

EVALUATING MRI SAFETY COMPLIANCE IN PUNJAB: AWARENESS, ADHERENCE TO GUIDELINES, AND INSTITUTIONAL PREPAREDNESS

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ABSTRACT

Magnetic Resonance Imaging (MRI) is an essential diagnostic tool in the modern world of healthcare; however, the use of MRI is accompanied by specific safety issues that require strict compliance with established guidelines. This study evaluated MRI safety standards in a few healthcare facilities located in Punjab, India, focusing on education, adherence to international and national guidelines, and readiness of the institution. The study employed a mixed-methods approach, which included surveys using quantitative data with health professionals from 78 facilities, as well as interviews with radiologists and facility managers. The results showed that, while the basic knowledge of MRI safety was prevalent among people, knowledge of specific guidelines like those of the Atomic Energy Regulatory Board (AERB) and the American College of Radiology (ACR) was minimal. In the area of infrastructure, there were gaps in the zoning system, signage, emergency preparedness, and the presence of specially trained MRI safety personnel. Qualitative analysis revealed concerns about inadequate staff training, lack of regular audits, and the absence of standardized procedures. The study highlights the urgent necessity of a well-structured policy, capacity-building programs, and regular institution audits. It suggests greater oversight of regulatory processes and synchronization with international standards for safety to improve MRI security within the region. These findings are part of the growing discussion about the safety of medical imaging in resource-constrained environments and provide practical recommendations for India's health policy.

Keywords: MRI safety, AERB, Punjab, institutional preparedness, guideline adherence, radiology safety, healthcare compliance

INTRODUCTION

Magnetic Resonance Imaging (MRI) plays an essential role in modern-day diagnostics, providing precise images of organs, tissues, and structures, without exposing patients to ionizing radiation. Although it has many advantages for patients, MRI also presents unique dangers to safety because of the powerful radiation fields, magnetic fields, and the energy that it utilizes. Potential risks like burns, projectile injuries, damage to the acoustic field, as well as undesirable reactions from contrast agents, are extensively reported without proper safety guidelines [1]. These dangers highlight the importance of strict conformity to safety guidelines in order to protect patients as well as healthcare professionals.

In India, regulatory bodies such as the Atomic Energy Regulatory Board (AERB) have established standards regarding radiation and imaging procedures, which include the operational and infrastructure procedures that support MRI safety. In the world, the American College of Radiology has defined safety standards, which include zoning, staff screening, labeling of equipment, and staff training [2]. Although these guidelines are widely accepted,

the implementation is different in healthcare settings, and particularly in regions with poor infrastructure or a shortage of workforce.

Punjab, the state of northern India, has a diverse variety of healthcare facilities that range from modern, state-of-the-art urban hospitals to smaller diagnostic facilities within rural regions. The growing need for diagnostic imaging in the region has raised concerns regarding the extent to which these facilities comply with MRI safety guidelines. Initial studies conducted in other regions of India and across the globe show the existence of a knowledge gap, insufficient training, and inadequate infrastructure in institutions, which often lead to unsafe methods in MRI settings [3]. However, there is not much evidence on the way MRI security is explicitly addressed in the Punjab setting.

The study assessed the current situation of MRI safety in specific medical facilities throughout Punjab. The study focused on assessing the levels of knowledge among healthcare professionals, the degree of compliance with international and national safety guidelines, and the level of preparedness of the institution in terms of the zoning of

facilities, signage, screening protocols, and personnel training. The results are expected to aid in identifying any gaps and provide suggestions to improve MRI safety standards within the region.

METHODOLOGY

Study Design

This study adopted a cross-sectional descriptive research design to examine MRI safety practices and adherence to existing guidelines in healthcare institutions across Punjab, India. The cross-sectional approach was chosen because it allows for the assessment of knowledge, practices, and compliance at a specific point in time, making it ideal for understanding current safety behaviors in MRI settings [4].

Study Setting and Participants

The study was conducted in a diverse range of healthcare institutions—including both public and private hospitals and diagnostic centers—across multiple districts in Punjab. Facilities were selected to represent urban, semi-urban, and rural contexts to ensure geographical and infrastructural variation. The target population included healthcare professionals actively engaged in MRI services, such as radiologists, MRI technologists, radiographers, and facility managers. These professionals are directly responsible for the implementation and monitoring of safety protocols, making them critical informants for the study [5].

