

## Patient perception and attitudes toward magnetic resonance imaging safety

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### RESEARCH

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### ABSTRACT

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#### Background

Magnetic resonance imaging (MRI) scanners use strong, static and fast magnetic fields to form images. Due to rapid developments in MRI technology, several accidents have been recorded in hospitals worldwide as a result of insufficient knowledge about the dangers of MRI on the part of the patient or a failure to follow safety guidelines. This study evaluates patients' perception and attitudes about MRI safety.

#### Aims

This is a cross sectional study to evaluate the perception and attitudes of patients regarding MRI safety procedures.

#### Methods

A 21 items questionnaire was collected from 119 patients in the MRI waiting area before the commencement of

examination. Data were analysed using Statistical Package for the Social Sciences (SPSS) software (version 22.0, IBM Corp, Armonk, New York). The odds (OR) and 95 per cent confidence interval (CI) were used for analysis, the level of significance was set at  $p=0.05$  using Chi-Square test to evaluate the relationship among the variables in the questionnaire.

#### Results

The responses were collected from the patients and their relatives (46 male (38.6 per cent) and 73 female (61.4 per cent)). Approximately 71 per cent of the participants have already read or heard about MRI and the related safety aspects. 76 per cent of overall participants stated that they are aware of the need for preparation before an MRI exam with more awareness of MRI safety issues among younger patients (88 per cent). In this instance, females showed a higher level of knowledge (26 per cent) compared to males (11 per cent) with  $p=0.035$ .

#### Conclusion

Patients reported insufficient information about MRI safety which may increase the potential for accidents.

#### Key Words

MRI, knowledge, attitudes, safety, patients

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#### What this study adds:

##### 1. What is known about this subject?

Lack of information about MRI safety guidelines may increase the drop off, termination and/or potential accidents in the MRI examination area.

## 2. What new information is offered in this study?

Although it raised the level of knowledge, providing information alone to MRI patients did not reduce anxiety especially in female patients.

## 3. What are the implications for research, policy, or practice?

There is an urgent need to design effective methods that ensure adherence of patients to MRI safety guidelines and therefore, reduce the potential accidents significantly.

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## Background

Magnetic Resonance Imaging (MRI) is a non-invasive medical imaging technique which is often the modality of choice for structural imaging. However, MRI depends on strong magnetic fields to operate and patient awareness of safety precautions and guidelines is essential when undergoing MRI scan.

MRI safety guidelines were designed to ensure a safe clinical environment for MRI staff and patients. Patients often lack knowledge of the hazards that could occur near an MRI scanner. The major risk in MRI scan room is the strong static magnetic field]. The presence of a magnetic object in the vicinity of the strong magnetic field could cause them to become projectiles, resulting in serious or fatal injury to medical staff and patients.<sup>1,2</sup> The static magnetic field strength decreases as the distance from the scanner increases with a ratio of one per cubic meter distance.<sup>3</sup> Modern MRI scanners are equipped with passive shielding that reduces the effective distance of the static field.<sup>4</sup> Thus, it is important to visually indicate the regions of safe distance to mitigate any potential risk. This is achieved with MRI zones<sup>5-8</sup> All zones are colour labelled with different signs to indicate the degree of hazard and to provide guidelines for accessing each area.

The second risk component is the gradient field.<sup>1,2</sup> This is because gradient field activation will vary the magnetic field along the patient rapidly during image acquisition, which can result in peripheral nerve stimulation and cause a muscle spasm.<sup>8</sup> Moreover, it will produce loud acoustic noises that could cause temporary or permanent hearing injuries.<sup>8</sup> Thermal injuries may occur when conducting loops (within the patient as skin-to-skin or skin-to-cable contacts) are present in a varying magnetic field due to the effect of electromagnetic induction.<sup>9</sup>

The final risk to be considered in the MRI system is the radiofrequency (RF) electromagnetic field. The RF energy used when acquiring MR images results in a temperature

rise in conductive materials inside the magnet bore including body tissues as they have a conductive capacity.<sup>1,2</sup>

