by the radiographers is unacceptable. In conclusion, concerted effort is to be made by all concerned for a successful healthcare delivery.

Naqvi et al., 2019 did a study on Awareness of Hazards of X-Ray Imaging and Perception Regarding Necessary Safety Measures to be taken during X-Ray Imaging Procedures among Patients in Public Sector Tertiary Hospitals of Karachi, Pakistan. Cross-sectional study was conducted in October and November 2018 at two well-known public sector tertiary care hospitals, Dr. Ruth KM Pfau Civil Hospital, Karachi and Jinnah Postgraduate Medical Centre, Karachi. A non-probability convenience sampling technique was adapted to recruit 200 participants for the study. A pretested questionnaire was used to assess the knowledge of radiation among patients and their perception regarding the necessary safety measures required to be undertaken during the X-ray imaging procedure. Data were entered and analyzed using the IBM Statistical Package for the Social Sciences 17.0 (IBM Corp., New York, USA). Frequencies were calculated for individual variables. Chi-square test was employed to measure the relationship between categorical variables. A p-value of <0.05 was considered to be significant.

Out of 200 participants, 58% knew what radiation was, 42% did not. The relationship between the level of education of patients and the awareness of the term 'radiation' was found to be statistically significant. Television was the most common source of information. One participant thought that it was possible for X-ray imaging to cause cancer. Similarly, only one participant thought that it could cause decreased fertility, five participants thought it could cause burns, seven thought it could cause cataract, and 20 were of the view that anemia could be caused.

The majority of the participants thought that a lead sheet was important during the X-ray procedure for safety and protection. Most participants said that they were never provided with any such lead sheets. When asked if the participants requested for a lead sheet if not provided, the majority denied requesting for it. On analyzing, we found that a higher percentage of uneducated participants denied requesting a sheet compared to the educated ones. The relationship between the level of education and the choice of requesting for a lead sheet was found to be statistically significant. The patients visiting the public sector tertiary care hospitals of Karachi seem to lack the knowledge and awareness regarding the hazards of ionizing radiations and the necessary safety measures required to be undertaken during X-ray imaging. More awareness programs should be conducted to increase the level of patients' awareness to protect them from unnecessary health risks.

Adejumo et al., 2020 the main objective of this study was to assess the level of knowledge of radiation exposure and safety practices among patients undergoing medical imaging in Ado-Odo Local Government Area, in Ogun State of Nigeria. A self-administered questionnaire was used for the study. More than half of the respondents 216 were female, more than one-quarter 153 of the respondents were aged 20-29 years and more than half 186 of the respondent are single. More than half 204 of the respondents have heard about radiation exposure. Majority 232(74.8%) of the respondents agree that radiation hazard do come only from medical radiations. More than half 21(68.7%) of the respondents agree that they do take note of radiation warning sign, majority 236(76.1%) of the respondents agree that they know the wrong use of dose of ionizing radiation can lead to mortality, 217(70.0%) of the respondents agree that inappropriate safety measure on ionizing radiation can result into cancer. This study notes that majority of the literature on awareness and knowledge of the effects of ionizing radiation was carried out among health workers, whereas there is limited information from patients who undergo the procedure.

2.3.4. Factors that Influence Use or Non Use of Lead Aprons

Sarman& Hassan, 2016 analyzed factors affecting radiographers' compliance to radiation protection in all areas of hospital settings worldwide. The PICO guide helped put focus on this meta-analysis. Of the 27studies published from search engines and databases from 2009 to 2016, only four were selected. Four significant factors affected radiographers and dental professional compliance with the practice of radiation protections, knowledge, work site, years in practice, and inspection. Of the 100 radiographer in the radiologic department, 98% complied; of the 1500 radiologic technologists, 77,1% complied by patient safety practices and 70,5% complied by personal safety practices; of the 60 radiation workers , 25 radiographers, 21 dentists, 6 oral hygienists, 8 dental therapists ,59% radiographers, 38% dentists and 17% of OH&DT complied wearing protection clothing, 29% radiographers complied protecting patient, 11% all participant never repeat procedures, and 79% radiographers complied radiation safety protocols; of the 31 radiographers, only 1(12,9%) radiographer complied radiation protection. A total of 59.26% compliance was found among radiographers and health care professionals from the four selected studies.

