DEPARTMENT OF RADIOGRAPHY,
SCHOOL OF BASIC MEDICAL SCIENCES
UNIVERSITY OF BENIN

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EVALUATION OF RADIATION PROTECTION MEASURES FOR PREGNANT PATIENTS UNDERGOING X-RAYS AT UNIVERSITY OF BENIN TEACHING HOSPITAL

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SASHA EROME ESIN
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CERTIFICATION

This certifies that this project titled "EVALUATION OF RADIATION PROTECTION MEASURES FOR PREGNANT PATIENTS UNDERGOING X-RAYS AT UNIVERSITY OF BENIN TEACHING HOSPITAL" was written by SASHA EROME ESIN with Matriculation Number BMS2101811 and supervised by MR. EGBUKICHI VICTOR .C. in partial fulfillment of the Bachelor in RADIOGRAPHY degree (B. RAD) in the DEPARTMENT OF RADIOGRAPHY, SCHOOL OF BASIC MEDICAL SCIENCES, UNIVERSITY OF BENIN.

SIGNATURE OF HOD. **DATE**

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DEDICATION

This research work is dedicated first to my God who is the almighty, the source of my strength, wisdom, and inspiration. Without His divine help, this project would not have been possible. And to my ever loving parents, thank you for your endless love, support, sacrifices, and prayers. You have been my greatest motivation, and I will always be grateful. I also dedicate this project to my future self—as a reminder of how far I have come, and how far I can still go through hard work, faith, and determination.

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All glory, All honour, and all praise I give to God Almighty for His unending grace, wisdom, strength, and guidance throughout the course of this project and my academic journey. Without His grace, this work would not have been possible. I am profoundly grateful to my loving parents for their unwavering support, sacrifices, prayers, and encouragement; their belief in me has been a constant source of motivation and strength. I would also like to sincerely appreciate my project supervisor, Mr. Chimezie Victor, for his invaluable guidance, patience, and constructive input, which significantly shaped this project. My heartfelt thanks extend to the entire staff and lecturers of the Department of Radiography, University of Benin, for the knowledge and mentorship I have received over the years. To my friends and colleagues, I am deeply thankful for your support, collaboration, and encouragement throughout this academic journey.

God bless you all.

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Abstract

The pregnancies present special safety concerns owing to the high levels of radiosensitivity of the embryo-fetus. This was an evaluation of radiation protection protocols used with pregnant patients when they undergo X-ray services at the University of Benin Teaching Hospital (UBTH). A cross-sectional (descriptive) survey of radiographers (N = 32) was done, where the survey utilizing a structured, self-administered questionnaire to respondents focused on the shielding practice, dose-reduction methods, and compliance aspects. Simple inferential test and descriptive statistics were used to analyze the data. The majority of the respondents were male (78.1%), the most frequent age group was 26-30 years (35.9%); 53.1% of them were interns, and 87.5% had already worked with pregnant patients. Practice was high in terms of overall shielding (grand mean = 3.88/5) with routine lead shielding (mean = 4.1) and proper etching of the fetal-region shielding (mean = 4.0) being reported most frequently. There was also strong dose-reduction behavior (grand mean = 3.98), with avoiding repeat exposures (mean = 4.4), reducing exposure factors (mean = 4.2) and tight collimation (mean = 4.1) being the leaders. The best compliance was observed with confidence in fetal-risk knowledge (mean = 4.0) and prior-training (mean = 3.9) with high workload (mean = 3.6) and moderate availability/use of pregnancy specific protocols (mean = 3.5) being considered gaps. All in all, the good shielding practice was demonstrated by 78.1 percent of radiographers. A chi-square test revealed no statistically significant difference between the practice categories of shielding (kh2= 0.08, df= 1, p= 0.77). To sum up, radiographers in the teaching hospital of the university of Benin demonstrate good commitments to practices in line with the ALARA to the care of pregnant patients, especially in shielding and collimation as well as reducing repeats. Prolonged CPD, protocols specific to pregnancy, enhanced workflow facilitation, and an unproblematic access to maternity-fit shielding are suggested in order to seal the remaining gaps. Data collection had to be pre-empted with ethical approval and institutional permissions.

Keywords: radiography practice, radiation protection, fetal dose, shielding, dose reduction, ALARA, pregnant patients, UBTH, Nigeria.

CHAPTER ONE

INTRODUCTION

1.1 Background of Study

The concept of radiation reaching the unborn on expectant women is not an issue of mere theory but is a practical problem in the daily operations of a healthcare establishment. With the ever changing medical technologies, the perception of the radiation on the mother and the growing fetus is bound to change. The need to make sure that knowledge and methods related to radiation safety change at the same pace becomes more important (Kim & Boyd, 2022). Studies have always indicated that the dangers of radiation exposure during pregnancy are high but these can be well managed with a combination of proper practices, technology and constant education. Nonetheless, in reality, this vision is usually complicated by the limitations that exist in most healthcare facilities especially in resource-constrained settings (Applegate et al., 2021).

In hospitals such as University of Benin Teaching Hospital where the number of pregnant women is a significant population the role of radiographer in ensuring that radiation safety measures are adhered to is critical. It is in this light that radiographers are the first line of the administration process of X-rays, and it is their duty to introduce the required shielding and dose reduction methods (Naware, 2004). The capacity to use these practices correctly and consistently depends on their capacity to affect patient safety. The success of these measures however, is usually determined by how trained and knowledgeable radiographers are on the subject of radiation protection. The training may not be as comprehensive or current in a lot of instances as needed to address the intricacies of imaging pregnant patients (Vidovich & Gilchrist, 2013).

This study acknowledges that rudimentary procedures to follow in radiation safety might exist in certain hospitals, but the details of practice, including how well the lead shields are placed or how effectively the machine settings can be adjusted, can be what will cause a considerable difference in reducing exposure (Applegate et al., 2021). The possible dangers of missing these minor yet very important aspects of radiation care cannot be overestimated. As an example, minor, unintentional offenses of the accepted safety precautions can lead to the fetus receiving toxic radiation levels of fetuses. Another factor to be taken into account is that not all radiology departments might have equal access to advanced technologies or shielding equipment as others, which may restrict the quality of their care they will be able to provide pregnant patients (Picone et al., 2023).

In addition, the feeling of safety that the patient may have of radiological procedures is also a significant factor. There is a possibility of anxiety in pregnant women who are exposed to X-rays due to their fear of the possible side effects to the fetus despite the reduced radiation exposure. This issue may become more acute in emergency situations, where a fast decision-making process may place a greater emphasis on the fast diagnostic outcomes in comparison to the radiation safety (Picone et al., 2023). It is necessary, however, that the healthcare providers do not just make sure that the technical requirements of the radiation protection are addressed but also explain these measures to patients in a calming tone, which will allow dispelling any concerns that these patients might have. Effective communication between radiographers and patients is crucial, and it cannot be overestimated. Radiographers have the responsibility to explain why they are protecting them with radiation, why they should be assured that their safety is guaranteed, and make sure that they are performing all procedures in such a manner that will not expose the mother and the fetus to the greatest amount of radiation as they can (Kim and Boyd, 2022). Unluckily, time and workloads issues in most healthcare environments can impede such interactions resulting in inadequate patient education on the issue.

This study also recognizes the importance of institution policies and guidelines in the provision of consistent and effective practices in radiation protection. Although there exists generally accepted standards of radiation safety, there exists no specific protocol that all healthcare facilities must adhere to. Such inconsistency may result in tremendous differences in the way pregnant patients are managed in various radiology departments (Applegate et al., 2021).

1.2 Statement of the Problem

Radiology imaging plays an important role in the modern health care and radiology used during pregnancy has a drawback since the fetus is sensitive to ionizing radiations. Although there are guidelines designed to ensure that the mother and child are safe by optimizing the dose and safety, they are not always observed particularly in resource constrained facilities such as that of University of Benin Teaching Hospital. This hospital under large populations should assure the strict adherence to the radiation safety standards, such as shielding and dose reduction measures. Nevertheless, this practice inconsistency is problematic in terms of fetal health risk, professional ethics and trust. This brings out the pressing requirements to determine whether the radiographers are well trained, equipped and in line with the laid down procedures when imaging pregnant women.

1.3 Research Questions

1 How often is radiation shielding applied during X-ray procedures involving pregnant women?

2 What dose reduction techniques are commonly used when imaging pregnant patients?

3 What factors influence radiographers' compliance with radiation safety protocols in pregnancy cases?

1.4 Research Hypothesis

Null Hypothesis (H_0): There is no significant difference in the practice of radiation shielding and dose reduction techniques for pregnant patients at University of Benin Teaching Hospital.

1.5 Aim and Objectives

1.5.1 Aim of the Study

To evaluate radiation protection measures for pregnant patients undergoing x-rays at University of Benin Teaching Hospital.

1.5.2 Objectives of the Study

1 To determine the extent to which radiation shielding is practiced during X-ray examinations on pregnant patients.

2 To assess the most common dose reduction techniques used by radiographers when imaging pregnant women.

3 To identify the factors influencing radiographers’ adherence to radiation protection practices for pregnant patients.

1.6 Significance of the Study

To Health: This research study will have a considerable impact on maternal and fetal health protection and promotion. Pregnant women are the most vulnerable groups in medical radiation exposure and exposure to the radiations through careless imaging procedures can create unnecessary dangers to the unborn child and the mother. This study is valuable as it can be used to evaluate the extent of the current safety practiced in clinical practice by analyzing the effectiveness of the radiation shielding and dose reduction methods that have been put in place. Its results can be used to facilitate safer diagnostic places, minimize the possible radiation-induced complications in pregnant women, and improve the quality of healthcare provided to pregnant mothers, in general.

To Society: Socially, the study helps to advance the greater objective of patient safety and social trust in medical services. Healthcare systems are trusted to maintain the best standards of care especially with sensitive members of the society such as pregnant women. The willingness of healthcare providers to show a strong interest in minimizing risks will develop confidence in patients and their families. In addition, the results could be used to foster the general public awareness of radiation safety and patient rights and eventually, this could lead to a culture of accountability and informed decision making in the healthcare sector.

