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Original Research Article

Assessment of radiation protection knowledge and practices among radiation workers in a radiology imaging department

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ABSTRACT

Background: Radiation protection is an essential component of radiology practice to minimize unnecessary occupational exposure among healthcare workers. Despite established safety standards, differences may exist in awareness and compliance with radiation protection principles among students and staff working in radiology departments. Objective was to assess the knowledge and practices related to radiation protection among radiation workers in a radiology imaging department.
Methods: A cross-sectional descriptive study was conducted over a period of five months among 168 radiation workers in the radiology imaging department of Mahatma Gandhi Medical College and Hospital, Jaipur. Data were collected using a structured 20-item questionnaire distributed through Google forms and direct circulation. Participants included students and staff members. Data were analyzed using frequencies, percentages, and group comparisons.
Results: Among 168 participants, 75.6% were students and 24.4% were staff members. Awareness regarding ALARA was high (89.3%), and 98.2% correctly identified TLD badges as radiation monitoring devices. However, only 28.6% correctly knew the minimum lead equivalence of aprons. Regular TLD badge use was reported by 85.7%, lead apron use by 83.9%, and attendance in radiation protection training by 68.5%.
Conclusions: The study demonstrated good overall awareness regarding basic radiation safety principles, but gaps remain in technical knowledge and training participation. Continuous education programs and strict compliance monitoring are recommended to strengthen radiation safety culture.

Keywords: ALARA, Occupational exposure, Radiation protection, Radiation safety, Radiology workers, TLD badge

INTRODUCTION

Radiology imaging has become an essential component of modern healthcare systems. Diagnostic imaging techniques such as conventional x-ray, computed tomography (CT), fluoroscopy, mammography, and interventional radiology procedures rely on ionizing radiation for the visualization of internal body structures. These modalities assist clinicians in the early diagnosis of diseases, monitoring of treatment progress, surgical planning, and emergency management of trauma cases. The rapid advancement of imaging technology has significantly improved the quality of patient care by providing faster and more accurate diagnostic information. In present-day hospitals, radiology departments are among the busiest units due to the increasing demand for imaging services.[1]

The widespread use of ionizing radiation in healthcare has also increased occupational exposure among radiation workers. Radiation workers include radiographers, radiologic technologists, technicians, students undergoing clinical training, residents, and faculty members who work in or around imaging environments. Although the radiation dose received during routine procedures is usually low, repeated exposure over long periods may accumulate and pose potential health risks. Occupational exposure is especially important in departments where fluoroscopy-guided and CT-guided procedures are frequently performed, as these may involve higher radiation levels than conventional radiography.[2]

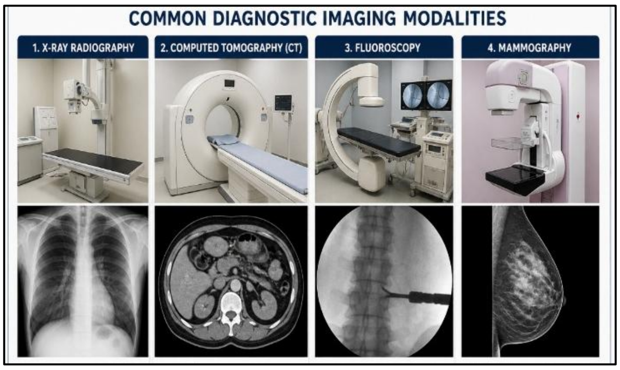

Figure 1: Common diagnostic imaging modalities (X-ray, CT, fluoroscopy, mammography).

Figure 2: Radiation workers performing procedures in radiology department.

Ionizing radiation can interact with living tissues and produce harmful biological effects. These effects are generally divided into deterministic effects and stochastic effects. Deterministic effects occur when radiation exposure exceeds a threshold dose and the severity increases with dose. Examples include skin erythema, cataract formation, temporary or permanent infertility, and tissue burns. In contrast, stochastic effects do not have a threshold dose, and the probability of occurrence increases with cumulative exposure. Examples include radiation-induced cancers and hereditary genetic mutations. Even low-level chronic exposure may increase long-term cancer risk. Therefore, radiation safety is a major concern for all healthcare workers exposed to radiation.[3]