Sampling Technique

A multistage stratified sampling method was employed. Punjab's districts were initially stratified into urban, semi-urban, and rural zones, ensuring balanced geographic representation. From each stratum, healthcare facilities offering MRI services were randomly selected. Within each facility, participants were chosen purposively, based on their roles and involvement in MRI operations—a technique appropriate for expert sampling in healthcare research [6]. A total of 30 institutions were included, and responses were obtained from 120 MRI-related professionals.

Data Collection Tools

Two validated tools were used:

- A structured questionnaire, developed based on existing MRI safety literature and international guidelines, including the American College of Radiology (ACR) and

Atomic Energy Regulatory Board (AERB) of India. The questionnaire assessed knowledge of MRI safety, awareness of zoning systems, prior safety training, familiarity with guidelines, and perceived barriers to compliance [5,7].

- An observation checklist, modeled on international MRI safety standards, was used to assess compliance at the institutional level. The checklist included items on:
 - Zoning protocols (Zones I–IV)
 - Screening and patient preparation procedures
 - Display of safety signage
 - Emergency response systems
 - Availability of non-ferromagnetic equipment and safety devices [8]

Both instruments were pilot-tested in two facilities not included in the final sample to assess validity and reliability. Minor revisions were made to enhance clarity and content validity [9].

Data Collection Procedure

Data was collected through site visits by trained research assistants. At each facility, participants completed the questionnaire under the supervision of the research team to ensure completeness and resolve any ambiguities. Simultaneously, structured observations were conducted using the checklist. Facilities were informed in advance, and assessments were carried out only after securing informed consent from both the institution and individual participants.

Data Analysis

Quantitative data were entered into SPSS (Version 25) for statistical analysis. Descriptive statistics such as frequencies and percentages were used to summarize findings on awareness, training, and safety compliance. To examine differences in compliance across facility types (e.g., public vs. private or urban vs. rural), Chi-square tests were applied. Open-ended responses were subjected to thematic analysis, allowing for the identification of recurrent patterns and concerns related to safety barriers and implementation gaps [10].

Ethical Considerations

Ethical approval for the study was granted by the Institutional

Results

Variable	Category	Frequency	Percentage (%)
Gender	Male	76	63.3
	Female	44	36.7
Age Group (years)	20–30	39	32.5
	31–40	51	42.5
	41–50	22	18.3
	>50	8	6.7
Profession	MRI Technologist	58	48.3
	Radiologist	34	28.3
	Radiographer	16	13.3
	Administrative Staff	12	10.0
Facility Type	Public	52	43.3
	Private	68	56.7
Facility Location	Urban	65	54.2
	Semi-Urban	31	25.8
	Rural	24	20.0

Table 1: Demographic Characteristics of Respondents (n = 120)

A total of 120 healthcare professionals from 30 MRI-providing institutions across Punjab participated in the study. Table 1 shows the demographic distribution of the respondents.

Most participants were male (63.3%), with the majority aged between 31–40 years. MRI technologists constituted nearly half of the sample. Over half (56.7%) were from private institutions, and a significant proportion were from urban settings (54.2%).

Item	Yes	No	Not Sure
Aware of AERB guidelines for MRI safety	82	26	12
Aware of ACR zoning and labeling system	69	39	12
Understands potential MRI-related hazards	104	8	8
Has read any formal MRI safety manual/guideline	58	50	12

Table 2: Awareness of MRI Safety Guidelines (n = 120)

Table 2 demonstrates awareness of MRI safety guidelines among the study participants. A majority (68.3%) reported being aware of AERB guidelines, while 57.5% were aware of the ACR zoning system. A significant number (86.7%) demonstrated awareness of MRI-related hazards. However, only 48.3% had read any formal MRI safety document, indicating a gap between general awareness and in-depth knowledge.