The duty of the MRI staff is to ensure the patient's safety through the use of different methods of screening. These methods include the safety check questionnaire, changing into the hospital gown and checking any patient implant devices for their MR compatibility.<sup>7,10</sup> However, many accidents have been reported in previous examinations for patients with implants such as defibrillators,<sup>11</sup> cochlear implants,<sup>12,13</sup> growing rods controlled by magnets<sup>14</sup> and, breast tissue expanders.<sup>15</sup>

Lack of sufficient information about medical examinations such as MRI may complicate the procedure, leading to uncertainty and fear among patients,<sup>16</sup> especially for those who undergo MRI examination for the first time.<sup>17</sup> Patients may experience feelings of insecurity and anxiety due to the structure of equipment, noise which they are not aware of,<sup>18</sup> in addition to the long scan time and the narrow environment of MRI bore.<sup>19</sup> Previous research in selected anxious populations, has shown that incomplete scan rates varied from 2.3 per cent to about 39 per cent, even in wider open bore scanners.<sup>20,21</sup> This may affect image quality and diagnostic accuracy and therefore lead to negative financial impacts as a result of non-diagnostic MRI scans.<sup>22,23</sup> Clear information may enable patients to anticipate unfamiliar situations and enhance the perceived level of control.

Safety guidelines must be adhered to all the time in MRI unit. However, there are a lack of studies assessing the patient's knowledge and attitudes towards MRI safety protocols. The aim of this study was to assess the subjective experiences of patients before undergoing MRI in order to identify those patients who may encounter problems and the major factors affecting their experiences.

## Method

The present study was designed to evaluate patient knowledge and attitudes with regard to MRI safety. Questionnaires were randomly distributed to 200 patients with response rate (n=119, 59.5 per cent) at King Fahad Specialist Hospital in Tabuk, Saudi Arabia. The convenience sampling method was used to collect the data electronically due to the coronavirus outbreak between February and April 2020. A link to the questionnaire was distributed in the second MRI zone, where patients met MRI staff. It was completed by patients with different levels of education including those with high school diplomas, bachelor's and master's degrees. Patients with known cognitive impairment were not included in this study while no missing

data of the collected sample was reported. Also, participants were categorized into four different age ranges: 21–31, 31–41, 41–50 and above 50 years old. The survey also included questions about gender, marital status and the patient's awareness of MRI safety (see appendix). The questionnaire was designed to include specific questions to allow an evaluation of patient knowledge regarding the safety standards for MRI in Saudi Arabia. The study participants were fully informed about the benefits of sharing information, ethical considerations, the purpose of the study and the possible risks. They were also informed that they could stop participating in the study at any time. The participants who agreed to participate in the study clicked the 'Agree' option before answering the survey, which took 10 minutes to complete. The results of the study provide the key risks potentially impacting patients that lack knowledge of MRI safety guidance.

### Instruments

This is a cross-sectional study to investigate the awareness of patients regarding MRI procedures. Our survey is designed to evaluate patient attitudes in relation to MRI safety and consists of 21 questions including MRI equipment, preparation, contrast media and time of examination. The patients could respond to the questionnaire with 'Yes', 'No' or 'I do not know' answers. This questionnaire was designed in-house and can be found in the appendix. Questions were reviewed by literature experts and translated to Arabic for non-English speakers. A pilot study was tested on 15 patients to ensure the clarity of the questionnaire and was excluded from the study.

### Ethical considerations and data collection

Ethical approval has been approved by The University of Tabuk. Regarding data collection, we gave the patients our survey before entering the MRI scanner, as well as distributing the online form via email, in order that the patient could complete it with utmost privacy. The patients answered each question individually and carefully. This study was performed at King Fahad Specialist Hospital, Tabuk, Saudi Arabia. Our cross sectional data were collected from February to April 2020.

### Statistical analysis

The data have been analysed using the Statistical Package for the Social Sciences (SPSS) software (version 22.0, IBM Corp, Armonk, New York). The odds (OR) and 95 per cent confidence interval (CI) were utilized and the level of significance was set at  $p=0.05$  using Chi-Square test to evaluate the relationship among the variables in the

questionnaire. All patient responses were analysed to evaluate the attitudes of patients who have undergone MRI scans.