Certain groups require additional attention regarding radiation safety. Pregnant workers are more vulnerable because radiation exposure may affect the developing fetus, particularly during early gestation. Young trainees and students are also considered sensitive groups because they may have a longer remaining lifespan during which radiation effects can manifest. For these reasons, regulatory authorities recommend strict dose monitoring, work modifications when necessary, and adherence to radiation safety guidelines for these groups.[4]

Radiation protection refers to the science and practice of preventing unnecessary exposure to ionizing radiation while maintaining the diagnostic quality of imaging procedures. The three fundamental principles of radiation protection are time, distance, and shielding. Reducing the time spent near a radiation source decreases the received dose. Increasing the distance from the source lowers exposure according to the inverse square law. Using protective shielding materials such as lead aprons, thyroid collars, mobile barriers, and lead glass screens significantly reduces scattered radiation exposure. These principles are universally applied in diagnostic radiology and radiotherapy settings.[5]

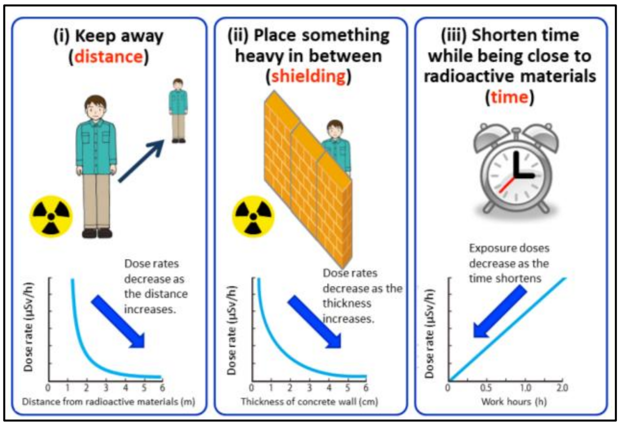

Figure 3: Three principles of radiation protection-time, distance, shielding.

Another important concept in radiation safety is the ALARA principle, which stands for "as low as reasonably achievable". ALARA emphasizes minimizing radiation exposure to patients and workers by using all practical methods without compromising the required diagnostic outcome. This principle encourages proper patient positioning, optimized exposure parameters, avoidance of repeat examinations, and the use of shielding devices whenever appropriate. ALARA is considered the foundation of modern radiation protection programs worldwide.[6]

Various protective measures are routinely implemented in radiology departments to ensure worker safety. Personal monitoring devices such as thermoluminescent dosimeters (TLD badges) or electronic dosimeters are used to measure cumulative occupational dose. Lead aprons, thyroid shields, gonad shields, lead gloves, and protective eyewear are used during procedures involving scatter radiation. Radiation warning signs, restricted access zones, and controlled areas help prevent unnecessary exposure to non-authorized personnel. In addition, regular equipment servicing, calibration, and quality assurance testing are necessary to ensure machines operate safely and efficiently.[7]

Figure 4: Personal protective equipment used in radiology.

Despite the availability of guidelines and protective tools, studies have shown that gaps often exist between knowledge and actual practice of radiation safety. Some workers may understand the importance of TLD badges but fail to wear them consistently. Others may know about protective shielding but neglect its regular use due to workload, discomfort, or negligence. Students may possess recent theoretical knowledge gained during academic learning but may lack hands-on practical compliance. On the other hand, experienced staff may have practical familiarity but outdated theoretical knowledge if they have not attended recent training programs. Therefore, evaluating both knowledge and practices is necessary for a complete understanding of radiation safety culture.[8]

Previous studies conducted in hospitals, universities, and diagnostic centers have reported variable levels of awareness regarding radiation hazards and protection measures. Several researchers found satisfactory knowledge about basic concepts such as ALARA and dosimeter use, while poor awareness was observed regarding annual dose limits, radiation-sensitive organs, and appropriate shielding thickness. Some studies also reported inadequate participation in training workshops and inconsistent use of personal protective equipment. These findings indicate that radiation protection education should be continuous rather than a one-time activity. Regular refresher courses, workshops, and competency assessments are necessary to maintain safe practice standards.[9,10]

Although many studies have evaluated radiation awareness separately among students or staff, limited research has assessed both groups together within the same radiology imaging department. Furthermore, only a few studies directly compare theoretical knowledge with actual daily practices. This creates an important research gap, as both groups contribute to the functioning of the department and may have different training needs. Understanding these differences can help institutions design targeted interventions for each group.[11]

The present study was therefore designed to assess the level of radiation protection knowledge and practices among radiation workers in a radiology imaging department. The study included students and staff members such as radiographers, technicians, and faculty involved in imaging services. By identifying areas of adequate awareness and areas requiring improvement, the study aimed to strengthen radiation safety culture, improve training strategies, and reduce unnecessary occupational exposure. Ultimately, enhancing radiation protection knowledge and compliance benefits both healthcare workers and patients by promoting a safer imaging environment.

