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Radiation Safety Awareness Among Nurses: Understanding Ionizing and Non-Ionizing Hazards in Clinical Practice

Asma Rehman[1], Dr.Urfa Mudassar[2], Omama Jawed[3], Saba Ashraf[4], Dr. Sunia Hameed[5], Sidra bukhari[6], Muhammad Junaid Iqbal[7], Aqsa Majeed[8]

[1]Senior Lecturer, Department of Medical Imaging Technology, Riphah International University, Islamabad, Pakistan, Asmarehman.61101@gmail.com

[2]Consultant Radiologist, Mukhtar A Sheikh Hospital Multanurfamudassar@gmail.com

[3]Academic coordinator, Dow Institute of Health Professionals Education, Dow University of Health Sciences, Jawedomama@gmail.com

[4]Assistant Professor, Medical imaging technology, college of allied health sciences Bakhtawar amin medical and dental college, Multan, sabaashraf031@gmail.com

[5]Consultant Radiologist, Mukhtar A Sheikh Hospital Multan, suniaomar@gmail.com

[6]Lecturer, Allied health college Bakhtawar Amin medical and dental college Multan, sidrabukhari123.sb@gmail.com

[7]Team Lead imaging services, Radiation Protection Officer, Mukhtar A Sheikh Hospital Multan, muhammad.junaid427@gmail.com

[8]Lecturer, University of Lahore, aqsa.majeed@uipt.uol.edu.pk

ABSTRACT

Introduction: *Radiology is essential in healthcare for accurate diagnoses, but exposure to radiation can lead to both stochastic and deterministic adverse effects. Medical exposure is the primary source of ionizing radiation. Therefore, it is critical for nursing staff working in radiation areas to be well-informed about radiation hazards and protection. This study aims to assess the awareness and practices regarding radiation hazards and safety measures among nurses working in departments with potential radiation exposure.*

Material and Methods: *A cross-sectional study was conducted using a validated questionnaire consisting of three parts: general information, radiation hazards and protection measures, and radiation knowledge. The questionnaire was distributed to nursing staff working in radiation-exposed areas at a tertiary care hospital in Islamabad.*

Results and Discussion: *Of the 300 respondents, 43.7% were male and 56.3% female. Most nurses (67.4%) held diplomas, and 41.5% were exposed to radiation several times a day. A significant portion (65.2%) had never attended any radiation training. The majority (59.2%) were aware of radiation protection measures, but 76.3% were unaware of pocket dosimeters, and 54.8% lacked knowledge of radiation protection principles like ALARA. Additionally, 57.7% could not differentiate between ionizing and non-ionizing radiation. These gaps in knowledge highlight the need for radiation safety training.*

Conclusion: *The study reveals that most nurses in radiation-exposed areas have inadequate knowledge of radiation hazards and protection. Regular training, workshops, and continuing education programs are essential to improve awareness and safety practices.*

Key Words: *Radiation Safety, Ionizing Radiation, Non-Ionizing Radiation, Nurses, Radiation Protection.*

INTRODUCTION

Ionizing radiation, a high-frequency electromagnetic wave, can damage DNA in living cells, leading to both stochastic and deterministic effects(1). Deterministic damage occurs when exposure exceeds established thresholds, resulting in conditions such as cataracts, skin erythema, and radiation burns, while stochastic damage, associated with higher doses, is linked to infertility, genetic mutations, and various cancers (2). Despite these significant risks, ionizing radiation continues to play a crucial role in medical diagnostics and therapeutic interventions. Its widespread application in imaging and treatment makes awareness of its hazards even more essential. However, while public awareness of radiation risks has increased over time, the fundamental principles of radiation protection, such as those outlined by the ALARA (As Low As Reasonably Achievable) principle, are often underutilized in clinical settings(3).

Healthcare professionals, especially nurses, are often exposed to radiation during their routine clinical duties, yet their knowledge of radiation safety measures is frequently inadequate(4). Nurses routinely assist in mobile X-ray procedures, helping to obtain radiographs while being aware of patient conditions, which places them in direct proximity to radiation sources. This makes their role critical in ensuring high-quality imaging and minimizing radiation exposure to both themselves and patients(5). Although most nurses'

radiation exposure levels are typically below permissible limits, it is essential to acknowledge and address any concerns about radiation exposure to maintain safe clinical practices(6, 7). The core principles of radiation protection—distance, duration, and shielding—are essential in minimizing the risks of radiation. Increasing the distance from the radiation source reduces the dose, while reducing the duration of exposure decreases the potential harm. Shielding further helps in minimizing radiation exposure by blocking or diverting the radiation (8).

