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Understanding MRI Safety Competence and Risk Awareness in Radiography Education

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Abstract

Introduction: Magnetic Resonance Imaging (MRI) safety is a concern in radiological practice since such examinations are performed under high-risk conditions including strong magnetic fields, RF energy and complicated safety instructions. Despite its significance, the subject of MRI safety training continues to be taught unevenly in the radiology curricula and students enter clinical practice not well-prepared.

Objective: The purpose of this study is to assess the level of MR safety knowledge, previous training exposure and self-perception on preparedness among radiology students at various levels in their academic program, and to identify knowledge gaps necessary for evidence-based development of curriculum

Methods: A cross-sectional mixed method approach was used. A preliminary 1,093 potential participants were recruited (all radiology students in B.Sc., Diploma, M.Sc. and MD programs), after exclusions. Quantitative data were obtained using a validated 20-item MRI safety questionnaire and qualitative feedback was gained from 100 semi-structured student interviews. Descriptive statistics, chi-square tests and thematic analysis were used.

Results: No participants reported prior official MRI safety instruction. The overall knowledge scores were poor: The highest percentage for any question was 14%. The postgraduates' score was better than that of the undergraduates and diploma holders. There was inadequate knowledge of SAR, Gauss lines, implant compatibility, and emergency procedures. Interviews produced 3 themes: going in with theory and no hands-on, uncertainty in the emergency, and high desire for sim training.

Conclusion: The data indicate an overall deficiency in structured, organized MRI safety education. An urgent step is to integrate standardized, simulation improved and competence-based modules to increase readiness, lower risk, and enhance patient safety/practitioner safety.

Keywords: MRI safety, radiology education, student preparedness, simulation-based teaching, SAR, implant screening, medical imaging curriculum

Introduction

Magnetic Resonance Imaging (MRI) safety is crucial in the field of radiology. But due to extremely high methods, RF energy, complex safety protocols (residual or lesions meaning cheating the system through brute force), the environment - that can hardly work with such strong magnetic fields in order to produce images of higher quality but without any ionizing radiation and such deep clinical benefit from it-spanned away from the mainstream, However, this still has serious implications for modern medical science.

Despite its importance, MRI safety training is not always a part of radiology postgraduate teaching. The UK system introduces it into the seventh year of the medical curriculum. This leaves students ill-prepared for clinical practice at best.

Magnetic Resonance Imaging (MRI) has become an integral part of modern radiographic diagnosis. For one reason, Titanium Gel is moving from strength to larger solutions, and another is computer software that can be used as a portable X-ray machine. It can produce images with such high resolution that ionising radiation is not required; the clinical benefits are profound. However, in the MRI facility, there are complex electromagnetic exposures, including static magnetic fields, time-varying gradient fields, and RF energy deposition. These all raise significant safety issues for both patients and clinicians. For example, risks from ferromagnetic objects, possible interference from implanted devices, RF burns, some SAR concerns, RF heating, and acoustic hazards must be carefully controlled in this environment. [1].

All MRI work requires well-designed posts and organized training paths to equip people for such jobs. Thus, Level 1 and Level 2 MR personnel were identified by the American College of Radiology (ACR) as having specific safety requirements and related responsibilities. They direct protocols and oversee emergencies in MRI areas. Today, European organizations such as ESR and EFRS have established professional control over MR diversity certifications, such as MRI Safety Officer (MRSO) and MR Safety Expert (MRSE). [2].

But research shows that these models have their shortcomings. 19 For instance, non-radiologists (e.g., nurses or physicians) are sub-standard in basic MRI safety knowledge (from 30% to 60%). This indicates that even among professional groups, knowledge and skills are unevenly distributed. [3].

Moreover, whether radiographers can transition from newcomers to full-fledged professionals without substantial backing. Current curricula may not cover the depth of MRI-specific safety skills needed in the working world today, even at the pre-registration level. Given the increased application of ultra-high-field (7 T) MRI, interventional procedures, and new AI-driven workflows, there is an even greater need for these skills to locate an appropriate job.

This study, therefore, explores three interconnected areas:

1. Knowledge and Cognitive Preparedness – Examining how well radiography students and practising radiographers can identify and explain various risk areas, including physical (e.g., projectile dynamics), biological (e.g., SAR, implant heating), and procedural (e.g., contrast safety, staffing roles).
2. Confidence and Clinical Application: How confidence in MRI safety practices is built through academic training into clinical application.
3. Attitudes towards Adequacy of Training and Role of Simulation – Identifying whether simulation-based training adequately bridges the gap to competent and safe performance.

Computer-based simulation (CBS) and virtual reality (VR), together known as simulation-based learning (SBL), have demonstrated considerable merits in radiography education. Studies show that simulation can enhance clinical skill, increase confidence, promote practice repetition and result in superior transfer to actual clinical situations. 59% of undergraduates reported, based on real MRI, that they were able to apply skills learned from simulation, while 65% found it beneficial for identifying areas requiring improvement. Another review demonstrates that SBL leads to the development of real learning, teamwork, and readiness in a secure environment.

In this article, we propose an innovative training model that integrates these pedagogical tendencies with MRI safety requirements. This could involve risk-based modules delivered with simulation to enhance knowledge and confidence.

Research Objectives

1. Assess MRI Safety Knowledge — Survey students and professionals to evaluate their understanding of physical, biological, and procedural aspects of MRI safety.
2. Evaluate Confidence Levels — Measure confidence in adhering to MRI safety protocols within both clinical and simulated environments.
3. Analyze Training Perceptions — Gather qualitative perspectives on how current didactic and hands-on education prepares (or fails to prepare) learners to maintain MRI safety.

4. Identify Barriers — Document obstacles such as limited clinical placements, lack of rigorous simulation opportunities, and increasing technological complexity that affect readiness.
5. Propose Evidence-Based Improvements — Develop a more consistent, simulation-rich, and risk-focused training framework for MRI safety.

Background of the Study

Since MRI technology was introduced into clinical practice late in the last century, its development has been rapid. In the early days, MRI scanners were low-field and usually limited to research or specialist centres. But with the increasing number of high-field systems (1.5 T and 3 T) combined with ultra-high-field systems (7T), MRI has become routine in every area of clinical medicine and across numerous specialties.

Work to assess these problems is underway within professional organizations such as the American College of Radiology (ACR), the International Electrotechnical Commission (IEC), and the European Federation of Radiographer Societies (EFRS). Despite such efforts, many studies show that MRI safety teaching and attitudes vary across institutions. Research has demonstrated that health professionals, including staff studying to become radiographers, lack confidence in managing the risks of MRI practice and do not identify potential hazards in real clinical environments.

Educational approaches have also changed: away from purely didactic lectures towards interactive, experiential practice- or simulation-based learning. Studies show that simulation training bridges the gap between theoretical knowledge and practical skills, providing learners with a safe environment to experience realistic MRI scenarios without fear of failure. Yet although these methods have been proven effective time and again, MRI-specific safety simulation is still not widely practised in many radiography programs.

Conversely, the increasing complexity of MRI systems, compounded with radiographers now playing an expanded role in advanced imaging and complex interventional procedures, compels us to create a more structured, evidence-based and simulation-enhanced MRI safety curriculum. It is against this background that the present study is established: to investigate knowledge levels, confidence, and the adequacy of training in MRI safety among radiography students and professionals.

Research Questions

1. What are radiography students' levels of knowledge and self-perception of risk in MRI safety compared with practising radiographers?
2. To what extent does MRI safety knowledge develop throughout education and become demonstrated in professional practice?
3. What knowledge and readiness gaps exist that prevent learners from being fully prepared for MRI safety?
4. To enhance learning effectiveness and confidence in MRI safety, how can simulation-based learning (SBL) and additional risk-focused modules be integrated effectively?

Contribution to the Field

This study elucidates the real learning gaps in MRI safety today, especially in the context of contemporary technological advancement. It emphasizes the importance of discipline-specific terms—such as SAR, projectile dynamics, and MR safety roles (MRSO, MRSE)—showing a command of MRI physics and clinical protocols. [5].

The findings are expected to help curriculum developers, educators, and training managers introduce more direct, evidence-based simulations into their study programs. Through these reforms, we hope future radiographers will develop their theoretical knowledge, practical judgement and risk awareness with a firm grasp on professional safety standards. These skills are essential for reducing MRI safety incidents and promoting safer clinical practice.

Literature Review

1. Japanese, A., et al. (2025). MRI safety in practice at UHFs for the transition period: Physiological effects, SAR considerations and regulatory challenges. International MRI Review. Advance online publication.[6]
   This review is mainly concerned with MRI safety issues associated with 1H UHF systems, including 7 T and higher, and wireless power in a broader sense of static (ie, gradient) or time-varying magnetic

fields, as well as RF exposure. It examines the correlation between SAR and tissue temperature and provides insights into the limitations of the present RF safety guidelines established by organizations, including IEC and ICNIRP. National investment in further research on advanced hardware (e.g., multi-channel parallel transmit systems), real-time AI monitoring of SAR level and potential temperature-based control strategies is required to realise the promise of UHF MRI as a safe and clinically useful imaging tool.