Aim and objectives

Aim

To assess the level of radiation protection knowledge and safety practices among radiation workers working or training in the radiology imaging department of Mahatma Gandhi Medical College and Hospital, Jaipur, Rajasthan.

Objectives

To evaluate the knowledge of radiation protection principles among radiation workers, including students and staff members. To assess awareness regarding important radiation safety concepts such as ALARA, occupational dose limits, TLD badge use, and protective shielding. To evaluate the routine practices followed by radiation workers regarding the use of personal protective equipment and radiation monitoring devices. To compare the level of radiation protection knowledge between students and staff members. To identify gaps between theoretical knowledge and actual radiation safety practices. To assess participation in radiation protection training programs, workshops, and continuing education activities. To suggest suitable measures for improving radiation safety awareness, compliance, and occupational protection within the department.

METHODS

Study design

A cross-sectional descriptive study was conducted to assess knowledge and practices related to radiation protection among radiation workers in the radiology imaging department.

Study setting

The study was carried out in the radiology imaging department of Mahatma Gandhi Medical College and Hospital, Jaipur, Rajasthan, including areas such as x-ray, CT, fluoroscopy, and other imaging units using ionizing radiation.

Study duration

The study was conducted over a period of 5 months, from June 2025 to October 2025.

Study population

Participants included radiation workers such as radiology students, radiographers, and technicians.

Sample size

A total of 168 participants was included, comprising 127 students (75.6%) and 41 staff members (24.4%).

Sampling technique

Convenience sampling was used, including participants who were available and willing to participate.

Inclusion criteria

Radiation workers in the radiology department. Students posted for clinical training. Staff involved in imaging procedures. Willing participants.

Exclusion criteria

Non-radiology personnel. Unwilling participants. Incomplete or duplicate responses.

Data collection tool

A structured Google form questionnaire with 20 questions covering demographics, radiation protection knowledge, safety practices, dose monitoring, PPE use, and training.

Data collection procedure

The questionnaire was distributed online and directly within the department. Participation was voluntary and anonymous.

Ethical consideration

Informed consent was obtained. Confidentiality and anonymity were maintained.

Outcome measures

Knowledge of radiation protection. Compliance with safety practices. Comparison between students and staff. Identification of training gaps

Data

A total of 168 radiation workers participated in the study, including both students and staff from the radiology imaging department. Among them, students constituted the majority with 127 participants (75.6%), while staff members accounted for 41 participants (24.4%).

Regarding professional experience, most participants (59.5%) had 0-1 year of experience, followed by 26.8% with 1-3 years, 8.9% with 3-5 years, and only 4.8% with more than 5 years of experience. This indicates that the study population was predominantly composed of early-career individuals.

A majority of participants (89.3%) correctly identified ALARA as “as low as reasonably achievable”. A small proportion selected incorrect responses, including “all light and radiation absorbed” (6.0%), “atomic level radiation awareness” (3.6%), and “none of the above” (1.2%).

Almost all participants (98.2%) correctly identified the dosimeter/TLD badge as the device used to measure occupational radiation exposure. Very few participants selected incorrect options such as thermometer (1.2%) or barometer (0.6%).

When asked about the recommended annual occupational dose limit, 78.0% of participants correctly selected 20 mSv. However, 11.9% selected 50 mSv, 7.7% selected 10 mSv, and 2.4% selected 100 mSv, indicating some gaps in precise knowledge.

Only 51.2% of participants correctly identified the thyroid gland as the most sensitive organ to radiation exposure. Incorrect responses included skin (33.9%), bone (14.3%), and muscle (0.6%), suggesting moderate awareness in this area.