Given the prevalence of X-ray procedures in clinical practice, it is crucial to assess the current levels of radiation safety knowledge among nursing staff to identify any existing gaps and ensure that they are adequately equipped to protect themselves and their patients. Understanding the absorbed dose, its effects, and associated risks is vital, as future estimates suggest that clinical radiation exposure may contribute to 1.5-2% of all cancers in the U.S. (9). Moreover, studies indicate a significant lack of awareness about radiation hazards among healthcare students in Pakistan(10), highlighting the need for more comprehensive education on radiation safety. Adequate and ongoing training programs in radiation protection should be an integral part of professional development for all healthcare workers involved in radiation-exposed areas (11). While clinical imaging is vital for diagnosing diseases and guiding treatment, it also poses potential risks that must be managed effectively through proper safety measures (12).

Nurses, as key players in radiology departments, are required to have a solid understanding of radiation risks and protective measures to safeguard both themselves and their patients (13). Additionally, special attention must be given to children, who are particularly vulnerable to the effects of radiation. Ensuring heightened awareness and protection measures for pediatric patients is essential (14, 15). This study aims to assess the awareness and practices regarding radiation hazards and safety measures among nurses working in various departments of a tertiary care hospital in Islamabad. It will also evaluate the need for further training and continuing education programs to enhance radiation safety practices in clinical settings, ultimately contributing to improved patient care and worker safety.

METHODOLOGY

An analytical cross-sectional design was employed to collect data from nursing staff working in radiation-exposed areas at a tertiary care private hospital in Islamabad. The study was conducted following approval from the Institutional Review Board (IRB). The recommended sample size of 300 was calculated using the WHO sample size calculator. The inclusion criteria for the study were: nursing staff working directly in areas where they are potentially exposed to ionizing or non-ionizing radiation, such as radiology, emergency, intensive care, and operating rooms. Nurses who were part-time, on leave during the study period, or working in non-radiation areas were excluded from the study(16). Additionally, those with less than one year of experience in their current department or those who had no direct exposure to radiation were excluded, ensuring that participants had adequate exposure to radiation and were relevant to the research.

Data collection was facilitated through a self-designed survey questionnaire, which included questions adapted from existing literature on radiation safety among healthcare workers. The questionnaire was based on studies by Eric Jones, Kathleen Mathieson, and other research on the knowledge and use of protective equipment among healthcare workers exposed to radiation. The survey was structured to assess both awareness of radiation hazards and practices related to radiation protection.

Statistical analysis was performed using SPSS version 21. Descriptive statistics were used to summarize demographic characteristics, while inferential statistics were applied to examine associations between variables. A confidence level of 95% and a significance level (alpha) of 5% were maintained throughout the analysis.

RESULTS

Demographic and Professional Characteristics

The demographic data revealed that the majority of respondents were female (56%) with a significant portion (44%) being male. Most of the nurses were in the 20-30 years age group, making up 91% of the sample. In terms of professional experience, a substantial 76% of nurses reported having less than 3 years of experience, reflecting a relatively young workforce. Regarding educational background, 67% held a diploma in nursing, while 20% had a BSc, and 11% had a BS. A notable proportion of nurses worked in high-exposure areas such as the emergency department (42%) and wards (38%), highlighting their

potential exposure to radiation. When asked about the frequency of radiation exposure, 42% of nurses reported being exposed to radiation several times a day. However, 65% indicated they had never received additional training in radiation safety, which points to a gap in specialized education regarding radiation protection. (Table No 1)

Table No 1. Demographic Variables

Variable	Catergories	Percentge
Gender	**Male**	(44%)
	Female	(56%)
Age	**20 to 30 years**	(91%)
	31 to 40 years	(8%)
	41 to 50 years	(0%)
	51 to 60 years	(0%)
	Above 60 years	(0%)
Experience	**< 3 years**	(76%)
	4 to 10 years	(23%)
	11-20 years	(1%)
	> 20 years	(0%)
Education	**Certificate**	(2%)
	Diploma	(67%)
	BSc	(20%)
	BS	(11%)
	MS	(0%)
Work Area	**IR**	(10%)
	Cath lab	(5%)
	Emergency	(42%)
	Wards	(38%)
	Radiation oncology	(5%)
Exposure Frequency	**None**	(17%)
	Several times a month	(19%)
	Several times a week	(22%)
	Several times a day	(42 %)
Additional Training	**Seldom**	(21%)
	Frequently	(14%)
	Never	(65%)

