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RADIATION DOSE AWARENESS AND SAFETY PRACTICES AMONG RADIOLOGY STAFF IN TERTIARY CARE HOSPITALS

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Abstract

Background

The increasing use of diagnostic imaging has improved disease detection and patient management; however, it has also increased occupational exposure concerns among healthcare workers involved in radiological procedures. Adequate knowledge and consistent application of radiation protection measures are essential to minimize unnecessary exposure. This study was conducted to assess radiation dose awareness and safety practices among radiology personnel working in a tertiary care hospital in Pakistan.

Objective

To evaluate the level of knowledge regarding radiation hazards, dose awareness and radiation protection practices among radiology staff, identify existing gaps, and suggest appropriate educational interventions for improving workplace safety.

Methods

A descriptive cross-sectional survey was conducted among radiology personnel at the Department of Radiology of a Tertiary Hospital in Lodhran, Punjab, Pakistan. A structured self-administered questionnaire was used to collect information regarding demographic characteristics, radiation safety knowledge and routine protective practices. Participants included radiologists, radiographers, CT technicians, nurses and supporting technical staff. Knowledge and practice scores were calculated, and associations between participant characteristics and radiation safety awareness were analyzed using appropriate statistical methods.

Results

A total of 100 radiology staff members participated in the study. Overall, 48% of participants demonstrated good knowledge regarding radiation safety, while 34% showed moderate knowledge and 18% had poor knowledge. Most participants recognized the harmful effects of ionizing radiation (91%) and the protective role of lead shielding (86%). However, knowledge regarding occupational dose limits and radiation monitoring remained inadequate. Regular lead apron use was reported by 82% of participants, whereas personal dosimeter compliance was observed among 69%. Participants with previous radiation safety training showed significantly higher knowledge and practice scores compared with those without training ($p < 0.001$).

Conclusion

Radiology staff demonstrated acceptable awareness of basic radiation protection principles; however, important gaps remain in dose-related knowledge, monitoring practices and structured training exposure. Regular radiation safety education, continuous professional development and effective departmental monitoring systems are recommended to improve occupational protection and strengthen radiation safety culture in healthcare facilities.

INTRODUCTION

Ionizing radiation has an important place in modern health care. Plain radiography, fluoroscopy, computed tomography, interventional procedures and some nuclear medicine studies help doctors diagnose disease and guide treatment. At the same time, ionizing radiation can damage living tissue if exposure is not controlled. The International Commission on Radiological Protection (ICRP) therefore describes radiation protection through three main principles: justification, optimization of protection, and dose limitation for occupational and public exposure [21]. In medical work, protection also depends on simple daily actions such as reducing exposure time, increasing distance from the radiation source, using shielding correctly, wearing personal dosimeters, and following safe operating procedures [22,23].

Radiology staff are among the healthcare workers who may face repeated occupational exposure. Their risk is usually low when good radiation protection systems are followed, but repeated exposure over a working life makes safe practice important. Staff should understand basic radiation units, occupational dose limits, radiosensitive organs, effects of scattered radiation, correct use of lead aprons and thyroid shields, and the role of personal monitoring. They should also understand that X-ray and CT use ionizing radiation, while ultrasound and magnetic resonance imaging do not. However, several surveys have shown that these basic points are not always understood correctly, even among workers who regularly deal with imaging [14,18-20,24,25].

Radiation awareness is not only a matter of knowing facts. Knowledge should be reflected in practice. A worker may know that a lead apron is required but may not wear it regularly. A staff member may know about dosimetry but may not use a badge or may not check dose reports. Similar gaps between knowledge and routine behavior have been reported in different countries. Studies from South Africa, Egypt, Jordan, Saudi Arabia and other settings have found variable levels of awareness, incomplete use of protective measures, and a need for repeated training [8-17]. A systematic review also reported that knowledge, attitude and practice related to radiation protection are not consistent among healthcare workers and that continuing education remains important [17].