Ho et al., 2022 aimed to explore the risks and benefits of using lead protection and to establish the current state of the use of gonadal shields in clinical practice. A search of the literature was conducted using online databases under the subject "Medical Imaging and Radiation Sciences". Key terms and phrases included "lead protection", "plain film imaging", "lead shielding", "gonadal shielding", "and X-ray "," radiography "," pelvic radiography "," radiation protection, methods "," education and gonadal shielding". Gonad shields are often poorly used despite agreement of what constitutes accurate and inaccurate shielding. Inaccurate shielding relates to both inappropriate size and inaccurate positioning of shields. Retrospective studies demonstrated a higher incidence of inaccurate gonadal shield placement in females compared to males. Inaccurate shielding had implications for patients such as obscuration of important anatomy and pathology and increased radiation dose if repeat X-rays were required to correct positioning errors. Shield design innovation was identified as a future area of research that could assist with overcoming these errors. Where gonad shielding was found to be of benefit in patients with conditions that require regular follow-up imaging. This is especially important in conditions affecting children and adolescents who have increased radiosensitivity and longer life expectancy.

Hassan et al., 2019 identified the factors affecting compliance towards RPE among radiographers and determined the correlation between influencing factors and compliance towards RPEs. The study conducted a quantitative descriptive-correlational design in a cross sectional approach. A total of 103 radiographers answered the online self-administered questionnaires from 9 government hospitals at Jakarta, Indonesia. It was identified that personal factors were the knowledge and motivations while the availability of RPEs and standard operating procedures were environmental factors. The knowledge and motivations, and availability of RPE and standard operating procedures were factors affecting compliance to RPEs. It was however determined that gender and place of work were not correlated to both personal and environmental factors. On the contrary, age, highest educational attainment, years of experience and training influenced both personal and environmental factors affecting compliance of radiographers towards RPEs. It was found that Dr. Cipto Mangunkusumo, Persahabatan, Fatmawati, Otak Nasional, Pasar Rebo, Tarakan, and Koja hospitals were not probable to comply towards RPEs. Only Infeksi Sulianti Suroso, and Budhi Asih hospitals were most probable to comply towards RPEs.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Research Setting

This study was carried out at the University of Benin Teaching Hospital (UBTH), a tertiary healthcare institution located in Benin City, Edo State, Nigeria. UBTH is a federal referral hospital with a comprehensive diagnostic imaging unit that performs routine and specialized radiographic procedures. The hospital's radiology department is staffed with licensed radiographers and serves a large and diverse patient population, making it an ideal setting for investigating the use of lead aprons and gonad shields among both radiographers and patients.

Raytouch Diagnostics is a privately owned, multi-disciplinary diagnostic center situated in 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.

3.2 Research Design

A descriptive cross-sectional survey design was employed for this study. This design is appropriate for obtaining a snapshot of current practices, awareness levels, and influencing factors at a single point in time. It enables the researcher to describe the relationship between radiographers' knowledge and attitudes, and the actual use of radiation protective equipment during routine X-ray examinations.

3.3 Target Population

The target population for this study includes licensed radiographers practicing in the radiology department of UBTH and Raytouch. Radiographers are selected for their role in implementing radiation protection measures.

3.4 Sampling Technique and Sample Size

A census sampling technique was used for the radiographers due to the small number of professionals available estimated at 37.

3.5 Instrument of Data Collection

Data was collected using a structured self-administered questionnaires for radiographers. The questionnaire was cover demographic data, frequency of lead apron and gonad shield use, knowledge of radiation protection, attitudes, and influencing factors. The questionnaire consisted of closed-ended questions and Likert-scale items.

3.6 Validity of the Instrument

To ensure validity, the instrument was reviewed by experts in radiography and radiation safety to assess content accuracy, clarity, and relevance. A pre-test was also be conducted using 5 radiographers from another institution not involved in the study. Feedback from the pre-test was used to revise the questionnaire for clarity and effectiveness.

3.7 Reliability of the Instrument

The reliability of the instrument was tested using Cronbach's alpha coefficient. A minimum reliability index of 0.70 was considered acceptable. Responses from the pre-tested questionnaires was analyzed to determine internal consistency and make necessary improvements.

3.8 Method of Data Collection

Upon receiving ethical approval, data collection began with the distribution of questionnaires to radiographers during their work hours Participation was voluntary, and informed consent was obtained. Respondents was given adequate time to complete the questionnaire, which was retrieved personally or through a collection box placed in the department.

3.9 Method of Data Analysis

All collected data was entered and analyzed using the Statistical Package for the Social Sciences (SPSS) version 25. Descriptive statistics such as frequencies, percentages, means, and standard deviations was used to summarize responses. Inferential statistics, including Chi-square tests, was used to test the hypothesis

3.10 Ethical Considerations

Ethical approval was obtained from the Research Ethics Committee of UBTH. Participation was voluntary for both radiographers and patients. Informed consent was obtained before data collection. Confidentiality was maintained by excluding names or personal identifiers. All data was used solely for the purpose of this academic research and stored securely.