Awareness of Radiation Hazards and Safety Measures

Regarding the awareness of radiation hazards, an overwhelming 96% of nurses acknowledged that X-rays could cause harmful effects. This strong recognition of the risks was also reflected in their understanding of radiation protection measures. Sixty percent of nurses were aware of all major protective measures, such as the use of lead aprons, shields, maintaining distance from radiation sources, and limiting exposure time. Despite this awareness, there was a significant gap in knowledge regarding personal radiation monitoring tools, with 76% of nurses unaware of TLD badges or pocket dosimeters. Moreover, while 76% considered radiation to be highly hazardous to health, 45% identified ovaries and testis as the organs most vulnerable to radiation exposure. However, awareness about specific radiation safety tools, like lead gloves and thyroid shields, was relatively low, with only 55% of nurses familiar with general protective equipment. Additionally, while many nurses understood basic radiation protection principles like time, distance, and shielding (72%), 58% were unaware of the difference between ionizing and non-ionizing radiation. In terms of radiation exposure modalities, 48% of nurses incorrectly identified MRI spine as the highest radiation exposure procedure, indicating a misconception about the use of non-ionizing radiation .(Table no 2)

Table No 2. Awareness of radiation hazards and protective measure

Questions	Catergories	%age
Do you think that X-ray can cause harmful effects?	Yes	96%
	No	3%
	No idea	1%
Identify patient's radiation protection measures you are aware of:	Lead aprons	11%
	Shields	4%
	Distance from the source of radiation	13%
	Time of exposure	2%
	Collimation of the radiation beam	4%
	All of the above	60%
	No idea	6%
In your opinion, how hazardous is radiation to your body?	Very hazardous	76%
	Not much hazardous	6%
	Non-hazardous	2%
	No idea	16%
Do you know what a TLD badge or pocket dosimeter is?	a)Yes I know	24%
	b)No idea	76%
Do you have an idea about different personal protective tools which help to reduce radiation exposure?	Lead Apron	13%
	Lead gloves	2%
	Thyroid shield	6%
	Gonadal shield	1%
	Staying away from the patient during exposure	10%
	All of the above	55%
	No idea	13%
Are you familiar with the following terms regarding radiation dose?	Time	1%
	Distance	15%
	Shielding	2%
	All	72%
	No idea	10%
In the intervention room, which of the following is the major source of radiation effect to healthcare workers?	Direct from primary beam itself	32%
	Reflection from patient	16%
	Other parts of the X-ray machine (not primary beam)	6%
	Reflection from the wall of the room	13%
	No idea	33%
To which organ, radiation can be more hazardous?	Ovary and testis	45%
	Thyroid gland	21%
	The eyes	19%
	No idea	15%

Knowledge of Radiation among Nurses

The two figures presented highlight significant gaps in radiation safety awareness among nurses, focusing on their understanding of ionizing vs. non-ionizing radiation and the potential hazards associated with various medical imaging modalities. Figure 1 reveals that the majority of nurses (58%) are unaware of the difference between ionizing and non-ionizing radiation, with only 42% understanding the distinction, which is crucial for ensuring safety in clinical settings. Additionally, 48% of nurses mistakenly identified

MRI spine, a non-ionizing modality, as having the highest radiation exposure, while 36% correctly identified X-ray abdomen, which involves ionizing radiation. In Figure 2, the knowledge of radiation sensitivity among different demographics showed that 60% of nurses correctly identified children as the most sensitive to radiation, but there was confusion about radiation exposure in medical procedures, with 50% of nurses unsure about which modalities produce ionizing radiation. These figures suggest that while nurses are generally aware of the risks associated with radiation, there is a clear need for further education and training on radiation safety and the specific risks posed by different types of radiation in medical imaging.