### Results

The aim of this study was to understand the knowledge and attitudes of patients and their relatives with regard to MRI and MRI safety in Tabuk. The survey was sent to a 200 of patients and relatives and 119 responses were recorded with response rate response rate of 59.5 per cent. The demographic information of participants and the type of MRI procedure performed (Table 1) showed that of the 119 patient and relative responses, there were 46 (38.6 per cent) male and 73 (61.4 per cent) female. Participants aged 21–30 were the most numerous group with 59 (49.5 per cent) respondents, followed by those aged 31–40 (26.0 per cent,  $n=31$ ), 41–50 (16.8 per cent,  $n=20$ ) and above 50 years old (7.56 per cent,  $n=9$ ).

The marital status has been recorded as married for nearly 59 per cent, whereas 41.2 per cent of the participates were single. Based on level of education, the majority of participants were bachelor's degree holders (61.3 per cent,  $n=73$ ) followed by high school graduates (31.9 per cent,  $n=38$ ) with only 6 participants having a lower education level than a high school certificate (5.04 per cent). Two participants were master's degree holders (1.68 per cent). The most frequent type of MRI scan the patients underwent was a brain MRI scan (27.4 per cent,  $n=36$ ), followed by spine MRI scans (18.3 per cent,  $n=24$ ), then neck and knee MRI for almost 17 per cent of patients. Abdomen and pelvis MRI were rarely performed for the participants (3.05 per cent and 1.52 per cent respectively). Shoulder and extremity MRI procedures were also recorded among the participants with only 11 (8.39 per cent) for shoulder MRI and 10 (7.63 per cent) for extremity MRI scan (Figure 1).

A number of questions were asked to understand the knowledge and the attitude of patients and their relatives in relation to MRI and MRI safety at Tabuk (Table 2). The results illustrated the distribution and percentage of responses for each question either with yes or no. About 55 per cent of the participants have undergone an MRI scan before conducting this study whereas 71.4 per cent of the participants have already read or heard about MRI and the related safety aspects (20–29=81 per cent, 30–39=67 per cent, 40–49=65 per cent, and >50=33 per cent). Overall, there was a significant association between a respondent having read about MRI and identifying the type of radiation used ( $p=0.02$ ).

About 76 per cent of overall participants stated that they are aware of the need for preparation before an MRI exam with more awareness among younger patients (88 per cent) and decreased awareness with age until it reaches 32 per cent among those age >50 years with  $p=0.001$ .

Of the 119 participants in this study, 49 (41 per cent) were claustrophobic. Most patients and their relatives who participated in this study acknowledge their awareness of patient preparation before an MRI procedure (76.5 per cent). They have also shown an understanding of the importance of screening family members before they enter the scan room (86.6 per cent). Awareness that children should be questioned in the presence of parents or guardians was almost 90 per cent. Moreover, as an MRI scanner is not a silent machine, about 64 per cent of the participants were expecting noise during the MRI scan.

The individual knowledge about how MRI works, the zoning system, type of radiation and, device compatibilities was extremely limited, as can be seen from responses to questions 3, 6, 7, 8 and 12. Only 20 per cent of the total respondents stated that they knew the difference between ionizing and non-ionizing radiation with females showing a higher level of knowledge (26 per cent) compared to males (11 per cent) with  $p=0.035$ . For example, when all respondents were asked if they believed the MRI scanner was on even if there are no patients, only 24 (20.2 per cent) of respondents answered with yes. The lack of participants' knowledge about the radiation used in MRI and the difference between ionizing and non-ionizing radiation was also poor with 43 participants (36.1 per cent) knowing the type of radiation used in MRI, and 24 (20.2 per cent) knowing the difference between ionizing and non-ionizing radiation. In addition, the responses showed that only one third of participants were aware of MRI zoning and devices compatibilities in MRI department (41 (34.5 per cent) and 38 (31.9 per cent) respectively).

Almost 90 per cent of participants agreed that children should be questioned in the presence of their parents (males=100 per cent, females= 86 per cent,  $p=0.002$ ).

