

Radiation Safety Awareness and Academic Knowledge Among Undergraduate Radiology Students in North India: A Multicentric Survey

Aditya Nagrath¹, Manpreet Singh², Amit Kumar³, Vivek Sharma⁴, Susheel Kumar⁵, Chirag K. Ahuja⁶

¹Senior Technician, Radiodiagnosis and Imaging, PGIMER, Chandigarh

^{2,4}Junior Technician, Radiodiagnosis and Imaging, PGIMER, Chandigarh

^{3,5}Tutor Technician, Radiodiagnosis and Imaging, PGIMER, Chandigarh

⁶Additional Professor, Radiodiagnosis and Imaging, PGIMER, Chandigarh

Abstract—Background: Radiation safety is a critical component of radiology education, yet awareness among undergraduate students remains variable. **Objective:** To assess radiation safety awareness and academic knowledge among undergraduate radiology students across multiple institutions in North India. **Methods:** A cross-sectional survey was conducted among 308 students from government and private institutions. A structured questionnaire assessed awareness, effectiveness of education, curriculum gaps, recommendations, and knowledge through 14 basic questions. **Results:** Only 33.1% of students demonstrated basic knowledge of radiation protection principles. First-year students showed weaker performance, reflecting curriculum gaps. Government institutions showed stronger progression in later years, while private institutions displayed wider variability. **Conclusion:** Radiation safety awareness among undergraduate radiology students is suboptimal. Early curriculum integration, practical sessions, and periodic assessments are recommended to strengthen knowledge and ensure safe practice.

Index Terms—Radiation Safety, Radiology, Safe Practice, Students knowledge

I. INTRODUCTION

Radiation safety is essential for radiology students who will work with ionizing modalities during their careers. Despite its importance, undergraduate curricula often delay formal exposure to radiation protection principles until later years. This study

evaluates awareness and knowledge among undergraduate radiology students in North India, highlighting institutional differences and curriculum gaps.

II. METHODS

Design: Cross-sectional survey using Google Forms. **Participants:** 308 undergraduate radiology students from government and private institutions. **Instrument:** Questionnaire with five parts:

- Awareness of radiation safety principles
- Effectiveness of radiation safety education
- Curriculum gaps
- Recommendations for improvement
- Knowledge check (14 questions; scoring rubric: 0–7 = below average, 8–10 = average, 11–13 = good, 14 = excellent)

Analysis: Descriptive statistics, institution-type comparisons (government vs. private), and year-wise trends.

Results

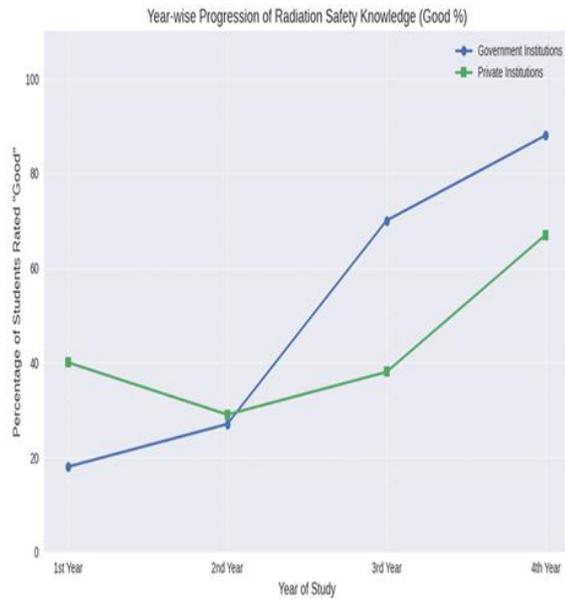
Demographics

- Age: Majority 18–22 years (81.2%)
- Gender: Female (50.1%), Male (49.9%)
- Year of study: 2nd year (37.9%), 3rd year (27.8%), 1st year (20.1%), 4th year/internship (14.1%)