Item	Frequency	Percentage (%)
Received formal training in MRI safety	46	38.3
Training conducted within the past 2 years	31	25.8
Believes current knowledge is sufficient	51	42.5
Would benefit from further training	88	73.3

Table 3: Staff Training and Familiarity with MRI Safety Protocols

Table 3 presents data on staff training and familiarity with MRI Safety Protocols among the study participants. Only 38.3% had undergone formal MRI safety training, with just a quarter receiving recent training. Although 42.5% felt their current knowledge was adequate, a large majority (73.3%) expressed a desire for additional training, highlighting the need for ongoing education.

Safety Feature	Compliant	Non-Compliant
Zoning System (Zones I–IV clearly demarcated)	14	16
Safety Signage in MRI area	21	9
Metal screening protocol in place	24	6
Emergency response plan available	11	19
Controlled access to Zone IV	17	13
Presence of MRI-compatible emergency tools	9	21

Table 4: Institutional MRI Safety Infrastructure Compliance (n = 30 Facilities)

Table 4 presents data on institutional MRI safety institutional infrastructure compliance among participating institutions. Only 46.7% of facilities had a clearly demarcated zoning system, and while 70% had safety signage, just 36.7% had MRI-compatible emergency tools available. Fewer than half had restricted access to Zone IV, and only 11 institutions reported having an emergency plan in place. These findings show inconsistent adherence to recommended infrastructure safety standards.

Indicator	Public	Private (n=68)	χ^2 / p-value
AERB awareness	36 (69.2%)	46 (67.6%)	0.04 / 0.84
Zoning compliance	6 (20.0%)	8 (26.7%)	0.46 / 0.50
Safety signage present	14 (46.7%)	18 (60.0%)	1.38 / 0.24
Formal training received	18 (34.6%)	28 (41.2%)	0.63 / 0.43

Table 5: Safety Compliance by Facility Type

Table 5 presents data on relationship between facility type and safety compliance. No statistically significant differences were found between public and private facilities in terms of awareness, zoning compliance, signage presence, or staff training. This suggests that safety challenges are widespread across both sectors.

6. Qualitative Themes

Open-ended responses were analyzed thematically, and three core themes emerged:

Theme 1: Lack of Institutional Priority for MRI Safety

Many respondents noted that hospital management often deprioritized safety investments in favor of operational or financial concerns. Safety equipment and structural modifications were seen as low priority unless an incident occurred.

"We rarely get budget approvals for training or new equipment unless there's an incident." (MRI Technologist, Private Hospital)

Theme 2: Inadequate Training Opportunities

A recurring concern was the lack of periodic training or workshops on MRI safety. Respondents expressed the need for standardized and compulsory refresher courses.

"Most of us learn on the job. Formal training sessions are rare, and many new staff don't even know what Zone IV means." (Radiographer, Public Facility)

Theme 3: Infrastructure Constraints in Smaller Facilities

Facilities in rural or semi-urban areas reported lacking the space or architectural provisions to implement zoning or install proper signage and access control.

"Our MRI room is in a converted store room. There's no way to implement proper zoning there." (Administrator, Rural Diagnostic Center)

DISCUSSION

The study examined the current state of MRI safety in Punjab with a focus on awareness, compliance with guidelines established by the government, and the preparedness of healthcare institutions in selected facilities. The results reveal a complicated interplay between practice, knowledge infrastructure, and the limitations of systems, echoing trends observed in similar middle- and low-income environments [12,5].

Despite the international importance of MRI safety as defined by reputable bodies such as those of American College of Radiology (ACR) and the Atomic Energy Regulatory Board (AERB) in India This study shows that a substantial percentage of healthcare professionals in Punjab have a low level of awareness of the essential MRI safety guidelines [2,7]. This is similar to studies that have been conducted in other

regions of India and have found the absence of training for staff and knowledge, especially among nurses and technologists [13,14]. A lack of understanding of the concepts of zoning, as well as restricted access rules and screening procedures, suggests that the safety culture surrounding MRI is still in flux and that more coordinated efforts must be made to integrate it into the norms of institutions [15].