Only 28.6% of participants correctly identified 0.5 mm lead equivalence as the standard thickness for protective aprons. The majority selected incorrect options, with 56.5% choosing 0.25 mm, followed by 8.3% selecting 1 mm and 6.5% selecting 2 mm. This reflects a significant gap in technical knowledge.

When asked about shielding devices used for patient protection, 73.8% of participants correctly selected “all of the above” (lead aprons, gonad shields, and thyroid shields). Individual selections included lead apron (19.0%), gonad shield (6.0%), and thyroid shield (1.2%).

Regarding participation in radiation protection training programs, 68.5% of participants reported attending such training, while 24.4% had not attended, indicating a need for improved training coverage.

Table 1: Knowledge of radiation protection and monitoring among participants (n=168).

Parameters	Response	Frequency	Percent
Meaning of ALARA principle	As low as reasonably achievable (correct)	150	89.3
	All light and radiation absorbed	10	6
	Atomic level and radiation awareness	6	3.6
	None of the above	2	1.2
Device used for personal radiation monitoring	Dosimeter/ TLD badge (Correct)	165	98.2
	Thermometer	2	1.2
	Barometer	1	0.6
Annual occupational dose limit	20 mSv (Correct)	131	78
	50 mSv	20	11.9
	10 mSv	13	7.7
	100 mSv	4	2.4
Most radiation-sensitive organ	Thyroid (Correct)	86	51.2
	Skin	57	33.9
	Bone	24	14.3
	Muscle	1	0.6
Minimum lead apron thickness recommended for radiation protection	0.25 mm	95	56.5
	0.5 mm (Correct)	48	28.6
	1 mm	14	8.3
	2 mm	11	6.5
Awareness of radiation safety guidelines	Yes	115	68.5
	No	41	24.4
	Not aware about It	12	7.1

RESULTS

A total of 168 participants were included in this study to evaluate radiation protection knowledge and practices among radiation workers in a radiology imaging department. The study population comprised both students and staff actively involved in radiological services or clinical training. Among them, 127 participants (75.6%) were students and 41 (24.4%) were staff members, indicating a predominantly academic study setting.

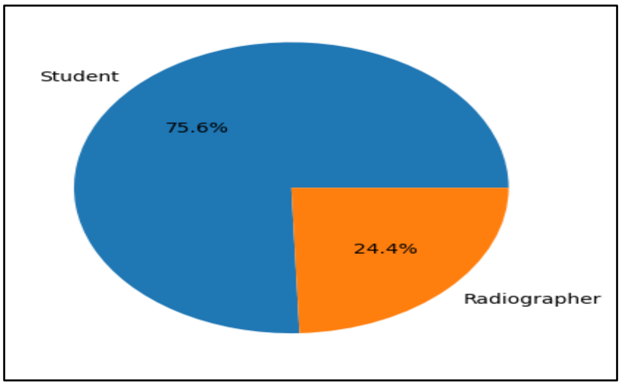

Figure 5: Role of participants.

In terms of professional experience, the majority of participants were relatively new to the field. About 100 participants (59.5%) had 0-1 year of experience, followed by 45 (26.8%) with 1-3 years, 15 (8.9%) with 3-5 years, and only 8 (4.8%) with more than 5 years of experience. This distribution suggests that most respondents were in the early stages of their professional or academic careers.

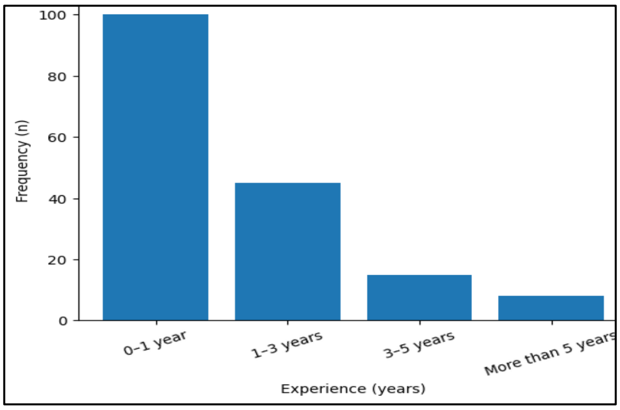

Figure 6: Experience of participants in the radiology field.