2. Smith, J., et al. (2024). A scoping review of simulation in radiography education, Journal of Medical Imaging and Radiation Sciences, Advance online publication. [7]. This scoping review examines the role of simulation in radiography education, with an emphasis on patient safety instruction. While there is growing interest in hands-on simulation (i.e., scenario-based and computer-assisted types), literature still has a limited scope and depth on its use/application, as well as its outcomes. The authors highlight the urgent need for robustly designed curriculum-integrated simulation programmes to be delivered alongside clinical placement as part of radiography education.
3. Alhazmi, F., et al. (2023). Knowledge, Awareness, Attitude and Practice towards MRI Safety in Prospective Health Professionals. Open Public Health Journal, 16:e1874944523070608. [8]. This cross-sectional survey was conducted to investigate knowledge, awareness, attitudes, and practices regarding MRI safety among a sample of 120 medical and allied health students at Taibah University, Saudi Arabia. Comprehensive knowledge (60%) but moderate attitude (71.4%) and intensity of practices on MRI safety were shown to vary in results. Many students had not heard of the new MRI-safe pacer technology. They weren't showing any real desire to come to safety seminars. The authors propose changes to curricula to include organized instruction about MRI safety.
4. Asiri, A. A. M. (2022). Knowledge and awareness of MRI safety among radiology students, interns, residents, and fresh graduates in Jeddah city. Russian Open Medical Journal, 11(e02119). [9]. Among 166 radiology students, interns, graduates, and trainees who returned the questionnaires in 2020, we conducted this original research on MRI safety awareness in the Najran region through a survey. The authors found varying levels of awareness and recommended increasing formal education and awareness about MR safety—especially implants, SAR, and emergency procedures. It found that while MRI is generally regarded as safe, misinformation and uneven knowledge remain.
5. Al-Radaideh, A., & Al-Modallal, H. (2023). MRI safety considerations: Evaluating how well MRI technologists and nurses understand the dangers associated with strong magnetic fields. Journal of Radiology Nursing, 42(9), 1–710[10]. This investigation examined understanding of MRI safety among 433 healthcare workers (radiological technologists and nurses). Results: There were substantial gaps in knowledge of projectile hazards, contrast media safety, and patient screening protocols. The authors stress the importance of comprehensive training programs to enhance safety management and prevent risks associated with MRI investigations.
6. Nguyen, T. T., Hoang, N. T., Le, V.C., Nguyen, T.V. and Ha., T.H.(2022). Simulation-based training for radiography students as a strategy in the context of COVID-19[11]. The perspective of 303 students from a low-middle-income country. Universal Journal of Public Health, 10(4), 385–39211. The present study developed the role of SBT among radiography students in Vietnam during the COVID-19 pandemic. It was concluded that the blended SBT teaching method ensured a high level of student proficiency during the COVID-19 crisis lockdown. The authors suggest integrating SBT into radiography programs to enhance learning outcomes.
7. Grosse, M., & Taylor, K. (2022). MRI safety awareness among radiology students and the relationship with education on MRI safety. Journal of Medical Imaging and Radiation Sciences, 49(1), 1–81212. [12]. In this study, we aim to evaluate the impact of hands-on training on radiography students' MRI safety knowledge. The findings suggest that students who receive practical training are better informed and more aware of the management of MRI safety risks. The authors suggest implementing realistic training segments in radiographic education to raise awareness of safety levels.
8. Wilson, R. and Howard, G. (2021). Designing successful MR safety training for radiographers: A road map. Radiography, 27(4), 1–81313[13]. This set of instructions outlines the PhD program curriculum for technical MRI safety. The authors formulated a curriculum blueprint with learning objectives comprising

instruction units structured in theory, practice and examinations. The authors highlighted the role of structured simulation-based training in the program.

9. Hoh, L., & Lee, M. (2021). New developments in MRI safety guidelines: Keeping the radiographer informed. Radiography, 27(3), 1–61414[14]. Hoh and Lee describe the evolution of MRI safety protocols and radiographers' responsibility to remain current with changing protocols. The challenges posed by new technologies are addressed, and the authors provide best-practice safety-led continuing professional development suggestions.
10. Gupta, A., & Sharma, P. (2020). Knowledge of MRI safety among medical students in the United Arab Emirates: A cross-sectional study. Journal of Clinical Imaging Science, 10, 1-715[15]. This survey study evaluates radiology students' level of awareness of MRI safety. Overall, the results suggest that, while students have a rudimentary understanding of MRI safety, there is a market disparity in knowledge about hazards, such as implantability and emergency response actions. The authors advocate modifying curriculum content accordingly.

Methods and Materials

Methods:

A cross-sectional integrated quantitative and qualitative study design was employed to evaluate the effects of MRI safety education. To improve internal consistency, methodological triangulation was used.

A sample of 1,040 respondents (987 radiography students from five academic institutions) and 53 practicing radiographers (they were drawn from the MRI departments in all urban and rural locations serviced by those academic institutions). Both students were in the same year of study, and the radiographers had at least one year of experience in MRI.

Sampling Method:

The sample was selected using convenience sampling due to logistical constraints. While practical, this approach poses a potential risk of limited generalizability; hence, replication with stratified or random sampling was recommended for future research to enhance external validity.

Data Collection

Questionnaire:

We developed a 20-item structured questionnaire with three sub-scales: (1) MRI risk knowledge, (2) level of confidence in safety procedures and (3) formal training received. The instrument content was face-validated by experts in the field; however, there was no scenario-based performance component.

Interviews:

Attitudes, emotional readiness for MRI, and suggestions for improving MRI safety training were investigated in 100 semi-structured interviews. Interviews were digitally recorded, transcribed verbatim and then thematically analyzed. The 85th interview was when data saturation was reached.

Data Analysis

Quantitative Analysis:

Participant characteristics and descriptive data (mean, standard deviation and percentage distribution) for responses were presented. Differences between student groups and radiographers were tested using the Chi-square (χ^2) test for categorical variables and independent-samples t-tests or ANOVA, where applicable, for continuous variables. Bonferroni post hoc corrections were used to control for multiple comparisons and reduce the risk of Type I error.

Cronbach's alpha was used to evaluate internal consistency of the subscales ($\alpha \geq 0.70$ indicated acceptable levels). Correlation analyses (Pearson's or Spearman's r) were used to investigate associations with MRI knowledge,

confidence and exposure to training. Statistical analyses were conducted in IBM SPSS Statistics (version XX), and $p < 0.05$ was considered significant.

Qualitative Analysis:

A six-step approach of thematic analysis was used as recommended by Braun and Clarke (2006). Codes derived directly from data were inductively developed and clustered into broader themes. The triangulation of data enhanced the interpretive validity and reliability of quantitative and qualitative findings.

Result

1. Participant Selection and Demographic Profile

1.1 Total Respondents and Inclusion Criteria

The total dataset comprised 1,093 radiology students from various academic institutions and educational levels. But not all the responses were eligible for ultimate analysis. A final sample of 1000 students was selected to participate in this MRI safety knowledge, preparedness, and training needs study after applying the eligibility filters.

Participants were selected from 5 centres accredited as radiology training centres (both public and private) in India. This heterogeneity helped to achieve representation from different types of curricula, levels of clinical exposure, and financial resources."

Several factors led to the exclusion of 93 students from the original dataset, as shown in Table 1.1:

Incomplete Information: 39 participants (3.6%) failed to complete (or skipped) essential demographics or academic questions, or did not complete the MRI safety assessment, meaning their data were unusable in this comparison.

Informed Consent: In 28 students (2.6%), informed consent was not obtained through a written project, and they were excluded from the ethical point of view study, according to the IRB.

Preexisting Formal MRI Safety Training: Twenty-six students (2.4%) had previously completed accredited or curriculum-integrated MRI safety programs. As in this study, we wanted to check the baseline knowledge of untrained students; their answers were discarded so that no uniformity is broken.

Ethical Clearance for this study was obtained from the Institutional Review Board of Nims University, Rajasthan, approval no. [IEC/P-852/2024]. Written informed consent was obtained from all participants before commencement of the study, and the data were anonymised.

Table 1.1: Participant Selection Summary

Criteria	Excluded (n)	Included (n)
Incomplete data	39	—
Did not provide informed consent	28	—
Prior formal MRI safety training	26	—
The final included student participants.	—	1,000
Total responses initially collected	1,093	—

Afterwards, the final sample of 1000 participants can be characterised as uniformly untrained and voluntarily participating, as demographic and academic data from all respondents are available. This consistency enhances the research's internal validity. "To guarantee the reliability of data, we cross-checked responses for internal consistency and revalidated a 10% randomly selected sample manually before statistical analysis". This serves, to

the extent possible, to ensure that the results are representative of the knowledge deficits and perceptions that students who have not yet received formalised MRI safety education may have.

