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Investigating the MRI Safety Knowledge of Healthcare Workers: A Cross-sectional Study

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Abstract *— The primary objective of this study was to investigate the basic knowledge of MRI and MRI safety among specific groups of healthcare workers at King Abdullah Medical City (KAMC) between May and June 2023. The research design employed a quantitative-descriptive approach, and data were collected from 63 qualified healthcare workers at KAMC. Statistical methods, including frequency count, t-test, weighted mean, and Pearson correlation, were applied to analyze the collected data. The study's findings indicated that doctors exhibited a high level of knowledge regarding the fundamental principles of MRI and MRI safety among the healthcare workers assessed. Moreover, the results showed that a greater amount of clinical experience was associated with a higher level of proficiency in MRI fundamentals. Further, anesthesiology technicians and nurses demonstrated inadequate knowledge in the areas of MRI safety. The study also revealed that there was no significant correlation between profession, years of clinical experience, level of education, and the level of knowledge in MRI safety. Additionally, the study concluded that there was no significant correlation between possessing a basic understanding of MRI and the level of knowledge in MRI safety. In simpler terms, having a good grasp of MRI does not necessarily guarantee a higher level of expertise in terms of safety protocols and practices.*

Keywords *— Healthcare workers, Level of MRI knowledge, MRI safety*

I. INTRODUCTION

For a range of clinical problems, magnetic resonance imaging (MRI) is becoming a diagnostic imaging modality of choice (1). The basis of MRI is the interaction of a strong magnetic field with the atomic nuclei of the body, especially the hydrogen protons found in water molecules. When a body is exposed to a strong magnetic field. The protons are then momentarily decoupled using radio frequency (RF) waves to break the alignment. The dyes around the body pick up the RF signals that protons emit when aligned with a magnetic field (2). Additionally, MRI offers excellent images without the need for ionizing radiation. In addition, unlike techniques based on ionizing radiation, it does not change the makeup, composition, or characteristics of atoms. (3).

Although MRI is safe, there is a high danger involved for both the patient and any other people who may encounter magnetic fields inside or surrounding the scanner. (4). The technology used for magnetic resonance (MR) procedures has evolved continuously, yielding MR systems with stronger static magnetic fields, faster and stronger gradient magnetic fields, and more powerful radiofrequency

transmission coils. Most reported cases of MR-related injuries and the few fatalities that have occurred have been the result of failure to follow safety guidelines, or of use of inappropriate or outdated information related to the safety aspects of biomedical implants and devices. All staff must be aware of and trained to eliminate MR hazards. It is important to emphasize that many safety investigations have been carried out on 1.5T scanners, although in the last few years, many centers install magnets of 3.0T and above. Because of this, further investigations will be regularly required to reassure staff and patients of their safety Because of this, further investigations will be regularly required to reassure staff and patients of their safety (5)

The well-known risks of MRI scanners range from the interaction of static magnetic fields (SMFs) with humans and ferromagnetic equipment, including exposure to radiofrequency fields (RF) and implant interference (6) or the high acoustic noises during MRI scans (7). There are additional risks associated with the procedure, including the potential for allergic reactions to the contrast agents, pain from the patient's position, anxiety for claustrophobic patients, risks associated with metals, damage to hearing, and some uncommon risks like seizures or thermal damage from the heating effects of the magnetic field (8). Even though there has been much written on patient safety in MRI treatments, it is important to remember that there are also significant hazards for the medical staff that help in the procedure. Some of these risks may include projectile accidents, whereby the powerful magnetic field produced by the MRI machine can cause metallic objects to fly into the air and possibly hurt medical professionals, hearing damage, whereby the loud noises produced by the equipment during the scan may cause hearing damage if proper ear protection is not worn, and radiofrequency radiation (RF) exposure, which may be harmful if it exceeds safe levels, can all occur. (9), ergonomic related injury – healthcare worker may need to maintain static postures for extended periods and psychological stress as some may stay with the patient during the procedure in a confined space dealing with an anxious or claustrophobic patient. Sahu and Singh (2012) recommended several measures for minimizing these hazards, including the use of proper screening methods, ensuring that workers are wearing appropriate personal protective equipment, and providing adequate training to workers to ensure they are aware of the hazards and know how to mitigate them (10). Furthermore, during the MR scan, the patient is also required to remove all metallic objects and change into a hospital gown (11). It is important to highlight that patients with implants and medical devices are only permitted to undergo an MR scan if the implants are MR-safe or compatible (11). Patients with implants should never be considered MR-safe unless the device comes with clear written documentation. It is reported that a higher perception of safety is related to fewer accidents and maintaining a safe diagnostic environment (12).

Any diagnostic method involving ionizing and nonionizing radiation places a high priority on patient and medical personnel safety. Prior to the execution of the MRI examination, the MR staffs are crucial in patient screening and preparation. All visitors to the MR area should have access to accurate written MR information as well as plainly visible labeling on the MR site. To prevent any MR mishaps, non-imaging health professionals' (physicians, nurses, and non-imaging technicians) understanding of MR safety standards is crucial (13). The MRI section of the King Abdullah Medical City (KAMC) in Makkah, KSA, utilizes MRI machines from 1.5 to 3.0 Tesla. It caters to an average of 600 patients every month. However, as with any medical procedure, there are safety concerns that need to be considered to ensure the well-being of patients. The purpose of this research paper is to review the current state of knowledge regarding MRI safety, including potential risks, safety guidelines and procedures, and strategies to minimize the risks of MRI among healthcare workers. This paper aims to assess the level of knowledge of MRI safety and to inform healthcare providers about best practices for MRI safety.