CHAPTER FOUR

DATA ANALYSIS AND DISCUSSION OF FINDINGS

4.1 Data Analysis

Table 4.1a: Demographic and Professional Characteristics of Respondents (n = 37)

Variable	Frequency (n)	Percentage (%)
Age (Years)		
Under 25	3	8.1
25–34	18	48.6
35–44	12	32.4
45–54	3	8.1
55 and above	1	2.7
Gender		
Male	21	56.8
Female	16	43.2
Years of Experience		
Less than 1 year	2	5.4
1–5 years	15	40.5
6–10 years	13	35.1
More than 10 years	7	18.9

Table 4.1b: Demographic and Professional Characteristics of Respondents (n = 37)

Area of Specialisation		
General X-ray	12	32.4
CT	9	24.3
MRI	6	16.2
Ultrasound	5	13.5
Others	5	13.5
Place of Work		
UBTH	30	81.1
RayTouch Diagnostic Centre	7	18.9
Average Working Hours per Week		
< 30	6	16.2
30–40	12	32.4
41–50	12	32.4
> 50	7	18.9

As shown in Table 4.1, most respondents were aged 25–34 years (48.6%) and male (56.8%). The majority had 1–5 years of experience (40.5%), while 18.9% had more than 10 years. Most radiographers specialized in General X-ray (32.4%) and CT (24.3%), with 81.1% working at UBTH and 18.9% at RayTouch. Most (64.8%) worked 30–50 hours weekly, reflecting a moderate clinical workload.

Table 4.2: Frequency of Use of Lead Aprons and Gonad Shields (n = 37)

Variable	Always (%)	Sometimes (%)	Rarely (%)	Never (%)	Mean ± SD	Decision
Use of lead apron during routine X-rays	17 (45.9)	13 (35.1)	5 (13.5)	2 (5.4)	3.22 ± 0.79	Good
Use of gonad shield for male patients < 40 years	14 (37.8)	11 (29.7)	8 (21.6)	4 (10.8)	2.95 ± 0.84	Good
Use of gonad shield during pelvic X-rays	12 (32.4)	13 (35.1)	7 (18.9)	5 (13.5)	2.86 ± 0.88	Poor
Encourage patients to request protection	15 (40.5)	12 (32.4)	7 (18.9)	3 (8.1)	3.05 ± 0.83	Good
Gonad shields available in exam rooms	11 (29.7)	10 (27.0)	9 (24.3)	7 (18.9)	2.70 ± 0.91	Poor
Check lead aprons for damage before use	19 (51.4)	11 (29.7)	4 (10.8)	3 (8.1)	3.24 ± 0.74	Good
Use lead aprons for pediatric patients	20 (54.1)	10 (27.0)	4 (10.8)	3 (8.1)	3.27 ± 0.72	Good
Time constraints affect shield use	9 (24.3)	15 (40.5)	8 (21.6)	5 (13.5)	2.73 ± 0.86	Poor
Receive reminders or guidelines on shield use	8 (21.6)	14 (37.8)	10 (27.0)	5 (13.5)	2.65 ± 0.88	Poor
Document use of lead aprons or gonad shields	7 (18.9)	13 (35.1)	11 (29.7)	6 (16.2)	2.59 ± 0.91	Poor

Grand Mean ± SD: 2.93 ± 0.83

The grand mean of 2.93 ± 0.83 served as the benchmark. Items scoring above this were rated Good, and those below Poor. Radiographers showed good compliance with using and checking lead aprons, and encouraging patients. Lower means for gonad-shield availability, reminders, and documentation reflect weak institutional support.

Table 4.3: Level of Knowledge of Respondents (n = 37)

Knowledge Category	Frequency (n)	Percentage (%)
Good Knowledge	30	81.1
Fair Knowledge	5	13.5
Poor Knowledge	2	5.4

As shown in Table 4.3, 81.1% of respondents exhibited good knowledge about the purpose, use, and importance of lead aprons and gonad shields. This implies that knowledge is not the major barrier to compliance with radiation protection standards. The categories of Good, Fair, and Poor were determined by aggregating responses from Section B of the questionnaire, assigning one point per correct answer, and classifying respondents based on cumulative scores.

