ASSESSMENT OF RADIOLOGY STAFF'S KNOWLEDGE ON RADIATION HAZARDS AND PROTECTION MEASURES IN THE PORT HARCOURT DEPARTMENT OF RADIOLOGY, NIGERIA

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Abstract— **While radiology staff work in an environment with ionizing radiation, comprehensive safety protocols and effective protective equipment are crucial in mitigating these risks. These measures include administrative controls, engineering controls, personal protective equipment, continuous education and training, and regular monitoring to ensure radiation exposure is kept as low as reasonably achievable (ALARA). To evaluate the level of knowledge and practice of radiation hazards and radiation protection among radiology staff in Port Harcourt, Nigeria, with the goal of identifying areas for improvement in safety practices. A cross-sectional survey was conducted among 179 radiology staff, including 65 medical doctors (radiologists), 12 nurses, 47 radiographers, and 55 other personnel. All 179 participants returned the survey, providing a 100% response rate. Participants completed a questionnaire consisting of 22 questions covering demographic information, awareness of radiation risks, radiation protection practices, regulatory knowledge, understanding of fluoroscopy units, training and education, radiation protection principles, quality assurance practices, radiation sensitivity awareness, knowledge of radiation effects, familiarity with radiation safety equipment, purpose of radiation dose administration, and understanding of optimizing radiation dose. The survey revealed that 82.1% of the staff understand the risks associated with radiation exposure in diagnostic radiology. All 179 participants (100%) attended a basic lecture on radiation exposure. However, significant gaps were found in regulatory knowledge, as only 88.3% of the staff were aware that Nigeria Nuclear Regulatory Authority (NNRA) approval is required for a machine to dispense radiation. This study emphasizes the need for continuous education and training programs tailored to the specific needs of radiology staff. Addressing these knowledge gaps and improving safety practices can enhance the overall safety and well-being of radiology staff in Port Harcourt, ultimately contributing to better patient care and outcomes.**

Keywords— **Radiation hazards, Radiation protection, Radiology staff, Knowledge assessment, Port Harcourt.**

I. INTRODUCTION

X-ray imaging is a cornerstone of medical diagnosis, but it involves exposure to ionizing radiation, which can damage tissues and potentially lead to cancer. Proper knowledge of radiation hazards and protection measures is crucial for radiology staff like radiologists, radiographers, medical Physicists and nurses [1]. Despite regulations by the Nigeria Nuclear Regulatory Agency (NNRA), studies suggest gaps in radiology staff's knowledge about radiation risks. This research aims to assess the knowledge of staff at the Port Harcourt Department of Radiology regarding radiation hazards and protection measures [2]. By identifying areas for improvement, this study seeks to enhance radiation safety practices in the department. This can lead to better patient care by minimizing radiation exposure for both patients and healthcare workers. The use of X-rays comes with inherent risks, particularly due to their ionizing nature, which can cause damage to living tissues [3, 4]. The ionizing radiation has the potential to cause cellular damage, including DNA mutations that can lead to cancer [5, 6]. The linear no-threshold (LNT) model, which is widely accepted in radiation protection, suggests that any dose of radiation, no matter how small, carries a corresponding risk of cancer [8, 9]. This model forms the basis for radiation protection standards, guiding efforts to minimize radiation exposure.

Optimizing radiation dose is essential in radiology to minimize the risks associated with radiation exposure while ensuring that diagnostically acceptable images are obtained [8]. This principle, known as ALARA (As Low As Reasonably Achievable), guides radiology professionals in balancing the need for diagnostic information with the potential risks of radiation exposure [9, 10]. Abuzaid emphasizes the ALARA principle for radiation protection which aligns with the methodology of ensuring patient safety and complements focus on proper practices. Justification of radiological procedures is equally important, ensuring that the benefits of the procedure outweigh the risks for the individual patient [11]. The International Atomic Energy Agency (IAEA) emphasizes the need for strong radiation safety regulations.