Moreover, the majority of participants (72.3 per cent,  $n=86$ ) were not aware of the possibility of an adverse reaction with MRI contrast agents and less than half of responses (45 per cent) indicated a knowledge that patients undergoing MRI with contrast need creatinine levels to be checked (females=53 per cent, male=32 per cent,  $p=0.021$ ). Of all respondents, 21 (17.6 per cent) said that pregnant women can be scanned by MRI whereas about 10 per cent stated

incorrectly that pregnant women can be given an MRI contrast agent.

Regarding safety procedures before the MRI exam, only 81 (68 per cent) of 119 participants completed the compulsory MRI safety questionnaire prior to entering the scan room and only 87 patients (73 per cent) were asked about their weight. Nearly 90 per cent of respondents confirmed that MRI technologist assured the patient that they were monitored all the time and 90 (75.6 per cent) of the respondents claimed that the procedure was fully explained by the MR technologist. In order to make sure patients are comfortable during the procedure, the study indicated that 86 (72.3 per cent) patients response 'Yes' to the question 'Did the technologist talk to you during the procedure to make sure you are comfortable?'

## Discussion

To our knowledge, this is the first study that provides valuable information for radiographers and radiologists to identify the level of patient awareness regarding MRI safety protocols.

A large proportion of participants (71 per cent) showed that they had read or heard about MRI safety procedures. This is a good impetus for healthcare providers to employ educational programs tailored for patients in order to minimize the potential risk of MRI accidents.

About 64 per cent of respondents reported that they have no idea about the type of radiation used in MRI which is comparable to a study conducted in Hong Kong in which 60 per cent of patients stated that they do not know the type of radiation used in MRI.<sup>24</sup> About half of respondents in a previous study conducted in Italy believed that MRI utilizes ionizing radiation and 56.4 per cent misunderstood which imaging modality uses ionizing radiation.<sup>25</sup> This is not surprising, as many studies reported misconception of MRI radiation even among health care professionals. For example, 86 per cent of health care professionals in Saudi Arabia believed that MRI emits a larger amount of ionizing radiation than a chest x-ray,<sup>26</sup> 25.5 per cent of medical students in Australia believed that MRI uses ionizing radiation.<sup>27</sup> However, in our study, knowledge of the type of radiation used in MRI tends to increase significantly when patients read more about MR,  $p=0.001$ .

Our results demonstrate that younger patients tend to read more about MRI. Respondents in this study aged 20–29 recorded the highest rate of reading (81 per cent). This rate decreases as with aging until it becomes 32 per cent in



people aged >50 years who had said they read or heard about MRI. This could be explained by updated academic curricula, in addition to the use of advanced technology such as smart phones, which can provide simple and easily accessed information about MRI. This also resulted in higher awareness rates among younger patients regarding the exam preparation (20–29 years=88 per cent) and decreased rates with age until 32 per cent of patients older than 50 years said they were aware of exam preparation procedures for MRI.

In a previous study, patients who were anxious before scanning were more likely to experience problems during MRI scan.<sup>17</sup> The level of patient anxiety may rise due to the enclosed nature of the MRI machine, anxiety about results, or the need to stay still for a long period of time during which they may suffer pain and discomfort.<sup>28,29</sup> Moreover, it was reported that oxygen saturation levels during MRI procedure decrease significantly due to anxiety compared to pre- and post-MRI levels.<sup>30</sup> Our results show that 41 per cent of participants felt anxious about the exam, where female patients were more anxious (55 per cent) compared to male patients 20 per cent ( $p=0.000$ ). In contrast, in a previous study conducted by Mubarak et al., 3.87 per cent of MRI exams were aborted due to claustrophobia with higher male rate (55 per cent) than females (45 per cent) where the most influential risk factors were male gender, middle age, higher socioeconomic status and education.<sup>31</sup> In another study, 0.53 per cent of MRI patients were claustrophobic resulting in 14.3 per cent of total cancelled exams.<sup>32</sup>

In our study, about 75 per cent of participants stated that the MRI technologist explained the procedure before commencing the scan. This was consistent with a previous study where 83 per cent of patients reported that they received information from radiology staff.<sup>33</sup> However, providing information alone before MRI exam may not ensure the adherence of patients to MRI safety guidelines, what matters is to what extent patient read and understand data. Our results show no significant association between receiving information about MRI and anxiety  $p>0.05$ . However, previous studies proved a significant link between anxiety level and receiving information.<sup>33-37</sup> This may raise the need to generalize our study to a larger sample size to obtain an accurate correlation.