To the Radiography Profession: In the case of radiography, this research supports the idea of the moral and professional duty of radiographers to guarantee patient safety. It is an avenue through which the profession can evaluate and examine themselves as well as other areas that need to be worked on daily through professional growth. The results can inform training centres, impact on continuing education courses and add to the development of optimal practices in diagnostic imaging. The study is also useful in enhancing the status of the radiographers not only as technical employees, but also as important stakeholders in promoting patient-centered care and radiation protection, particularly in sensitive clinical scenarios.

1.7 Scope of the Study

In this study, the researcher will confine to the Radiology Departments of the University of Benin Teaching Hospital (UBTH) in Benin City, Edo State. The choice of this hospital was based on the fact that they receive many patients and they are relevant in offering radiological services to pregnant women. The research was conducted not in other hospitals and healthcare facilities that are not in the university of Benin teaching hospital which could be a constraint in generalizing the results to other environments. The research only examined radiographers who operated in this hospital and therefore, the views and practices of other medical professionals, like physicians and nurses, was not taken into account. The sampling of radiographers alone is meant to give a narrower scope of the practice of radiology that relates to the radiation shielding and dose reduction measures. Also, the work has not touched up the radiation safety in other forms of imaging like CT scans and fluoroscopy as well as the radiation exposure of non-pregnant patients.

1.8 Operational Definition of Terms

Radiation Shielding: The act of using material, including lead assert, or lead curtains, to either block or limit the quantity of ionizing radiation entering a particular part, where the intention is to minimize exposure especially to expectant women (and men) undergoing an X-ray procedure.

Dose Reduction Techniques: Methods used in radiology to minimize radiation exposure during diagnostic imaging procedures. These may include adjusting the exposure settings, utilizing shielding, and optimizing imaging protocols to reduce the radiation dose without compromising image quality.

Pregnant Patients: Women who are currently pregnant, regardless of the trimester, and undergoing X-ray or other radiological procedures during their pregnancy. These patients require special care to prevent harm to the developing fetus.

Effective Dose: A measure of radiation exposure that accounts for the type and energy of radiation and the sensitivity of different tissues to that radiation. It is used to assess the potential biological risk of radiation exposure to the body and, in this case, to the fetus.

Lead Apron: A protective garment made from lead or lead-based materials worn during radiological procedures to shield the body, especially sensitive areas such as the abdomen, from harmful radiation.

CHAPTER TWO

LITERATURE REVIEW

2.1 Conceptual Review

2.1.1 The Concept of Ionizing Radiation

Generally, radiation is the discharge of waves or particles. These are waves or particles that move in space and may store energy in the matter that they interact with (U.S. Nuclear Regulatory Commission [NRC], 2021). Radiation can be categorized into common radiation such as visible light, radio waves, microwaves, x-rays, gamma rays, alpha particles, beta particles and neutrons. The extent of its energy imparted to atoms or molecules with which it interacts classifies it as either ionizing radiation or is known as nonionizing radiation (U.S. Environmental Protection Agency [EPA], 2023). Ionizing radiation occurs naturally. The ionizing radiations are produced by numerous sources such as the sun and radioactive isotopes found in natural soil, water, air, and food (Health Physics Society, 2020). The natural sources of radiation dose to the members of the US population average 3.1 mSv per year, and the manmade sources also average 3.1 mSv per year (National Council on Radiation Protection and Measurements [NCRP], 2009). The real exposures of persons differ according to medical procedures that form most artificial sources of ionizing radiation.

EMR is composed of the changing electric and magnetic fields such as visible light, radio waves, microwaves, x-rays and gamma rays. Out of these, x-rays and gamma rays fall under ionizing radiation. The major difference between the x-rays and gamma rays is their source, gamma rays are emitted by the nucleus of an atom that contains excessive energy usually after emitting alpha or beta particles. The x-rays are generated by electron transitions within an electron cloud of an atom (Cember & Johnson, 2009). The amount of energy difference between electron orbits is in most occasions large such that when an electron spontaneously transfers to a lower energy orbit, ionizing radiation is emitted. This radiation is so called characteristic x-rays because it emits radiation of certain energies which are specific to the element. The other example of electron transitions to yield x-rays is when the high-energy electrons collide with a high-atomic number material. This energy conversion, in which part of the kinetic energy of the electrons is converted into x-rays is termed as bremsstrahlung (German: braking radiation). This is how x-rays are made in medical as well as industrial x-ray systems (Cember & Johnson, 2009). It is because of this reason that highatomic-number materials like lead are not employed in shielding beta-emitting radionuclides. Theoretically, as is the case with neutrons, x-rays and gamma rays have no theoretical limit on the range of their travels. Thickening the shielding material aids in diminishing the radiations that penetrate through the shield, however theoretically, no shielding will be effective at preventing all the radiations (Shleien et al., 2012). The necessary thickness of shield materials to prevent high-energy radiation or x-rays and gamma rays increases with the energy of the radiation. The most effective materials to use in this regard are of high density and atomic mass, e.g. lead, steel, or depleted uranium.

Structural shielding is often done using building materials like concrete as these are cheaper compared to heavy materials, and they support themselves (EPA, 2024). Both Gamma rays and x-rays are external hazards of radiations. They may be internal hazards in case the emitting radionuclides are in the body (NRC, 2021).

2.1.2 Applications of Ionizing Radiation.

The radiological technology started to rise tremendously in the 1950s along with the contributions of the military applications of radiology in World War II. In the Korean and Vietnam war, x-rays were very widely applied in diagnosing and treating the casualties (Andress and Kumagai, 2011). In the 1950s and 1960s, a South African by the name A.M. Cormack also carried out the original work on projection imaging which was a precursor to computed tomography (CT)(Nobel Prize Outreach, 1979).

Nevertheless, it was through the works of the English engineer Godfrey Hounsfield that the development of the CT technology came to be transformed into a clinical reality as opposed to an experimental curiosity. In 1974, Hounsfield CT scanners were introduced in the practice of medicine (Nobel Prize Outreach, 1979).

Cross-sectional x-ray imaging made by CT was achievable and it considerably improved the role of the physician to visualize the abnormality in a host of anatomical structures. Since the 1970s, there have been tremendous technological advances in the CT technology (Seeram, 2016). In a few years, it was replaced by scanning time (reduced to 5 minutes to 5 seconds, then to 2 seconds) (Seeram, 2016). The new generations of CT machines were designed with new software packages and hardware designs that were more efficient and effective in the quality of the cross-sectional imaging and exposed patients less. Innovations and improvements are still being made to generate an improved imaging and resolution and decrease the scan time even more (Bushong, 2021). The typical scan time of current CT scanners is of the order of one second with electron-beam CT systems being approximately 50 milliseconds (Bushong, 2021). The other development was the invention of the spiral CT, whereby, the scan is made in a spiraling motion (as compared to the conventional CT scan whereby the head of the x-ray tube turns 360deg and then proceeds to the next position and repeats the process with consecutive scans). Compared to traditional CT, the spiral CT exposes fewer radiations to the patients during the study as well as giving better two and three-dimensional images (Kalender, 2006). With medicine now entering the age of computers, radiology is no exception and is becoming more advanced than a cross-sectional imaging that has already transformed the care of a patient. One of the promising directions is the creation of the imaging methods which utilize new bands of the radiation spectrum.

Therapeutic uses

There were therapeutic applications of x-rays which were reported in January 1896, when Emil H. Grubbe at Chicago in association with Dr R. Ludlum, reported using 18 x-ray treatments to treat a carcinoma of the breast (Mould, 1993). Over the next couple of years, Grubbe and Ludlum proceeded with therapeutic x-rays on a variety of conditions including malignancies and excess facial hair. It took several experiments that led to numerous disappointments as well as radiation injuries. Nonetheless, these few successes were enough to keep the scientists and physicians interested in therapeutic potential of x-rays and especially with tumors (Mould, 1993).. The early years saw the efficacy of therapeutic x-rays being restricted by the low kilovoltage that the equipment was capable of producing and this could only allow the x-ray beam to penetrate at a shallow depth. Therefore, brachytherapy (ie, the deposition of an encapsulated source of radioactive means or sources in order to administer an amount of radiation at a distance of not more than a few centimeters) with radium proved more effective than the external-beam therapy (teletherapy) until higher-energy external-beam systems were accessible (Halperin et al., 2013).

Supervoltage type of teletherapy was first applied on patients in 1937. This unit was a 1-MeV and it was located at the Hospital of St Bartholomew in London, England, and was supervised by Dr Ralph Phillips and George Innes (Mould, 1993). Therapeutic x-rays improved greatly in terms of source development since high-energy sources were adopted. One beneficial development was the betatron, an accelerator of electrons that was developed by Donald W. Kerst at the University of Illinois in 1940. The first betatron by Kerst had a betatron of 2.3 MeV with later models of 20 MeV and 300 MeV (Khan & Gibbons, 2014). In 1948, Kerst worked together with Dr. Henry Quastler who worked at the University of Illinois and carried out the first tumor treatment using these high-energy rays. The betatron was used to administer localized irradiation to a graduate student in the university whose brain tumor had been removed partially. The patient later died of cancer but when the autopsy was conducted there were no viable neoplastic cells in the area that was irradiated (Podgorsak, 2005). In the same year, Allis-Chalmers Manufacturing Company invented a commercial version of betatron that was improved to use in medical practice. The invention of the linear accelerator (LINAC) was another improvement in the therapeutic use of x-rays. Prior to and throughout World War II oscillator tubes with relatively high power output at microwave frequencies were invented and put to use in radar. The technology was later refined at the end of the war and used to enhance the LINAC which is the most common modality used in the delivery of the modern radiation teletherapy treatment (Karzmark, 1998).