Despite the efforts of regulatory bodies such as the Nigeria Nuclear Regulatory Agency (NNRA), studies have indicated gaps in the knowledge of radiology staff regarding radiation hazards and protection [12] &13). Existing surveys might not be tailored to the specific protocols, equipment, and regulations used in the Port Harcourt Department of Radiology. A new survey can be designed to target these specific aspects, ensuring a more accurate assessment of the staff's knowledge about radiation hazards and protection measures relevant to their daily practice [14, 15]. This study aims to contribute to the ongoing efforts to enhance radiation safety in radiology by assessing the knowledge of radiology staff and identifying areas for improvement.

Through education, training, and continued research, the field of radiology can continue to advance while ensuring the safety of patients and healthcare workers.

II. METHODOLOGY

Questionnaire Design and Administration

The survey instrument (included as supplementary material) comprised 22 questions, the four demographic questions are Multiple Choice Questions (MCQ) and more than four answer options. The first four questions collected demographic data such as age, gender, and professional experience of the participants. The following 15 multiple-choice questions (MCQs) with four answer options focused on evaluating participants' understanding and application of radiation protection principles. One subjective that probe into understanding of ALARA Principle. One MCQ with six answer options to tick as appropriate concerning the biological effects of ionizing radiation and one MCQ with three answer options on knowledge of the fluoroscopic system. These MCQs covered various aspects of radiation safety, including Biological effects of ionizing radiation, Radiation protection principles (e.g., justification, optimization, dose limitation), Safe operating procedures for X-ray equipment, Use of personal protective equipment (PPE).

The survey was reviewed by radiation safety experts and radiology professionals to ensure its content accurately reflects current practices and targets relevant knowledge areas. A pilot test with a small sample group helped refine the survey for clarity and comprehensiveness. The survey was distributed to a diverse group of participants within the Department of Radiology, including Radiologists, Medical physicists, Radiographers, Radiology technologists, Residents and Students.

Google Forms was chosen for its user-friendly interface and efficient data collection capabilities. The survey link was electronically distributed to the target population. An informed consent statement explained the study's purpose and assured participants of anonymity and confidentiality. Participation was voluntary, and responses did not affect professional standing.

Ethical Considerations

The study adhered to the ethical guidelines of the University of Port Harcourt Teaching Hospital. Measures were implemented to ensure responses were anonymous and confidential.

Data Collection Details

Data collection spanned from 1st November 2023 to 29th February 2024, providing a thorough assessment period. The department comprises a multidisciplinary team including radiologists, nurses, radiographers, medical physicists, radiologic technologists, and residents. Participants received the survey link through departmental platforms, emails, and WhatsApp messages. Additionally, the principal investigator conducted a hardcopy questionnaire survey, overseeing participants as they completed it. Each correct answer was awarded a score of "1," with no negative marking for incorrect responses.

Data Analysis Software

The data was entered into Python software, using Visual Studio Code, for analysis. A descriptive analysis was conducted, along with relevant statistical tests to ascertain the level of knowledge regarding radiation protection among the participants. The knowledge levels were categorized based on the percentage of correct responses: inadequate (<60%), adequate (60–80%), and excellent (80–100%). Tocompute the p- value and determine the statistical significance using Python, scipy.stats module was used to perform a Chi-square test'. For statistically significant findings from the Kruskal-Wallis H-test, a pairwise post-hoc test with Bonferroni correction was applied. A p-value ≤ 0.05 was considered statistically significant.

III. RESULTS

There's near-equal representation with 53.1% female and 46.9% male staff. A significant portion (53.1%) falls within the 30-39 age group, indicating a core of staff in their prime working years. The presence of staff in the 20-29 (23.5%) and 40-49 (23.5%) age brackets suggests a healthy mix of experience and new talent. Notably, there are currently no staff aged 50-59 or 60-69. Nearly half (46.9%) of the staff have 1-5 years of experience, highlighting a substantial number of early-career professionals. The remaining workforce is spread across experience levels with 29.1% (6-10 years), 17.9% (11-15 years), and a smaller group with 16-20 years of experience.