This study highlights possible areas for improvement, such as providing well-prepared information for patients prior to an MRI scan. In our study, gender and age were the factors

that most influenced patient knowledge of and attitudes toward MRI safety.

### Limitations

- This is a single site study therefore, the small sample size made it important to interpret the results with caution.
- Results may reflect how deeply patients have read information before MRI exam rather than their knowledge itself.
- Further study may be needed to measure the level of anxiety precisely to associate its relationship to other risk factors.
- Further interventional study would be of interest to compare patient perceptions and awareness about MRI before and after an educational course.

### Conclusion

Although the vast majority of patients have read or heard about MRI, awareness and attitudes are still an issue. Reading about MRI would raise the knowledge about the type of radiation used in MRI, but it did not reduce the amount of anxiety experienced by patients. The results of our study highlight the importance of providing precise information about the potential risks when patients do not adhere to MRI safety protocols. More generally, this study provides insights about patient perception of MRI exams, which can be used as a benchmark for further studies to determine if improvements can be made through educational interventions.

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### CONFLICTS OF INTEREST

The authors declare that they have no competing interests.

### PEER REVIEW

Not commissioned. Externally peer reviewed.

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None

**Table 1: Demographic characteristics of participants and type of MRI procedure (n=119 participants and n=131 procedures)**

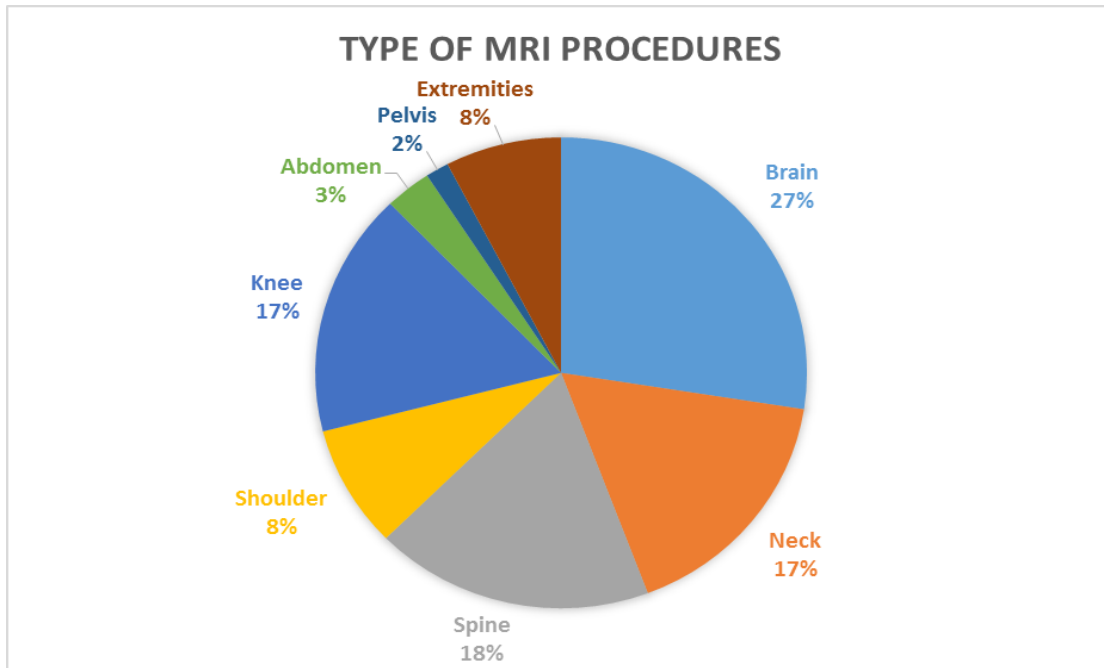
Variable		Number	Percent%
Gender	Male	46	38.6
	female	73	61.4
Age	21-30	59	49.5
	31-40	31	26.0
	41-50	20	16.8
	>50	9	7.56
Marital status	Single	49	41.2
	Married	70	58.8
Level of education	< high school	6	5.04
	high school	38	31.9
	bachelor	73	61.3
	master	2	1.68
Type of MRI procedure	Brain	36	27.4
	Neck	22	16.7
	Spine	24	18.3
	Shoulder	11	8.39
	Knee	22	16.79
	Abdomen	4	3.05
	Pelvis	2	1.52
	Extremities	10	7.63

