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# ASSESSMENT OF KNOWLEDGE REGARDING HARMFUL EFFECTS OF RADIATION AND PROTECTION PROTOCOLS AMONG RADIOLOGY UNDERGRADUATE PRIVATE SECTOR STUDENTS

*Original Research*

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## ABSTRACT

**Background:** Radiation is an essential tool in medical imaging; however, exposure to ionizing radiation poses potential health risks to both healthcare providers and patients. Ensuring adequate knowledge and adherence to radiation protection protocols is critical, particularly for radiology students who are transitioning into clinical practice. Developing a strong foundation in radiation safety during undergraduate education can significantly reduce occupational hazards and promote safe imaging practices.

**Objective:** To assess the knowledge, awareness, and application of radiation protection measures among undergraduate radiology students enrolled in private-sector institutions in Peshawar, Pakistan.

**Methods:** This cross-sectional study was conducted among 383 undergraduate radiology students actively engaged in clinical rotations. A purposive sampling technique was used to recruit participants from multiple private-sector universities. Data were collected using a structured, pre-validated questionnaire comprising items on radiation hazards, protective measures, and compliance with safety protocols. Descriptive statistics were calculated using SPSS version 29.0, and chi-square tests were applied to determine associations between knowledge levels and demographic variables, with $p < 0.05$ considered statistically significant.

**Results:** Among 383 participants, 54% were female and 46% male, with the majority (79.4%) enrolled in the fifth semester. Overall, 90.3% demonstrated awareness of general radiation hazards, 78.6% were familiar with the ALARA principle, and 66.3% understood stochastic and deterministic effects. Only 29.5% knew occupational dose limits, while 35.2% were unaware of dosimeter usage. A total of 60% reported using personal protective equipment, and 50% had received formal training. Awareness varied across gender, semester, and institution.

**Conclusion:** The findings highlight a strong theoretical base but significant practical knowledge gaps among radiology students. Strengthening educational frameworks through hands-on training, structured curricula, and institutional support is vital to improve radiation safety practices.

**Keywords:** ALARA, clinical training, ionizing radiation, occupational exposure, radiation protection, radiology students, safety education.


## INTRODUCTION

Radiation, defined as the transfer of energy through space or a medium in the form of waves or particles, plays a vital role in modern medicine, particularly in diagnostic radiology. It has revolutionized the ability to detect, monitor, and manage a wide range of medical conditions (1). With advancements in imaging technologies such as computed tomography (CT) and fluoroscopy, radiological procedures have become indispensable tools in clinical decision-making and treatment planning. However, the benefits of radiological imaging are accompanied by the potential risks associated with ionizing radiation exposure, especially in occupational settings (2). These biological effects, including both stochastic effects such as cancer and genetic mutations, and deterministic effects like skin erythema and cataracts, underscore the need for stringent radiation protection practices (3). International organizations, including the International Commission on Radiological Protection (ICRP) and the International Atomic Energy Agency (IAEA), have emphasized the importance of radiation safety through established guidelines and dose limits for occupational exposure (4). Central to these efforts is the ALARA principle—"As Low As Reasonably Achievable"—which advocates for minimizing radiation doses while preserving image quality and clinical utility (5). Despite the presence of these frameworks, research has repeatedly highlighted gaps in the awareness and implementation of radiation safety protocols among healthcare professionals, with radiology students often demonstrating insufficient understanding of fundamental protection measures (6).

These concerns are particularly significant in regions with limited resources or inconsistent institutional training, such as in certain private-sector institutions. The increasing complexity of imaging techniques and the growing number of radiological examinations have elevated the risk of cumulative radiation exposure, not only for patients but also for students and professionals undergoing training in clinical settings (7). Factors contributing to inadequate adherence include a lack of formal education on radiation physics and protection, limited availability of shielding devices, and weak enforcement of institutional safety policies (8). Given the essential role of future radiologists in maintaining patient and staff safety, it is critical to ensure that undergraduate radiology students are well-equipped with knowledge and practical skills related to radiation hazards and protection (9). Several studies have suggested that integrating structured training on radiation safety into undergraduate curricula can significantly improve awareness and compliance (10). Addressing these educational deficits is not only a matter of improving clinical competence but also a legal and ethical responsibility to safeguard long-term health outcomes for healthcare providers (11). Therefore, this study aims to assess the awareness and understanding of radiation risks and protection protocols among undergraduate radiology students in private sector institutions in Peshawar. By identifying knowledge gaps and potential areas for educational intervention, the objective is to inform the development of more effective training programs, ultimately contributing to safer radiological practices in the future.