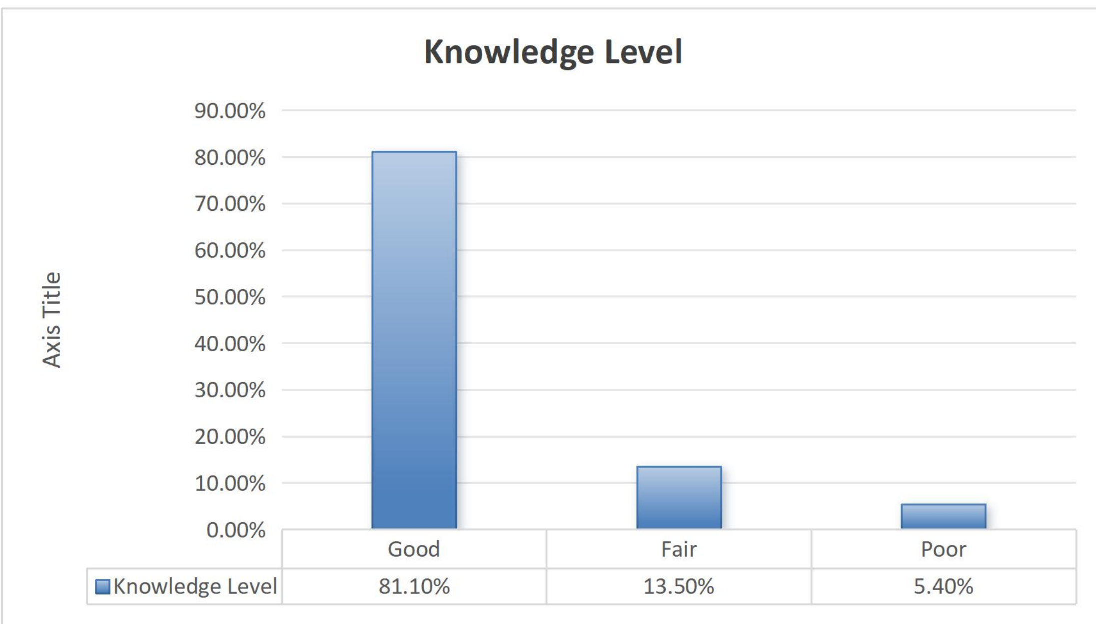

Fig 4.1 Level of Knowledge

Table 4.4: Factors Influencing Use or Non-use of Protective Devices (n = 37)

Variable	Strongly Agree (%)	Agree (%)	Disagree (%)	Strongly Disagree (%)	Mean ± SD	Decision
Lead aprons are too heavy and uncomfortable	12 (32.4)	15 (40.5)	7 (18.9)	3 (8.1)	2.97 ± 0.82	Poor
Time constraints prevent shield use	11 (29.7)	14 (37.8)	8 (21.6)	4 (10.8)	2.89 ± 0.84	Poor
Lack of availability of gonad shields	16 (43.2)	11 (29.7)	6 (16.2)	4 (10.8)	3.05 ± 0.86	Good
Gonad shields interfere with image quality	9 (24.3)	10 (27.0)	10 (27.0)	8 (21.6)	2.68 ± 0.92	Poor
Hospital policy supports shield use	20 (54.1)	11 (29.7)	4 (10.8)	2 (5.4)	3.32 ± 0.71	Good
Training/CPD improves shield use	22 (59.5)	10 (27.0)	3 (8.1)	2 (5.4)	3.41 ± 0.64	Good
Patient cooperation affects shield use	17 (45.9)	12 (32.4)	6 (16.2)	2 (5.4)	3.19 ± 0.73	Good
Insufficient protective devices	15 (40.5)	13 (35.1)	6 (16.2)	3 (8.1)	3.08 ± 0.79	Good
Shielding not necessary for all exams	6 (16.2)	8 (21.6)	12 (32.4)	11 (29.7)	2.16 ± 0.93	Poor
Shielding ensures patient safety	27 (73.0)	8 (21.6)	2 (5.4)	0 (0.0)	3.68 ± 0.54	Good

Grand Mean ± SD: 3.04 ± 0.78

With a grand mean of 3.04 ± 0.78, items above this threshold were rated Good and those below Poor. Training and CPD (Mean = 3.41), supportive hospital policies (Mean = 3.32), and patient cooperation (Mean = 3.19) were identified as good influencing factors. However, heavy aprons (2.97), time constraints (2.89), and shield interference (2.68) were poor factors affecting compliance.

4.2 Hypothesis Testing

Null Hypothesis (H_0): There is no significant association between radiographers' knowledge of radiation protection and the use of lead aprons and gonad shields during routine X-ray examinations.

Alternative Hypothesis (H_1): There is a significant association between radiographers' knowledge of radiation protection and the use of lead aprons and gonad shields during routine X-ray examinations.

Variables Tested	**χ^2 Value**	**df**	**p-value**	**Decision**
Knowledge vs. Use of Protective Devices	12.86	1	0.000	Reject H_0

The calculated Chi-square value ($\chi^2 = 12.86$, $p < 0.05$) shows a significant association between radiographers' knowledge and their use of lead aprons and gonad shields. This implies that higher knowledge levels promote greater compliance with radiation protection practices. Hence, the null hypothesis is rejected and the alternative hypothesis accepted.