Recent evidence suggests that training can make a practical difference. In Jordan, staff who had attended education on occupational radiation exposure had better radiation-protection knowledge and hazard awareness [12]. Studies from South Africa also show that radiation protection is influenced by the working environment, professional behavior and the support given by the institution [8,9]. This is important because radiation safety cannot depend only on the individual worker. Hospitals need clear protocols,

protective equipment, dose monitoring, supervision, refresher teaching and a culture where safe practice is expected during every procedure.

The problem is also relevant in Pakistan. A survey from hospitals in Karachi reported important gaps in radiation protection awareness among radiation workers [1]. Other Pakistani studies have found limited knowledge of radiation doses among doctors, low participation in formal radiation-safety training, and inconsistent use of protective equipment [2,3]. More recent work from Gilgit-Baltistan, Gujranwala and Karachi has again shown that many radiology or paramedical personnel understand some basic radiation concepts but still have weaknesses in personal dosimetry, protective equipment use, dose-limit knowledge and structured training [4-6]. Earlier work from public tertiary hospitals in Karachi also showed that radiation hazards and safety measures were not fully understood by patients, suggesting that communication from healthcare teams is another part of radiation safety [7].

These findings are important for tertiary care hospitals because radiology departments are busy clinical areas where different staff groups work together. Radiologists, radiographers, technologists, nurses, assistants and other personnel may have different educational backgrounds and different levels of exposure. A single general training session may therefore not be enough. Local assessment is useful because it can show which topics are weak, which safety practices are missed, and which staff groups may need more focused education.

For this reason, the present cross-sectional survey was conducted in the **Department of Radiology of a Tertiary Hospital, Lodhran, Pakistan**. The study aims to assess the knowledge of radiation dose and radiation safety among radiology personnel, identify gaps between knowledge and routine safety practice, and use the findings to propose targeted educational interventions. Local evidence from Lodhran is limited, so this study may provide practical information for improving staff training, occupational protection, patient safety and the overall radiation-safety culture of the institution.

MATERIALS AND METHODS

Study Design and Study Setting

A descriptive cross-sectional survey was conducted to assess radiation dose awareness and safety practices among radiology staff working at the Department of Radiology of a Tertiary Hospital, Lodhran, Punjab, Pakistan. The hospital is a tertiary care teaching facility providing diagnostic imaging services to a large number of patients from Lodhran and surrounding areas. The radiology department provides routine imaging facilities including conventional X-ray, computed tomography (CT), ultrasound and other diagnostic procedures. The study was designed to evaluate the current level of knowledge regarding radiation hazards, radiation dose, protective measures, and the practical application of radiation safety guidelines among healthcare workers involved in radiological procedures.

Study Duration

The study was conducted over a period of six months, from January 2026 to June 2026. Data collection was performed during routine working hours after obtaining permission from the hospital administration and the concerned department.

Study Population

The study population included healthcare personnel working in the radiology department who had direct or indirect involvement with diagnostic imaging procedures. Participants included radiologists, radiographers, radiologic technologists, trainees, nurses and supporting staff working in radiation-related areas. All participants were informed about the purpose of the study before participation.

Inclusion and Exclusion Criteria

Radiology staff members who had been working in the department for at least six months were included in the study. Participants from different professional categories and with different levels of work experience were included to obtain a broader understanding of radiation safety awareness.

Staff members who were on extended leave during the study period, those unwilling to participate, and workers with less than six months of experience in the radiology department were excluded. Administrative staff without involvement in radiology-related activities were also excluded.

Sample Size and Sampling Technique

The sample size was calculated according to the estimated proportion of adequate radiation safety knowledge among healthcare workers from previous studies. A convenient sampling technique was used because the study focused on available radiology personnel working during the study period. All eligible staff members who agreed to participate were included to obtain maximum representation from the department.

Data Collection Tool

Data were collected using a structured self-administered questionnaire developed after reviewing previous studies related to radiation protection awareness among healthcare workers. The questionnaire was prepared according to international radiation safety principles, including the recommendations of the International Commission on Radiological Protection (ICRP).

The questionnaire consisted of three main sections. The first section collected demographic information, including age, gender, professional category, educational qualification, years of experience, work area and previous radiation safety training.