1.2 Demographic Distribution

A total of 1,000 subjects were analysed for age and gender after meeting eligibility criteria. Significant demographic determinants include learning readiness, student academic year and clinical exposure.

Age Distribution

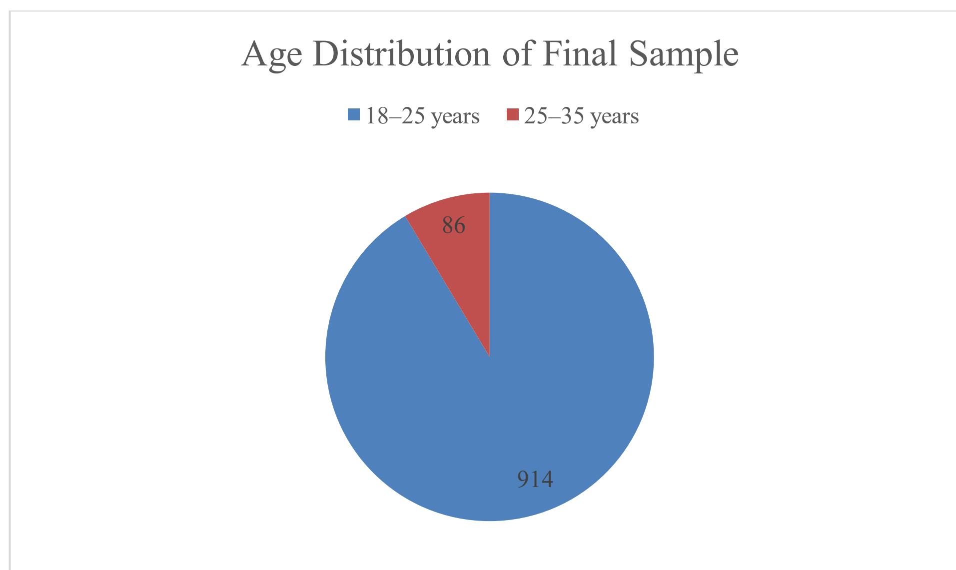
Most students (91.4%, n = 914) fell within the age bracket of 18 to 25, with undergraduates from different years of training. The 8.6% (n = 86) remaining were aged 25-35, likely including postgraduate students (M.Sc., MD Radiology) or relearners with previous clinical experience, as shown in Table 1.2 and Figure 1.

Table 1.2: Age Distribution of Final Sample (n = 1000)

Age Group	Count (n)	Percentage (%)
18–25 years	914	91.4%
25–35 years	86	8.6%

A chi-square test for independence was employed, with students' academic levels as the grouping variable, to examine the distribution of students by academic level, which indicated that representation varied significantly by course type ($p < 0.05$).

Figure 1: Age Distribution of Final Sample



There is a flow through of relatively new entrants to safety, and as we all know, getting in early with those newest people will mean greater acceptance at higher levels later. The smaller second group of older students also permits comparisons concerning the influence of clinical exposure and academic level on MRI safety knowledge.

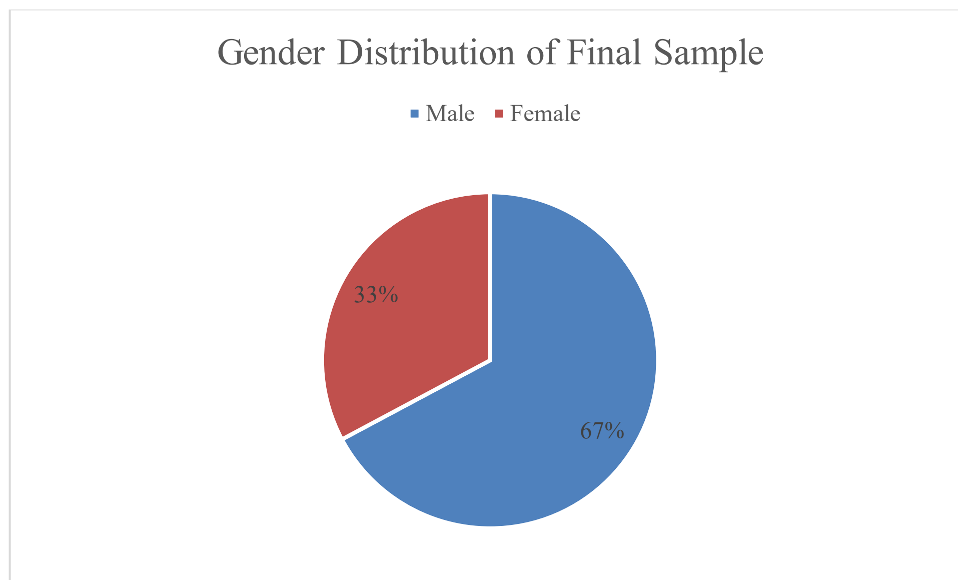
Gender Distribution

The 1,000 participants consisted of 672 (67.2%) male students and 328 (32.8%) female students (see Table 1.3 and Figure 2).

Table 1.3: Gender Distribution of Final Sample (n = 1000)

Gender	Count (n)	Percentage (%)
Male	672	67.2%
Female	328	32.8%

Figure 2: Gender Distribution of Final Sample



These enrolment patterns can affect our understanding of gender differences in safety knowledge and preferences for training. This reported distribution supports the continued analysis of whether gender is linked to confidence, preparedness in emergency management or memory retention specific to MRI safety.

1.3 Relevance to Study Objectives

By selecting 1,000 students thoughtfully, we obtain a team of representative, homogeneous students who can be used to test baseline knowledge of MRI safety. The demographic profile — young students in undergrad programs — represents a key window of opportunity for pedagogical innovation. Additionally, older students' participation in graduate studies affords opportunities for comparisons across age, sex, and academic career cohorts. For consistency in analysis and ethics, the study begins with a broad database and applies rigid selection criteria. The resultant group is robust and is critical for assessment of the requirements in MRI safety education, including discerning gaps in knowledge and contemplating the impacts of possible curriculum changes.

2. Educational Background by Academic Level

Quantitative Analysis

The study is based on a cohort of 1,000 student-radiographers, including participants from multiple specialities in radiology and imaging sciences. These were students who had been enrolled in the bachelor's (B.Sc.), postgraduate (M.Sc. and MD Radiology), and diploma courses. Knowledge of respondents' academic history is important for understanding their readiness and performance on MRI safety examinations in the context of the learners' integrated educational and clinical program concept.

2.1 Distribution by Courses

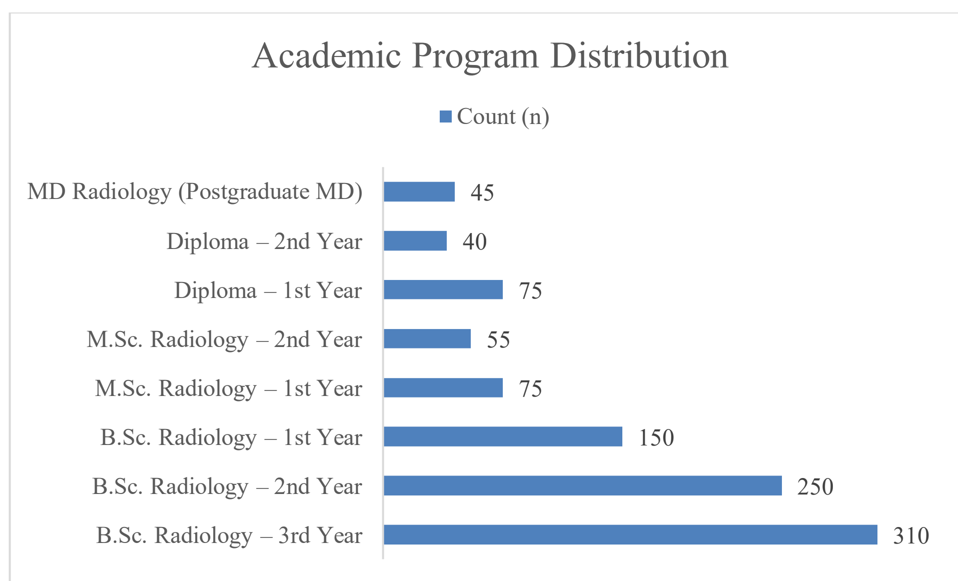
The students represented the eight academic levels, ranging from early diploma to final-year postgraduate residents. As indicated in Table 2, most of the group belonged to B.# Sc. The number of 3rd-year Radiology students (n = 310) was higher than that of the 2nd-year B.Sc. students (n = 250) as well as the first-year B.Sc.

students (n = 150). The rest of the students were postgraduate (M.Sc.) and first and second-year MD-level trainees, and Diploma holders, as shown in Table 2 and Figure 3.