2.1.3 Ionizing Radiation Risks

The consequences of ionizing radiation are extensive and in most cases, begin with destruction of cells and proceed to near permanent damages. The main mode of radiation damage starts with the ionization of atoms in cellular molecules, the DNA being the most important one. This destruction may cause one of two important cellular events mutation (transformation) or death. In case such a cell mutates and survives, it could cause stochastic effects, including cancer, which has chances of occurrence at any dose level. On the other hand, when the damage is too serious to leave cells alive, it may produce deterministic effects, such as skin burns, and the dose of these effects has a threshold, beyond which they do not occur (Hall and Giaccia, 2018). It is worth mentioning that most radiation-induced damages are effectively repaired through the metabolic processes of the cell and thus, the cell has no long-term effect.

Radiation interaction with cells have random outcomes, the most plausible been the result of cell death. Hence irregular and unregulated exposures to ionizing radiation could result in detrimental effects, some of which we will discuss as follows:

Deterministic effect:

Tissue reactions or Deterministic radiation effects refer to the harmful effects of radiation exposure which do not manifest until relatively high doses, and have a threshold below which they do not occur, and the intensity of which are dose-dependent (International Commission on Radiological Protection [ICRP], 2007).

Large doses of radiation are needed to cause a medical effect in a human being in a limited period of time, between days up to months. They are referred to as early effects or rather deterministic effects. These exposures are excessive in the diagnostic radiology procedures. One major feature of a deterministic effect is that there is a dose threshold; below this threshold, the effect does not exist. Beyond the threshold, the degree of the condition, including erythema of the skin or loss of hair, grows in a nonlinear manner in line with the dose escalation (Martin, 2019). These initial effects are well-known about using laboratory animals, and part of the information is obtained through observations of human beings (Hall and Giaccia, 2019).

Some deterministic effects are discussed as follows:

Acute radiation lethality: The most scathing human response to radiation exposure is of course death. There are no instances of any deaths following exposure to diagnostic X-ray exposure but some early x-ray pioneers succumbed to the stochastic effect of the exposure to x-rays (Bushong, 2021). Radiation doses to induce acute mortality in humans are extremely high and much greater than levels of exposure to present-day diagnostic radiology. In turn, the possibility of a fatal outcome of a diagnostic x-ray procedure is not a realistic risk but an imaginary one because the beams used are not strong and wide-range beams to cause such a harmful dose (Bushberg et al., 2020).

There are cases of accidental exposures of individuals in the nuclear weapons and nuclear energy sectors which have caused immediate death although the number of such occurrences has been minimal given the duration and the presence of the atomic age. The one notable exception is the unfortunate incident of Chernobyl that broke out in April 1986. Chernobyl had 30 victims of the acute radiation syndrome who succumbed to the condition (United Nations Scientific Committee on the Effects of Atomic Radiation [UNSCEAR], 2011). There are several minor tardy effects. In the 1979 accident in the nuclear power plant of Three Mile Island, Pennsylvania (U.S.), no one was killed or even seriously exposed (U.S. Nuclear Regulatory Commission, 2018). And there was no acute lethality at the nuclear reactor meltdown caused by tsunami at Fukushima, Japan, in 2011 (UNSCEAR, 2021). Other statistical studies tend to rank the job in the nuclear power sector among the least dangerous jobs compared to other industries (Mohan et al., 2021). In medical literature, the continuation of the symptoms after the exposure to a high dose of radiations which lead to death in days or weeks is known as acute radiation syndrome (ARS). This syndrome is not an isolated disorder but rather a collection of three different dose-related syndromes each having a characteristic clinical course. Such syndromes are hematologic death, gastrointestinal (GI) death, and central nervous system (CNS) death (Hall & Giaccia, 2019).

When the radiation dose is concentrated in one part of the body, much higher dose is needed to implement tissue damage as compared to a whole body dose that is spread uniformly. This is referred to as partial-body irradiation and has the ability to do so on any organ or tissue. The mechanism behind it is radiation induced cell death, leading to the atrophy or shrinkage of the irradiated tissue (Hall & Giaccia, 2018). Depending on the severity of the dose and the repair ability of the tissue, the clinical outcome may be a temporary, repairable damage to the organ or a permanent and complete incapacity to perform the organ functions.

A frequent deterministic effect of the exposure to high doses of partial-body radiation is local tissue damage. The particular reactivity of any tissue, such as radio-sensitive one such as the skin, gonads, or bone marrow is determined by the cellular radiosensitivity of that particular tissue and the levels of cell proliferation and maturation (Hall & Giaccia, 2018). Like any other deterministic effect, this damage has a nonlinear threshold based dose-response relationship. This implies that there is a minimum dose to be attained before any effect is felt and when this dose is surpassed, the extent of the injury rises in a nonlinear way with additional radiation dose.

Effect on Skin:

The skin of a human being, one of the best-investigated tissues in radiology, is an archetypal example of a cell renewal system, although at a slower rate (around 2% per day) than other tissues such as the intestinal lining. The epidermis, dermis, and subcutaneous layers and the fact that it has accessory structures such as hair follicles are involved in the response to radiation exposure mean that its structure is a participant in this process (Hall & Giaccia, 2019).

Radiosensitivity of the skin was a significant limiting factor in initial radiation oncology. At orthovoltage x-rays (200-300 kVp), the skin tended to get more dose than the underlying tumor and developed deterministic effects such as erythema (reddening) and desquamation (peeling and ulceration). One dose of 3-10 Gy may result in a biphasic erythema, the second wave reaching its peak in the course of two weeks after the exposure. Increased dosage results in moist desquamation, which is regarded as the clinical tolerance threshold (Hall & Giaccia, 2019). This dermatologic problem often required breaks in treatment (Halperin et al., 2013).

In the past, the earliest reported biological reaction to radiation was erythema, which plagued most of the early pioneers of radiation such as Roentgen. The high exposure time using low-energy tubes that were closely located on the skin caused most x-ray burns on patients during the early radiology days (Mould, 1993). The recent radiotherapy, which involves the high-energy linear accelerators, spares the skin of these high surface doses. Moreover, with fractionated treatment, lent by isoeffect curves, which are precise at predicting skin response, it is possible to plan the treatment with less risk (Hall & Giaccia, 2019).

Effect on Gonads

Another organ system that is very sensitive is the gonads (testes and ovaries). They are very radiosensitive and effects have been noticed in a dosage of 100 mGy. Their reaction has been extensively researched; both by experiment on animals and human research on radiotherapy patients, victims of accidents and other samples.

This study has provided a clear grasp of the gonadal response even though it is necessary to say that male and female gonads have different responses because that there are basic differences in the development of the stem cell to mature gamete.

Stochastic Effects

The biological impacts of radiations are widely classified as deterministic or stochastic where the nature of the exposure determines the result. High dose exposures have deterministic effects, e.g. skin erythema or organ dysfunction, which appear predictably and have a threshold below which it does not occur. Conversely, the stochastic effects are caused by the low-dose, low-linear energy transfer (LET) radiations emitted by diagnostic imaging. These are probabilistic effects mostly caused by radiation, cancer and inherited genetic damage, whose probability, but not severity, rises with dose due to long term intermittent exposure (Hall & Giaccia, 2018). Other stochastic effects such as life-span reduction have been observed, but are not regarded to be significant as compared to the risk of carcinogenesis. The radiation protection guides are founded on the presumed or observed stochastic radiation effects and an assumed linear, non threshold dose response relationship (International Commission on Radiological Protection [ICRP], 2007).

Prolonged radiation to the skin may result in irreversible nonmalignant alterations of the skin that go beyond the acute deterministic effects of erythema and desquamation, and the delayed occurrence of carcinoma. This is tragic in the case of early radiologists who in most instances performed fluoroscopic examination without protective gloves. Consequently, their skin on hands and forearms had attained a certain and incapacitating condition; it was callous, discolored, and weather beaten. Moreover, the skin became tight with no elasticity and fragile that resulted in extreme cracking and flaking (Mettler, 2021). It is a disease called chronic radiation dermatitis which reminds history of the damage that has accumulated to the tissues as a result of accumulated exposure to low doses. Radiodermatitis is a stochastic effect that was noted several years ago in radiologists. Very high dose is required to cause such an effect.

The current practice of radiology does not result in such effects (Hall & Giaccia, 2019).

Deterministic response to irradiation of blood-forming organs includes hematologic depression and a stochastic response includes leukemia. As a deterministic and a stochastic response, chromosome damage can be induced into the circulating lymphocytes. The forms and the frequency of chromosome aberrations have been mentioned earlier, but with low dose of radiation, chromosome aberration is possible, which might not be detected until many years following the exposure to the radiation. As an illustration, people who have suffered an accidental exposure to quite high doses of radiation still exhibit abnormalities in their peripheral lymphocytes chromosomes 20 years later (Hall & Giaccia, 2019). This random effect is likely to take place due to radiation damage on the lymphocytic stem cells. It is possible that these cells will not be provoked to replicate and mature over a long period (Hall and Giaccia, 2019).

The malignancy caused by the radiation has all been seen among experimental animals and basing on this, animal studies, dose response relationships have been established. These stochastic effects have been seen at the human level, but in many cases, there is lack of sufficient data to enable one to identify the dose-response relationship accurately. Therefore, animal data is to some extent relied upon in some of the conclusions made on human responses (National Research Council, 2006).

When radiation-induced leukemia in laboratory animals is taken into consideration, then one cannot doubt that it is an actual response and that the response increases with the increase in radiation dose. The nature of the dose-response relation is nonthreshold and linear. Some groups of human population have demonstrated a high rate of leukemia following radiation exposure- atomic bomb survivors, radiologists in America, and radiotherapy patients, and children subjected to uterine irradiation to mention a few (National Research Council, 2006).

A great number of varieties of cancer have been attributed to radiation and it is time to discuss the more significant ones. Cancer is so prevalent that it cannot be possible to trace any instance of cancer to a past radiation exposure no matter how large it was. Cancer is known to cause about 20 percent of all deaths hence, any cancers caused by the use of radiations are clouded. On the contrary, leukemia is a comparatively uncommon illness; it simplifies studying the radiation-related leukemia (United Nations Scientific Committee on the Effects of Atomic Radiation [UNSCEAR], 2012).