## METHODS

This cross-sectional study was conducted in Peshawar with the objective of assessing the awareness and understanding of radiation hazards and protection protocols among undergraduate radiology students from private-sector institutions. The target population comprised students enrolled in recognized Bachelor of Science in Radiology programs who had commenced their clinical rotations, ensuring that participants had direct exposure to radiological procedures in real-world settings. Students in the first to fourth semesters were excluded from participation, as they had not yet started clinical training and were unlikely to possess practical experience with radiation-related practices. A sample size of 383 was calculated using a 53% prevalence rate derived from relevant previous studies, applying standard sample size determination methods for cross-sectional research (3). Participants were selected through a purposive sampling technique, enabling targeted recruitment of individuals meeting specific inclusion criteria (2,3). This approach ensured that clinically active students were prioritized, though generalizability beyond the study population may still be limited. Data were collected using a structured and pre-validated questionnaire adapted from existing literature and reviewed by subject experts for relevance and clarity. The instrument was divided into two sections: one assessing knowledge of radiation hazards, and the other focusing on awareness and adherence to radiation protection protocols. The questionnaire included both closed-ended and multiple-choice items and was administered either in person or electronically, depending on institutional coordination and participant accessibility.

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Ethical approval for the study was obtained from the Institutional Review Board (IRB) of the Peshawar Institute of Medical and Management Sciences (PIMMS). All participants provided informed consent prior to data collection, following a clear explanation of the study's purpose, voluntary nature, and confidentiality measures. Participants were informed of their right to withdraw from the study at any point without consequence. The data were analyzed using IBM SPSS Statistics version 29.0. Descriptive statistics, including frequencies, percentages, means, and standard deviations, were used to summarize demographic and categorical variables. Inferential analysis was conducted using the chi-square test to examine associations between knowledge or awareness levels and demographic characteristics. A p-value of less than 0.05 was considered statistically significant in all inferential assessments, establishing thresholds for identifying meaningful relationships among the study variables.

## RESULTS

The study comprised a total of 383 undergraduate radiology students from private-sector institutions in Peshawar. Among the participants, 54% were female and 46% were male. The majority of students (79.4%) were enrolled in the fifth semester, while 20.6% were from the eighth semester. Institutional representation showed that City University had the highest participation rate at 29.8%, followed by Iqra University with 18.3%, and Ghazali Institute with 12.8%. Findings indicated that 90.3% of students demonstrated awareness of radiation risks, reflecting a generally high level of theoretical knowledge. However, only 78.6% were familiar with the ALARA (As Low As Reasonably Achievable) principle, and 66.3% correctly understood the difference between stochastic and deterministic effects of radiation. In contrast, awareness of occupational exposure limits was notably lower, with only 29.5% of participants correctly identifying the maximum permissible radiation dose for healthcare workers. Regarding protective practices, 69.5% of students supported the use of protective screens during radiographic procedures. However, 35.2% were unaware of the purpose or use of dosimeters, indicating a significant gap in knowledge about personal radiation monitoring. Additionally, 67.1% reported adherence to the ALARA principle during X-ray examinations, suggesting a moderate level of compliance with standard safety protocols. Practical understanding appeared limited, as less than half of the respondents believed that radiological equipment should undergo annual inspection—a critical component of ensuring patient and staff safety.