This study aimed to assess the level of knowledge among KAMC healthcare workers on MRI safety and to identify areas where further education and training may be needed to promote safe MRI practices. Further, the results will benefit healthcare workers to ensure their safety during MRI

exposure specifically Doctors, Nurses, Respiratory Therapists, and Anesthesia Technician.

Statement of the Problem

This paper aimed to identify and explain the basic knowledge and level of knowledge on MRI safety among specific groups of healthcare workers.

This study specifically seeks to answer the following questions:

1. What is the average basic knowledge of MRI among respondents when grouped according to:

1.1 Profession

1.2 Years of experience

2. What is the level of knowledge on MRI safety among respondents when grouped according to:

2.1 Profession

2.2 Years of clinical experience

3. Is there a significant correlation between the level of knowledge on MRI safety when grouped according to:

3.1 Profession

3.2 Years of clinical experience

3.3 Level of education

4. Is there a significant difference in the basic knowledge of MRI when grouped according to the profession?

5. Is there a significant difference in the level of knowledge on MRI safety when grouped according to the profession?

6. Is there a correlation between basic knowledge of MRI and the level of knowledge of MRI safety?

II. LITERATURE

With the ongoing goal of consistently and effectively minimizing risks, preventing unnecessary harm, lowering the likelihood of errors, and mitigating their effects whenever they do occur, patient safety encompasses a structured set of actions aimed at establishing cultures, systems, methods, conduct, technologies, and settings within healthcare. (WHO). However, healthcare professionals' concerns—who face specific risks at work—rarely receive any attention. Healthcare personnel can fully utilize the diagnostic imaging capabilities of MRI by implementing the advised safety measures, ensuring the safety of both patients and them. Healthcare personnel must receive training in MRI safety due to the rising clinical demand for this technology in order to protect patients from any potential risks (15).

In MRI, the word "magnetic" alludes to magnetism's significant contribution to the imaging process. Three different types of coils are used in MRI scanners to produce distinct magnetic fields that serve as the basis for images. First, there is the primary magnet, which typically creates a strong static magnetic field and is either a permanent magnet or a superconducting electromagnet. A coil is also used to create the radiofrequency electromagnetic field (RF field), and imaging gradient coils, also referred to as "the gradients," creating magnetic fields that encode spatial information. These coils' interactions with matter are essential to produce pictures, yet they can occasionally pose major risks to human life and well-being (16). A commercial MRI system's main magnet, which distinguishes it from other devices, is its main draw. But this magnet also carries the greatest risk. The magnetic field it generates, which typically ranges from 1.5 to 3.0T, is significantly stronger than the magnetic fields we regularly come into contact with. It is roughly 300 to 600 times more powerful than a conventional refrigerator magnet and between 30,000 and 60,000 times stronger than the ordinary magnetic field at the surface of the Earth.

There has been a rising correlation between the occurrence of thermal injuries or burns in individuals receiving MRI and specific garment materials. More recently, ferromagnetic and/or conductive compounds (such antibacterial silver and copper) have been used in the production of clothes and associated products, however these materials are not always declared on product labels (17). Tattoos on the skin, especially those with dark ink (black, brown, and blue) and curved designs, can result in conductive loops. (18). There was significant underreporting of incidents related to MRI, and some of these incidents had the potential for catastrophic outcomes (19).

In MRI, "zones" are utilized to categorize various areas of the MRI suite depending on their proximity to the magnetic field and the associated risks. While specific definitions and guidelines for these zones a widely adopted ACR guidelines and framework is as follows: Zone I refers to the outermost section of the MRI suite, often referred to as the "unrestricted zone." It is the least restricted area, and specific magnetic field precautions are not required. This zone is accessible to individuals who do not have any contraindications to MRI, such as those without pacemakers or metallic implants. Zone II, commonly known as the "controlled access zone," is situated closer to the MRI scanner. Access to this zone is limited to authorized personnel who have undergone proper screening for MRI safety and received adequate training. It encompasses areas where the magnetic field strength and associated risks may be higher. Zone III, also known as the "limited access zone" or "MRI examination room," is located nearest to the MRI scanner. It is strictly reserved for essential personnel directly involved in the MRI procedure, including radiologists, technologists, and necessary support staff. Access to this zone is restricted to maintain a high level of safety. Additional safety measures, such as controlled access doors and warning signs, may be implemented in this zone. Zone IV pertains to the precise area within the MRI scanner's bore or tunnel, where the patient receives the actual imaging procedure. Only the patient and essential medical personnel are granted access to this zone. Strict adherence to safety protocols and guidelines is imperative in Zone IV to safeguard the patient's well-being and mitigate any potential risks associated with the magnetic field. The primary objective of these zone classifications is to implement suitable safety measures, access limitations, and protocols that align with the potential risks linked to the magnetic field strength in various sections of the MRI suite. This comprehensive approach ensures the safety of patients, healthcare professionals, and visitors in the MRI environment, promoting a secure and protected atmosphere.