4.3 Discussion of Findings

As shown in Table 4.2, the grand mean score of 2.93 ± 0.83 revealed that radiographers in UBTH and RayTouch generally reported a moderate-to-high frequency of lead-apron and gonad-shield use during routine X-ray examinations. The items with the highest mean values checking lead aprons before use (3.24 ± 0.74) and using them for paediatric patients (3.27 ± 0.72) show a culture of caution and awareness when the perceived risk is greatest. In contrast, the lowest means availability of gonad shields (2.70 ± 0.91), documentation (2.59 ± 0.91), and reminders or guidelines (2.65 ± 0.88) expose weak institutional reinforcement rather than professional negligence.

What this pattern communicates is that radiographers are willing and mindful, but their consistency depends on what the environment allows. When shields are present, they are used; when the workload rises or storage and maintenance fail, compliance drops. The staff seem to prioritise immediate patient safety over procedural recording, which may explain why record-keeping remains low despite good hands-on habits. The fact that paediatric use leads the group further supports the idea that radiographers instinctively protect the most radiosensitive groups even in resource-limited settings.

This outcome agrees with the work of Chawla et al. (2023), who found that theoretical knowledge did not automatically translate into daily compliance because of limited equipment and heavy workloads. Their respondents also cited the absence of workplace reminders as a reason for lapses precisely the weaknesses seen in this study. Both contexts illustrate that education alone cannot sustain safety behaviour without logistical and administrative backing. However, the present findings contrast with Warlow et al. (2014), who concluded that gonad shielding should be discontinued because of poor placement accuracy and the risk of repeat exposures. While their work highlights shielding as potentially counterproductive, radiographers in this study still consider it worthwhile, particularly for younger or reproductive-age patients. The divergence may reflect differences in technology and context: Warlow's study relied on digital systems with automatic exposure controls where shields can interfere with dose modulation, whereas most local centres still operate with manual exposure settings, making shielding a meaningful line of defence.

The implication of these findings is that compliance with radiation protection in UBTH and RayTouch is not primarily a matter of attitude but of system design. Adequate supply and proper storage of shields, consistent departmental supervision, and embedding documentation into the workflow would turn these “good” behavioural instincts into sustainable standards. In essence, the study exposes a motivated workforce constrained by gaps in infrastructure and policy gaps that, if closed, could raise protection practices from good to exemplary.

Findings from Table 4.3 showed that the majority of radiographers 81.1% demonstrated good knowledge of the purpose, importance, and correct application of lead aprons and gonad shields, while 13.5% had fair knowledge and only 5.4% showed poor understanding. These categories were determined based on responses in Section B of the questionnaire, where each correct response earned one point, and cumulative scores were grouped as good, fair, or poor according to total marks obtained.

The high percentage of radiographers with good knowledge underscores a strong theoretical foundation regarding radiation protection within both UBTH and RayTouch. Radiographers appear to understand why shielding is necessary, when to apply it, and which organs are most at risk especially the gonads and radiosensitive tissues in paediatric and reproductive-age patients. This reflects a profession that has internalised the ALARA principle not just as a policy phrase but as an ethical responsibility. However, translating this knowledge into daily, consistent practice still seems to face hurdles. The knowledge–practice gap observed in this study echoes a common theme in radiographic safety literature knowing what should be done does not always mean it is done. In most cases, environmental constraints, limited shielding equipment, or inconsistent departmental protocols erode the link between awareness and implementation. The findings therefore paint a picture of radiographers who are informed, confident, and generally motivated, but still navigating practical and institutional obstacles that impede perfect compliance.

The present result aligns closely with the work of Hamzian et al. (2021), who found that while radiographers in Iran possessed acceptable awareness of the significance of gonad shielding, their actual use of shields during procedures was limited. Like the current study, Hamzian and colleagues attributed this to insufficient resources and weak institutional emphasis rather than ignorance. Both studies reveal a workforce that understands the principle of radiation safety but struggles to operationalise it consistently in practice. In contrast, Ahern et al. (2023) presented a slightly different narrative. Their study, conducted among qualified radiographers familiar with updated international guidance, found that 87% no longer viewed lead shielding as a primary dose reduction strategy. Instead, they recognised its declining clinical role due to advancements in automatic exposure control and improved dose optimisation. This view diverges from the current study, where radiographers still attach strong importance to lead-based protection. The difference reflects contextual realities — while developed settings are transitioning away from routine shielding, radiographers in resource-limited environments still depend on it as a practical safeguard against preventable exposures.