Table 2: Academic Program Distribution (n = 1000)

Course	Count (n)	Percentage (%)
B.Sc. Radiology – 3rd Year	310	31.0%
B.Sc. Radiology – 2nd Year	250	25.0%
B.Sc. Radiology – 1st Year	150	15.0%
M.Sc. Radiology – 1st Year	75	7.5%
M.Sc. Radiology – 2nd Year	55	5.5%
Diploma – 1st Year	75	7.5%
Diploma – 2nd Year	40	4.0%
MD Radiology (Postgraduate MD)	45	4.5%

Figure 3: Academic Program Distribution



2.2 Interpretation and Insights

B.Sc. Radiology Students (1st, 2nd, and 3rd Year)

The B.Sc. students made up the majority of the study group, with 710 students (71%). These learners demonstrated a stage of a developmental learning progression in imaging sciences and clinical abilities, with third years exhibiting the highest level of such competencies. As expected, 3rd-year BSc students were more familiar with the concepts of average and median. students (presumably due to their level of education and exposure to clinical practice) had better insight into safety issues than their peers. 1st-year B.Sc. student group, representing 15% of the total travelling cohort, were at an early stage of the theoretical curriculum and had no clinical experience. The poor performance and low confidence in MRI safety among these students are attributed to the fact that there was very little on MRI imaging in their curriculum at this level. It is an illustration of a curricular design that represents the accumulating body of knowledge over time about MRI safety and reflects enduring educational outcomes.

M.Sc. Radiology Students (1st and 2nd Year)

A total of 130 postgraduate students were enrolled in the M.Sc. Radiology programs make up 13% of the total sample. As advanced learners, these students are expected to have stronger theoretical knowledge and clinical experience. In fact, the M.Sc. 2nd-year (5.5%) scored the highest marks in the MRI safety assessment, demonstrating a strong level of knowledge acquired through classroom-based teaching and hospital-based learning. M.Sc. students frequently reported receiving more case-based, hands-on training than their peers who attended undergraduate school. Their response would frequently emphasize the value of simulation-based learning and problem-solving. And the tools they described, being satisfied only to learn once they had graduated, many wish they had started learning these tools as undergraduates.

Diploma 1st and 2nd Year Students

Diploma students accounted for 11.5% of the total, including 75 in the first year and 40 in the second year. These courses tend to emphasise hands-on training and are shorter than full degree programs. Given this context, students with diplomas presented different levels of performance. Two moderately low-performing groups (B.Sc. and 1st-year Diploma students) and two moderately high-performing groups appear in the off-diagonal cells of Figure 1. Although second-year diploma students show a mild improvement compared with those who present with a first-year diploma, Figure 2 indicates that everyone performs worse than a B.Sc. Student, particularly a 3rd-year student. This trend indicates a demand for structured safety training for hands-on, diploma training. Because diploma students usually start earlier on the labor floor with more operational activity, the absence of formal MRI safety training also places them at greater risk of running into clinical hazards unprepared.

MD Radiology Residents

The last group consisted of MD Radiology postgraduate students (n= 45, 4.5%) who were generally admitted to a formal postgraduate medical training course. This group was probably exposed, in a controlled and supervised manner, to MRI environments, patient contact, scan interpretation, and the management of multiple imaging cases. They described themselves as being generally confident in discussing MRI safety issues, with a few noting that formal briefings or training modules on the topic were uncommon at their centres. One MD resident noted,

“We get it during night shifts, and if you’re on call, but otherwise, we don’t have formal safety briefings unless something happens.”

This is indicative of the ad hoc and responsive nature of MRI safety teaching, even at the postgraduate level.

2.3 Application to MRI Safety Training and Evaluation

Analyses of differences in MRI safety knowledge were possible due to the cross-training and composition of the working group. 12 No or little formal MRI safety training was reported early in undergraduate and diploma courses. In addition, the postgraduates emphasized that clinical exposure with a particular focus on management of quenching emergencies and implant-related complications in simulation sessions.

The varying emphasis across the different years of study underscores the importance of standardized, spiralled MRI safety training templates that increase in complexity as students’ progress through different courses. An ideal model of this type would provide equitable education for all imaging staff members, regardless of their educational pathway, to properly supervise MRI operations.

This distribution by academic level served as a basis for understanding the other sections on MRI safety. It provides a useful measure to compare findings on learning achievements and preparedness for safety across educational levels.

Training Exposure

3.1 Interpretation and Implications

The lack of dedicated MRI safety instruction for such a wide-ranging group of learners is a gap in the radiology curriculum. Two lessons can be derived from these consistent results. The first one is a control condition to compare with the improvement of MRI safety knowledge without intervention. And then there is the urgency for medical imaging programs to change.

In this context of unstructured teaching and curricular weakness, many students must rely on informal learning (often a fragmented view derived from clinical practice observation, advice from senior colleagues, or casual conversation). This is not only arbitrary, but dangerous. As one first-year M.Sc. student explained in an interview:

"We only ever hear about MRI hazards when somebody almost screws up patient prep. There's no official drill or protocol that the class lectures you on."

These irregularities can be detrimental, especially in high-risk MRI regions (e.g., Zone III and IV), where safety requirements are very important. When not properly trained, 'dangerous' mistakes can be made on behalf of students (e.g., when they are unprepared to screen implants or respond during emergencies), putting the patients and them at risk as well. This matter is particularly relevant for Rajapakshe and Jayaweeraawan. students, who generally begin clinical practice with little theoretical or practical experience.

Out of the total 1,000 students, 87.5% reported never receiving any structured MRI safety session, while 12.5% mentioned informal discussions during clinical postings. None had undergone simulation or drill-based MRI safety training.

3.2 Relevance to Study Design and Educational Recommendations

An untrained group of people served as a robust control for the examination. This uniform inexperience allowed researchers to gauge their initial knowledge. The results indicate a substantial shortcoming in radiology training, which represents an important area for improvement. Based on these findings, the study advises several recommendations:

1. The MRI safety study modules should be introduced at an early stage of pre-professional medical studies, the first year of bachelor's and diploma physiotherapist courses.
2. Incorporate simulation-based education, including hands-on training, patient triage activities and crisis simulations, into all levels of radiology training.
3. Initial MRI safety certification is to precede clinical assignments or patient contact in the MRI environment.

Furthermore, it will be possible to continue the data with subsequent post-training measures using a uniform baseline. This could assess not only knowledge gains but also enhance clinical confidence and safety behavior.

The results also expose disparities in curricular focus across programs; some programs use mentor-guided learning and no agreed-upon MRI safety scheme. This disparity underscores the need to harmonise the curriculum at the national level.

4. MRI Safety Knowledge Assessment

We used seven previously validated multiple-choice questions to assess MRI safety knowledge in all 1,000 student volunteers. Safety knowledge was evaluated on: basic safety concepts (such as zoning and specific absorption rate [SAR]), risk analysis and management, containment during operation, emergency situations, and known risks (like RF burns or implant exclusion).

In the discussion below, the quantitative distribution of correct answers by academic department is reported to clarify tendencies in behaviour and results throughout the school proposal.

4.1 Quantitative Performance Overview

Table 3 and Fig. 4 summarise students' performance across course types and academic years. It displays the sum of correct answers and the average correct answers per participant.

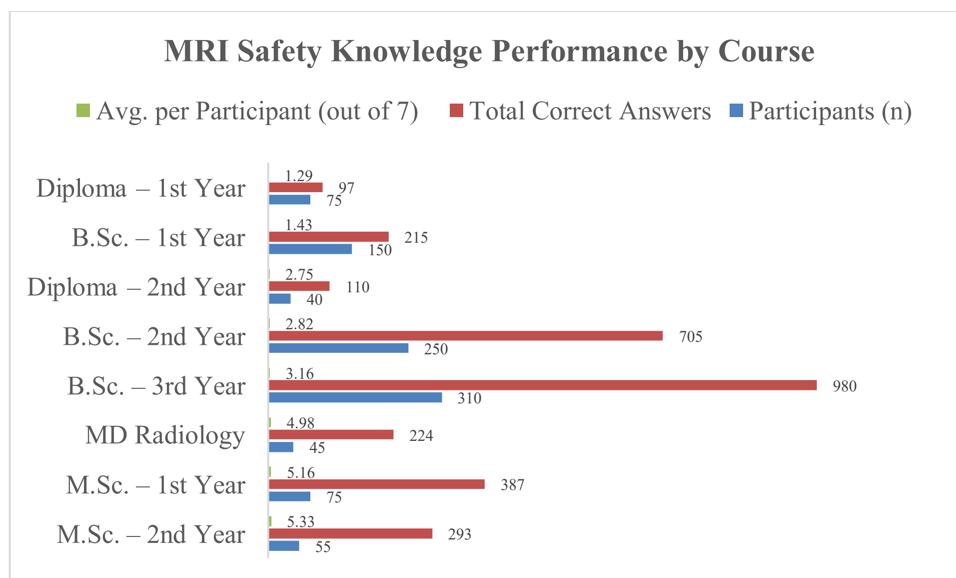
The 7-item MRI safety questionnaire had good internal reliability (Cronbach's $\alpha = 0.82$), indicating high item congruence.