When asked about strategies to improve radiation safety awareness, the majority of students identified workshops and seminars as the most effective educational interventions. These findings highlight areas of strong theoretical knowledge but also emphasize critical gaps in practical understanding and protocol compliance. Stratified analysis revealed slight variations in awareness of radiation risks across demographic variables. Female students demonstrated marginally higher awareness levels compared to their male counterparts. Similarly, students in the fifth semester reported greater awareness than those in the eighth semester. Among institutions, City University students showed the highest level of awareness, followed by Iqra University and Ghazali Institute. Half of the participants reported receiving formal training on radiation safety, while 60% confirmed the use of personal protective equipment (PPE) during clinical practice. Despite this, only 65% reported consistent availability of protective equipment such as lead aprons, thyroid shields, and dosimeters in their institutions, indicating uneven access to essential safety tools.

**Table 1: Demographic Distribution of Participants**

| Gender | Semester | Institution | Frequency |
|---|---|---|---|
| Female | 5th | Others | 67 |
| Female | 5th | City University | 55 |
| Male | 5th | City University | 44 |
| Male | 5th | Others | 44 |
| Male | 5th | Ghazali Institute | 28 |
| Female | 5th | Iqra University | 25 |
| Female | 8th | Others | 20 |

| Gender | Semester | Institution | Frequency |
|---|---|---|---|
| Male | 5th | Iqra University | 19 |
| Male | 8th | Others | 16 |
| Female | 5th | Ghazali Institute | 15 |
| Female | 8th | City University | 14 |
| Male | 8th | City University | 11 |
| Male | 8th | Iqra University | 11 |
| Female | 8th | Iqra University | 6 |
| Female | 8th | Ghazali Institute | 4 |
| Male | 8th | Ghazali Institute | 4 |

**Table 2: Awareness of Radiation Risks by Gender (%)**

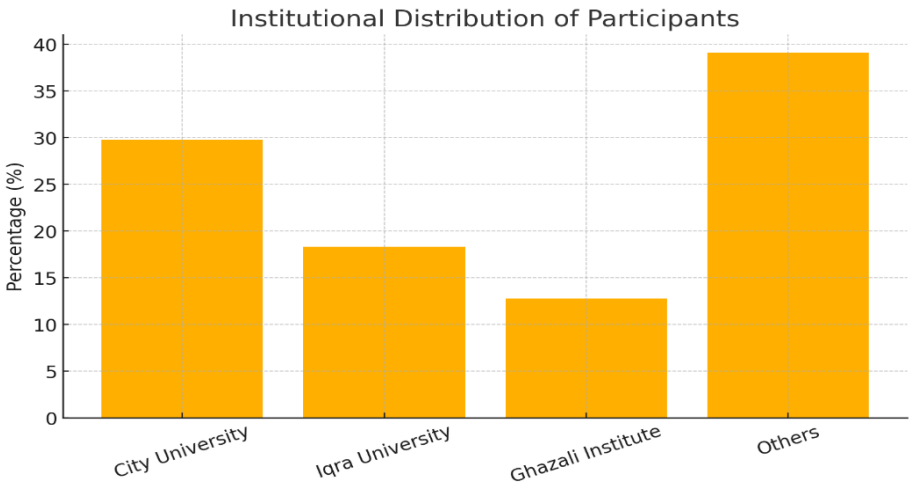
| Gender | No | Yes |
|---|---|---|
| Female | 9.223 | 90.776 |
| Male | 9.604 | 90.395 |