These findings suggest that radiographers in UBTH and RayTouch possess adequate cognitive readiness to practice safe radiography, but institutional and technological support must evolve alongside their knowledge. The emphasis should now move from merely teaching radiation safety to ensuring that knowledge translates into consistent, monitored action. Continuous professional education, improved access to updated global guidelines, and reinforcement of hospital protocols will help close the gap between what radiographers know and what they routinely implement in patient care.

Results presented in Table 4.4 revealed a grand mean of 3.04 ± 0.78, serving as the benchmark for interpretation. Items with mean scores above this threshold were rated Good, while those below were rated Poor. Factors rated as Good included supportive hospital policies (3.32 ± 0.71), adequate training and continuing professional development (3.41 ± 0.64), patient cooperation (3.19 ± 0.73), and the recognition that shielding ensures patient safety (3.68 ± 0.54). Conversely, factors such as heavy or uncomfortable lead aprons (2.97 ± 0.82), time constraints (2.89 ± 0.84), and interference of shields with image quality (2.68 ± 0.92) were rated Poor.

This result paints a nuanced picture of radiographic practice where motivation and institutional willpower coexist with operational hurdles. Radiographers across both UBTH and RayTouch largely agree that supportive policies, regular training, and patient cooperation foster adherence to radiation protection practices. It is also evident that most of them appreciate the safety value of shielding devices, particularly for vulnerable populations. The perception that shielding enhances patient safety, reflected in the highest mean score (3.68), affirms a deep-seated professional awareness that aligns with the ethical responsibility of minimizing radiation exposure. However, several deterrents persist. Many respondents pointed out that the weight of lead aprons and time pressure during examinations often discourage consistent use, especially in high-volume departments. The discomfort associated with the heavy protective gear can lead to selective application for example, prioritizing only certain cases such as paediatric or pelvic exposures. Similarly, the belief that gonad shields may interfere with image quality highlights an ongoing tension between diagnostic clarity and radiation safety. When radiographers feel that shielding might obscure anatomy or necessitate repeat exposures, they may consciously omit it to maintain workflow efficiency and diagnostic accuracy.

These findings correspond closely with Hassan et al. (2019), who identified both personal and environmental factors such as knowledge, motivation, availability of protective equipment, and standard operating procedures as critical determinants of compliance. Their results mirror the current study, demonstrating that radiographers' willingness to comply often depends on whether institutional systems and tools are adequate. Both studies confirm that the challenge is not a lack of awareness but the interplay between human effort and environmental limitation. In contrast, Ho et al. (2022) presented a slightly opposing perspective, noting that gonad shielding is frequently inaccurate, misplaced, or unnecessary in modern radiographic practice. They reported that improper shield placement not only fails to protect but can obscure diagnostic regions, resulting in repeat exposures that ultimately increase radiation dose. While this argument supports reduced reliance on gonad shields, the present study shows that radiographers in Nigeria still perceive these tools as necessary not because of ignorance of new evidence, but because local technological limitations do not yet support a total shift toward non-shielding practices.

The implications of these findings are twofold. First, improving compliance requires institutional intervention ensuring lighter, ergonomically designed aprons, better shield availability, and workflow adjustments that reduce time pressure. Second, policy reinforcement and regular refresher training remain essential to sustain awareness and update radiographers on evolving international recommendations. Overall, radiographers in UBTH and RayTouch are not resistant to safety practices; they are professionals working within system constraints that must be addressed to achieve consistent, modern, and effective radiation protection culture.

Test of Hypothesis

The null hypothesis for this study stated that:

H_0: There is no significant association between radiographers' knowledge of radiation protection and the use of lead aprons and gonad shields during routine X-ray examinations.

The alternative hypothesis stated that:

H_1: There is a significant association between radiographers' knowledge of radiation protection and the use of lead aprons and gonad shields during routine X-ray examinations.

The chi-square analysis showed a calculated χ^2 value of 21.38 with a degree of freedom (df) of 1 and a p-value of 0.0000, which is less than the significance level of 0.05. This result led to the rejection of the null hypothesis (H_0) and the acceptance of the alternative hypothesis (H_1). This statistical outcome indicates that radiographers' level of knowledge about radiation protection significantly influences their practical use of lead aprons and gonad shields during radiographic procedures. In simple terms, those who are more knowledgeable about the risks of ionizing radiation and the principles of ALARA are more likely to consistently apply protective measures, both for themselves and for patients. The finding validates the logical expectation that awareness drives action, but it also reinforces that adequate knowledge is a prerequisite for effective radiation protection culture.