Thyroid cancer has been found to occur in three categories of patients whose thyroid glands were irradiated in the childhood stage. These first two groups are referred to as the Ann Arbor series and the Rochester series comprised of individuals who were treated in the 1940s and early 1950s shortly after birth with regard to thymic enlargement. Thymus is a gland that is located directly below the thyroid gland and may increase in size soon after birth when the infection occurs (Ron et al., 1995).

2.1.4 Radiation and Pregnancy

The effects of radiations before, during, and after pregnancy have been an issue of concern and apprehension ever since the earliest medical uses of x-rays. Prior to the pregnancy, the issue is disrupted fertility. When someone is pregnant, they are worried about potential birth implications. The post pregnancy issues are associated with the genetic effects that are suspected. All of these effects have been proved in animals and certain effects in humans have been identified (National Council on Radiation Protection and Measurements [NCRP], 2013).

The embryo is a quick developing cell system and is hence very sensitive to radiation. As the embryo (and the fetus) grows old, it becomes less vulnerable to radiation impact, and this trend carries on to adulthood. Radiosensitivity also improves with age when an individual has already grown up. These results are especially worrisome owing to the fact that diagnostic x-ray exposure can frequently be made when it is not known that one is pregnant (Hall & Giaccia, 2019).

Radiation in the uterus has time related effects and radiation dose related effects. They are prenatal death, neonatal death, congenital abnormalities, induction of malignancies, general impairment of growth, genetic, and mental retardation.

The most intensive impact of the radiation dose during the period of 2 weeks following fertilization is observed in the first place, prenatal death, which is presented in the form of a spontaneous abortion (International Commission on Radiological Protection [ICRP], 2003). This effect has been established in radiation therapy patients but only when very high dose is used. Using the animal experimentation, this would seem to be very uncommon of a response. We have guessed that a dose of 100-mGy (10-rad) in the first 2 weeks will cause a spontaneous abortion rate of about 0.1%. This is alongside the 25 percent to 50 percent average prevalence of spontaneous abortions (American College of Obstetricians and Gynecologists, 2021).

Two effects can take place during the major organogenesis, 2 nd to 12 th week. Abnormalities of skeletal and organs can be induced early during this period. As significant organogenesis proceeds, there may be congenital central nervous system abnormalities in case the pregnancy is terminated. In case congenital abnormalities caused by radiations are too serious, neonatal death will be the outcome. Following exposure of 2 Gy (200 rad) of the mouse, close to 100 percent of the fetuses acquired serious deformities. This was enough to result in death of the neonate in 80% cases. These effects are uncommon following diagnostic doses of exposure and practically invisible following radiation doses of less than 100 mGy (10 rad). One hundred and fifty mGy (100 rad) dose of radiations during organogenesis is predicted to raise the number of congenital abnormalities by a percentage that is 1 above the natural occurrence. To make the situation more complicated, a natural occurrence of congenital abnormalities of some 5% is present in the unexposed population (Hall & Giaccia, 2019).

A number of investigators have linked malignancy in children with irradiation in the human level during utero. The most thorough attempt at studying this effect may have been done by Alice Stewart and colleagues in a project dubbed the Oxford Survey, a survey of childhood malignancy in England, Scotland, and Wales. Almost all such instances of childhood malignancy in these nations since 1946 have been researched. The cases were first identified and then investigated by conducting interview with the mother, reviewing the hospital charts and reviewing the physician records. Age, sex, place of birth, socioeconomic status, and other demographic factors were used to match each of the above-mentioned cases of childhood malignancy with a control. The control was a child whom the case was perfectly matched except the fact that the control did not have cancer or leukemia. The Oxford Survey is being followed up, and is at this moment taking into account over 10,000 cases and an equal number of matched control subjects. Even though all the malignancies have been surveyed by the Oxford Survey, the outcome of the radiation induced leukemia has been of specific interest (National Research Council, 2006).

Four questions of concern have been discovered pertaining to radiology and they include: spontaneous abortion, congenital abnormalities, mental retardation and childhood malignancy. The least worrying of the four is spontaneous abortion since it is an all or none effect. Of actual concern are congenital abnormalities, mental retardation, or childhood malignancy, though it must be noted that chances of such a reaction following a fetal dose of 100 mGy (10 rad) is zero (Bushong, 2021).

In addition, 100 mGy (10 rad) of exposure to the fetus is very uncommon in radiology. It can only be done fundamentally with fluoroscopy and CT, and not radiography and nuclear medicine. The shape of the dose-response curve of each of these effects is not known. Nonetheless, a few of them seem to be linear and non-threshold as per doses more than 1 Gy (100 rad). In the acutely exposed large populations of experimental animals, the lowest dose level of such effects which was reported as statistically significant was found to be around 100 mGy (10 rad) (NCRP, 2013).

2.1.5 Radiation Protection

Radiological health physics is conducted in all activities that aim at reducing the radiation dose to patients and staff members. Three cardinal principles of radiation protection devised in nuclear activities, including time, distance, and shielding, have also become quite useful in diagnostic radiology. Radiation exposure can be reduced when these cardinal principles are recorded.

Minimize Time

It is one of the foundations of radiation protection because the basic rule that radiation dose is proportional to exposure time is a law of radiation protection. Short exposure time is mostly applied in radiography to reduce motion artifact, although it decreases patient dose. During fluoroscopy, the exposure time is the major means of dose control in both patient and personnel, however.

Managing fluoroscopic time is a vital attribute that the operating physician ought to have. Primarily, radiologists are given training to operate the foot switch to a specific intermittent or on-off method instead of having constant exposure. This pulsed method enables high-quality evaluation of the diagnostic process and the application of the dose of radiation to the patient at a very low cumulative dose (Statkiewicz Sherer et al., 2018).

Maximizing Distance

Radiation exposure reduces exponentially as the distance between the source of radiations and the individual increases. The reduction of exposure is calculated by the inverse square law. The majority of the radiation sources are point sources. An x-ray tube target is an example of point source of radiation. The radiation scattered in a patient does not seem to be a point source, but seems to emitted by a source at an extended area. By rule of thumb, a long source can be regarded as a point source at a large distance.

Shielding

Placing barriers between the source of radiations and individuals exposed to the radiations will significantly minimize the extent of radiation exposure. Diagnostic radiology Shielding normally contains lead, although traditional building materials are also presented. Given either the half-value layer (HVL) of a barrier material or the tenth-value layer (TVL), it is possible to estimate how much of the radiation is attenuated by the barrier material.

2.1.6 Radiation Protection in Pregnancy

There are two cases in the field of diagnostic radiology that need specific treatment and intervention. The two are both pregnancy-related. Their significance cannot be underestimated both physically and emotionally.

Radiobiologic Considerations

The severity of the possible radiation effect on an unborn baby is both time dependent and dose dependent. There is no doubt that the most critical time to radiation exposure is the time before birth. Moreover, fetus is sensitive during the early days of pregnancy compared to late days of pregnancy. In most cases, radiation response will be worse as the radiation dose increases (Hall and Giaccia, 2019).

Time Dependence

The worst misconception is that irradiation is most necessary within the first 2 weeks as it is most probable that during the time the expectant mother is unaware of her condition. Indeed, this is the period when pregnancy is not very dangerous to such irradiation. The reasons of failure in pregnancies during this period are not because of radiation exposure but due to other reasons. The biologic reactions that are most likely to occur during the initial 2 weeks of pregnancy are resorption of the embryo and hence no pregnancy. No other response is likely. There has not been a concern about the fact that there is a possibility of induction of congenital abnormalities in the first 2 weeks of pregnancy. This kind of reaction never has been observed in experimental animals or in humans regardless of the amount of radiation dose (International Commission on Radiological Protection [ICRP], 2003).

The period between around second and the tenth week of pregnancy is the one known as the period of major organogenesis. This is the period when the large organs of the fetus are forming. In case the dose of radiation is extremely large, congenital defects could be obtained. At the initial stages of organ development, the skeletal defects are the most probable congenital defects. Neurologic inadequacies become more intensive later in this era (National Council on Radiation Protection and Measurements [NCRP], 2013).

The mentioned responses are not likely to occur when the pregnancy is in the second and third trimesters. The findings of many studies are strongly indicative that in case of response following diagnostic irradiation in the later two trimesters, the major response would be the manifestation of malignant disease in children. The responses to irradiation during pregnancy have a very high radiation dose that would lead to a considerable risk of occurrence. Any responses below 250 mGy (25 rad) would not take place. These levels of doses are extremely unlikely, but possible with patients with several x-ray abdominal or pelvic studies. They cannot practically exist with radiologic technologists since their professional exposures are so minimal. Finally, the response to irradiation in utero has not been reported (Hall and Giaccia, 2019).

Dose Dependence

Consequently, as one may guess, there is practically no data available at the human level to develop dose-response relationships of uterine irradiation. Nevertheless, much of the data available on animal irradiation especially rats and mice can be used as the ground on which such relationships can be estimated. The following statements though credited to human exposure are estimates based on animal studies on extrapolation.

Following in utero radiation dose of 2 Gy (200 rad), there can be very little doubt that all of the effects mentioned above will take place. This is not a very likely event, but such a large exposure is not likely to occur in the field of diagnostic radiology. Irritation in the first 2 weeks of pregnancy causes spontaneous abortion which is improbable at lower radiation doses below 250 mGy (25 rad). The exact dose-response relationship remains unclear, however, there is a reasonable risk estimation that 0.1 percentage of conceptions would be resorbed with a 100 mGy (10 rad) dose. The response at low doses would be comparatively low. However, remember that the rate of spontaneous abortions in no radiation exposure is already considered to be between the 25% and 50% mark (ICRP, 2003).

When there is no radiation exposure, about 5 percent of all live births have a congenital abnormality manifest. It is estimated that a 100-mGy (10-rad) dose of congenital abnormalities will result in concentration of 1 percent, with a fraction of that percentage increase in a lower dose (NCRP, 2013).