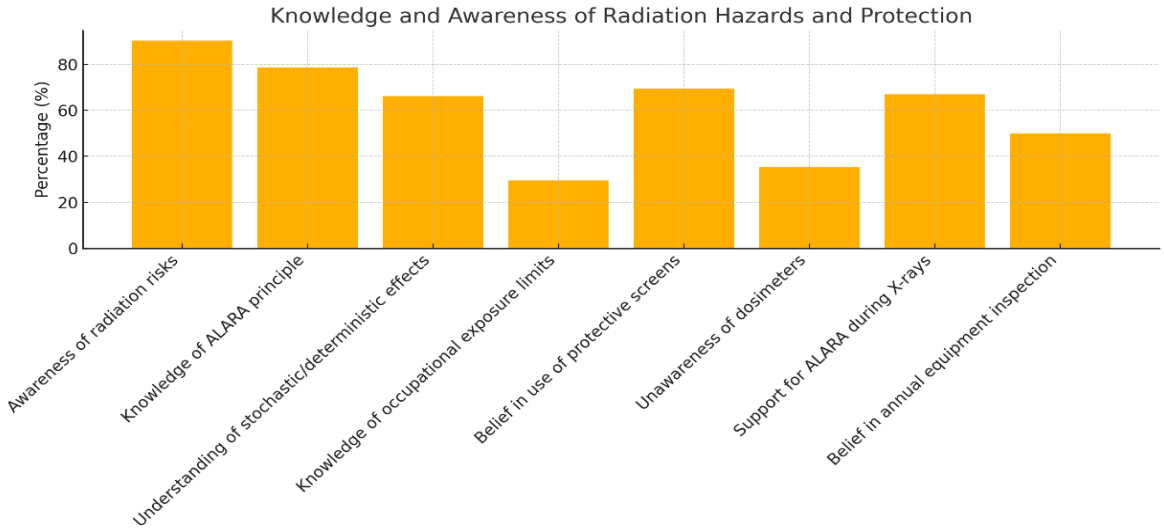
**Table 3: Awareness of Radiation Risks by Semester (%)**

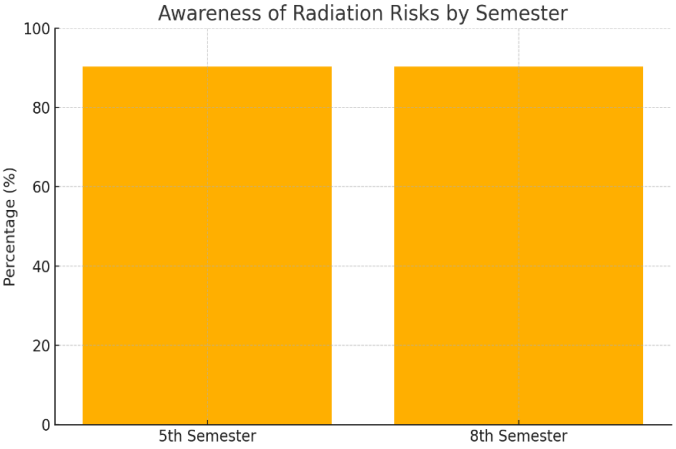
| Semester | No | Yes |
|---|---|---|
| 5th | 10.101 | 89.898 |
| 8th | 6.976 | 93.023 |

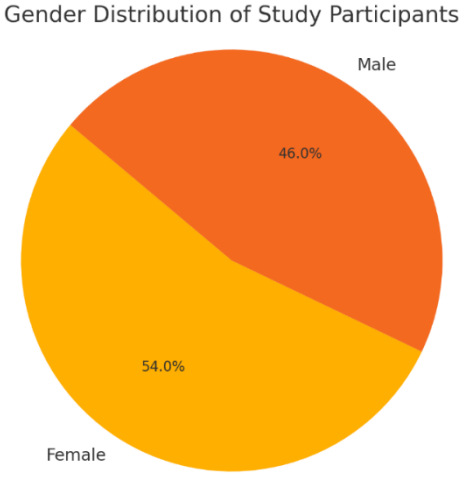
**Table 4: Awareness of Radiation Risks by Institution (%)**

| Institution | No | Yes |
|---|---|---|
| City University | 5.645 | 94.354 |
| Ghazali Institute | 9.803 | 90.196 |
| Iqra University | 18.032 | 81.967 |
| Others | 8.843 | 91.156 |