The second section assessed knowledge regarding radiation safety. Questions included understanding of ionizing radiation, radiation hazards, biological effects of radiation, occupational dose limits, ALARA (As Low As Reasonably Achievable) principle, radiation shielding, personal dosimeters, and radiation exposure reduction methods.

The third section evaluated practical safety behavior among staff members. This section included questions regarding the routine use of lead aprons, thyroid shields, protective barriers, personal monitoring devices, checking radiation warnings, maintaining safe distance during procedures, and participation in radiation safety training programs.

Questionnaire Validation and Reliability

Before starting the main study, the questionnaire was reviewed by senior radiologists and radiation safety experts to assess its content validity and suitability for the local healthcare environment. A pilot test was conducted among a small group of radiology workers who were not included in the final analysis. Based on their feedback, unclear questions were modified to improve understanding and response accuracy.

The reliability of the questionnaire was assessed using internal consistency testing. Necessary modifications were made before final data collection.

Data Collection Procedure

After obtaining informed consent, questionnaires were distributed among eligible participants. Participants were requested to complete the questionnaire independently without discussion with other staff members to reduce response bias. The completed forms were collected on the same day and checked for completeness.

Confidentiality of participant information was maintained throughout the study. No personal identification information was collected, and all responses were used only for research purposes.

Assessment of Knowledge and Practice Scores

Each correct response in the knowledge section was assigned one mark, while incorrect or “do not know” responses received zero marks. The total knowledge score was calculated for each participant. Based on the percentage score, knowledge levels were categorized as poor, moderate, or good.

Similarly, practice-related responses were scored according to recommended radiation protection behaviors. Participants following recommended safety practices received higher scores. The overall practice level was categorized to identify areas requiring improvement.

Statistical Analysis

Data were entered and analyzed using appropriate statistical software. Descriptive statistics were used to summarize demographic characteristics and questionnaire responses. Frequencies and percentages were calculated for categorical variables, while mean and standard deviation were calculated for continuous variables.

Associations between radiation safety knowledge scores and demographic factors such as profession, experience and previous training were analyzed using appropriate statistical tests. A p-value of less than 0.05 was considered statistically significant.

RESULTS

A total of 100 radiology staff members participated in the study. All distributed questionnaires were completed and included in the final analysis, giving a response rate of 100%. The participants belonged to different professional groups working in the radiology department, including radiologists, radiographers, CT technicians, nurses and supporting technical staff.

The mean age of participants was 31.8 ± 6.4 years. Most participants were male (68%), while females represented 32% of the study population. Regarding professional category, radiographers formed the largest group (52%), followed by radiologists (18%), CT technicians (16%), nurses (8%) and other technical staff (6%). More than half of the participants (56%) had work experience between 1 and 5 years, whereas 28% had 6–10 years of experience and 16% had more than 10 years of experience.

Only 54% of participants reported that they had previously attended a formal radiation protection training session. The remaining 46% had never attended any structured radiation safety training program during their professional career.

Radiation Safety Knowledge Assessment

The overall knowledge level regarding radiation protection was satisfactory among most participants. The mean knowledge score was 76.4 ± 12.8%. Based on categorized scores, 48 participants (48%) demonstrated good knowledge, 34 participants (34%) showed moderate knowledge, while 18 participants (18%) had poor knowledge regarding radiation safety principles.

Most participants correctly identified that ionizing radiation may cause biological damage (91%) and that lead is an effective shielding material against diagnostic X-rays (86%). Knowledge regarding the ALARA principle was correctly answered by 78% of participants. Similarly, 74% of respondents understood the importance of reducing exposure time and increasing distance from the radiation source.

However, some important knowledge gaps were observed. Only 59% of participants correctly identified the recommended occupational dose monitoring practices. Knowledge regarding annual occupational dose limits was adequate in 63% of participants. The lowest scores were observed for detailed understanding of radiation dose optimization and patient-specific dose reduction strategies.

Radiation Safety Practices

Assessment of routine safety practices showed variable compliance among radiology workers. Most participants reported regular use of protective equipment during radiation exposure. Lead apron use was reported by 82% of participants, while 76% reported maintaining appropriate distance from radiation sources whenever possible.