The readiness of institutions was not as high in a number of areas, especially in the absence of or inadequate delineation of MRI zones of safety [16]. Zone-based MRI access control is crucial in preventing injuries such as radiofrequency burns and projectile accidents. However, in many of the surveyed facilities, the zoning system was inadequately implemented or totally absent, which suggests the need for mandatory guidelines for infrastructure. Insufficient signage, lack of safety MR labels, and the absence of warnings on the visual side also raise worries about the lack of a security culture that is prevalent in many facilities [17]. These structural deficiencies in the infrastructure, further compounded by the lack of training for staff programs, can expose personnel and patients to a variety of dangers.

These findings also raise important issues for policymakers. Contrary to countries that have centralized and strictly enforced MRI safety guidelines, India lacks a standardized national policy that requires MRI safety accreditation or monitoring, in addition to AERB regulations pertaining to radiation-emitting equipment [18]. Because MRI equipment does not emit ionizing radiation, oversight can slip through the cracks of the regulatory mechanisms that govern radiological equipment, leading to inadequate regulation. This is why there is a need for a nationwide MRI security policy that requires the implementation of zoning as well as training for safety, preparation plans, and regular audits. Medical councils and policymakers should look into introducing obligatory MRI safety certifications for radiology technologists and staff similar to the radiation protection training required in radiographic images [19].

The study also revealed that private facilities, especially those that are affiliated with corporate hospital chains, did better in terms of compliance and preparedness than public institutions. This is in line with prior observations that private institutions, motivated by the competition and accreditation

needs, tend to be quicker in adopting international standards [20]. Government-run hospitals suffer from budget constraints, staff shortages, and a lack of motivation to adopt non-mandatory standards, which frequently exclude MRI safety from top priority lists [21]. To bridge this gap between the private and public sectors, specific policy intervention that includes budget allocation and safety compliance requirements, as well as workshops for training provided by the state health departments, is required.

The qualitative findings added depth to the results, highlighting a consistent pattern of neglect by employees and revealing the absence of regular information regarding MRI safety protocols. The fear of misinformation, confusion, and a lack of engagement in regular training were among the reasons cited. These findings highlight the necessity of instituting ongoing professional development and auditing procedures. Like the findings by [22], it is essential to develop a safety culture not only through protocols but also through active engagement in supervision, as well as an explicit commitment from the leadership.

The study has some notable limitations. The data came from a few facilities located in Punjab but may not be representative of the entire practice of the state. Self-reported questionnaires could have triggered social desire bias, which led respondents to exaggerate their knowledge or habits. While observational assessments are helpful, they were restricted to structural and visual indicators and could not reflect the operational behavior under stress or in times of emergency. In addition, the size of the sample, while reasonable, could not be sufficient to allow generalization to all institutions in urban and rural contexts.

In sum, the study points out urgent shortcomings in MRI safety compliance and preparedness in Punjab. In Punjab, institutional neglect, inadequate policy enforcement, and inadequate staff training levels continue to exist in spite of international guidelines. These findings call for reforms to policies, along with infrastructure enhancements, as well as standardized education programs to ensure secure MRI settings across India. Suppose we place a high priority on MRI security in national healthcare plans. In that case, India can move closer towards a more secure, efficient imaging environment that is aligned with international best practices.

CONCLUSION

This study critically examined the state of MRI safety practices across healthcare institutions in Punjab, with a focus on awareness, adherence to established guidelines, and institutional preparedness. Findings revealed considerable variations in compliance, with many facilities lacking standardized protocols, proper signage, and comprehensive staff training on MRI safety. The study highlighted that while some tertiary-level institutions demonstrated awareness and partial adherence to national and international guidelines such as those by AERB and ACR, smaller diagnostic centers and rural facilities often operated with minimal safety infrastructure. The qualitative insights also revealed a need for stronger safety culture, clearer zoning, and frequent audits.

Policy-level attention is essential to bridge the identified gaps. Regulatory bodies and hospital administrators must ensure that MRI units across the region are not only structurally compliant but also supported by a well-trained workforce capable of managing safety hazards. Additionally, routine assessments and accreditation processes should be reinforced to align MRI safety practices with international standards. Investing in staff training and awareness programs, particularly at the grassroots level, will significantly improve patient and occupational safety outcomes.

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