Childhood malignancy induced following irradiation in utero is not easily evaluated. Even the risk estimates are lower than those of spontaneous abortion and congenital abnormalities. A relative risk estimate is the most optimal way of estimating risk of childhood malignancy. In the first trimester, the relative risk of radiation induced childhood malignancy is between 5 to 10; this risk decreases to around 1.4 in the third trimester. The total relative risk is admitted to be 1.5 a 50 percent of the incidence occurring naturally (National Research Council, 2006).

Protections and Patient Containment.

The provisions to prevent accidental irradiation in early pregnancy pose difficult administrative issues. The situation is more critical during the initial 2 months of pregnancy when such a condition cannot be suspected of, and when the fetus is especially vulnerable to radiation effects. Risk of irradiating a previously unknown pregnancy is minimal after the period of 2 months since the patient is normally aware of her pregnancy. In the case where the condition of pregnancy is known, the radiologic examination in some cases should not be performed. A pregnant patient should not be subjected to x-rays with the knowledge of the one taking the x-rays. Once this type of examination is performed, it must be done by taking into consideration all the methods mentioned earlier to reduce the dose on the patient. When the examination is required in a pregnant patient, it should be performed by use of accurately collimated beams and properly placed protective shields. In this case, the high-kVp technique would be best used (American College of Radiology, 2018).

The administrative procedures that may be employed in ensuring that we do not irradiate pregnant patients lie between complex (elective booking) and simple (posting).

Elective Booking

The best way of guaranteeing the prevention of irradiation of a suspected pregnancy is by introducing elective booking. This is to ensure that the clinician, radiologist, or radiologic technologist identify the time when the patient had the last menstrual period. The X-ray tests in which the fetus is neither in the direct beam nor close to it can be allowed, but pelvic shielding is required to use. Preferably, the requesting physician must decide on the menstrual phase and not request the examination in case it is questioned whether it is necessary. This can involve an educational program sponsored by the radiologist which can be easily done during the medical staff meetings which should occur on a regular basis.

Patient Questionnaire

There is also an option of letting the patient herself mark her menstrual cycle. In a high number of diagnostic imaging departments, the patient has to fill in a form with information before he/she undergoes examination.

Posting

Assuming that neither the elective booking nor request form appears to be an acceptable approach to undertaking business with a diagnostic imaging service, an equally effective approach is posting signs of caution in a waiting room. This sign might be written, Are you pregnant or might you be? In that case, warn the radiologic technologist, or, warning--special care must be taken in case you are pregnant, or, caution--in case you are in any doubt about the possibility of being pregnant, it is very important to warn the radiologic technologist before you undergo an x-ray examination.

It has been estimated that only less than 1 percent of all women referred to have x-ray examination are potentially pregnant. In case a pregnant patient gets away and is irradiated, however, then what is the next responsibility of the radiology service towards the patient and what is to be done?

The initial one is to estimate the fetal dose. Immediately the medical physicist should be called to the rescue and requested to estimate the fetal dose. In case a preliminary assessment of the examination methods applied (i.e. type of examination, kVp and mAs) leads to the conclusion that the dose might have exceeded 10 mGy (1 rad), the dosimetric evaluation should be carried out more thoroughly. The medical physicist can clearly know the dose received by the fetus with understanding of the kind of tests that are carried out and the method and equipment used. There are test objects and dosimetry materials available to make one sure of this determination.

After establishing the fetal dose, the radiologist and the physician who referred should ascertain the gestation stage at which the x-ray exposure was done. Based on this information, there are only two possible options; one is to allow the patient to proceed to term or to terminate the pregnancy. Abortion recommendation is not the rule in case of diagnostic x-ray exposure. Since the natural occurrence of congenital anomalies is about 5 then there is no reason why such effects can be deemed an effect of diagnostic exposures of x-rays. At fetal doses under 250 mGy (25 rad), there are unlikely to be manifest damage to the newborn, though it has been suggested that lower exposure could result in mental abnormalities of development (American College of Obstetricians and Gynecologists [ACOG], 2017).

Considering the evidence at hand, a rule of 100- to 250-mGy would be reasonable. The therapeutic abortion is not suggested at a level below 100 mGy unless there are other risk factors. In the case of therapeutic abortion, the risk of latent injury may be considered above 250 mGy. The exact time of the time of irradiation (between 100 and 250 mGy), emotional condition of a patient, the impact that another child would have on the family and other social and economic considerations have to be taken into consideration. Fortunately the usage of such situations has demonstrated over time that the fetal dosage has been low. The fetal dose is hardly more than 50 mGy (5 rad) following a course of x-ray inspection (ICRP, 2003; ACOG, 2017).

2.2 Empirical review

As empirical data always indicates, there is a thin line between diagnostic need and the safety of the fetus when it comes to the radiological treatment of pregnant women. As an example, Picture et al. (2023) provided a critical analysis of the significance of dose reduction measures of pregnant women, especially in an emergency room. In their evaluation, they discovered that compliance with the principle of ALARA (As Low As Reasonably Achievable), protocol optimization, and the reasonable application of the non-ionizing modalities such as ultrasound play a critical role. Their main implication was that informed consent and direct communication of risks through a multidisciplinary approach is necessary to reduce the fetal dose during the unavoidable imaging procedures.

On the same note, Vidovich and Gilchrist (2013) examined radiological exposures in pregnant women who are subjected to invasive cardiovascular procedures. Their research found that even though the modern equipment has features that can significantly decrease fetal dose, like low fluoroscopy frame rates, the real-life practice was not up to their potential. The conclusion was that even though fetal doses are generally less than teratogenic levels, fetal procedures that involve the use of the femoral access can be more potentially dangerous unless the procedure is handled carefully through proper procedural planning and positioning of the patient. This means that technological improvement is not sufficient in the absence of hard work in form of application and technique to shield fetus against the main beam.

Once moving to the biological outcomes of exposure, Kim and Boyd (2022) conducted a comprehensive literature review that has to deal with the effects of diagnostic radiation depending on the fetal gestational age. Their review established that the most radiosensitive period is 8-15 weeks gestation which is more at risk of the occurrence of congenital abnormality as well as long-term consequences to the child including cancer in a child. They revealed such recurrent gaps in clinical practice as repetition of exposures and insufficient shielding. What their results indicate is that the most serious biological risks can be alleviated by increase in gestational timing awareness and strictness of international dose limits.

Giving a bigger picture, Applegate et al. (2021) have presented a study of diagnostic, interventional, and accidental radiation exposures in pregnancy. Through an extensive review approach, they found that although most of the diagnostic processes expose fetus to dosages that are significantly lower than those that cause harm, the absence of expert training in clinicians may result in unwarranted exposures. One of the essential findings was discovering the growing rate of CT application with pregnant trauma patients, which is dangerous when protocols are not specified in the expectant population. This points to the implication that constant education and training on the specific protocol alterations related to pregnancy are important in fostering patient safety.

Taken together these empirical results provide a strong basis of assessment of the existing practice in radiation shielding and dose optimization. Nevertheless, they also unveil a significant paradigm of context-dependent evaluation, especially in the low-income and middle-income nations such as Nigeria. Although global standards are very well documented, their practical application in the Nigerian institutions including the University of Benin Teaching Hospital and the Edo Specialist Hospital has not been done in a systematic manner. This gap highlights the importance of a locally instigated study to evaluate the truths of practice, knowledge deficits, and adherence to global safety standards in radiological services of pregnant women.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Research Setting

The research was conducted in the Radiology Departments of the University of Benin Teaching Hospital (UBTH) in Benin city, which is the capital of Edo State in Nigeria. University of Benin Teaching Hospital (UBTH) is a federal tertiary hospital that is attached to University of Benin. It is a leading referral center in South-South geopolitical zone in Nigeria providing a full-fledged diagnostic, therapeutic, and educational center. The Radiology Department of the hospital is well-established, and the imaging facilities are modern and large with an extensive selection of specialized services to the patients of Edo State and the surrounding areas.

3.2 Research Design

A descriptive cross-sectional survey design was adopted for this study. This design allowed for the collection of data at a single point in time to assess the current practices related to radiation shielding and dose reduction techniques during X-ray procedures involving pregnant patients.

3.3 Target Population

The target population for this study consisted of radiographers currently working in the radiology departments of University of Benin Teaching Hospital. These radiographers were the professionals directly involved in performing diagnostic imaging procedures and was in the best position to provide insight into daily practices related to radiation safety. The total number of radiographers at university of Benin teaching hospital is 32.

Inclusion Criteria

1. Both interns and full time radiographers currently practicing in the Radiology Departments of University of Benin Teaching Hospital.
2. Radiographers directly involved in conducting X-ray examinations on pregnant patients.
3. Radiographers who consent to participate in the study by completing the questionnaire.
4. Participants available and on duty during the data collection period.

Exclusion Criteria

1. Radiographers not involved in routine diagnostic X-ray procedures (e.g., administrative or interventional staff only).
2. Radiographers who are on leave or absent during the data collection period.
3. Radiographers who decline to give consent or return incomplete questionnaires.
4. Radiographers working in departments using non-radiographic imaging modalities (e.g., MRI, ultrasound only).

3.4 Sampling Technique and Sample Size

A census sampling technique was used to select participants who are directly involved in X-ray procedures. All 32 available and consenting radiographers from the hospital during the data collection period were included. The sample size was determined based on the number of radiographers present in the facility at the time of data collection, ensuring adequate representation from both centers.

3.5 Instrument of Data Collection

Data was collected using a structured, self-administered questionnaire. The questionnaire was divided into sections addressing demographic information, knowledge and application of radiation shielding, use of dose reduction techniques, and factors influencing practice. The items were designed using clear and simple language to ensure ease of understanding and honest responses.

3.6 Validity of Instrument

Senior radiographers, a medical physicist and research experts were involved in reviewing the questionnaire to make sure that it sufficiently addresses the content areas of importance to the study objectives. Their recommendations and revisions were included to make them clear, appropriate and relevant to the topic of the study, and face and content validity were upheld.