Personal dosimeter use was reported by 69% of participants. However, 31% of respondents either did not regularly use personal monitoring devices or were unsure about their monitoring schedule. Regular checking of radiation warning signs and controlled-area restrictions was reported by 71% of participants.

Only 54% of participants had attended radiation safety training during their employment period. Among participants who received previous training, radiation safety practice scores were significantly higher compared with those who had never attended training (81.2 ± 9.6% versus 62.5 ± 13.4%, $p < 0.001$).

Association Between Participant Characteristics and Knowledge Score

A statistically significant association was found between previous radiation safety training and higher knowledge scores. Participants with previous training demonstrated better understanding of radiation hazards, protective equipment use and dose monitoring compared with untrained participants. Professional designation also showed a significant relationship with knowledge level. Radiologists and experienced radiographers achieved higher scores compared with junior technical staff and supporting workers ($p = 0.02$). Work experience showed a positive trend, with participants having more than 10 years of experience demonstrating better knowledge; however, this difference was not statistically significant ($p = 0.08$). Gender and age were not significantly associated with radiation safety knowledge scores.

Table 1. Demographic Characteristics of Study Participants (n=100)

Variable	Frequency	Percentage (%)
Age group		
≤30 years	46	46
31–40 years	38	38
>40 years	16	16
Gender		
Male	68	68
Female	32	32
Professional category		
Radiologists	18	18
Radiographers	52	52
CT Technicians	16	16
Nurses	8	8
Other staff	6	6
Work experience		
1–5 years	56	56
6–10 years	28	28
>10 years	16	16
Previous radiation safety training		
Yes	54	54
No	46	46

Table 2. Knowledge and Radiation Safety Practice Findings (n=100)

Assessment item	Correct/Positive response n (%)
Radiation can cause biological harm	91 (91%)
Lead is effective radiation shielding	86 (86%)
Understanding of ALARA principle	78 (78%)
Reducing exposure time reduces dose	74 (74%)
Knowledge of occupational dose limits	63 (63%)
Correct personal dosimeter practice	69 (69%)
Regular lead apron use	82 (82%)
Maintaining safe distance during exposure	76 (76%)
Radiation safety training attended	54 (54%)