Identifying the 5-gauss line, putting access control measures in place, providing lockers for both MR and non-MR staff to store their personal items, limiting worker exposure to MRI electromagnetic fields, ensuring visibility of a health and safety policy, using hearing protection during patient examinations, carrying out extensive safety screenings, and prominently displaying a red illuminated sign indicating that the magnet is always "ON" are all examples of ways to reduce worker exposure to MRI electromagnetic fields (20) and are just a few of the recommendations concerning MRI safety. Guidelines have been established by the American College of Radiology (ACR) to encourage the effective and safe application of MRI technology. These suggestions address a variety of MRI safety issues, including the need to screen patients for potential dangers, design MRI facilities and equipment, train staff, and be ready for emergencies. Healthcare institutions can lessen possible risks, enhance patient safety, and promote a culture of safety within MRI environments by following these ACR MRI safety recommendations. The development of standardized code management systems within the MR setting requires collaboration with anesthesiologists, the sedation team, radiology nursing colleagues, and adherence to the American College of Radiology (ACR) principles for safe practice. In the end, this cooperative strategy reduces potential dangers to both patients and staff, improving overall safety in the MR environment (21).

In implementing the ACR MRI safety guidelines, healthcare professionals must possess adequate knowledge of magnetic resonance imaging (MRI) safety to guarantee safety and maintain a seamless workflow. According to Alelyani et al.'s (22) study of healthcare professionals, rigorous health education programs are required to raise their level of comprehension and knowledge of MRI. The end goal of promoting an MRI safety culture is to achieve a thorough understanding of the MRI technology, imaging principles, the use of contrast media, adherence to safe practices, written guidelines, and the implementation of standardized protocols that can be used throughout the entire center (23).

III. METHODOLOGY

In this study, a quantitative descriptive-cross sectional design was utilized to assess the frequency, distribution, and relationships between variables or sets of scores. Statistical methods such as

t-tests and Pearson's r coefficient were employed to quantify and explain the extent of differences and associations.

The study was conducted to assess the average basic knowledge of MRI and determine the level of knowledge on MRI safety among healthcare workers in KAMC specifically doctors, nurses, respiratory therapists, and anesthesiology technicians directly involved in MRI procedures. However, the Radiology staff, particularly technologists and technicians, were excluded from the study.

Research Instrument

This study adopted two questionnaires from previously published research. One is from the study of Magbool Alelyani et.al, 2021 (23) entitled "Saudi Arabian Health Workers' Perception and Attitudes toward Magnetic Resonance Imaging Safety" published in the Journal of Radiology Nursing, and the other one is from Nur Nadiah Syafawani et.al, 2021 (24) entitled "Assessment of Knowledge and Perception towards MRI Safety Among Healthcare Workers" distributed online. A total of 20 closed-ended questions were used across two different parts. In the first part, participants will explore their demographic information and their basic concept of MRI. The second part is the question on their level of knowledge on MRI safety.

The first part of the questionnaire that assessed the respondent's basic knowledge of MRI was composed of 10 multiple-choice questions. The scores were evaluated on the frequency of correct answers by the respondents. On the other hand, there were 10 questions to test the level of knowledge on MRI safety. There was a five-response Likert scale to choose from, ranging from Not at all knowledgeable (1), Slightly knowledgeable (2), Moderately knowledgeable (3) Very knowledgeable (4), and Highly knowledgeable (5). The use of the Likert - scale is important to achieve the most comprehensive measurement possible, humans need to transform abstract concepts into tangible representations. This process is deeply intertwined and influenced by the perspective and subjectivity of the researcher (25).

Ethical Consideration

Ethical approval was sought from the KAMC Institutional Review Board (IRB) – IRB # 23-1083 and received an exemption. Participants' confidentiality was always protected. Respondents provided their consent willingly where it guarantees that they have a clear understanding of the study's objectives, methods, and the potential risks or benefits involved in their participation.

Statistical Treatment of Data

In this study, the utilization of a percentage frequency distribution allowed for the presentation of survey responses and other collected data in tabular or graphical formats, demonstrating the relative frequency along with their corresponding percentages. Also, a t-test and correlation statistics were employed. Pearson-product moment correlation coefficient was utilized to assess the association and measure the extent to which two variables are influenced by each other. It quantified the impact of changes in one variable on changes in the other variable.

IV. RESULTS AND DISCUSSION

There was a total of 72 responses retrieved from the data collected online, of which 63 responses qualified for the study. Male participants comprised 52% and 48% females. The participants came from various fields of

study but since the inclusion criteria of target respondents are very specific, researchers opt to exclude responses from specialties not directly involved in MRI procedures.