On knowledge of radiation exposure risks in diagnostic radiology, the results showed in table 2, that 41.3% of respondents of the question “The ways to reduce the risk of radiation exposure for patients in the radiology department” recognized the importance of reducing the time spent performing x-ray procedures. This understanding aligns with the "as low as reasonably achievable" (ALARA) principle, emphasizing the importance of minimizing radiation exposure time to reduce risks. Furthermore, 53.1% of participants acknowledged the main goal of optimizing radiation dose in radiology and as well as listing the three principles of radiation protection in the correct order. Assess knowledge of departmental practices for dose optimization, such as: “What is the main goal of optimizing radiation dose in radiology” this question highlights potential knowledge gaps in implementing dose optimization within the Port Harcourt Radiology departmental workflow. The finding that 53.1% of respondents correctly identified the order of radiation protection principles (Time- Distance-Shielding) is a positive indicator. This demonstrates a foundational understanding of minimizing radiation exposure. However, the remaining 46.9% who provided incorrect responses (25% Distance-Shielding-Time, 11.8% Distance-Time-Shielding, and 11.8% Shielding-Time- Distance) reveal a crucial knowledge gap. This will foster a culture of safety that prioritizes staff well-being while maintaining optimal image quality for patient care.

Table1: Demographic Characteristics

Serial Number	Demographic Characteristics	Frequency	Percentage (%)
	Gender		
1	Male	84	46.9
2	Female	95	53.1
	Age Groups (In years)		
3	20 – 29	42	23.5
4	30 – 39	95	53.1
5	40 – 49	42	23.5
	Work Experience (In years)		
6	1 – 5	84	46.9
7	6 – 10	52	29.1
8	11 – 15	32	17.9
9	16 – 20	11	6.1
	Job Title		
10	Radiologists	65	36.3
11	Radiographers	47	26.3
12	Nurses	12	6.7
13	Medical Physicists	4	2.2
14	Technologists	15	8.4
15	Health Assistants	36	20.1

Additionally, 53.1% of respondents recognized the thickness of the mobile Protective Barrier (MPB) used in the x-ray room. emphasizes the importance of integrating knowledge into daily practices. Standardized departmental protocols and clear visual signage in the X- ray room serve as constant reminders and reinforce the crucial role of the MPB in radiation safety. This ongoing reinforcement strengthens staff's understanding and promotes consistent application of best practices. The finding that 64.8% of respondents correctly identified pregnant women as the most radiation-sensitive patients demonstrates a good understanding of a critical principle. However, the remaining 35.2% who selected other options (presumably children) highlight a potential knowledge gap that requires a more clinically innovative approach. While recognizing pregnant women's vulnerability is crucial, true innovation lies in risk stratification for different patient populations. This will ultimately lead to a more individualized and risk-stratified approach to patient care.

The finding that 88.3% of respondents correctly identified DNA damage as an effect of radiation exposure in the question "What are some of the effects of ionizing radiation that you are aware of?" demonstrates a good understanding of long-term carcinogenic risks. However, the lower percentages for other effects, particularly regarding acute effects, reveal a potential knowledge gap.

The finding that 53.1% of respondents indicated situational awareness regarding lead apron usage is a positive sign. However, a significant portion (29.4% sometimes, 11.8% never) demonstrates a need for clearer guidelines and training on appropriate lead apron use in various scenarios.

The finding that a significant majority (70.4%) of respondents reported never wearing both thyroid collars and lead eye glasses reveals a critical gap in radiation protection practices This has significant clinical implications for both staff and patient safety. Thyroid and eye tissues are particularly susceptible to radiation exposure. Consistent non-use of these protective measures significantly increases staff's risk of developing thyroid and eye cancers over time. Abuzaid's findings on areas where adherence might be lower (e.g., thyroid collar usage) due to factors like increased workload or PPE shortages [18].

The high percentage (93.9%) of staff reporting consistent TLD use indicates a strong understanding of their basic function – monitoring radiation exposure. This adherence is crucial for ensuring staff safety and adheres to established radiation protection protocols. However, the additional information that 6.1% reported sometimes wearing TLDs suggests a potential gap in understanding. This might indicate:

Lack of knowledge on proper TLD wear during specific procedures and misconceptions about the importance of consistent data collection for accurate exposure assessment. This gap is addressed by exploring staff understanding of TLD data interpretation.