Table 1. Year-wise Knowledge Levels in Government vs. Private Institutions

Year of Study	Institution Type	Below Average (%)	Average (%)	Good (%)	Excellent (%)
1st Year	Government	20–38	45–55	6–30	–
	Private	10–31	27–75	6–73	–
2nd Year	Government	32–49	5–43	12–42	–
	Private	14–38	21–64	16–42	–
3rd Year	Government	20–40	40–43	40–100	–
	Private	0–39	30–67	26–50	–
4th Year / Internship	Government	–	25–50	75–100	–
	Private	0–17	25–100	34–100	–

Table 2. Line Chart: Year-wise progression of students rated “Good” in Government vs. Private institutions.



government and private institutions across North India. The majority of respondents were aged 18–22 years (81.2%), reflecting the typical undergraduate cohort. Gender distribution was balanced, with 50.1% female and 49.9% male participants. Year-wise representation included 20.1% first-year, 37.9% second-year, 27.8% third-year, and 14.1% fourth-year/internship students. This distribution provided a comprehensive view of knowledge progression across the academic trajectory.

III. OVERALL KNOWLEDGE LEVELS

When aggregated across all institutions, the knowledge check revealed that only 33.1% of students demonstrated “good” knowledge of radiation safety principles. A similar proportion (34%) fell into the “average” category, while 33% were below average, and less than 1% achieved “excellent.” This balanced but suboptimal distribution underscores the limited penetration of radiation safety concepts in undergraduate curricula.

Table 3. Overall Knowledge Levels Among All Students (n = 308)

Knowledge Level	Percentage (%)	Approximate Number of Students
Below Average	33	~102
Average	34	~105
Good	33	~101
Excellent	<1 (negligible)	~0–2

Results

Demographic Profile

A total of 308 undergraduate radiology students participated in the survey, representing both

Year-Wise Trends

First Year

First-year students consistently demonstrated weaker knowledge. Across both government and private institutions, below-average and average scores dominated, with only a small proportion achieving “good.” Government institutions tended to cluster around average performance (45–55%), while private institutions showed greater variability, ranging from 10–31% below average to 6–73% good. These findings highlight curriculum gaps in early exposure to radiation safety.

Second Year

Second-year cohorts displayed mixed outcomes. Government institutions reported 32–49% below average, with modest proportions of good performers (12–42%). Private institutions showed slightly better balance, with 16–42% good, but also significant below-average proportions (14–38%). This variability suggests differences in curriculum design and teaching emphasis between institution types.

Third Year

Third-year students generally showed improvement. Government institutions demonstrated strong progression, with some cohorts achieving 100% “good” ratings. Private institutions displayed moderate outcomes, with 26–50% good and persistent below-average groups (up to 39%). These results indicate that structured training and practical exposure in government institutions may be more effective in consolidating knowledge.

Fourth Year / Internship

Final-year and internship students across both institution types performed better, with 75–100% rated “good” in government institutions and 34–100% in private institutions. This reflects the cumulative impact of clinical exposure, hands-on practice, and reinforcement of safety principles in advanced stages of training. The near absence of “excellent” scores, however, suggests that even at the culmination of training, mastery of radiation safety principles remains limited.

Institution Type Comparison

When comparing government and private institutions:

- Government institutions demonstrated consistency and stronger progression, particularly in later years. Their cohorts showed steady improvement, culminating in high proportions of “good” ratings in the third and fourth years.
- Private institutions displayed greater variability, with some strong performers but also significant gaps in early-year training. The wide range of outcomes suggests differences in faculty expertise, curriculum emphasis, and practical exposure.

Knowledge Distribution Summary

The compiled results reveal several key trends:

- Early years (1st and 2nd): Weak knowledge levels, dominated by below-average and average scores.
- Middle years (3rd): Improvement evident, especially in government institutions, though variability persists in private institutions.
- Final year/internship: Stronger outcomes across both institution types, reflecting cumulative exposure.
- Overall: Balanced distribution across categories, but with limited excellence, underscoring the need for curriculum reform.