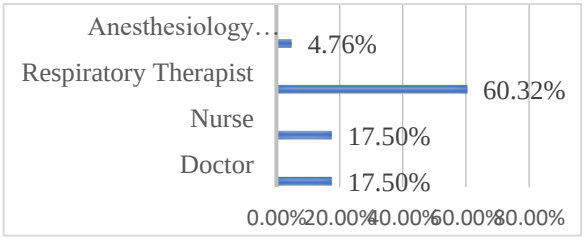

Fig. 1: Distribution according to the profession

Figure 1 shows the distribution of respondents according to the profession. Professionals who participated in the study included doctors (11), nurses (11), respiratory therapists (38), anesthesiology technicians (3), and other professionals including pharmacists, laboratory specialists, QA specialists, and administrators. But since this study focuses on patient safety related to healthcare professionals directly involved in MRI procedures, other professionals' responses were not included in the study.

Table 1 shows the distribution according to the years of experience among respondents. Many of the respondents were between 4-8 years of service (37.5%) and 9-11 years (23.61%) respectively. Data also indicates the level of education among respondents that include diploma (7), bachelor's degree (48), master's degree (9), Ph.D. (2), Physician-subspecialty (4), and Physician (2) respectively.

Table 1. Distribution according to years of experience.

Years of service	Percentage
1-3 Years	12.5%
4-8 Years	37.5%
9-11 Years	23.61%
12-15 Years	16.67%
Above 16 years	9.72%

The questions introduced in the study are categorized into 1) basic knowledge of MRI and 2) level of knowledge of MRI safety. According to Ghadimi and Sapra, 2022 (26), healthcare personnel must receive MRI safety training to safeguard patients from the possible dangers of MRI as clinical demand for MRI has increased.

Table 2. Distribution of basic knowledge on MRI when grouped according to the profession.

BASIC KNOWLEDGE OF MRI	DOCTOR	NURSE	RESPIRATORY THERAPIST	ANESTHESIOLOGY TECHNICIAN
Q1: What is MRI?	100%	66.64%	94.74%	33.33%
Q2: How does MRI work?	72.7%	45.45%	76.32%	33.33%
Q3: Which of the following body structures are imaged in MRI?	100%	100%	97.4%	100%
Q4: Which of the following is not the preparation for MRI?	0%	0%	2.63%	0%
Q5: What is the duration of an MRI scan?	91%	63.6%	42%	0%

Q6: Which is the route the dye is administered during the procedure?	91%	100%	86.8%	100%
Q7: What is the pain level after the MRI procedure?	91%	100%	86.8%	100%
Q8: How long the patient must take rest after MRI?	81.8%	45.5%	76.3%	100%
Q9: What do you expect during an MRI scan?	100%	45.5%	68.4%	66.67%
Q10: Which item is not contraindicated in the MRI procedure?	91%	91%	84.2%	100%
AVERAGE	81.85%	63%	70.5%	63%

Table 2 provides a visual representation of the first part of the questionnaire using frequency and distribution which describes the basic knowledge of MRI among healthcare professionals. The adopted 10-items multiple-choice questions determine the respondent's basic knowledge. *Question 1*: The profession "Doctor" is 100% knowledgeable on the question "*What is MRI?,* it is also observed that the profession "Anesthesiology Technician" is 33.33% knowledgeable. A complete grasp of the effects of the magnetic field and the underlying concepts behind

the difficulties, restrictions, and even the placement of MRI equipment is necessary for equipment design and monitoring principles in the MRI environment specifically for anesthesiology (27). *Question 2*: Nurses are less knowledgeable when it comes to the question on how MRI works at 45.45% compared to Respiratory Therapists (76.32%). This result is supported by a study by Alghamdi, et.al, 2021 (28) where they concluded that nurses have limited knowledge about MRI and moderate adherence to MRI safety procedures. *Question 3*: Almost all the respondents answered correctly on the question regarding

body structures to be imaged or scanned. Although MRI offers better resolution and image value compared to other modalities, it is limited to specific body structures. *Question 4:* Almost all respondents failed to answer correctly the question related to preparation. Although it is known that metallic objects, voiding before the procedure, and administration of anesthesia are common preparations, the patient doesn't need to wear a hospital gown. This misconception has led to the failed responses related to question number 4. *Question 5:* While 91% of the professional "Doctors" answered the question correctly, data also revealed that Anesthesiology technicians had no idea about the duration of an MRI examination. An MRI scan usually lasts between 30-60 minutes depending on the area to be examined. Several variables, such as the precise type of scan being performed, the area of the body being examined, and the intricacy of the investigation, can affect how long an MRI scan takes. Both practical and physiological repercussions may result from the length of an MRI scan, recent improvements in MRI technology and methods aim to shorten scan times while retaining image quality. These include the employment of customized coils, motion correction algorithms, and faster imaging techniques. These advancements assist in addressing some of the difficulties brought on by lengthier scan times. *Question 6:* Professions "Nurse" and "Anesthesiology Technician" perfectly answered the question related to dye administration. Intravenous (IV) contrast material is used extensively for CT and MRI scans (29), it is crucial to remember that the decision to use a contrast agent during an MRI scan is dependent on the precise clinical indication and the radiologist's or clinician's professional judgment. Before deciding if contrast administration is required and appropriate, elements including the diagnostic advantages, potential hazards, and the specific patient's medical history are to be considered. *Question 7:* This question relates to the knowledge of pain levels after MRI procedures. It is observed that 100% of the profession "Anesthesiology Technician" and 76.3% of the profession "Respiratory Therapist"