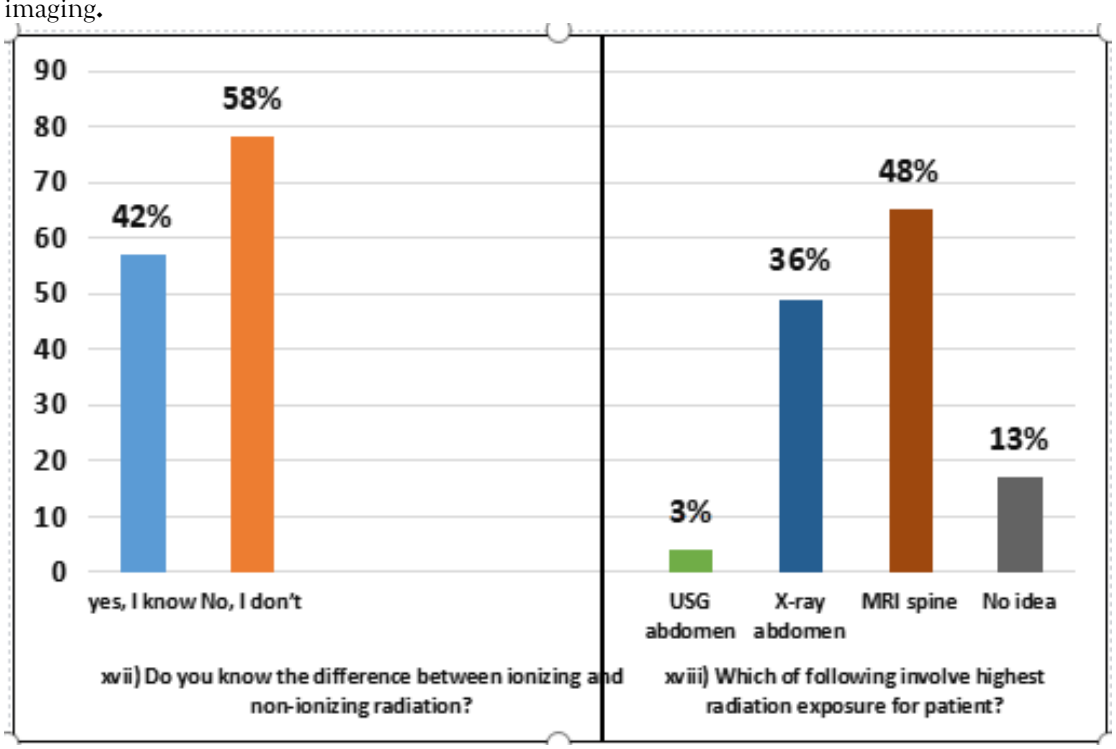

Fig 1

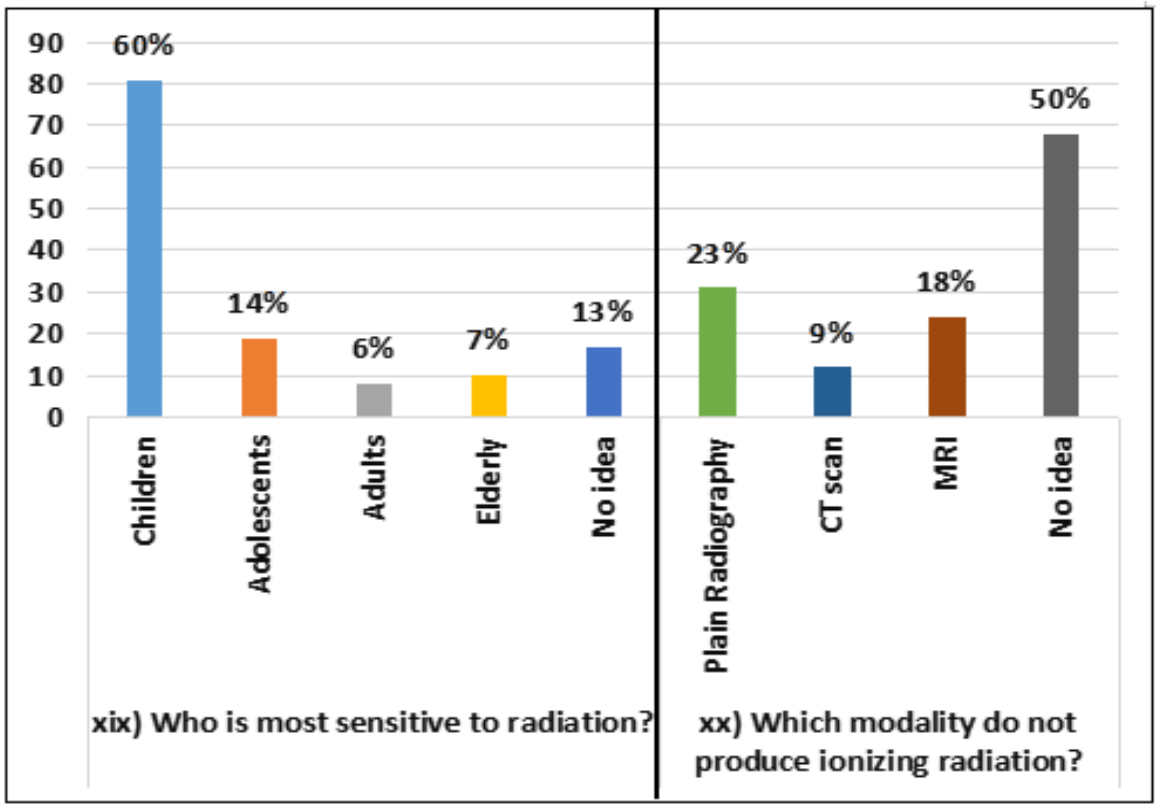

Fig 2

DISCUSSION

This study aimed to assess the level of knowledge regarding radiation safety and hazards among nurses working in radiation-exposed areas of a tertiary care private hospital. The findings revealed that while most nurses were aware of general radiation protection measures, significant gaps existed in their practical knowledge and application. Specifically, many nurses had never used essential protective equipment such as thyroid shields during radiation exposure, and were unfamiliar with pocket dosimeters, primarily due to a lack of participation in formal radiation safety training courses. This highlights the urgent need for structured education and training programs on radiation protection and the use of radiopaque devices to ensure the safety of both nurses and patients from the harmful effects of ionizing radiation.

A similar study by Muchui J. Thambura et al. (2019) on nurses' understanding of ionizing radiation in Northern Gauteng State Hospitals in South Africa observed that the lack of awareness about radiation safety among nurses was largely due to insufficient training in the fundamental principles of ionizing radiation(17). This finding reinforces the necessity for formalized training programs aimed at improving knowledge and practice in radiation safety.

Furthermore, nearly half of the participants in our study were unaware of the basic principle of radiation protection, known as ALARA (As Low As Reasonably Achievable). This was linked to their insufficient understanding of radiation protection principles, a finding that aligns with the results of Hirvonen, Schroderus-Salo et al. (2019) and RK Yürük et al (2024), who raised similar concerns about the lack of awareness regarding ALARA in their global study on nurses' knowledge of radiation protection (6, 18). The lack of awareness of ALARA could lead to unsafe practices, potentially exposing both healthcare workers and patients to avoidable radiation risks.