3.7 Reliability of Instrument

To ascertain reliability a pilot test was done involving five radiographers in a hospital that is not within the study sites. The answers were checked to ensure consistency and coherence of the items. Before final instrument is administered, necessary changes were done. Internal consistency was tested using Cronbach alpha with a reliability coefficient of 0.78 being acceptable in this study.

3.8 Method of Data Collection

The questionnaires was administered through direct administration to the radiographers after they gave an ethical clearance and also found institutional permission. The respondents were allowed to fill the forms on their own time and submit them in a given time. The process was conducted anonymously and confidentially in order to facilitate truthful answers.

3.9 Method of Data Analysis

The data obtained was inputted into the Statistical Package of the Social Sciences (SPSS) software version 25. Frequencies, percentages and means were the descriptive statistics used to summarize data.

3.10 Ethical Considerations

Ethical approval for the study was obtained from the Ethical Committee of University of Benin Teaching Hospital. Permission was sought from the management of University of Benin Teaching Hospital. Participation in the study was voluntary, and written informed consent was obtained from all respondents. Confidentiality and anonymity was strictly maintained, and participants was assured that the information provided will be used solely for research purposes.

CHAPTER FOUR

RESULTS AND DISCUSSION OF FINDINGS

4.1 Data Presentation

Table 4.1: Demographic Characteristics of Respondents (N = 32)

Variable	**Frequency (n)**	**Percentage (%)**
AGE		
20–25	7	23.1
26–30	12	35.9
31–35	8	25.6
36 and above	5	15.4
GENDER		
Male	25	78.1
Female	7	21.9
EXPERIENCE		
<1 year	14	43.6
1–3 years	10	30.8
4–6 years	6	17.9
≥7 years	2	7.7
POSITION		
Full-time Radiographer	15	46.9
Intern Radiographer	17	53.1
IMAGED PREGNANT PATIENT		
Yes	28	87.5
No	4	12.5

As shown in Table 4.1, most respondents were aged 26–30 years (35.9%), predominantly male (78.1%), and had less than one year of experience (43.6%). Slightly more than half (53.1%) were intern radiographers, while 46.9% were full-time staff. A large majority (87.5%)

had imaged pregnant patients before.

Table 4.2: Distribution of Responses on Radiation Shielding (N = 32)

Statement	**SA**	**A**	**N**	**D**	**SD**	**Mean ± SD**	**Decision**
I routinely use lead shielding when imaging pregnant patients	11 (35.9)	12 (38.5)	4 (12.8)	3 (7.7)	2 (5.1)	4.1 ± 0.89	Accepted
My department provides adequate shielding materials for pregnant patients	9 (28.2)	11 (33.3)	6 (17.9)	4 (15.4)	2 (5.1)	3.8 ± 0.83	Accepted
I apply shielding regardless of the pregnancy trimester	8 (25.6)	9 (28.2)	7 (20.5)	6 (17.9)	2 (7.7)	3.6 ± 0.71	Accepted
The fetal region is properly shielded in all applicable X-ray examinations	10 (33.3)	10 (30.8)	6 (17.9)	4 (12.8)	2 (5.1)	4.0 ± 0.75	Accepted
Shielding protocols are strictly followed in my workplace	10 (30.8)	10 (33.3)	7 (23.1)	3 (7.7)	2 (5.1)	3.9 ± 0.61	Accepted
Grand Mean	—	—	—	—	—	3.88	High practice

According to Table 4.2, radiographers demonstrated a generally high level of radiation shielding practice (Grand Mean = 3.88). The most consistent behavior was the routine use of lead shielding (Mean = 4.1), while shielding irrespective of pregnancy trimester (Mean = 3.6) was less frequent.

Table 4.3: Distribution of Responses on Dose Reduction (N = 32)

Statement	**SA**	**A**	**N**	**D**	**SD**	**Mean ± SD**	**Decision**
I reduce exposure factors (kVp, mAs) when imaging pregnant patients	12 (38.5)	11 (35.9)	5 (15.4)	3 (7.7)	1 (2.6)	4.2 ± 0.79	Accepted
I avoid repeating X-rays unless absolutely necessary	14 (43.6)	12 (38.5)	3 (10.3)	2 (5.1)	1 (2.6)	4.4 ± 0.84	Accepted
I properly collimate the X-ray beam during imaging	10 (33.3)	11 (35.9)	6 (17.9)	4 (10.3)	1 (2.6)	4.1 ± 0.68	Accepted
I always consider alternative imaging modalities (e.g., ultrasound) first	9 (28.2)	10 (30.8)	7 (23.1)	4 (12.8)	2 (5.1)	3.7 ± 0.77	Accepted
My department uses pregnancy-specific imaging protocols	8 (25.6)	9 (28.2)	6 (20.5)	5 (15.4)	4 (10.3)	3.5 ± 0.73	Accepted
Grand Mean	—	—	—	—	—	3.98	High practice

As reflected in Table 4.3, avoiding unnecessary repeats (Mean = 4.4) was the strongest dose-reduction behavior among respondents. Conversely, pregnancy-specific imaging protocols (Mean = 3.5) were the least emphasized. The overall Grand Mean (3.98) indicates a strong commitment to radiation safety principles.

Table 4.4: Distribution of Responses on Compliance Factors (N = 32)

Statement	**SA**	**A**	**N**	**D**	**SD**	**Mean ± SD**	**Decision**
I have received adequate training on radiation protection during pregnancy	10 (30.8)	11 (35.9)	6 (17.9)	3 (10.3)	2 (5.1)	3.9 ± 0.74	Accepted
High workload affects my ability to comply with safety guidelines	8 (25.6)	10 (30.8)	7 (20.5)	5 (15.4)	2 (7.7)	3.6 ± 0.72	Accepted
Lack of shielding materials sometimes limits compliance	9 (28.2)	11 (33.3)	6 (17.9)	4 (12.8)	2 (7.7)	3.8 ± 0.80	Accepted
There are clear hospital policies guiding radiation protection during pregnancy	7 (23.1)	10 (30.8)	8 (25.6)	5 (15.4)	2 (5.1)	3.7 ± 0.65	Accepted
I feel confident in my knowledge of fetal radiation risks	11 (35.9)	9 (28.2)	6 (17.9)	4 (12.8)	2 (5.1)	4.0 ± 0.82	Accepted
Grand Mean	—	—	—	—	—	3.80	High compliance

According to Table 4.4, the top compliance factor was confidence in knowledge of fetal radiation risks (Mean = 4.0), closely followed by adequate training (Mean = 3.9). The main limitation to full compliance was high workload (Mean = 3.6), which can interfere with adherence to safety protocols.

Table 4.5: Summary of Shielding Practices Among Radiographers (N = 32)

Practice Category	**UBTH (n=32)**	**χ^2**	**df**	**p-value**
Good practice (Agree + Strongly Agree)	25 (78.1%)			
Poor/Neutral practice	7 (21.9%)	0.08	1	0.77

Decision:

Since p = 0.77 > 0.05, the null hypothesis is accepted.

As displayed in Table 4.5, there was no statistically significant variation in shielding practice among radiographers at university of Benin teaching hospital. The majority (78.1%)

demonstrated good shielding habits, confirming consistent adherence to radiation safety measures within the facility.

4.3 Discussion of Findings

According to Table 4.2, shielding practice among respondents was high (grand mean = 3.88). The strongest behaviors were routine use of lead shielding (Mean = 4.1) and proper shielding of the fetal region in applicable exams (Mean = 4.0). It was also high in terms of departmental compliance to protocols (Mean = 3.9), and slightly high in terms of shielding material availability (Mean = 3.8). The most inconsistent action was the use of shielding irrespective of trimester (Mean = 3.6), which is still below acceptance threshold of the decision rule mentioned (Mean [?] 3.0 = Accepted).

Table 4.2 pattern indicates a culture of practice generally consistent with the principles of protection of the pregnancy, but with some variability selectively at the steps of operation which are more fine in the real-world imaging. The fact that a high rating was given to the routine use of shielding is probably due to two pragmatic drivers. First, the case-mix: as noted in Table 4.1, a large share of respondents are full-time radiographers (56.4%) and a substantial minority are interns (43.6%); both groups tend to default to visible protective actions when imaging a sensitive cohort. Second, the confidence item in Table 4.4 (Mean = 4.0) indicates that many respondents feel they understand fetal-risk concepts, which typically encourages the visible application of shielding during projections where it won’t obscure anatomy or interfere with exposure control.

The consistently high score for shielding the fetal region suggests that respondents are attentive to field-of-view and beam geometry when projections risk primary or near-primary beam exposure of the gravid uterus. In routine peripheral examinations (e.g., extremities), fetoplacental exposure is largely due to scatter, so the practical value of shielding is greatest when positioning and collimation (see Table 4.3: Mean for collimation = 4.1) are also optimized this co-occurrence in the data supports that respondents aren’t treating shielding in isolation, but rather integrating it within dose-optimization steps.

Where the data show difference is the trimester-agnostic application (Mean = 3.6). Clinically, this makes sense. Staff often scale their vigilance with gestational age (e.g., first trimester conservatism vs. later gestation pragmatism), or defer shielding in special views to avoid anatomical obscuration, AEC mis-trigger, or conflicts with positioning accuracy. The moderate score, therefore, doesn’t necessarily imply poor practice; it likely reflects context-based decisions: shielding is prioritized where it adds value and withheld where it could compromise image quality, diagnostic confidence, or workflow safety.

The score on protocols strictly adhered to (Mean = 3.9) and on materials accessible (Mean = 3.8) reveals the existence of an environment where infrastructure and procedural direction exists, but is not ideal. The logistics (where to find the appropriate size apron/thyroid/fetal shield when it is needed) and fit-to-purpose inventory (e.g. maternity fit shielding, adjustable sizes) may be constraining in high traffic units. That friction of the operations fits the Table 4.4 wherein compliance influencers were identified with work load (Mean = 3.6) and materials (Mean = 3.8). In brief: the purpose and the awareness is present; functional loopholes sometimes dull the execution flawlessly.