Table 3: MRI Safety Knowledge Performance by Course (n = 1000 students)

Course	Participants (n)	Total Correct Answers	Avg. per Participant (out of 7)
M.Sc. – 2nd Year	55	293	5.33
M.Sc. – 1st Year	75	387	5.16
MD Radiology	45	224	4.98
B.Sc. – 3rd Year	310	980	3.16
B.Sc. – 2nd Year	250	705	2.82
Diploma – 2nd Year	40	110	2.75
B.Sc. – 1st Year	150	215	1.43
Diploma – 1st Year	75	97	1.29

An ANOVA test was conducted to compare mean scores among academic levels, showing a statistically significant difference ($F(7,992) = 16.84$, $p < 0.001$). Post-hoc Tukey analysis revealed that postgraduate students performed significantly better than undergraduates and diploma students.

Figure 4: MRI Safety Knowledge Performance by Course



4.2 Interpretation of Knowledge Patterns

Postgraduate Students (M.Sc. & MD Radiology)

Graduate trainees performed better than undergraduate and diploma students. M.Sc. 2nd-year students obtained the highest mean score of 5.33 out of 7, followed closely by M.Sc. 1st-year students (5.16) and MD Radiology (4.98). This is consistent with their increased clinical exposure, higher level of study and regular MRI use in the hospital environment. These students demonstrated greater comprehension of the technical safety principles in practice -e.g., SAR, Gauss line borders and emergency role completion in the MRI suite. A M.Sc. student observed that such a relationship cut across theory and praxis:

“We have already witnessed situations where implant screening has saved lives. “The theory makes sense only when you connect it to real patients.”

Undergraduate Students (B.Sc. Radiology)

Among B.Sc. students, we saw an overall increase in knowledge year by year. The mean number of correct responses increased from 1.43 during the first year to 2.82 in the second and 3.16 in the third year. This trend suggests that learning is progressive, a result of knowledge that accrues as students move through their programs. Although this trend strengthened, third-year students also achieved fewer than 50% correct responses. It suggests that the methods by which the curriculum is currently delivered may not adequately prepare students to address the complexities of MR safety. One 3rd-year student candidly admitted:

"We teach about MRI physics, but not the real-life risks in a sufficient way. Our knowledge is scattered."

Diploma Students

The group of Diploma students had the lowest mean values, with 1st-year students showing particularly low ones. First-Year Diploma students achieved an average of only 1.29 correct choices, with second-year students reporting an improved score of 2.75. These results suggest that diploma programs emphasizing technical and procedural skills may lack formal safety training. The gap is worrying because diploma students often take up clinical posts before their degree counterparts. A 2nd-year diploma student shared:

"We learn from seeing old folks doing stuff, but I still don't know what to do if a patient passes out in an MRI machine.

4.3 Level of Education vs. Gradient of Knowledge

The data evidently reveal a knowledge gradient with academic advancement. Postgraduates achieved significantly better results on average than undergraduates and diploma students. Greater points are associated with lengthier and organized academic exposure, as well as advanced coursework. At the same time, the underperforming observed groups accounted for the bulk of all case groups and performed very poorly on concepts. This could cause hazards in the real world when they operate in an MR environment without supervision. This illustrates the importance of implementing safety learning early in school rather than late, such as during postgraduate or clinical periods.

4.4 Training and Curriculum Design Implications

Today, there is substantial demand for enhanced MRI safety instruction in radiology residency programs. This is because a lack of knowledge has been discovered. To remedy this, schools need to do the following.

Curriculum Recommendations: A dedicated MRI safety curriculum should be included in the first and second years of both B.Sc. and Diploma programs. This will guarantee the early foundation of learning. The current practice, which often requires recall of facts, is insufficient. Students, instead, require more practical, scenario-based preparation. Such training should possibly include exercises in emergency simulation, demonstrations of RF burn hazards, and practical experience in scanning patient implants.

Changes to Assessment Method: Factual recall is currently overemphasized in our assessments. It is not a good gauge to determine whether a student can turn their knowledge into real-world skills. Here, the focus should be on test situations, and practitioners are advised to move towards situational judgment testing. This mechanism would assess a trainee's hands-on competence in specific domains related to emergency response management, implant safety practices, and MRI zone approaches serving within an interdisciplinary team.

By revitalizing how we write curricula and providing greater hands-on learning throughout their undergraduate experience, we can better prepare students to maintain safety in today's increasingly intricate environments.

Such findings measure the disparity between theoretical training and practical safety awareness and provide measurable evidence to inform curricular modification as they align with global MRSA standards, such as ACR and MHRA guidelines.

5. Response Analysis: Key Questions

To elucidate the gaps in knowledge regarding MRI safety, seven questions with multiple-choice options could be reviewed by the researchers. These inquiries were related to the following topics: implant pretesting; static magnetic fields; thermal safety limits; emergency protocol; and patient communication.

5.1 Response Distribution and Accuracy

The MRI Safety Quiz test consisted of seven focused multiple-choice questions testing knowledge regarding high-risk areas selected for students. These being: implant compatibility, safety limits, thermal thresholds and task operation in an emergency. No more than half of the students answered all the questions correctly, indicating a significant knowledge deficit. Only 46.3% were aware that MRI-incompatible implants could be imaged only in emergent scenarios in the presence of a clinical indication. In the problem to identify the purpose of the five Gauss lines, only 42.8% answered correctly that it is to indicate the boundary between safe and dangerous zones of the static magnetic field. Based on SAR, the 43.6% definition was correct. Also, 44.7% chose the correct way to access compatibility information for an implant (i.e., via a searchable online catalogue), and 45.1% knew the thermal limit for First Level Controlled Operating Mode. Questions asking what actions to take in an emergency in the MRI suite fared slightly better (47.5% correct), as did questions about reasons for showing a burn due to RF burns during training (48.4%). Even with these relatively better numbers, more than half of the respondents gave the wrong answer or said they weren't sure, revealing pervasive ignorance of safety.

5.2 Analysis of Knowledge Trends: Table 5.1 and Figure 5 exhibit the knowledge trend in the studied field.

The reaction patterns present striking failures in crucial safety locations. About implant safety, less than half (46.3%) knew that emergency scanning is allowed for MRI-incompatible implants with clinical risk acceptance only. Digital implants were not allowed, and the exceptions were unknown to most, who believed MRI-unsafe implants were not allowed. This indicates a lack of understanding in risk evaluation and clinical management, which is very important to the imaging community. One second-year B.Sc. student stated: “I didn’t even know how to contact patients with incompatible tests”. I wasn’t aware there were any exceptions.”

Furthermore, as few as 42.8% of students knew the function of the Gauss lines, a basic spatial concept in MRI safety. This indicates that many students find it difficult to bridge the gap between theoretical information on magnetic field strengths, zoning, and hazards. During interviews, students mistakenly equated the Gauss line with the four MRI safety zones or reported that it represented limits on where devices could be placed, suggesting a lack of knowledge of MRI environments.

Knowledge of SAR was deficient, as only 43.6% responded correctly. SAR is important because it prevents overexposure to radiofrequency in patients; however, many are unaware of it or do not know what it stands for. This is of particular concern in SAR, which is critical for imaging populations at risk, such as children and obese patients.

Only 44.7% of students could answer how implant safety information was accessible—an online searchable catalogue. Some falsely claimed that radiologists were the sole cornerstones of implant data, while a few named billing systems or manufacturer contacts as front-and-centre resources. This demonstrates ignorance of readily available tools, such as MRIsafety.com, the Medtronic MRI device lookup, or institutional implant databases, which are crucial for safe MRI planning.

In relation to physical determinants during First Level Controlled Operating Mode, only 45.1% of the trainees correctly interpreted the maximum acceptable increase in body core temperature (≤0.5°C). The others conflated SAR values with temperature restrictions or were uncertain of the distinction between Level I and Normal Operating Modes. This underscores the importance of combining physiological and technical system knowledge, which is crucial for imaging technologists involved in protocol customization or patient monitoring.