correctly answered the question respectively. It is important to note that after an MRI procedure, discomfort is often extremely little or nonexistent. MRI does not directly harm tissue or cause discomfort because it is a non-invasive imaging technique that doesn't require any incisions or intrusive procedures. *Question 8.* Data about this question reveals that 100% of Anesthesiology Technicians and 45.5% of respondents "Nurses" answered the question correctly. There is typically no set amount of time that must pass after an MRI procedure. After the scan, most patients can resume their regular activities right away. Since MRI is a non-invasive imaging method that doesn't need any physical effort or tissue harm, a lengthy time of rest is often not required. *Question 9*. The professional "Doctor" answered the question related to the expectations during MRI procedures perfectly. On the other hand, the profession "Nurse"(45.5%) ranked last in this group. The choices given to answer this question are hearing loud banging noise, silence, alarming sound, and speaking loud respectively. During the scan, the MRI machine makes loud knocking, thumping, or buzzing noises. To help reduce noise and improve the experience, earplugs or headphones with music may be offered to the patient. Several different things might generate noise in MRI pictures, such as field strength, radio receiver bandwidth, radio frequency wobble, and frequency pulses. An MRI generates noise due to a metal coil vibrating because of a rapid electric pulse. Noise levels in MRIs can exceed 90 to 100 decibels or vary between 65 and 135 decibels, requiring the wearing of ear protection (27). *Question 10:* The choices given to answer this question are: pacemaker, vascular stent, cochlear implant, and hospital gown. The hospital gown is not contraindicated for the MRI procedure. The result suggests that 100% of professionals "Anesthesiology Technician", Doctor" (91%), "Nurse" (91%), and "Respiratory Technician" (84.2%) respectively answered the question correctly. The purpose of wearing a gown is to ensure that there are no metallic objects or clothing with metal components that could potentially affect the quality of the MRI images or pose a safety risk. Metal objects can cause artifacts in the images or heat up in the magnetic field, leading to potential injury.

Table 3. Distribution of basic knowledge on MRI when grouped according to years of clinical experience.

BASIC KNOWLEDGE OF MRI	1-3 Years	4-8 Years	9-11 Years	12-15 Years	Above 16 Years
Q1: What is MRI?	88.89%	78.26%	100%	91%	85.7%
Q2: How does MRI work?	77.78%	78.26%	69.23%	54.54%	85.7%
Q3: Which of the following body structures are imaged in MRI?	100%	82.6%	100%	100%	100%
Q4: Which of the following is not the preparation for MRI?	0%	17.4%	0%	0%	0%
Q5: What is the duration of an MRI scan?	33.33%	34.8%	61.5%	72.7%	85.7%
Q6: Which is the route the dye is administered during the procedure?	100%	4.35%	92.3%	72.7%	100%
Q7: What is the pain level after the MRI procedure?	88.89%	56.5%	100%	100%	71.4%
Q8: How long the patient must take rest after MRI?	55.56%	65.2%	77%	54.5%	28.6%

Q9: What do you expect during an MRI scan?	66.67%	21.7%	61.5%	91%	57.1%
Q10: Which item is not contraindicated in the MRI procedure?	88.9%	78.3%	84.6%	91%	71.4%
AVERAGE	70%	51.74%	74.6%	72.7%	68.6%

Table 3 reveals the respondent's basic knowledge of MRI according to their years of clinical experience. The respondents were grouped into 1-3 years. 4-8 years, 9-11 years, 12-15 years, and above 16 years respectively. ***Q1:*** Data strongly suggests that "9-11 years" respondents answered the question perfectly, while it is also noted that only 78.26% of the "4-8years" respondents were able to do so. Often longer clinical experience would allow healthcare workers to possess a wide range of knowledge and proficiency in their specialized disciplines. The amount of knowledge and competence can, however, differ amongst people, even those with similar years of experience, depending on a variety of factors, including continued education, specialty, and a person's commitment to professional development. ***Q2:*** Respondents with 12-15 years of clinical experience were less able to answer the question correctly at 54.54% compared to other groups. To protect patients and improve the quality of the pictures generated, healthcare professionals must comprehend the MRI concepts. This includes understanding the effects of the magnetic field, situating patients and equipment correctly, and being aware of the risks and safety measures for patients who have specific medical implants or devices. However, this result invalidates the study of Wu et.al, 2018 (28) where they concluded that longer years of clinical experience were related to scoring higher on the long-term knowledge assessment. ***Q3***: Three groups were able to give perfect responses to the question related to body structures to be scanned by MRI, a result that is also supported by Table 2. For correct diagnosis, ideal picture interpretation, patient safety, and a solid understanding of bodily structures are essential. It is essential for delivering high-quality medical treatment and enhancing patient outcomes. ***Q4.*** Contrary to Q3, this question received negative responses. Regarding the patient's readiness for the MRI procedure, none of the three groups were able to provide a favorable reaction. To ensure patient safety, improve picture quality, increase patient comfort, facilitate an efficient workflow, and enable precise diagnosis and treatment planning, patient preparation for MRI procedures is essential. Healthcare providers can offer their patients effective MRI services and high-quality care by following the right preparation practice. ***Q5:*** Respondents with 1-3 and 4-8 years of clinical experience exhibited less knowledge of the duration of MRI procedures compared to other groups. It is also evident from the results that the higher the years of clinical experience, the higher the knowledge about the question of MRI scan duration. ***Q6*:** Respondents with 1-3 (100%) and above 16 (100%) years of clinical experience were exemplary on this specific question. However, "4-8 years" respondents' knowledge of dye administration is minimal at 4.35%. ***Q7*:** This question pertains to the knowledge of respondents regarding pain levels after MRI procedures. Data reveals that respondents from 9-11 and 12-15 years of clinical experience were highly knowledgeable on the topic, however only a little more than half of respondents under 4-8 years of clinical experience (56.5%) were knowledgeable. It is known that MRI procedures are not painful although they might cause discomfort due to lying still for a length of time. ***Q8*:** Respondents who have above 16 years of clinical experience (28.6%) were less knowledgeable on the question regarding post-MRI scan care compared to other groups. The MRI imaging process itself is non-invasive, requiring no physical effort or intrusive treatments. It rarely results in considerable physical stress or exhaustion. Therefore, prolonged periods of recovery or rest are typically not required. ***Q9*:** Data suggests that only 21.7% of respondents with 4-8 years of clinical experience answered "hearing loud banging noise" while 91% of respondents under 12-15 years of clinical experience answered the same. In an MRI