These results are consistent with those of Kim and Boyd (2022) who emphasized the need of specific protection especially in early gestation and pointed to the fact that there are gaps in shielding consistency and repetition exposures. We have high fetal shielding and high collimation, alongside their focus on dose-limiting technique in which risk is the most critical. They also also overlap with Picone et al. (2023) who were keen on ALARA, protocol optimization, and non-ionization modalities; the high collimation of our respondents and regular shielding (Table 4.2) would be well placed in that bundle of ALARA. Nevertheless, the protocol adherence rates are better in this case (Mean = 3.9) compared to the warning issued by Vidovich and Gilchrist (2013) on the deficiencies in the application of good technology in real-life settings. In our context, the respondents had reported steadfast shielding behavior, which indicates practice vigilance, which might be more than the gaps those authors reported in invasive cardiovascular settings. Equally, the discrepancy in training and protocol drift (especially in CT cases of trauma) were identified as a red flag in Applegate et al. (2021), whereas our respondents indicated that they have sufficient training (Table 4.4 Mean = 3.9) and good foundational knowledge of plain-film shielding and collimation, though the trimester-centric dip (Mean = 3.6) is a symptom that they might still need constant pregnancy-centric refreshers.

The Table 4.2 indicates that shielding practice in relation to pregnant patients is usually high and combined with other dose-saving measures. The trimester soundness and performance rub (materials/workload) is the reason why execution does not work well instead of intent and knowledge deficiency. This trend is largely supported by literature, which focuses on ALARA and gestational sensitivity and has formalized procedures, whereas our findings seem more convincing than other published reports that reported actual deficits, probably due to local training focus and rigidity of protocol in those facilities.

Table 4.3 shows that the general compliance with dose-reduction methods was high (grand mean = 3.98). The most commonly observed behaviors were avoidance of repeat exposures (Mean = 4.4) and proper collimation (Mean = 4.1) with the next being reduced exposure factors (kVp/mAs) (Mean = 4.2). Two areas followed: use of pregnancy-specific protocols (Mean = 3.5), which, though accepted by the decision rule ([?] 3.0), were less powerful than the others, followed and considering alternative modalities first (e.g., ultrasound) (Mean = 3.7).

As Table 4.3 indicates, the technique profile indicates respondents value operator dependent, at the console actions that directly narrow dose without reducing diagnostic objectives, namely, preventing repeats, tight collimation, and exposure factor moderation. The fact that the mean on avoiding repeats (4.4) is very high means that there is high procedure discipline concerning first-time-right imaging: attentive positioning, immobilization and pre-exposure checks that do not waste time on retakes. The latter is naturally combined with collimation (4.1), which reduces the scatter to the gravid uterus and enhances the contrast in the image that is useful in preventing repeats in the first place. The strong result in the reduction of kVp/mAs (4.2) suggests that the respondents feel comfortable in lowering technique factors when it is clinically safe, which is probably supported by the current receptor sensitivity and post-processing.

In comparison, the middle range score of the consideration of ultrasound as the first option and the minimal score of pregnancy-specific protocols (3.7 and 3.5, respectively) show the areas of practice that are more system-dependent than are operator-dependent. The choice in favor of the non-ionizing modalities depends on referral paths, equipment availability, availability at the bedside in emergencies, and the agreement with clinicians, which is outside the control of the radiographer. Likewise, pregnancy-specific protocols require departmental authorship, formal adoption, and ongoing audit; even motivated staff can only partially compensate if such protocols are absent, inconsistent, or not integrated into the RIS/console presets. These findings dovetail with compliance influences in Table 4.4 notably materials/logistics (Mean = 3.8) and workload (3.6) which often determine whether the ideal pathway (ultrasound first, adapted protocol) can be executed under real-world pressures.

Clinically, this pattern is coherent. In many plain-film scenarios where pregnancy is incidentally present or the anatomy of interest is remote from the uterus, the fastest, safest wins come from collimation, exposure moderation, and no retakes. The “ultrasound-first” ethos is most applicable where sonography can answer the question with equivalent or better diagnostic yield (e.g., many abdominal/pelvic queries); when the indication is inherently radiographic (e.g., certain extremity or chest assessments with specific clinical demands), the pathway to ultrasound may be less direct. Thus, the operator-level techniques outperform the system-level pathway changes in our data, which is exactly what Table 4.3 reflects.

Our results agree with Picone et al. (2023) on the centrality of ALARA bundles—tight collimation, parameter optimization, and minimizing repeats—and their emphasis on multidisciplinary pathways (including ultrasound preference) explains why system-level items (ultrasound-first, formal pregnancy protocols) scored lower than console-level behaviors here. They also align with Kim & Boyd (2022), who highlight gestational radiosensitivity and common practice gaps tied to repeats and shielding discipline; the very high mean for avoiding repeats in Table 4.3 shows our respondents are actively mitigating a well-documented risk driver. Conversely, our relatively moderate uptake of ultrasound-first (3.7) and pregnancy-specific protocols (3.5) is less favorable than the standard envisioned by Picone et al. (2023) and the training-driven pathway adaptation advocated by Applegate et al. (2021), who warned that protocol drift and limited pregnancy-specific training can lead to unjustified exposures. Finally, while Vidovich & Gilchrist (2013) observed that technology's dose-saving features are often under-utilized in practice, our high scores for exposure moderation and collimation suggest better real-world execution in these centers though the protocolization gap they'd caution about is visible in our lowest-scoring item.

As evidenced in Table 4.3, respondents strongly apply operator-centric dose-reduction techniques (no repeats, collimation, exposure moderation). The comparatively lower means for ultrasound-first and pregnancy-specific protocols pinpoint system and pathway gaps areas best addressed through formal protocol development, inter-departmental referral agreements, and periodic pregnancy-focused training/audit. Literature largely supports this pattern, while also challenging the system to close the protocolization and modality-triage gaps.

According to Table 4.4, overall compliance-related factors were rated high (grand mean = 3.80). The strongest enablers were confidence in knowledge of fetal radiation risks (Mean =

4.0) and adequate training on radiation protection during pregnancy (Mean = 3.9). Other important influences included availability of shielding materials (Mean = 3.8) and clear hospital policies (Mean = 3.7). The lowest-rated factor was high workload affecting compliance (Mean = 3.6), which, although accepted, indicates a practical barrier to consistent practice.

Table 4.4 reveals a trend according to which knowledge and training are the core of compliance. Radiographers that are sure about their knowledge of fetal radiosensitivity and dose-risk associations tend to implement protective actions in their day-to-day work. This is consistent with the high means of practice observed in shielding (Table 4.2) as well as dose-reduction (Table 4.3) indicating that cognitive confidence is reflected in behavior. The high weight of appropriate training (3.9) demonstrates the importance of systematically designed CPD (continuing professional development) and in-service training, as it does not only support the principles of ALARA but also makes them more applicable to local workflow. The implication is that training seems to fill this gap between theory and practice and makes radiographers not only aware of the safety guidelines to follow but also in a position to apply them when faced with clinical pressure.

The infrastructural and institutional support of compliance is shown by material availability (3.8) and the clarity of the hospital policy (3.7). Radiographers can be encouraged to take care of the patients, yet, unless shielding equipment is adequate or the instructions are clear, intentions cannot always turn into the regular actions. These aspects are also consistent with the barriers mentioned in Table 4.2 (shielding availability: 3.8) and Table 4.3 (protocol gaps:

3.5). This, in practice, implies that compliance cannot be reduced to individual will, but system support is also present. Lastly, there is the workload effect (3.6) which points out the operational difficulty: when the patient throughput is large, radiographers might omit or reduce the amount of protection taken not on the basis of negligence but as a result of time constraint and resource at their disposal. This demonstrates that the aspect of compliance is weak in high traffic situations where radiographers have to decide between speed and safety.

The results are in line with the study by Applegate et al. (2021), which also highlighted the inappropriate exposures related to the lack of specific training. Training and knowledge were also some of the most powerful enablers of compliance in this study, which is similar to Applegate et al. who argue that continuous learning and training specific to pregnancy are essential. On the same note, we find our findings to agree with those of Picone et al. (2023), who emphasized the importance of multidisciplinary compliance with ALARA and the fact that risk communication should be informed. The fact that clear hospital policies were present in our data (Mean = 3.7) demonstrates the same principle that safety is based on systematic systems and not individuals. On the other hand, workload barrier effect (3.6) is similar to the concerns of Vidovich and Gilchrist (2013), who discovered that the protection measures in practice cannot meet the complex procedural requirements. Though our respondents answered high intent and knowledge, workload pressures can be traced to the warning of the authors that technical feasibility should be equivalent to the operational one.

Knowledge and training have the greatest impact on compliance with radiation protection on pregnant patients, as illustrated in Table 4.4, though infrastructure, clear-cut policies and workload pressures moderate this effect. The results are mostly in line with international sources that emphasize the role of education and systemic support as the cornerstone of safe practice, as well as they introduce the situation-specific obstacle of workload, which continues to be a significant source of barrier in clinical settings.

CHAPTER FIVE

SUMMARY, CONCLUSION AND SUGGESTION FOR FURTHER STUDIES

5.1 Summary of Findings

This study investigated radiation protection practices for pregnant patients among radiographers at the University of Benin Teaching Hospital (UBTH). According to Table 4.1, the majority of respondents were male (78.1%), aged 26–30 years (35.9%), with 53.1% being interns and 46.9% full-time radiographers. Most had imaged a pregnant patient (87.5%). As shown in Table 4.2, radiation shielding practice was generally high (grand mean = 3.88), with the strongest adherence in routine use of lead shielding and shielding of the fetal region. However, shielding across all trimesters was less consistent. In Table 4.3, dose-reduction practices were highly rated (grand mean = 3.98), especially avoiding repeat exposures and proper collimation. Weaker areas included the use of pregnancy-specific protocols and preference for alternative modalities such as ultrasound. Table 4.4 indicated that compliance factors were strongly influenced by confidence in knowledge (Mean = 4.0) and adequate training (Mean = 3.9). Materials and clear hospital policies also supported adherence, while workload pressures (Mean = 3.6) were identified as barriers. Finally, hypothesis testing (Table 4.5) revealed no statistically significant difference in shielding practice among radiographers at university of Benin teaching hospital (78.1% good practice), $\chi^2 = 0.08$, df = 1, $p = 0.77$. This implies that radiation protection practices are broadly consistent among radiographers.