Key Observations

1. Curriculum gaps are most evident in the first and second years.
2. Government institutions provide more structured progression, with stronger outcomes in later years.
3. Private institutions show wider variability, highlighting the need for standardized training modules.
4. Practical exposure and continuous evaluation are critical in improving knowledge retention and performance.
5. Excellent scores are rare, indicating that mastery of radiation safety principles is not achieved even at advanced stages.

IV. DISCUSSION

Radiation safety is a cornerstone of radiology education, yet the present study demonstrates that undergraduate students in North India exhibit only moderate awareness and knowledge of protection principles. While the results revealed clear year-wise progression and differences between government and private institutions, the discussion must move beyond descriptive statistics to explore the underlying causes, implications, and pathways for reform.

Curriculum Timing and Early Exposure

One of the most striking findings is the consistently weaker performance among first-year students. This pattern is not unique to the surveyed institutions; international studies have similarly reported that radiation safety is often introduced late in training, leaving early cohorts underprepared. The absence of

structured modules in the first year delays the acquisition of foundational knowledge, which is critical given that students are often exposed to imaging environments early in their programs. Without early integration, misconceptions may persist and safety practices may be compromised during clinical rotations.

Institutional Variability and Pedagogical Approaches
The divergence between government and private institutions highlights the role of curriculum design and teaching methodology. Government institutions demonstrated steadier progression, suggesting that structured syllabi, faculty expertise, and access to advanced clinical facilities contribute to stronger outcomes. Private institutions, by contrast, displayed wider variability, which may reflect differences in resource allocation, faculty training, and emphasis on safety education. This variability underscores the need for standardized national guidelines to ensure uniformity across institution types.

Practical Exposure and Experiential Learning
The improvement observed in later years, particularly during internships, points to the value of practical exposure. Students who engage directly with radiological equipment and clinical workflows appear to internalize safety principles more effectively. This aligns with global recommendations from the International Atomic Energy Agency (IAEA), which emphasize hands-on training and simulation exercises as essential complements to theoretical instruction. The findings suggest that experiential learning should not be reserved for advanced stages but introduced progressively from the first year onward.

Knowledge Retention and Reinforcement
The decline in performance observed in some cohorts after initial gains raises concerns about knowledge retention. Radiation safety, like other technical competencies, requires continuous reinforcement. Sporadic lectures or isolated modules may lead to temporary improvement but fail to sustain long-term understanding. Periodic assessments, refresher courses, and integration of safety principles into routine coursework could mitigate this decline. The use of digital platforms, interactive modules, and gamified learning may further enhance retention by engaging students actively.

Implications for Patient and Workforce Safety
The suboptimal awareness among undergraduates has direct implications for patient care and workforce safety. Radiology professionals are frontline custodians of radiation protection, and inadequate training at the undergraduate level may translate into unsafe practices in clinical settings. This not only increases risks for patients but also exposes staff to unnecessary occupational hazards. Strengthening undergraduate curricula is therefore not merely an academic exercise but a public health imperative.

Policy and Regulatory Perspectives
National regulatory bodies such as the Atomic Energy Regulatory Board (AERB) and training initiatives by the Bhabha Atomic Research Centre (BARC) provide frameworks for radiation safety education. However, the variability observed in this study suggests that these frameworks are not uniformly implemented across institutions. A policy-driven approach, mandating standardized modules and periodic certification, could bridge the gap between government and private institutions. Collaboration with professional societies and accreditation bodies would further ensure compliance and accountability.

Recommendations for Reform
Building on these insights, several reforms are warranted:

- **Early integration:** Radiation safety modules should be introduced in the first year of undergraduate programs.
- **Continuous reinforcement:** Safety principles must be revisited throughout the curriculum, not confined to isolated courses.
- **Experiential learning:** Practical sessions, simulations, and workshops should be embedded at every stage.
- **Digital innovation:** Online modules, interactive case studies, and virtual reality simulations can enhance engagement.
- **Standardization:** National guidelines should mandate uniform curricula across government and private institutions.
- **Assessment and certification:** Periodic evaluations and mandatory certification can ensure competency before clinical exposure.