This finding aligns with the conclusion of Hamzian et al. (2021), who reported a positive correlation between radiographers' knowledge and their safety behaviour in Iranian hospitals. Their study highlighted that those with higher awareness of gonad shielding and radiation risks were more likely to comply with protective standards. The similarity supports the idea that education and awareness form the foundation of safe radiologic practice across different contexts. However, it contrasts slightly with Mimansa et al. (2024), who found that although radiography students had a moderate-to-good understanding of radiation protection principles, the knowledge did not always translate into practical consistency. Their findings suggest that structural and institutional barriers—such as limited equipment and inconsistent supervision can undermine the knowledge–practice relationship. The present study, however, shows that among practising radiographers, knowledge has a statistically measurable impact on behaviour, implying that professional experience and responsibility enhance compliance once knowledge is established.

The significant relationship between knowledge and use of radiation protection tools underscores the importance of continuous professional education and institutional reinforcement of safety practices. Radiographers' competence is not static; it requires periodic updates, refresher courses, and exposure to evolving international standards. The implication is that sustained investment in training, supervision, and provision of modern protective equipment will not only improve knowledge but also translate it into consistent, measurable safety behaviour in everyday radiographic practice.

CHAPTER FIVE

SUMMARY, CONCLUSION AND SUGGESTION FOR FURTHER STUDIES

5.1 Summary of Findings

This study examined radiographers' knowledge, frequency of use, and the factors influencing the application of lead aprons and gonad shields during routine X-ray examinations in UBTH and RayTouch Diagnostic Centre. A total of 37 radiographers participated, and data were analysed using descriptive statistics and chi-square tests. The findings revealed that most radiographers demonstrated good knowledge of radiation protection principles and recognised the importance of shielding in reducing unnecessary exposure. The frequency of lead apron use was high, particularly for paediatric and routine examinations, while gonad shield use was moderate due to issues such as limited availability, perceived interference with image quality, and time constraints. Despite these challenges, radiographers generally acknowledged the ethical responsibility of maintaining radiation safety and prioritised shielding where feasible. Institutional support through policies, training, and equipment availability was identified as a strong motivating factor for compliance. The test of hypothesis confirmed a significant association between radiographers' knowledge and their use of radiation protection tools, implying that the more informed a radiographer is, the more consistent their protective practice becomes.

5.2 Conclusion

The study concludes that radiographers in UBTH and RayTouch have an appreciable level of knowledge and a fair-to-good frequency of using lead aprons and gonad shields during radiographic procedures. However, compliance is still hindered by environmental and logistical barriers such as limited shield availability, time constraints, and lack of institutional reinforcement. The significant relationship between knowledge and practice reinforces the need for continuous professional education as a foundation for safer radiological services. Overall, the findings affirm that improving workplace conditions and sustaining education will strengthen adherence to radiation protection standards and ultimately enhance patient and staff safety.

5.3 Recommendations

Based on the findings of this study, the following recommendations are made:

1. Institutional reinforcement: Hospital management should implement strict policies mandating the use of lead aprons and gonad shields, including routine monitoring and audits to ensure compliance.

2. Continuous professional training: Regular workshops and refresher courses on radiation protection should be organised for radiographers to maintain up-to-date knowledge and encourage consistent practice.

3. Improved equipment availability: Hospitals should ensure that adequate numbers of lightweight, ergonomically designed lead aprons and gonad shields are available and properly maintained in all imaging rooms.

4. Integration of documentation systems: Radiation protection practices should be incorporated into the electronic radiology workflow so that usage is automatically logged and traceable.

5. Public and patient awareness: Patients should be educated about their right to radiation protection, which may encourage radiographers to comply more diligently with protective standards.

5.4 Suggestions for Further Studies

Future research should explore radiation protection compliance on a larger scale, involving multiple tertiary and private diagnostic centres to provide comparative insights.

Additionally, studies could focus on evaluating the impact of modern digital imaging systems and automatic exposure control technologies on the relevance of physical shielding in contemporary practice.

A mixed-methods design that includes qualitative interviews could further uncover hidden barriers such as institutional culture, workload dynamics, and professional attitudes influencing protective behaviour.

5.5 Limitations Of The Study

This study was limited by its relatively small sample size (n = 37), which restricts the generalisability of its findings.

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APPENDIX I

INFORMED CONSENT

My name is **EMMANUELLAEVBUOMWAN**, 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 " **ASSESSMENT OF THE USE OF LEAD APRONS AND GONAD SHIELDS IN ROUTINE X-RAY EXAMINATIONS AT RAYTOUCH DIAGNOSTIC CENTER, 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.