exam, the hammering noise you hear is a typical byproduct of the scanning procedure, resulting from the MRI machine's magnetic field gradients turning on and off. Detailed images produced by the MRI scan require magnetic field gradients. The magnetic field rapidly changes when these gradients are engaged, creating the tapping, or pounding sound. Throughout the scan, the noise may change in frequency and intensity, depending on the imaging sequences being employed. Louder or more frequent noises may be made by some sequences than others. Additionally, the volume of the sound may fluctuate between different MRI machines**.** ***Q10*****:** 91% of respondents with 12-15 years of clinical experience were knowledgeable that a hospital gown is an item not contraindicated in MRI procedures. The choices given to answer this question are pacemaker, vascular stent, cochlear implant, and hospital gown respectively. The primary reason for wearing a hospital gown is to ensure that there are no metallic objects or materials that could interfere with the MRI imaging or pose a safety risk to the patient.

Table 4. Level of MRI knowledge on MRI safety when grouped according to the profession.

LEVEL OF KNOWLEDGE ABOUT MRI SAFETY	DOCTOR (WM)	NURSE (WM)	RESPIRATORY THERAPIST (WM)	ANESTHESIOLOGY TECHNICIAN (WM)
Q1: Do you know that the MRI scanner is always on even without a patient?	4.18	3.64	3.55	2.33
Q2: Do you know that an MRI CONTRAST agent causes an adverse reaction?	4.36	4.1	3.53	3.33
Q3: Do you know that patients undergoing MRI with contrast agents must have their creatinine levels checked (GFR)?	4.82	3.91	3.08	3.33
Q4: Do you know that pregnant patients can be scanned by MRI?	4.77	3.27	3.26	3.33
Q5: Do you know about the compatible devices used in the MRI environment?	4.36	2.50	3.63	4.67
Q6: Do you know that running the emergency code inside the MRI room is prohibited?	2.82	2.55	2.95	1.67
Q7: Do you know that all MRI patients will be screened for any metallic implants before the procedure?	4.91	3.63	4.0	3.33
Q8; Do you know how to handle a patient having an adverse reaction from an MRI contrast agent?	4.27	3.09	2.66	2.0
Q9: Do you know of the different ZONES in the MRI environment?	3.82	3.09	2.45	2.0

Q10: Do you know that the MRI scanner is in ZONE-4?	2.73	1.45	2.43	2.0
ACCUMULATED MEAN	4.10	3.12	3.15	2.8

Scale range:

1.0-1.75-Not at all knowledgeable; 1.76-2.5 Slightly knowledgeable

2.51-3.25-Moderately knowledgeable; 3.26-3.99 – Very knowledgeable; 4.00-5.00 Highly knowledgeable