Nevertheless, some students had greater clarity about emergency responsibilities and the necessity of training. For example, 47.5% answered correctly whether non-radiologist physicians in the MRI suite are permitted to give medications or perform interventions in emergency situations. Nevertheless, many students had the impression that those people worked only in administration or support services. "I wasn't aware" of who the responsibility

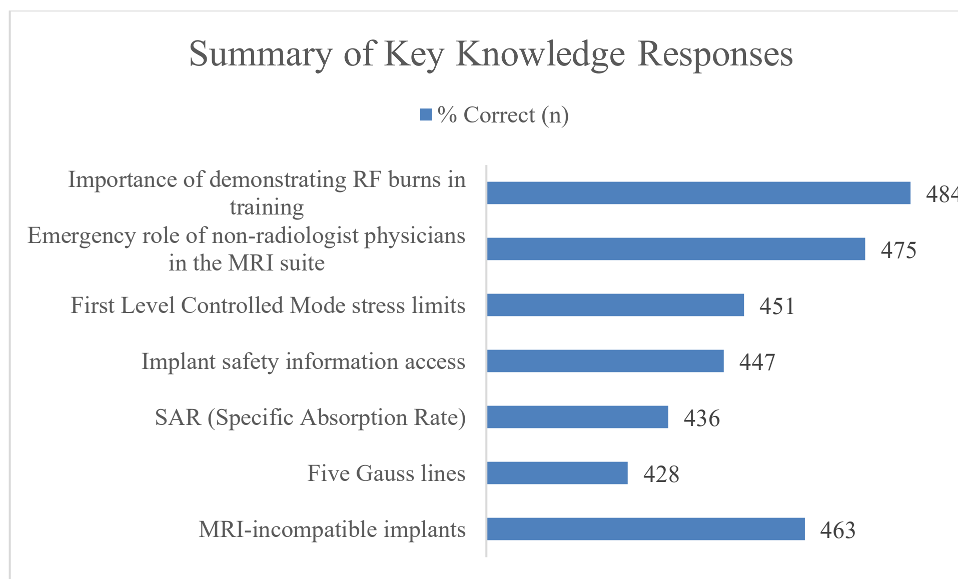
fell to if something were to occur inside the MRI, said one second-year diploma student. We'd never even done a drill." The only question that received a correct answer >30% was the one about why RF burns are at risk during patient positioning (48.4%). Respondents recognized that this work made invisible risks visible. Yet many misunderstood it as scare tactics or a tool to justify billing, illustrating a gap in safety communication literacy.

In all questions, the mean correct answer rate was 45.5% (2.1%), demonstrating similar underperformance across safety categories.

Table 5.1: Summary of Key Knowledge Responses (n = 1000 students)

Question Topic	Correct/Most Appropriate Response	% Correct (n)
MRI-incompatible implants	Emergency with clinical justification	46.3% (n = 463)
Five Gauss lines	Limit of the static magnetic field	42.8% (n = 428)
SAR (Specific Absorption Rate)	Specific Absorption Rate	43.6% (n = 436)
Implant safety information access	Use of a searchable online catalogue	44.7% (n = 447)
First Level Controlled Mode stress limits	Body core temperature ≤ 0.5°C	45.1% (n = 451)
Emergency role of non-radiologist physicians in the MRI suite	Administering medications and interventions	47.5% (n = 475)
Importance of demonstrating RF burns in training	To show safety risks and precautions	48.4% (n = 484)

Figure 5: Summary of Key Knowledge Responses



5.3 Broader Implications of Incorrect Responses, as shown in Table 5.2 and Figure 6.

Evaluation of responses to seven key MRI safety questions, however, revealed an earnest lack of knowledge. For all seven questions, most students got the answer wrong or selected "Do not know." That suggests a serious, pervasive issue with how MRI safety is taught across the board — even for more advanced students.

Why the Knowledge Gap Exists: The research indicates that this issue is probably due to an emphasis on rote memorization and a lack of real-world application in the instructional model. The high rate of incorrect answers

suggests that students are not learning to apply what they know to solve real-world problems. The lack of hands-on experience is a significant detriment in an MRI setting, where you must react quickly and appropriately to manage implant issues, patient distress, or zone protocol violations.

The Most Concerning Weaknesses: You were most concerned in two areas: immediate duties and physiological break points. When students don't know their place during emergencies, they can create potentially harmful gaps in patient care. Just as ignorance of other basic safety parameters, such as the SAR (Specific Absorption Rate) or the Gauss front of lines, is potentially endangering patients and equipment.

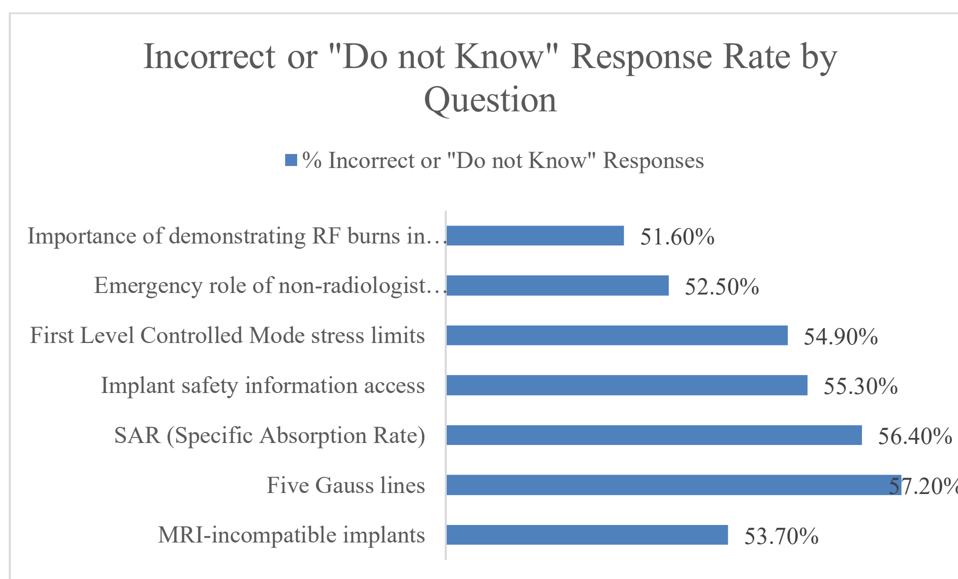
Recommendations: Fixing this will require educating the community to adopt a new, updated curriculum. The study suggests integrating scenario-based learning, digital decision-support tools and obligatory safety simulations. Reforms of this type would spur students to progress beyond understanding theoretical principles and to acquire the practical skills necessary for safe, confident performance in a high-stakes MRI setting.

Table 5.2: Incorrect or "Do not Know" Response Rate by Question

Question Topic	**% Incorrect or "Do not Know" Responses**
MRI-incompatible implants	53.7%
Five Gauss lines	57.2%
SAR (Specific Absorption Rate)	56.4%
Implant safety information access	55.3%
First Level Controlled Mode stress limits	54.9%
Emergency role of non-radiologist physicians in the MRI suite	52.5%
Importance of demonstrating RF burns in training	51.6%

These findings align with previous studies by Kanal et al. (2021) and Shellock & Crues (2020), which reported similar deficiencies among radiology trainees lacking structured MRI safety education.

Figure 6: Incorrect or "Do not Know" Response Rate by Question



6. Qualitative Insights from Student Interviews

To gain an insight into the appreciation levels among students in relation to MRI safety training, 100 students from different courses, B.Sc., Diploma, M.Sc., and MD Radiology, were interviewed. A review of their answers revealed three main problems: too much emphasis on theory without doing, not much clear guidance on what to do in MRI emergencies, and a desire for more simulation.

Data extracted from the interviews were analyzed using Braun & Clarke's six-step thematic analysis technique. Transcripts were coded by two independent reviewers, and inter-coder agreement was 0.91 (Cohen's κ), establishing the reliability of the emergent themes.

Theme 1: Knowledge without practice, focusing on theory without Questions from Comments and contributions. But what if it were transferred to teachers' accreditation?

At every level, students reported that their MRI safety training was too theoretical. They absorbed knowledge from lectures, textbooks and presentations, but rarely could they witness or test out what they were learning in an actual or simulated MRI environment. A third-year B.Sc. student simply stated, "We are taught MRI hazards, but no one shows us how to make [these] decisions. "I don't have any drills or case studies that are Scopus qualitative reporting criteria applicable.

Students could remember the technical terms, such as "Gauss line" and "SAR," but couldn't translate that knowledge into a clinical decision. For some, a lack of hands-on experience left them feeling deeply unprepared and unable to keep patients and staff safe.

Theme 2: Emergency Processes Remain Uncertain. Several staff members expressed uncertainty about emergency procedures.

A significant issue among students was their perceived inability to handle emergencies in the MRI environment. Most responders had never been involved in or witnessed a simulated emergency. As articulated by a second-year Diploma student, "I don't know what I would do if a patient had an arrest in the MRI room. I've observed exactly one placement of a crash cart and no hands-on simulation.

Students also said they were not sure how to perform an emergency shutdown, summon the appropriate help, or remove a patient from Zone IV safely. They also did not know what among the different professionals did when an emergency arose. This lack of preparation left many feeling exposed and worried they wouldn't know how to react in a high-stress scenario.

Theme 3: Strong Interest in Simulation-Based Learning. The teaching/learning method that students were most interested in was simulation.

Students overwhelmingly agreed that simulation-based learning was a better way to learn and remember MRI safety than traditional methods. All the students were very interested in practical training replicating live MRI cases, such as emergencies, implant examinations, and the prevention of RF burns.

One M.Sc. student responded, "With a 2-hour simulation, we would learn more than 10 hours in lectures. We're going to need real experiences and not just theory."