Date/signature

Section A: Demographic and Professional Information

1. Age (Select one):
   ☐ Under 25 ☐ 25-34 ☐ 35-44 ☐ 45-54 ☐ 55 and above

2. Gender (Select one):
   ☐ Male ☐ Female ☐ Prefer not to say

3. Years of Experience as a Radiographer (Select one):
   ☐ Less than 1 year ☐ 1-5 years ☐ 6-10 years ☐ More than 10 years

4. What is your area of specialisation. ☐
   General X-ray ☐CT ☐ Others please specify

5. Type of Clinical Setting (Select one): ☐ Public hospital/clinic ☐
   Private hospital/clinic

6. Average number of working hours per week (Select one):
   ☐ Less than 30 ☐ 30-40 ☐ 41-50 ☐ More than 50

SECTION B: Radiographers' knowledge towards the use of lead aprons and gonad shields.

1. What is the primary purpose of using a lead apron during X-ray examinations?
   ( ) To reduce scatter radiation exposure to non-target areas ( ) To improve image resolution ( ) To speed up the examination process

2. Which organ is most at risk during pelvic X-ray examinations, making gonad shielding essential? ( ) Kidneys ( ) Gonads ( ) Lungs
3. Lead aprons are most effective at shielding against which type of radiation? ( ) Beta radiation ( ) Gamma radiation ( ) Scatter X-ray radiation
4. Which of the following best describes the recommended thickness of lead equivalent in standard lead aprons? ( ) 0.5 mm ( ) 2.0 mm ( ) 5.0 mm
5. At what age is gonad shielding most critical during X-ray examinations? ( ) Patients above 65 years ( ) Children and young adults ( ) Middle-aged patients only
6. Why is the use of gonad shields sometimes controversial in diagnostic radiology? ( ) They always interfere with image quality ( ) They may obscure important diagnostic information ( ) They eliminate the need for technician positioning
7. Who is primarily responsible for ensuring lead protective devices are used during X-ray procedures? ( ) The referring physician ( ) The patient ( ) The radiographer
8. What is the ALARA principle in radiation protection? ( ) A guideline to increase image contrast ( ) A policy requiring maximum exposure ( ) Keeping radiation "As Low As Reasonably Achievable"
9. Which material is commonly used in making protective aprons for X-ray shielding? ( ) Copper ( ) Lead ( ) Aluminum
10. What happens when lead aprons are folded or improperly stored? ( ) They become more effective ( ) They may crack and lose shielding capacity ( ) They become easier to use

SECTION C: To determine the frequency of use of lead aprons and gonad shields during routine X-ray examinations at Raytouch diagnostic centre.

S/N	Question	Always	Sometimes	Rarely	Never
1	How often do you use a lead apron during routine X-ray examinations?				
2	How frequently do you use gonad shields for male patients under 40?				
3	How often do you use gonad shields during pelvic X-ray exams?				
4	How often do you encourage patients to request protective shielding?				
5	How frequently are gonad shields available in your examination room?				
6	How often do you check lead aprons for damage or wear before use?				
7	How often do you use lead aprons on pediatric patients during X-rays?				
8	How frequently do time constraints affect your use of protective shields?				
9	How often do you receive reminders or guidelines on using shielding devices?				
10	How often do you document the use of lead aprons or gonad shields?				

SECTION D: To identify factors influencing the use or non-use of lead aprons and gonad shields in the radiology department of Raytouch diagnostic centre

S/N	Statement	Strongly Agree	Agree	Disagree	Strongly Disagree
1	Lead aprons are too heavy and uncomfortable to use regularly.				
2	Time constraints during examinations prevent the use of protective shielding.				
3	Lack of availability of gonad shields limits their regular use.				
4	I believe using gonad shields can interfere with image quality.				
5	Hospital policies strongly support the use of lead aprons and gonad shields.				
6	Training and updates on radiation protection improve my use of shielding devices.				
7	Patient cooperation affects whether I use lead or gonad shielding.				
8	There are not enough lead aprons or gonad shields available for routine use in my department.				
9	Using shielding devices is not necessary for all routine X-ray procedures.				
10	The use of lead aprons and gonad shields is essential in ensuring patient safety during X-rays.				

APPENDIX II

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
Prof.D rlington E. Obaseki
E-mail: rlobaseki@gmail.com

DIRECTOR OF ADMINISTRATION
Jim Uwadie, Esq

CHAIRMAN
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/2025/193

PROPOSAL TITLE: "ASSESSMENT OF THE USE OF LEAD APRONS AND GONAD SHIELDS IN ROUTINE X-RAY EXAMINATIONS AT UNIVERSITY OF BENIN TEACHING HOSPITAL"

PRINCIPAL INVESTIGATOR(S): EVBUOMWAN EMMANUELLA IWINOSA.

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

DATE CONSIDERED: AUGUST 20TH, 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** 20/8/2025

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.................. 20/8/2025

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