The level of knowledge about MRI safety is determined by the 10 questions displayed in Table 4. ***Q1:*** Among the professions admitted in the study, respondents "anesthesiology technician" expressed that they are slightly knowledgeable that the MRI scanner is always on even without a patient with a weighted mean of 2.33, respondents "doctor" however are highly knowledgeable (4.18) on the matter. Respondents "nurse" (3.64) and "respiratory therapist" (3.55) declared that they are very knowledgeable respectively. MRIs do not instantly shut down and start up again after being turned off, unlike a lot of other pieces of medical imaging equipment. Unless otherwise stated, magnetic fields in MRI devices stay steady even when power is lost. The MRI scanner needs a refrigerant system because it must run continuously, seven days a week, for 24 hours, it is therefore preferable to keep an MRI scanner operating continuously rather than turning it on and off frequently because its magnetic field uses so much energy. In terms of ***Q2,*** it is observed that the respondent's "doctor" (4.36) and "nurse" (4.1) are highly knowledgeable when it comes to MRI contrast agent adverse reactions. Positive (T1) or negative (T2) contrast agents (CAs) are frequently injected intravenously to increase the contrast between healthy and abnormal parts of the human body (Gallo, et.al, 2020), however, MRI contrast agents including gadolinium are harmful to mitochondrial respiratory function and cell viability and as an agent's concentration rises and its kinetic stability falls, toxicity rises as well (Bower, et.al, 2019). ***Q3*:** On the other hand, respondents' "doctor" (4.82) expressed high knowledge when it comes to the necessity of creatine level investigation before any MRI procedure while "respiratory therapist" respondents were moderately knowledgeable (3.08) about it. Creatinine levels should frequently be evaluated before an MRI that uses a contrast agent, more specifically one that contains gadolinium (GBCA). A byproduct of muscle metabolism called creatinine will indicate how well the kidneys are functioning. Gadolinium-based contrast agents are mostly eliminated through the kidneys, and those who are vulnerable to the condition of nephrogenic systemic fibrosis (NSF) may be at a higher risk if renal function is compromised. Gadolinium chelate-related NSF poses a concern to patients with poor renal function which is why it is important to remember that before an MRI scan, patients with known or suspected renal impairment should have their renal function assessed. ***Q4:*** A weighted mean of 4.77 suggests that respondent "doctor" is highly knowledgeable when it comes to the question on pregnant patients undergoing MRI examination. On the other hand, all other respondents expressed that they are very knowledgeable on this topic. According to Lum and Tsiouris (2020), there are currently no studies demonstrating any direct risks of MRI during any trimester of pregnancy. ***Q5*:** When it comes to the knowledge of compatible devices within the MRI environment, "doctor" (4.36) and "anesthesiology technician" (4.67) respondents made it known that they are highly knowledgeable while respondent "nurse" conveyed that they are slightly knowledgeable on this topic. It's crucial to remember that not all medical equipment or implants work with MRIs. The presence of metallic parts or other materials in some electronics makes them susceptible to a high magnetic field, which might result in malfunctions or safety hazards. Before performing the treatment, healthcare professionals must be informed of any implants or other equipment a patient may be using and confirm their suitability for MRI. ***Q6:*** All three groups of respondents namely the doctor, nurse, and respiratory therapist conveyed moderate knowledge regarding running an emergency code inside the MRI room with weighted means of 2.82, 2.55, and 2.95 respectively. However, respondents "anesthesiology technician" (1.67)

expressed that they are not at all knowledgeable on the matter. Running an emergency inside the MRI is generally prohibited due to safety hazards, safety risks are one of the main justifications for banning emergency codes inside the MRI room. Intense magnetic fields can transform metal things into deadly projectiles which are too risky and at the same time running an emergency code while an MRI is being performed may cause interference and can disrupt signals that may affect an MRI scan's precision and quality. ***Q7*:** Due to the intense magnetic field present in the MRI setting, the presence of metallic implants or devices may present a safety risk. Certain implants might not be suitable for MRI or might need to be treated differently, therefore it is necessary to screen all patients before the MRI procedure. Data reveals that respondent's "doctor", and "respiratory therapist" are highly knowledgeable at a weighted mean of 4.91 and 4.0 respectively in terms of patient screening for metallic implants. The screening procedure and determining the safety of MRI for each patient are crucial tasks that must be performed by medical professionals to ensure MRI safety. ***Q8:*** To protect the patient's safety and wellbeing, handling patients who are having an adverse reaction to an MRI contrast agent necessitates quick and appropriate intervention. Among the professions, "doctors" (4.27) declared that they are highly knowledgeable in handling events of adverse MRI reactions. It is also observed that professional "nurses" and "respiratory therapists" are moderately knowledgeable and respondents "anesthesiology technicians" are not at all knowledgeable. Gadolinium chelates with varying degrees of stability, viscosity, and osmolality are used as MRI contrast agents. Although gadolinium is a relatively extremely safe contrast, patients may occasionally experience adverse responses to it (26). ***Q9*:** A section within a medical facility known as the "MRI zone" is allocated and created, particularly for MRI scans. The removal of ferromagnetic materials and things that might be impacted by the magnetic field is one of the main factors in the MRI zone. This guarantees that nothing will be drawn to the MRI machine, avoiding potential risks, and preserving the accuracy of the scan. Among the responses, respondents 'doctor" reveals high knowledge on the topic with a weighted mean of 3.82, however, respondents "anesthesiology technician" suggests slightly knowledgeable on the topic. The bulk of modern MR scanners are superconducting high-field (1.5 T) devices, which means that after installation and magnet ramping, the primary magnetic field (*Bo*) is always present. Areas inside and surrounding the MR scanner are constructed with safety zones to reduce the danger of injury or death to humans or damage to the MR scanner because of a projectile incident. The literature provides detailed examples of zoning maps that serve to demarcate and identify areas within and around the MR suite in terms of their respective safety risks and measures necessary to ensure the safety of both staff and patients. Of the four zones (I, II, III, & IV) as defined by the American College of Radiology (ACR), Zone I is open to the public and has the lowest risk of an MR-related injury. Zone II is the transition zone between Zone I, which is open to the public (i.e., uncontrolled), and Zones III and IV, which are strictly restricted. While Zone IV comprises the MR scanner chamber and is, therefore, the area with the highest safety risk, Zone III is the limited area outside of the MR scanner where unscreened access by non-MR staff may have negative impacts (29). ***Q10*:** Respondents "nurse" (1.45) indicates that they are not at all knowledgeable that Zone-4 houses the MRI scanner, while "doctor"(2.73) is moderately knowledgeable. Data also suggests that respondents "respiratory therapist" and "anesthesiology technician" are slightly knowledgeable regarding the location of the MRI scanner. The ACR advises keeping Zone IV access closed unless it is being used for patient care or maintenance, and when it is open, they advise utilizing a "caution" barrier to prevent unintentional passage from Zone III to Zone IV (such as adjustable straps or plastic chains) as mentioned by Greenberg, et.al, 2019 (30).