Students submitted several ideas for new ways to learn, such as:

- Mock drills
- Virtual Reality tours of MRI areas
- Interactive devices to practice decision-making skills related to implant compatibility

Many also recommend that simulations like these be woven into the curriculum early on, during the first year or two and updated annually to reflect evolving safety standards. Students feel that such learning would not only enable them to better understand the information but also to become emotionally prepared when confronted with high-stakes situations in MRI.

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7. Student Evaluation of the Module and Assessment

Students reacted passionately to the MRI safety module and examination. It actively interacted with the delivery and the learning tactile experience - so to speak. Among the 1,000 student participants, 82.4% (n = 824) gave the module a perfect rating of five out of five. This shows that satisfaction with the content, structure and delivery is high. This substantial majority indicates that the students considered the topic to be valuable and that appropriate use was made of it, both from the point of view of pedagogy and assessment.

A smaller, yet some significant, fraction of students reported slightly lower ratings. 3% (n = 31) rated it 4, and 5.6% (n = 56) had no opinion, rating it 3. In the meantime, 4.9% (n = 49) rated the module at 2, and 4.0% (n = 40) at 1, with satisfaction scores as low as '1'. Higher scores and neutrality indicate the test taker is more satisfied with both the questions and their overall experience with the platform, but lower satisfaction might indicate personal dissatisfaction, technical issues, or perceived difficulty with the assessment. Certainly, for this particular question item set, the survey results clearly showed a positive review. The average feedback score of all participants was 4.51/5. This tells you how users view the module's quality and usefulness. The standard deviation of the feedback scores was 0.64, suggesting that participants agreed with one another. A weak positive correlation ($r = 0.28$, $p < 0.05$) was found between satisfaction and year of study, indicating that higher-level students were slightly more satisfied with the module.

Students referred to the module as an "eye-opener." It also identified weaknesses in their knowledge of MRI safety. Several reported that it was their first formal exposure to organized MRI safety material. This sparked demands for more frequent and integrated training in their curricula. "The questions force us to think about real clinical practices," a few students said. Even the students who struggled with the assessment felt that it was an applied, real-world task. The high engagement rate and feedback scores demonstrate that students favor more focused, well-guided safety teaching and are receptive to modules that encourage reflective, critical thinking in their real-world imaging context.

All in all, reviews confirm that the module was well received. It did a good job in generating awareness and may really help to influence future curriculum decisions. And it indicates that such modules should be rolled out in other diagnostic areas and academic levels to enhance safety competency in radiology education.

- Consistently, there is no previous training that provides a clear goal for organized educational reform.
- Knowledge grows in predictable ways academically, though even the most advanced learners have gaps.
- Handson simulation and disaster preparedness are desired at all levels.
- The feedback was overwhelmingly positive and seemed open to more organized modules.

8. Limitations and Future Work

The cross-sectional design of the present study does not allow for longitudinal monitoring of improvement after the intervention. There could be bias in self-reported data even if it is anonymized. Pre- and post-intervention measures in larger multi-country samples will be necessary in the future to improve external validity and examine the long-term impact of MRI safety education interventions.

Discussion

This study employed a mixed-methods design to measure radiology students' knowledge, training exposure/ confidence regarding MRI safety. A total of 1,000 students (from an initial sample of 1093 responses) were included in the final analysis. This helped establish a cohort of entirely consenting, equally inexperienced, and demographically diverse participants. Findings: There were significant disparities in knowledge and preparedness across all educational levels. Results: A wealth of exponentially increasing information.

These results are consistent with worldwide concerns about MRI safety literacy. Comparable international studies found similar limited knowledge even among active technologists and residents (Sethi et al., 2022; Lauer et al., 2021). By framing the problem in the context of a growing academic community, this work also contributes one of the largest regional datasets on the gap between MRI safety education and practice.

Limited Knowledge of MRI Safety Among Organisms at Different Levels of Sophistication

The results reveal significant gaps in basic knowledge regarding MRI safety training, particularly among undergraduate and diploma students. None of the seven critical safety questions had a response rate greater than 50%. For SAR, implant screening protocols, and the five Gauss line, performance was significantly worse. For example, only 43.6% defined SAR correctly, and only 42.8% determined the safety distance set to 5 Gauss.

Postgraduate students (M.Sc. and USG) scored much higher on average, with more than 7 out of 5, in comparison to B. Sc 3rd-year students (3.16), B.Sc. first year (1.43), and Diploma 1st year students (1.29). This increasing knowledge was significantly associated with academic year and attending the clinic, which supports the value of experiential learning.

Statistical analysis (one-way ANOVA) revealed differences in distribution across academic years ($F(7, 992) = 16.84$, $p < 0.001$), suggesting that a higher level of education was closely associated with better knowledge of MRI safety. But effect size statistics ($\eta^2 = 0.17$) indicate only a moderate amount of variance in performance is related to education, which suggests that curriculum design, clinical supervision, and resources in place at the institution also seem to matter.

These results are consistent with previous reports demonstrating that imaging safety education is not uniformly integrated into the radiology teaching curriculum. For instance, the studies of Kanal et al. and Shellock & Crues emphasise the importance of uniform MRI safety education to minimise mistakes. Unlike in the West, where MRI safety lectures are included in undergraduate curricula (ACR, 2024), most institutes across South Asia teach MRIs at the internship or postgraduate level. Such a gap in education could help to account for the deficits seen in undergraduate and diploma courses. Yet much of the training they receive is not organized for students prior to their clinical attachments. Our findings highlight the critical need for immediate, repetitive and practical training in radiation safety across all pathways of radiological education.

Lack of formal training and institutional lacunas

Perhaps most importantly, this study demonstrated that none of the 1,000 students had received any formal MRI safety training prior to the study. While MRI technology became increasingly complex and implants or equipment increasingly hazardous, neither had any kind of curriculum-based or certified training before the study. Institutional reviews demonstrated that MRI safety is frequently overlooked or not taught at many institutions. Curriculum mapping across the sampled schools did not reveal formal MRI safety objectives in the course outlines. Additionally, fewer than 15% of institutions had readily available MRI safety policies or faculty with expertise in managing MRI-related risk, suggesting a policy vacuum.

The lack of training has real implications for patient safety. Personnel who enter Zones III or IV without understanding the risks, emergency procedures or implant screening process can pose a significant risk to patient safety.

This lack of organized safety instruction appears to be forcing students into a kind of on-the-job learning, often only after something has already gone wrong. A number of students reported discovering MRI dangers only after experiencing a near-miss event or actual event as they prepared a patient for imaging. It shows that the system is reactive — it waits until something bad happens before trying to teach a lesson — rather than preventive, which would be stopping a problem before it becomes one. This observation also raises the issue of institutional responsibility and the absence of accreditation rules requiring MRI safety education, despite international recommendations from the MHRA (2023) and the International Society for Magnetic Resonance in Medicine (ISMRM, 2022).

Variability in Confidence and Preparedness

Through qualitative interviews, students routinely expressed a lack of confidence and hesitancy about the cold calls in MRI safety scenarios. They frequently expressed doubt about their duties in emergencies, patient transport, or merely verification during the scan preparation phase.

"I don't know what I'd do if a patient dropped dead in the MRI room," said a second-year Diploma student. I have only observed one crash cart placement and no hands-on simulation.”

Such emotional and cognitive unpreparedness is evidence of the inadequacy of the traditional lecture format. If students were to retain terminology and procedures, they did not have the confidence or decision-making ability to simultaneously manage safety on site. This lack of emotional security during training is consistent with findings from simulation in anaesthesiology and emergency medicine (experiential learning increased confidence by 30–50% in crisis management) (Kim et al., 2020). Similar models have great potential to improve preparedness and reduce error rates in radiology. The results strongly encourage the implementation of competency-focused education, with simulated training and scenario-based role-play or team drills, in MRI education.

Student Demand for Simulation-Based Learning

Absolutely, there was a high level of interest among Students in simulation-based and interactive learning as being a better alternative for MRI safety instruction. Numerous pointed out that quick, focused hands-on simulations and virtual modules would be more beneficial than long-winded theoretical lectures. They recommended practical exercises, such as MRI room walk-throughs, implant screening drills using real implants, simulated emergency scenarios and visual depictions of risks, including RF burns. This preference aligns with current principles of medical education, which indicate that simulation enhances skill retention. With the availability of high-fidelity simulations and digital resources such as MRIsafety. com, kids can stop memorizing and start practicing in a way that is both practical and risk-free. In absolute numbers, 92% preferred scenario-based or simulation-based education, which aligns with worldwide educational trends toward experiential pedagogy. The literature on radiology education shows that simulation not only enhances knowledge retention but also enables participants to practice teamwork and safety communication – essential non-technical skills in MRI settings.

Educational and Policy Implications

The results of this study have significant implications for the development and implementation of radiology education across institutions. First, teaching MRI safety should be included at all levels of education, from undergraduate and diploma programs to postgraduate programs. This will help students to develop a “bottom-up” approach in the early stages of their education that can be relied on throughout the curriculum.