5.2 Conclusion

The results indicate that radiographers in university of Benin teaching hospital have good methods in radiography protection to pregnant patients especially in shielding effects, collimation and repetition avoidance. The most prominent enablers of compliance were training and knowledge, whereas workload or absence of pregnancy-specific guidelines were found to be the gaps. Notably, the radiographers at the hospital did not differ significantly, which indicated that protective practices are always put in use regardless of the tier of radiographers. The paper draws a conclusion that the level of baseline practice is high, but reinforcement of institutional policies and protocols may further increase compliance.

5.3 Recommendations

According to the results, the following recommendations are put forward:

1. Enhance pregnancy-specific procedures - Hospitals ought to create and implement written directives unique to imaging pregnant women, so that there is uniformity throughout the various trimesters.
2. Increase continuous professional development - Continuous professional training should be conducted regularly in the form of workshops and CPD sessions, where radiographers will be informed of the risk of the fetus, the concept of ALARA, and the international safety standards.
3. Enhance access to shielding materials - The departments are to make sure that there is a sufficient supply and easy access to well-fetched fetal and gonadal shields.
4. Promote multidisciplinary teams - Radiologists, obstetricians and radiographers must

collaborate in order to emphasize ultrasound and other non-ionizing modalities when necessary.

5. Overcome the barriers associated with workloads - The workload and manageable staffing levels must be streamlined to ease the pressure of time that might undermine protective actions.

5.4 Recommendations in Future Research.

1. Studies investigating the effects of training on radiographers in terms of real fetal dose in practice.
2. Comparisons between the knowledge, attitudes and practices of radiographers and those of other healthcare providers (e.g., radiologists, obstetricians).
3. Researches on patient awareness and perception of the radiation risks during pregnancy to supplement the views of radiographers.

5.5 Limitations of the Study

1. There might be bias in self-reported responses as the respondent might give socially desirable responses.
2. Direct dose measurement was not done, so the study was not able to objectively quantify fetal exposure, but relied on reported practices.
3. The sample size of University of Benin teaching hospital was utilized in this study because of the failure to achieve ethical approval of other radiographic centers in the region.

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APPENDIX I

QUESTIONNAIRE
DEPARTMENT OF RADIOGRAPHY
SCHOOL OF BASIC MEDICAL SCIENCES
UNIVERSITY OF BENIN, BENIN CITY, EDO STATE

Dear Respondent,

I am a student of University of Benin carrying out a research study on “**.”Evaluation of Radiation Protection Measures for Pregnant Patients Undergoing X-Rays at University of Benin Teaching Hospital.** Your co-operation is highly needed in answering the questions below, as this will enhance success of the study. All information given will be strictly confidential and used for the purpose of the study only.

Thanks for your co-operation.

Section A: Demographic Data

1. Age:

☐ 20–25 ☐ 26–30 ☐ 31–35 ☐ 36 and above

2. Gender:

☐ Male ☐ Female

3. Years of Experience as a Radiographer:

☐ Less than 1 year ☐ 1–3 years ☐ 4–6 years ☐ 7 years and above

4. Current Position

☐ Full time radiographer ☐ Intern radiographer

5. Have you ever imaged a pregnant patient for an X-ray examination?

☐ Yes ☐ No

Section B: Practice of Radiation Shielding during X-rays for Pregnant Patients

S/N	Statement	STRONGLY AGREE	AGREE	NEUTRAL	DISAGREE	STRONGLY DISAGREE
6	I routinely use lead shielding when imaging pregnant patients.					
7	My department provides adequate shielding					

	materials for pregnant patients.					
8	I apply shielding regardless of the pregnancy trimester.					
9	The fetal region is properly shielded in all applicable X-ray exams.					
10	Shielding protocols are strictly followed in my workplace.					

Section C: Use of Dose Reduction Techniques

(Please indicate your level of agreement with the following statements)

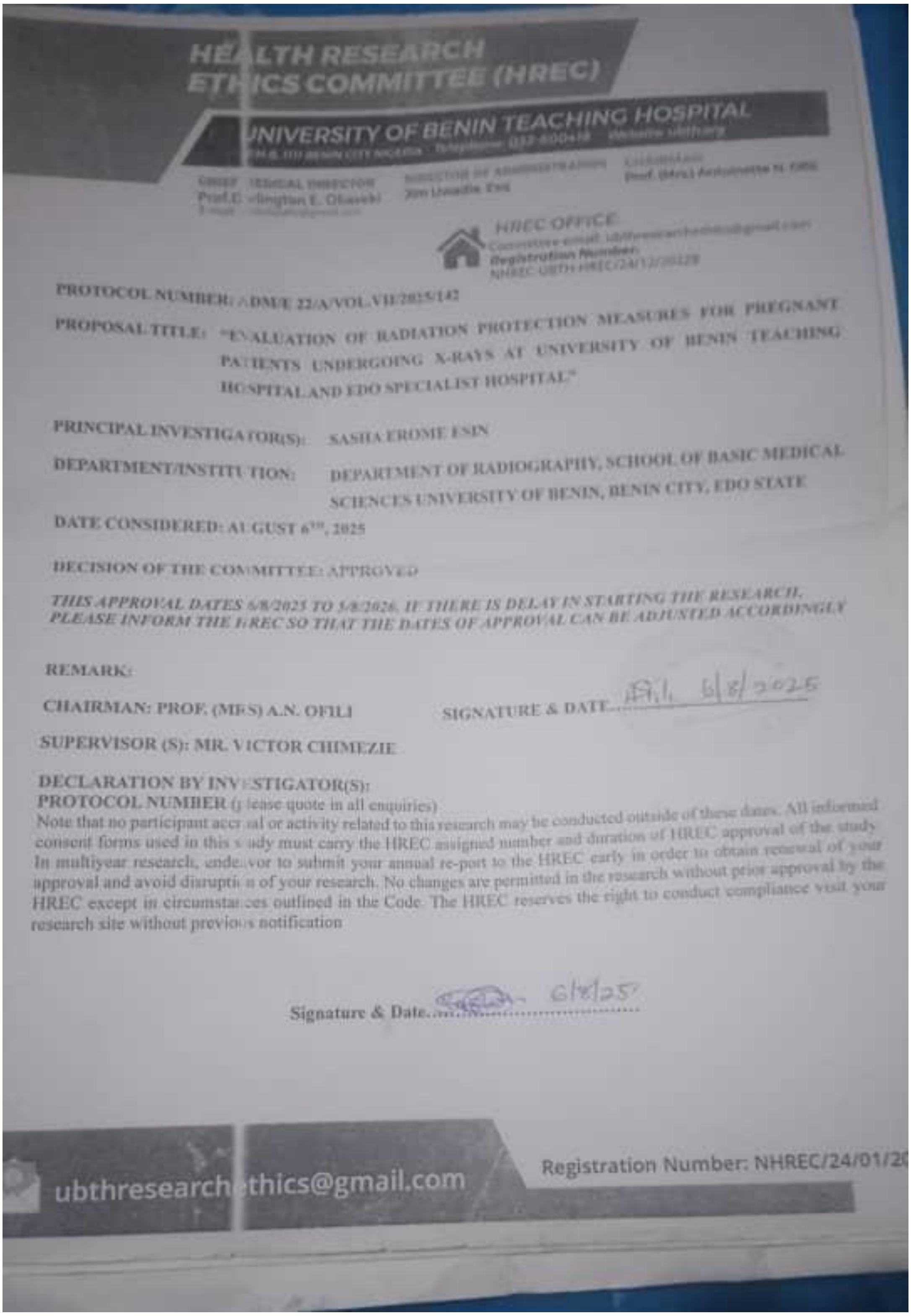
S/N	Statement	STRONGLY AGREE	AGREE	NEUTRAL	DISAGREE	STRONGLY DISAGREE
11	I reduce exposure factors (kVp, mAs) when imaging pregnant patients.					
12	I avoid repeating X-rays unless absolutely necessary for pregnant patients.					
13	I properly collimate the X-ray beam during imaging of pregnant women.					
14	I always consider alternative imaging					

	modalities (e.g., ultrasound) first.					
15	My department uses pregnancy-specific imaging protocols.					

Section D: Factors Influencing Compliance with Radiation Protection
(Please indicate your level of agreement with the following statements)

S/N	**Statement**	**STRONGLY AGREE**	**AGREE**	**NEUTRAL**	**DISAGREE**	**STRONGLY DISAGREE**
16	I have received adequate training on radiation protection during pregnancy.					
17	High workload affects my ability to comply with radiation safety guidelines.					
18	Lack of materials (e.g., shielding) sometimes limits compliance.					
19	There are clear hospital policies guiding radiation protection during pregnancy.					
20	I feel confident in my knowledge of fetal radiation risks.					

APPENDIX II



HEALTH RESEARCH
ETHICS COMMITTEE (HREC)

UNIVERSITY OF BENIN TEACHING HOSPITAL

CHIEF MEDICAL DIRECTOR
Prof. Darlington E. Obaseki

HREC OFFICE

PROTOCOL NUMBER: ADM/E 22/A/VOL.VII/2025/142

PROPOSAL TITLE: "EVALUATION OF RADIATION PROTECTION MEASURES FOR PREGNANT PATIENTS UNDERGOING X-RAYS AT UNIVERSITY OF BENIN TEACHING HOSPITAL AND EDO SPECIALIST HOSPITAL"

PRINCIPAL INVESTIGATOR(S): SASHA EROME ESIN

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

DATE CONSIDERED: AUGUST 6TH, 2025

DECISION OF THE COMMITTEE: APPROVED

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

REMARK:

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

SUPERVISOR (S): MR. VICTOR CHIMEZIE

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 6/8/25

ubthresearchethics@gmail.com Registration Number: NHREC/24/01/2