Moreover, many nurses in the present study could not differentiate between the various types of radiation (ionizing vs. non-ionizing) used in common radiology modalities such as X-rays, CT scans, MRI, USG, and mammography. This lack of understanding could directly impact patient care and the protection of both nurses and patients. The same issue was observed in a study by Mohammed Ali Alzubaidi et al. (2020), which assessed the understanding and perspective of nurses working in the radiology department in Jeddah City. Their study revealed that nurses with greater experience and higher educational qualifications demonstrated significantly better understanding and adherence to radiation protection practices(11). These findings highlight the importance of improving educational interventions and practical training for nurses, particularly those in radiology departments, to enhance their knowledge and application of radiation safety measures.

This study emphasizes the need for regular and comprehensive radiation safety training for nurses working in radiation-exposed areas. This training should focus on the correct use of protective equipment, the principles of radiation protection, and an understanding of the different types of radiation involved in medical imaging. Only with proper training can nurses effectively safeguard themselves and their patients from the harmful effects of radiation exposure.

CONCLUSIONS AND RECOMMENDATIONS

In conclusion, this study highlights significant gaps in radiation safety knowledge among nurses, particularly regarding protective equipment, radiation protection principles like ALARA, and understanding ionizing vs. non-ionizing radiation. To address these gaps, hospitals should implement mandatory radiation safety training, provide continuous education, and establish clear protocols for protective measures. Promoting interdisciplinary collaboration and conducting further research on the effectiveness of training will ensure safer practices and improve overall care in radiation-exposed areas.

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