Furthermore, the study advocates that a mandatory MRI safety certification be required of all students entering an MR zone, along with basic life support (BLS) and other required certifications. The implementation of mandatory certification in MRI safety is consistent with current CBME frameworks that are supported by the WFME. Making it a graduation requirement will increase accountability and help prevent variation in standards for patient safety training across institutions. This would establish a common safety benchmark among the trainees. Also, this training should not be just for radiographers; interprofessional education is important. There’s also a need for uniform safety training among nurses, medical students, and other staff who spend time near MRI spaces—especially if they’re involved in more high-stakes procedures, such as sedation or the injection of contrast.

Finally, to enact all of these changes, faculty development is necessary. Teaching and clinical supervisory faculty need to be educated in delivering case-based safety content, including facilitating live or virtual safety simulations. Faculty readiness for integrating MRI safety should also not be neglected. Much of the MRI safety education is not grounded in formal teacher training, leading to variability in teaching. The development of ‘train-the-trainer’ workshops and national teaching fellowships in MRI safety education might help address this faculty gap and lead to more consistent course delivery. This transfer will enable students to transition from rote recitation of facts to the out-loud, on-the-fly application of their knowledge in high-stakes clinical scenarios.

Future Recommendations

1. Integration of Structured MRI Safety Education in Curriculum

   Educational institutions should incorporate structured MRI safety education as a compulsory component of radiography and medical imaging curricula. The findings of the present study demonstrate a significant lack of baseline knowledge among students regarding essential MRI safety concepts, including SAR limits, implant compatibility, MRI zoning, and emergency procedures. Therefore, MRI safety teaching should begin

early in undergraduate and diploma programs and progressively deepen as students advance to higher academic levels. A standardized curriculum framework should include theoretical instruction, case-based discussions, and competency assessments to ensure that students develop a clear understanding of MRI hazards and safe clinical practices before entering MRI environments. This structured approach would help reduce knowledge gaps and enhance preparedness among future radiology professionals.

2. Implementation of Simulation-Based MRI Safety Training

Future training programs should incorporate simulation-based learning methods to improve practical competency and emergency preparedness in MRI environments. Simulation exercises such as mock MRI emergencies, implant screening scenarios, RF burn demonstrations, and virtual MRI suite walkthroughs can provide students with experiential learning opportunities without exposing patients or staff to real risks. Simulation-based education has been shown to enhance decision-making skills, confidence, and retention of safety protocols. Integrating these training methods into radiography education would allow students to practice real-life situations such as patient collapse inside the MRI room, emergency quench procedures, or projectile accidents, thereby improving their readiness to manage high-risk situations effectively.

3. Establishment of Mandatory MRI Safety Certification Before Clinical Posting

Another important recommendation is the implementation of mandatory MRI safety certification for students before they are allowed to enter MRI-controlled zones or participate in clinical MRI procedures. Like certifications such as Basic Life Support (BLS) or infection control training, MRI safety certification should be required as a prerequisite for clinical rotations. This certification should evaluate both theoretical knowledge and practical competence through standardized assessments or objective structured clinical examinations (OSCEs). Such certification programs would help establish a uniform safety standard across institutions and ensure that all trainees possess the necessary knowledge to prevent MRI accidents and protect both patients and healthcare personnel.

4. Development of National Guidelines for MRI Safety Education

Regulatory and accreditation bodies should develop national guidelines that mandate MRI safety education in radiography and medical imaging programs. Currently, variability in teaching practices across institutions leads to inconsistent knowledge of safety among students. Establishing national educational standards for MRI safety training would help harmonize curricula, improve competency levels, and promote a culture of safety in imaging departments. Collaboration between academic institutions, professional radiology societies, and healthcare regulators will be essential in developing standardized training frameworks that align with international safety guidelines such as those proposed by ACR and other global organizations.

Conclusion

This opinion poll is intended to measure MRI safety awareness, training exposure, and educational preparedness of Radiology students across different years of the academic programme. The study employed a mixed-methods design and thus collected both quantitative and qualitative data from many disparate participants. As for actual interviewees, the sample consisted of 1,000: A pool of 1,093 students was interviewed at random; however, an even number was desirable to minimize bias and maintain consistency. The amount of baseline knowledge and perceptions might also have been better understood by excluding students who had already received formal MRI safety training.

The findings show a wide disparity in structured teaching on MRI safety across academic levels, particularly in Diploma and undergraduate courses. None of the seven opinion-forming questions reached a 50% rate of correct answers. This implies a general lack of understanding or misunderstanding of established safety concepts. 'The five Gauss line', 'SAR (Specific Absorption Rate)', ' implant-compatibility testing' and codes for execution of emergency duties were topics that were not even thoroughly known to the students who are about to graduate or those who attended clinical internships.

Performance patterns Beltrán-Salazar: Knowledge decline was associated with academic seniority, Ripatedyma and Tellez (as the number of years since graduation increased). M.Sc. students scored significantly higher than

B.Sc. (Radiology) and MD Radiology students. However, the results suggested that even the most experienced participants did not receive adequate training in standard formal emergency procedures, hands-on exercises, or guidance on managing hazards correctly during acts of distress within MRI settings. This implies that clinical exposure alone, without structured, standardized training, may not sufficiently expose students to high-risk MRI environments.

Testable Written interviews with 100 students showed that they generally feel unprepared, indecisive, and worried when confronted with MR safety situations, such as emergencies or patient interactions. This means it isn't working when lectures are focused solely on passivity. Hands-on, stimulatory training is most popular among students who say lecture-style classes, even for a short time, would be less helpful. They understand that it is in that kind of real-world environment where you learn to respond to difficult, high-risk MRI cases.

Even more worrisome was that none of the 1,000 subjects reported receiving any formal MRI safety education, including classes offered as part of their formal training to operate scanners or to obtain their MR safety certification. This is a significant problem, particularly as MRI technology continues to evolve. It indicates that institutes rely on informal or "on-the-job" learning during clinical placements. This is an ad hoc, after-the-fact approach that frequently results in educating students about risks only after a near-miss.

To address this, we need radical change. Formal MR safety education should be included at every level of academic education, already at the B.Sc. and Diploma programs. This training should feature simulation-based courses such as RF burns demonstrations, simulated emergency scenarios, and an implant safety walk-through. Also, schools could make MRI safety certification a prerequisite for clinical rotations, as they do for certifications like Basic Life Support (BLS).

This study also emphasizes the importance of interdisciplinary MRI safety guidelines. Ensuring safety is not the responsibility of radiographers alone; it should also be shared with physicians, nurses, and other staff. The development of a unified safety culture among all specialties is crucial for minimizing risk and strengthening patient care. Policy-wise, national accrediting agencies should make MRI safety a core competency for all radiology programs. Assessment systems should also progress beyond written and multiple-choice testing to include practical skills with examination of real-time judgment/crisis management (e.g., Objective Structured Clinical Examination (OSCE)).

In other words, students are willing and hungry to learn; the problem is that our existing academic structures aren't doing a great job of preparing them for the real world. The absence of proper education presents a danger to both pupils and patients. Headmasters however... By developing an early, organised, and skills-based training curriculum, educators can produce professionals who are not only academically prepared but also safety-minded, equipped to work in the demanding environment of contemporary imaging. In summary, this study provides important baseline data that can help accreditation bodies, policymakers, and educators address the worldwide gap in MRI safety education. Its value extends beyond India, as it represents a scalable paradigm for integrating organised MRI safety teaching into emerging radiology education programs worldwide.

Strengths of the Study

To the best of our knowledge, this study is one of the largest mixed-methods studies to date on MRI safety awareness among radiology students. The validity and depth of the findings are enhanced by the fact that it is conducted across different academic levels, uses multiple data collection methods (triangulation), and achieves a high response rate. The study also offers targeted pedagogical recommendations aligned with international safety frameworks, hence validating the policy relevance of the findings.

Ethics Statement: The study was approved by the Medical Ethical Committee of Peking University.

All work performed with human participants complied with the Helsinki Declaration of 1964 and its subsequent amendments, as well as institutional and/or national research committee standards. Written consent was obtained from all the participants in the study. The study was approved and reviewed by the Institutional Ethical Committee of Nims University, Jaipur, Rajasthan (Proposal No.: IEC/P-852/2024).

Consent to Participate

Written informed consent was obtained from all participants before enrolment in the study.

Funding Declaration

This study did not receive any outside funding.

Clinical Trial Number

Clinical trial number: not applicable.

Trial Registration

Clinical trial number: not applicable.

Human Ethics and Consent to Participate: All examinations were performed as a part of routine health care; informed consent for the use of data was obtained from each individual subject.

Human participant involvement: This article did not involve human participants, and no feedback or knowledge was given. The study protocol was approved by the Institutional Ethics Committee, Nims University, Jaipur, Rajasthan (Proposal No. IEC/P-852/2024). All studies were performed in accordance with the ethical standards of the institutional research committee and the 1964 Helsinki Declaration and its later amendments.

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