Broader Educational Implications

The findings also resonate with broader debates in medical education. Radiation safety exemplifies the challenge of balancing theoretical knowledge with practical skills, and the variability across institutions reflects systemic issues in curriculum governance. Addressing these challenges requires a shift from content-heavy teaching to competency-based education, where safety principles are embedded as core competencies rather than optional add-ons. Such a shift would not only improve radiation safety but also strengthen overall patient safety culture in healthcare.

This study underscores the urgent need to rethink radiation safety education at the undergraduate level. The observed variability across institution types and years of study reflects systemic gaps in curriculum design, pedagogical approaches, and policy enforcement. By integrating safety principles early, reinforcing them continuously, and standardizing curricula nationally, institutions can ensure that future radiology professionals are equipped with the knowledge and skills necessary to protect both patients and themselves. The discussion thus moves beyond descriptive outcomes to highlight actionable reforms that can elevate the quality and safety of radiology education in India and beyond.

This multicentric survey highlights significant variability in radiation safety awareness among undergraduate radiology students. Several key trends emerged:

- **Early Years (1st & 2nd Year):** Both government and private institutions reported weaker performance among first-year students, with higher proportions of below-average and average scores. Private institutions showed more variability, with some cohorts performing well (up to 73% “good”), while others had over 30% below-average. Government institutions tended to cluster around average performance, with fewer high achievers in the early years. These findings suggest that radiation safety principles are not adequately integrated into the curriculum at the entry level.
- **Middle Years (3rd Year):** Government institutions demonstrated a marked improvement, with some cohorts achieving 100% “good” ratings. Private institutions showed mixed outcomes, with moderate proportions of “good”

performers (26–50%) but also persistent below-average groups. This indicates that structured training and exposure to practical radiology modules in government institutions may be more effective.

- **Final Year / Internship:** Both institution types showed stronger outcomes, with higher proportions of “good” ratings (75–100%). This reflects the cumulative impact of clinical exposure, hands-on practice, and reinforcement of safety principles in advanced stages of training.
- **Government vs. Private Comparison:** Government institutions demonstrated consistency and stronger progression, particularly in later years. Private institutions showed greater variability, highlighting the need for standardized training modules. The variability suggests differences in curriculum design, faculty expertise, and emphasis on radiation safety education.

Recommendations

- Introduce radiation safety modules in the 1st year of BMRIT programs.
- Conduct regular seminars and CME sessions to reinforce knowledge.
- Encourage student participation in conferences and workshops.
- Utilize digital resources effectively for radiation safety education.
- Implement periodic assessments to monitor progress.

V. CONCLUSION

This multicentric survey highlights that radiation safety awareness among undergraduate radiology students in North India remains suboptimal, particularly in the early years of training. While knowledge levels improve progressively with academic advancement, the absence of structured modules in the first and second years leads to significant gaps in foundational understanding. Government institutions demonstrated more consistent progression, whereas private institutions displayed wider variability, underscoring the need for standardized curricula across institution types.

The findings carry important implications for both patient safety and workforce wellbeing. Inadequate knowledge of radiation protection principles at the undergraduate level can translate into unsafe practices in clinical environments, exposing patients and staff to unnecessary risks. Strengthening undergraduate education is therefore not only an academic priority but also a public health necessity.

To address these gaps, radiation safety must be integrated early, reinforced continuously, and delivered through a combination of theoretical instruction, practical exposure, and digital innovation. National regulatory bodies and professional societies should collaborate to establish uniform guidelines and mandatory certification, ensuring that all institutions government and private alike equip students with the competencies required for safe radiological practice.

In conclusion, the study underscores the urgent need for curriculum reform, experiential learning, and standardized assessment to elevate radiation safety education. By embedding these principles into the core of undergraduate training, institutions can ensure that future radiology professionals are not only technically proficient but also committed to safeguarding patients, colleagues, and themselves.

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