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## DISCUSSION

The present study demonstrated that undergraduate radiology students possessed a satisfactory level of theoretical knowledge regarding radiation hazards, with over 90% of participants expressing awareness of the general risks associated with ionizing radiation. However, this theoretical understanding did not extend comprehensively to practical safety measures, particularly in areas concerning the ALARA principle, dose limits, and the usage of radiation monitoring tools such as dosimeters (12). These findings align with international literature, where similar patterns of inadequate awareness among healthcare professionals have been reported, indicating a global gap in radiation safety education (13). The limited understanding of occupational exposure thresholds is a matter of concern, as it reflects a disconnect between academic instruction and clinical applicability. A study conducted in Turkey similarly reported underestimation of radiation-related risks by healthcare workers, highlighting a consistent lack of emphasis on radiation protection training across diverse healthcare settings (14). While the importance of theoretical knowledge remains undisputed, effective implementation of safety protocols in clinical environments is critical. Evidence suggests that the absence of structured, hands-on training leads to non-compliance with essential radiation protection guidelines, which ultimately compromises both patient and staff safety (15).

In this study, knowledge regarding the role and use of dosimeters was found to be insufficient among a significant proportion of students. Given the central role of personal monitoring devices in occupational radiation safety, such a gap raises serious concerns about the preparedness of future radiology professionals (16). Simulation-based education and real-time monitoring practices have been proposed in previous literature as effective tools to reinforce learning and promote safe clinical behavior (17). These findings further advocate for integrating these methods into radiology training programs. Institutional influence was also evident in the disparity of awareness levels among students from different universities. This underlines the importance of institutional policies and infrastructure in promoting a culture of safety (18). Regular training sessions, strict enforcement of protective protocols, and the mandatory use of lead aprons, thyroid shields, and dosimeters should form the core of institutional radiation safety strategies. Past research has emphasized the role of regulatory frameworks in elevating safety standards, suggesting that compliance improves significantly when institutions adopt and enforce clear policies supported by national guidelines (19).

One of the strengths of this study lies in its inclusion of clinically active students, ensuring that participants had firsthand exposure to radiological procedures. The multi-institutional representation further adds value by providing a comparative perspective on institutional practices. However, the study had several limitations. The study relied on self-reported data, which is subject to response bias and may not accurately reflect actual clinical practices. The lack of stratified analysis across additional variables such as previous training experience or frequency of clinical exposure further limited the ability to identify specific educational gaps. Future research should aim to evaluate the effectiveness of structured radiation safety programs through longitudinal study designs, focusing on both knowledge retention and behavioral outcomes. Incorporating objective measures, such as practical assessments and radiation dose monitoring, would strengthen the validity of findings. In addition, exploring barriers to the availability and use of protective tools across institutions would provide further insights into systemic challenges. The findings support the urgent need for standardized, curriculum-integrated training modules that combine theoretical instruction with practical exercises. Institutional accountability, resource allocation, and collaboration with regulatory bodies must be prioritized to cultivate a proactive safety culture in radiology departments (20). As medical imaging technologies continue to evolve, so too must the strategies to equip students with the knowledge and tools necessary to protect themselves and their patients.

## CONCLUSION

This study concluded that while undergraduate radiology students demonstrated a foundational understanding of radiation hazards, their knowledge of specific safety protocols and regulatory standards remained limited. The findings highlight a clear gap between theoretical awareness and practical application, emphasizing the urgent need for structured and comprehensive educational strategies within radiology programs. Strengthening radiation safety training through curriculum integration, hands-on workshops, and institutional support is essential to ensure that future professionals are not only informed but also equipped to practice safely and responsibly in clinical settings.

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**Author Contribution**

| Author | Contribution |
|---|---|
| Hassan Khan* | Substantial Contribution to study design, analysis, acquisition of Data<br>Manuscript Writing<br>Has given Final Approval of the version to be published |
| Bilal Ahmad | Substantial Contribution to study design, acquisition and interpretation of Data<br>Critical Review and Manuscript Writing<br>Has given Final Approval of the version to be published |
| Ifran Ullah | Substantial Contribution to acquisition and interpretation of Data<br>Has given Final Approval of the version to be published |
| Basmeena | Contributed to Data Collection and Analysis<br>Has given Final Approval of the version to be published |
| Gulmeena | Contributed to Data Collection and Analysis<br>Has given Final Approval of the version to be published |

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