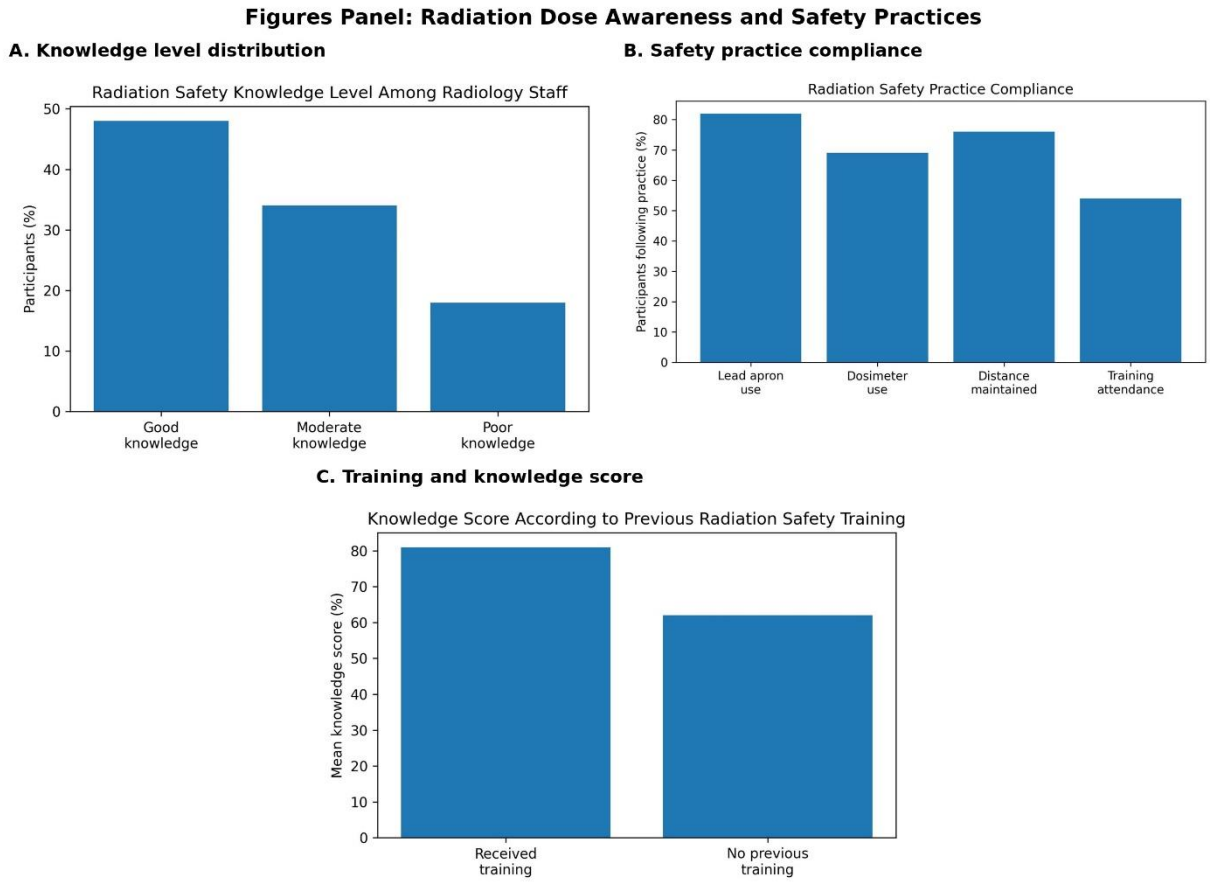


Figure 1 demonstrates the distribution of knowledge categories among radiology staff. Figure 2 shows compliance with major radiation safety practices. Figure 3 compares knowledge scores between participants who received radiation safety training and those without previous training.

DISCUSSION

Radiation safety is an essential component of quality radiological practice because radiology professionals are continuously exposed to low levels of ionizing radiation during their routine work. The present study assessed radiation dose awareness and safety practices among radiology staff at Tertiary Hospital, Lodhran. The findings showed that although most participants had acceptable knowledge regarding basic radiation hazards and protection principles, important gaps remained in detailed dose awareness, personal monitoring practices and participation in formal radiation safety training.

In this study, 48% of participants demonstrated good knowledge, while 34% showed moderate knowledge regarding radiation protection. This finding indicates that general awareness about radiation hazards is present among radiology workers, but deeper understanding of radiation protection concepts requires further improvement. Similar observations have been reported in Pakistan and other countries. Jafri et al. reported variable levels of radiation protection awareness among radiographers and highlighted that knowledge about basic protective measures was better than knowledge related to radiation dose limits and monitoring systems [1]. Recent Pakistani studies have also demonstrated that healthcare workers commonly understand the harmful effects of radiation but show deficiencies in advanced radiation safety concepts and occupational protection practices [4,5].

The current study found that 91% of participants recognized that ionizing radiation can cause biological damage, and 86% correctly identified lead shielding as an effective protective measure. These findings are consistent with previous studies where healthcare workers demonstrated good awareness of general radiation hazards and the role of shielding devices. However, awareness of general hazards alone does not always translate into safe occupational behavior. Radiation protection depends on the consistent

application of the ALARA principle, appropriate dose monitoring and correct workplace practices rather than only theoretical knowledge [21,22].

An important finding of this study was that only 63% of participants had adequate knowledge regarding occupational dose limits, and only 69% reported appropriate personal dosimeter use. These areas represent important safety concerns because occupational monitoring helps identify unnecessary exposure and supports long-term radiation protection. Previous research has also identified personal dosimetry as one of the weaker areas among radiology workers. Studies from different healthcare settings have shown that some staff members either do not regularly use monitoring devices or have limited understanding of their importance [10,11]. According to ICRP recommendations, occupational exposure should be controlled through dose monitoring, optimization strategies and institutional safety systems [21].