Results showed that the majority of respondents (88.3%) were aware that NNRA approval is required for a machine to dispense radiation. This indicates a high level of awareness among radiology staff regarding the regulatory process for radiation- emitting machines. However, 11.7% of respondents incorrectly believed that only machines that produce radiation require approval from the NNRA. This misconception highlights the need for further education and clarification regarding the regulatory requirements for all machines that dispense radiation, including those used in diagnostic and therapeutic radiology.

Understanding the type of fluoroscopy unit in use is crucial for optimizing its operation and ensuring safety. In this study, participants were asked about the type of fluoroscopy unit in their institution, specifically whether it is an under-couch or over-couch C-arm system.

This research sheds light on a potential knowledge gap regarding staff familiarity with the specific type of fluoroscopy unit used in their department. While the majority (74.9%) reported using an over-couch C-arm system, a significant portion (18.8%) used an under-couch system, and a concerning 6.2% were unsure of the type altogether.

These findings reveal an opportunity to enhance staff knowledge and optimize radiation safety practices: The research can advocate for clear and consistent labeling of fluoroscopy units within the department. This can be achieved through signage or visual identification markers to ensure staff are always aware of the specific system type they are using. Develop training protocols that are tailored to the specific type of C-arm system used in the department. This ensures staff receive proper instruction on safe positioning techniques and radiation protection considerations relevant to the unit's design (over-couch vs. under-couch exposure).Create a platform (online forum, knowledge base) where staff can share experiences and best practices for specific C-arm systems. This fosters a culture of continuous learning and knowledge exchange, addressing any lingering uncertainties about the equipment used in daily practice

While the finding that 100% of respondents attended a basic radiation exposure lecture demonstrates a commitment to staff education, it doesn't necessarily address a knowledge gap. The 100% attendance rate for the basic radiation exposure lecture indicates a positive trend in staff training. However, it doesn't guarantee complete knowledge retention or preparedness for all radiation safety scenarios encountered in daily practice. Implementing follow-up assessments or knowledge retention tests to gauge staff comprehension of the fundamental radiation safety principles covered in the lecture will yield optimum result. This can help staff apply their theoretical knowledge to practical situations.

The results showed that 88.3% of respondents identified the main justification for administering a radiation dose in radiology as visualizing the anatomy and pathology of the body. This aligns with the primary goal of diagnostic radiology, which is to obtain detailed images for accurate diagnosis and treatment planning. In contrast, 11.8% of respondents incorrectly believed that the main justification was to destroy cancer cells, highlighting a potential misunderstanding of the role of diagnostic radiology in cancer treatment.

Regarding the optimization of radiation dose, 52.9% of respondents identified the main goal as improving image quality. This is crucial for obtaining clear and detailed images for accurate diagnosis while minimizing radiation exposure. Additionally, 47.1% identified the main goal as reducing the risk of radiation-induced cancer, demonstrating an understanding of the importance of minimizing radiation exposure to patients and healthcare workers.

When asked about the main purpose of wearing a Thermoluminescent Dosimeter (TLD), 94.1% of respondents correctly identified it as measuring the amount of radiation exposure. This is essential for monitoring and controlling radiation exposure levels among radiology staff.

Furthermore, 93.9% of respondents correctly identified the purpose of periodic quality assurance tests of x-ray equipment as being useful for maintaining the quality of equipment and ensuring safe operation. These findings highlight the importance of continuous education and training to ensure that radiology staff understand and adhere to best practices for radiation dose administration and optimization.

Finally, when asked about the primary purpose of a Geiger counter in the radiology department, 64.8% correctly identified it as measuring radiation dose. This is essential for monitoring radiation levels in the environment and ensuring safe practices in radiology departments.