The assessment of radiation protection knowledge revealed generally positive results. A high proportion of participants (89.3%) correctly identified the meaning of ALARA (as low as reasonably achievable), reflecting strong awareness of a fundamental radiation safety principle. Similarly, 98.2% correctly recognized the dosimeter or TLD badge as the device used for measuring occupational radiation exposure, indicating excellent knowledge of personal monitoring systems.

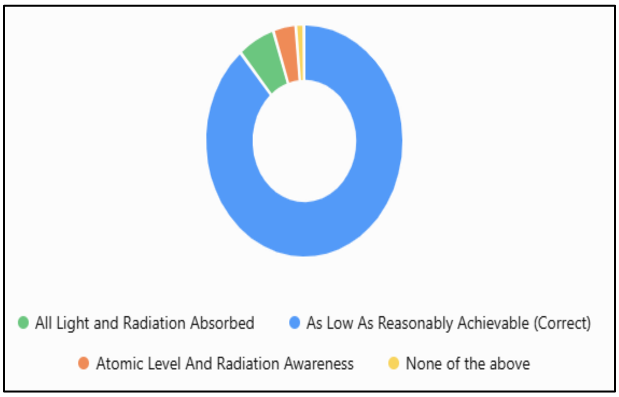

Figure 7: Distribution of responses regarding the full form of ALARA principle.

Knowledge regarding occupational dose limits was also satisfactory, with 78.0% correctly identifying 20 mSv as the recommended annual limit. However, some participants selected incorrect values, highlighting partial gaps in understanding radiation dose standards. Awareness of radiation-sensitive organs was moderate; only 51.2% correctly identified the thyroid gland as highly sensitive, suggesting the need for improved education in this area.

A notable deficiency was observed in knowledge of protective equipment standards. Only 28.6% of participants correctly identified 0.5 mm lead equivalence as the minimum standard for lead aprons, indicating insufficient awareness of technical safety specifications. On the other hand, knowledge of basic radiation protection principles was strong, with 86.3% correctly identifying that brightness is not a principle of radiation protection.

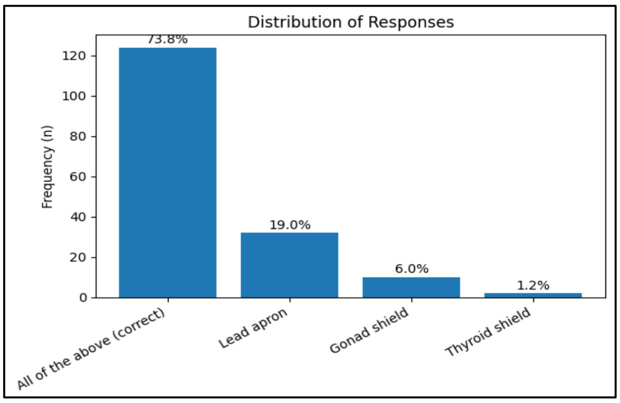

Figure 8: Responses to “which of the following shields is commonly used to protect patients?”.

In terms of practices, most participants demonstrated good compliance with safety measures. About 88.7% reported knowing how to properly use and store a TLD badge, and 85.7% stated that they consistently wore it during work. Similarly, 83.9% reported regular use of lead aprons, although a small proportion admitted inconsistent or no usage, indicating room for improvement. Environmental safety awareness was also satisfactory, with 86.3% of participants regularly checking radiation safety signage. Regarding training, 68.5% had attended radiation protection programs, but a significant number had either never attended or were unaware of such opportunities.

Comparatively, students performed better in theoretical knowledge, while staff showed stronger practical understanding. Overall, the study highlighted good general awareness but identifies gaps in technical knowledge and training, emphasizing the need for continuous education and strengthened safety practices.

DISCUSSION

The findings of the present study indicate a generally satisfactory level of awareness regarding radiation protection among participants. A majority (89.3%) correctly identified the meaning of the ALARA principle, demonstrating a strong theoretical understanding of one of the fundamental concepts of radiation safety. This finding advises that radiation workers are aware of the need to keep radiation exposure as low as reasonably achievable while maintaining diagnostic image quality. Similar levels of awareness have been reported by Paolicchi et al and Zewdneh et al, who observed good knowledge of radiation protection ideologies among radiology personnel and healthcare workers. The high awareness observed in the present study may be attributed to formal academic training and regular exposure to radiological practices.[6]