**Table 2: Knowledge and attitude responses from the participants**

<b>Knowledge and attitude Responses</b>		
<b>Questions</b>	<b>Yes</b>	<b>No</b>
1. Have you done an MRI scan before?	65 (54.6%)	54 (45.4%)
2. Have you read or heard about the MR safety procedures?	85 (71.4%)	34 (28.6%)
3. Are you aware of the MR zones?	41 (34.5%)	78 (65.5%)
4. Are you aware of the patient preparations before the MRI procedure?	91 (76.5%)	28 (23.5%)
5. Are you claustrophobic?	49 (41.2%)	70 (58.8%)
6. Do you know the type of radiation used in MRI?	43 (36.1%)	76 (63.9%)
7. Do you know the difference between ionizing and non-ionizing radiation?	24 (20.2%)	95 (79.8%)
8. Do you know the difference between MR compatible and incompatible devices?	38 (31.9%)	81 (68.1%)
9. Do you think the family members should be screened before entering the scan room?	103 (86.6%)	16 (13.4%)
10. Do you think children should be questioned in the presence of parents or guardians?	107 (89.9%)	12 (10.1%)
11. Are you aware of the noise produced by the MRI scanner?	74 (63.9%)	43 (36.1%)
12. In case that there are no patients, do you think that the MR scanner is on?	24 (20.2%)	95 (79.8%)
13. Do you know the adverse reactions of MR contrast agents?	33 (27.7%)	86 (72.3%)
14. Are you aware why patients undergoing MRI with contrast need creatinine levels to be checked (glomerular filtration rate (GFR))?	54 (45.4%)	65 (54.6%)
15. Can a pregnant woman be scanned by MRI?	21 (17.6%)	98 (82.4%)
16. Can a pregnant woman be given an MR contrast agent?	12 (10.1%)	107 (89.9%)
17. Did you fill the MR safety questionnaire before entering the MRI room?	81 (68.1%)	38 (31.9%)
18. Did the technologist explain the procedure to you?	90 (75.6%)	29 (24.4%)
19. Did the technologist assure you that you are monitored all the time?	106 (89.1%)	13 (10.9%)
20. Did the technologist talk to you during the procedure to make sure you are comfortable?	86 (72.3%)	33 (27.7%)
21. Did the staff take your weight?	87 (73.1%)	32 (62.9%)



**Figure 1: Type of MRI procedure performed on participant**



**Appendix**

<b>Knowledge and attitude Responses</b>		
<b>Questions</b>	<b>Yes</b>	<b>No</b>
1. Have you done an MRI scan before?		
2. Have you read or heard about the MR safety procedures?		
3. Are you aware of the MR zones?		
4. Are you aware of the patient preparations before the MRI procedure?		
5. Are you claustrophobic?		
6. Do you know the type of radiation used in MRI?		
7. Do you know the difference between ionizing and non-ionizing radiation?		
8. Do you know the difference between MR compatible and incompatible devices?		
9. Do you think the family members should be screened before entering the scan room?		
10. Do you think children should be questioned in the presence of parents or guardians?		
11. Are you aware of the noise produced by the MRI scanner?		
12. In case if there are no patients, do you think that the MR scanner is on?		
13. Do you know the adverse reactions of MR contrast agents?		
14. Are you aware why patients undergoing MRI with contrast need to be checked for the creatinine level (glomerular filtration rate (GFR))?		
15. Can a pregnant woman be scanned by MRI?		
16. Can a pregnant woman be giving an MR contrast agent?		
17. Did you fill the MR safety questionnaire before entering the MRI room?		
18. Did the technologist explain the procedure to you?		
19. Did the technologist assured you that you are monitored all the time?		
20. Did the technologist talked to you during the procedure to make sure you are comfortable?		
21. Did the staff take your weight?		