IV. DISCUSSION

The staff's demographic distribution underscores the need for continuous education and training to ensure that all staff are well-prepared to handle the challenges of radiological practices (16). Awareness of radiation risks among radiology staff is crucial for safe practices (17). A significant finding is that 82.1% of staff understand the risk of cancer associated with radiation exposure in diagnostic radiology, which is adequate and in agreement with Assiri et al.2020(18). This high level of awareness is promising but further underscores the need for ongoing education and training to maintain and enhance safety practices in the field. These findings indicate a satisfactory level of awareness among radiology staff regarding strategies to reduce radiation exposure for patients. However, continuous education and reinforcement of these principles are essential to ensure consistent adherence to best practices in radiation protection. Effective radiation protection practices are essential for ensuring the safety of both patients and healthcare workers in radiology departments (19). This study aimed to assess the adherence of radiology staff to key radiation protection practices, including the consistent use of lead aprons, thyroid collars, lead eyeglasses, and radiation dosimeters (TLDs). The findings are inadequate and in agreement with. Khamtuikrua, and Suksompong, (2020) study, highlighting the need for increased awareness and education regarding the importance of wearing lead aprons consistently to minimize radiation exposure (20). The Nigerian Nuclear Regulatory Authority (NNRA) mandates approval for machines dispensing radiation to ensure safety. Compliance with NNRA regulations is crucial for radiology departments.

The NNRA requires approval for all radiation-dispensing machines, not just those producing radiation. Proper use of personal protective equipment (PPE), including lead aprons, thyroid collars, and lead eyeglasses, is essential. Compliance with these regulations is necessary to minimize radiation exposure risks and ensure the safety of both patients and healthcare workers. Ongoing education and training are excellent and vital and in an agreement with Mngxekeza, (2019) study, to ensure that radiology staff are aware of and adhere to NNRA regulations, promoting a culture of safety and regulatory compliance within radiology departments (21).

As stated in the International Commission on Radiological Protection (ICRP) publication, The primary purpose of radiological protection is to provide a high level of protection for man and the environment against the harmful effects of ionizing radiation. Fluoroscopy units are essential in diagnostic radiology for real-time imaging procedures. The findings shows knowledge score of adequate indicating staffs awareness towards radiation safety which is also in agreement with the study of Hayashi et al(2021)

V. LIMITATIONS OF THE STUDY

The limitations of this study include the potential for response bias as participants may have provided answers, they deemed socially desirable (23). This study is susceptible to response bias, similar to Abuzaid et al. (2022). Participants might report practices that are considered ideal rather than their actual behavior.

The single-institution design limits generalizability of findings to other radiology departments in Port Harcourt or Nigeria as a whole. The use of self-reported data could introduce recall bias, as participants may not accurately remember past training or experiences (22). This study assesses knowledge but doesn't directly measure actual adherence to safety protocols during radiology procedures. Despite these limitations, this study provides valuable insights into the knowledge of radiation hazards and protection among radiology staff, highlighting areas for improvement in radiation safety practices. Future studies could benefit from longitudinal designs and multi- center collaborations to enhance the generalizability and validity of the findings.

VI. CONCLUSION

In conclusion, this study identified varying levels of knowledge on radiation hazards and protection measures among radiology staff at the institution. While overall awareness seems adequate, specific areas like proper use of lead aprons and thyroid collars require improvement. These findings highlight the critical need for continuous education.

Regularly conducting training programs can enhance radiation safety practices among radiology professionals. These programs should address identified knowledge gaps, such as the importance and proper use of personal protective equipment (PPE) like lead aprons and thyroid collars. Implementing regular audits and quality assurance measures can ensure consistent adherence to established safety protocols within the department. Building on this study, future research could evaluate the effectiveness of training interventions. This would involve implementing targeted training programs and measuring their impact on staff knowledge and adherence to safety protocols.

Supplementing self-reported data with direct observation of practices during radiology procedures could provide a more holistic picture of adherence to safety measures.

Then future studies could involve multiple institutions in Port Harcourt or across Nigeria to enhance the generalizability of findings.

VII. ETHICAL STATEMENT

Hereby, I, Igoniye Williams consciously assure that for the manuscript /insert title/ the following is fulfilled:

1) This material is the authors' ownoriginal work,

which has not been previously published elsewhere.

2) The paper is not currently beingconsidered for publication elsewhere.

3) The paper reflects the authors' own research and analysis in a truthful and complete manner.

4) The paper properly credits the meaningful contributions of coauthors and co- researchers.

5) The results are appropriately placed in the context of prior and existing research.

6) All sources used are properly disclosed (correct citation). Literally copying of text must be indicated as such by using quotation marks and giving proper reference.

7) All authors have been personally and actively involved in substantial work leading to the paper and will take public responsibility for its content.

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