The study assessed radiation protection knowledge and practices among radiation workers, including students and staff, in a radiology imaging department. Radiation safety is a critical aspect of radiological practice due to continuous exposure to ionizing radiation during diagnostic and interventional procedures. Ensuring adequate knowledge and adherence to protective measures is essential for minimizing occupational risk and maintaining a safe working environment.[12]

The study demonstrated a high level of awareness regarding key radiation protection concepts. Notably, 89.3% of participants correctly identified the ALARA principle (“as low as reasonably achievable”), reflecting strong theoretical understanding. Similarly, 98.2% correctly recognized the TLD badge or dosimeter as a tool for monitoring occupational radiation exposure, indicating excellent awareness of personal dosimetry practices. These findings are comparable with previous studies reporting satisfactory awareness of basic radiation protection principles among healthcare workers.[13,14]

Knowledge of the recommended annual occupational dose limit (20 mSv) was correct in 78.0% of respondents. While this represents a satisfactory majority, a considerable proportion selected incorrect values, suggesting incomplete understanding of regulatory standards. Similar observations have been reported in previous studies assessing radiation safety knowledge among radiology professionals.[15]

Awareness of radiation-sensitive organs was moderate, with only 51.2% correctly identifying the thyroid gland, highlighting a gap in understanding of biological radiation effects. Similar deficiencies have been reported among healthcare workers and medical trainees in earlier investigations.[16]

A major deficiency was observed in knowledge of protective equipment standards. Only 28.6% correctly identified 0.5 mm lead equivalence as the minimum standard for lead aprons. This indicates a gap between general awareness and technical knowledge, particularly important in clinical practice. Staff members performed better in this area, likely due to greater hands-on experience. Similar findings have been reported in previous studies evaluating radiation protection practices.[17]

Knowledge of the fundamental principles of radiation protection- time, distance, and shielding- was strong. In terms of practices, most participants reported good compliance with TLD badge usage and lead apron utilization. However, incomplete adherence in some cases indicates the need for stricter monitoring and reinforcement.[18]

Environmental safety awareness was also satisfactory, with most participants regularly checking radiation safety signage. However, participation in training programs was limited, indicating a need for continuous professional education and refresher courses.[19]

Comparatively, students performed better in theoretical knowledge, whereas staff demonstrated stronger practical skills. This highlights the need for integrated education combining theoretical learning with practical training.[20]

Overall, the study indicated good general awareness and satisfactory safety practices but identifies gaps in technical knowledge, biological understanding, and training participation. Regular training, policy reinforcement, and continuous monitoring are recommended to strengthen radiation safety culture.[21]

CONCLUSION

The present study evaluated radiation protection knowledge and practices among students and staff in a radiology imaging department. Radiation safety is a critical responsibility in diagnostic imaging, as workers are routinely exposed to ionizing radiation. Adequate knowledge, safe practices, and adherence to guidelines are essential to minimize occupational exposure and maintain a safe working environment.

Overall, participants demonstrated good general awareness of key radiation protection principles. Most respondents correctly identified the ALARA principle, recognized the importance of TLD badges for dose monitoring, and understood the fundamental concepts of time, distance, and shielding. In addition, safety practices were largely satisfactory, with a high proportion reporting regular use of dosimeters, lead aprons, and attention to radiation safety signage. These findings indicate a positive safety culture and acceptable compliance within the department.

However, the study also revealed important gaps. Knowledge of technical aspects, such as the standard lead equivalence of protective aprons, was limited. Awareness of radiation-sensitive organs and precise occupational dose limits was also moderate. Such deficiencies suggest that while general concepts are understood, detailed technical knowledge is lacking and may affect the effectiveness of protective measures in practice.

Furthermore, not all participants consistently followed safety practices. A small proportion reported irregular use of TLD badges and lead aprons, which may increase long-term occupational risk. The study also highlighted limited participation in formal radiation safety training programs, emphasizing the need for continuous education and regular refresher sessions.

Differences between students and staff were observed, with students showing stronger theoretical knowledge and staff demonstrating better practical understanding. This underscores the importance of integrating academic learning with hands-on training.

In conclusion, while radiation workers showed satisfactory awareness and practices, gaps in technical knowledge and training remain. Strengthening education, ensuring consistent compliance, and promoting a proactive safety culture are essential for improving radiation protection standards.

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