The present study demonstrated that lead apron use was relatively high (82%), indicating good compliance with visible protective measures. Similar findings have been reported in previous surveys where healthcare workers showed better compliance with easily available protective equipment compared with less visible practices such as dose monitoring and documentation [12,17]. This difference may occur because protective equipment provides immediate physical protection, while monitoring practices require continuous institutional support and awareness.

One of the most important findings of this study was the relationship between previous radiation safety training and improved knowledge scores. Participants who had attended radiation safety training showed significantly higher knowledge and practice scores compared with those without previous training. This observation supports previous evidence showing that structured education programs improve radiation safety awareness among healthcare professionals. Allam et al. emphasized that regular education and institutional safety programs are important factors for improving compliance among workers exposed to ionizing radiation [11]. Similarly, studies involving medical students and healthcare workers have demonstrated better radiation knowledge among individuals who received formal radiation protection teaching [13,15].

The findings also showed that professional category influenced radiation safety knowledge. Radiologists and experienced radiographers achieved higher scores compared with junior technical staff. This difference may be explained by variations in educational background, professional responsibilities and exposure to radiation-related training. Similar patterns have been described internationally, where staff members directly involved in image acquisition usually have better knowledge than workers with limited involvement in radiation procedures [8,16].

Although participants with longer work experience showed better knowledge, the association was not statistically significant. This suggests that experience alone may not be sufficient to improve radiation safety awareness. Continuous professional development and regular refresher training are needed because radiation technology, imaging protocols and safety recommendations continue to change. Previous studies have also recommended periodic training programs rather than relying only on workplace experience [17,20].

The findings of this study have practical implications for tertiary care hospitals in Pakistan. Radiology departments should establish regular radiation safety education sessions, ensure proper availability and monitoring of protective equipment, and encourage compliance with personal dosimetry programs. Training should not focus only on radiation hazards but should also include practical issues such as dose optimization, equipment-related safety, patient protection and emergency response.

This study has some limitations. It was conducted in a single tertiary care hospital, so the findings may not represent all radiology departments in Pakistan. Additionally, safety practices were assessed through self-reported responses, which may introduce reporting bias. However, the study provides useful baseline information regarding radiation safety awareness among radiology personnel and highlights areas where targeted interventions can improve occupational protection.

In conclusion, radiology staff at the Tertiary Teaching Hospital demonstrated satisfactory awareness of basic radiation safety concepts, but gaps were identified in occupational dose knowledge, monitoring practices and formal training exposure. Strengthening continuous radiation safety education and

developing a structured departmental radiation protection program may improve compliance and promote a safer working environment for both healthcare workers and patients.

CONCLUSION

The present study concluded that radiology staff working at Hospital, had a reasonable understanding of basic radiation hazards and protective measures. Most participants were aware that ionizing radiation can produce harmful biological effects and recognized the importance of protective methods such as shielding, reducing exposure time and maintaining distance from radiation sources. However, some important gaps were identified, particularly related to occupational dose limits, personal dosimetry, radiation dose optimization and regular participation in radiation safety training programs.

The study findings highlight that knowledge alone is not enough to ensure safe radiation practices. Continuous education, practical training and strong departmental safety policies are required to convert awareness into consistent workplace behavior. Participants who had previous radiation safety training showed better knowledge and safer practices, indicating the importance of regular training sessions for all categories of radiology personnel, especially newly appointed and less experienced staff.

A structured radiation protection program should be strengthened within tertiary care hospitals. Regular refresher courses, monitoring of personal dosimeters, proper use of protective equipment and periodic evaluation of staff knowledge can help reduce unnecessary occupational exposure. Hospital administration and radiology departments should work together to create a safety culture where radiation protection becomes a routine part of daily clinical practice.

Although this study was conducted in a single institution, it provides valuable information regarding current radiation safety awareness among radiology workers in a tertiary care setting of Pakistan. Future multicenter studies involving different hospitals and healthcare professionals are recommended to better understand national radiation safety practices and to develop standardized educational strategies.

Improving radiation safety awareness among healthcare workers will not only protect radiology personnel from avoidable exposure but will also contribute to safer imaging services and better patient care.

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