Table 5. Correlation of variables with the level of knowledge of MRI safety

Variable		PROFESSION	YEARS OF CLINICAL EXPERIENCE
1. PROFESSION	Pearson's r	—	
	p-value	—	
2. YEARS OF CLINICAL EXPERIENCE	Pearson's r	0.755	—
	p-value	0.012	—
3. LEVEL OF EDUCATION	Pearson's r	-0.017	0.344
	p-value	0.963	0.330

**Level of significance= 0.05*

Table 5 shows the correlation of the level of knowledge towards MRI safety with the variable profession, years of clinical experience, and level of education. Using Pearson's correlation, data reveals that variable profession and years of clinical experience are not significantly correlated with a p-value of 0.012, higher than the level of significance (0.05). There is also a positive correlation (*r= 0.755*) between the variables. It is further indicated that the level of education and years of clinical experience are not at all correlated when it comes to the level of knowledge of MRI safety. The level of education and variable profession are negatively correlated (-0.017), which means that if one of the variables changes, the other variable will also change in the opposite direction. Years of clinical experience can significantly affect a healthcare professional's degree of knowledge and expertise. Through years of work, healthcare professionals encounter a variety of instances, settings, and difficulties as their experience grows. They can have a broader awareness of medical issues, procedures, and patient care thanks to this exposure.

Table 6. Distribution of the significant difference in basic

Table 6. MRI knowledge when grouped according to profession.

PROFESSION	t	df	p-value	INTERPRETATION
Doctor	8.625	9	p <.001	Significant
Nurse	6.453	9	p <.001	Significant
Respiratory Therapist	7.460	9	p <.001	Significant
Anesthesiology Technician	4.323	9	0.002	Significant
Doctor	8.625	9	p <.001	Significant

**Level of significance=0.05*

Table 6 shows the significant difference between the variables when grouped according to profession. The t-test statistical analysis produced a p-value of less than 0.001 and a degree of freedom of 9, suggesting a substantial difference in basic MRI knowledge among the professions of "doctor," "nurse," and "respiratory therapist.". Further, according to the statistical analysis, the role of

"anesthesiology technician" in the context under investigation differs statistically significantly with a p-value of 0.002, which is below the 0.05 crucial level of significance.

Table 7. Distribution of the difference in level of knowledge on MRI safety when grouped according to profession.

PROFESSION	t	df	p-value	INTERPRETATION
Doctor	16.822	9	p <.001	Significant
Nurse	17.066	9	p <.001	Significant
Respiratory Therapist	18.605	9	p <.001	Significant
Anesthesiology Technician	9.366	9	p <.001	Significant

**Level of significance=0.05*

According to the t-statistical analysis presented in Table 7, the findings show that, depending on the respondents' different professions, there is a substantial variance in the level of knowledge towards MRI safety. The computed p-value of 0.001 indicates that there is a statistically significant difference in the variables. The difference in knowledge levels between different professions can be attributed to their training and awareness (31).

Table 8. Correlation between basic knowledge of MRI and level of knowledge on MRI safety

Variable	BASIC KNOWLEDGE ON MRI
LEVEL OF KNOWLEDGE ON MRI SAFETY	Pearson's r (-0.064) p-value (0.861)

**Level of significance = 0.05*

Based on the information provided in Table 8, the correlation analysis using Pearson's correlation coefficient (r) between basic MRI knowledge and the level of knowledge on MRI safety among respondents yielded a value of -0.064 which indicates a negative correlation, the p-value of 0.861 however suggests that this correlation is not statistically significant. In statistical hypothesis testing, the p-value is used to determine the significance of a correlation. In this case, the p-value of 0.861 is higher than the set level of significance of 0.05. This means that there is no significant correlation between basic MRI knowledge and the level of knowledge of MRI safety. This result indicates that the findings do not suggest a significant relationship or association between respondents' level of knowledge about MRI safety and their basic understanding of MRI. It further suggests that having more general knowledge about MRI does not necessarily equate to having more information, especially about MRI safety.

V. CONCLUSION

The study revealed that doctors exhibited a greater level of knowledge regarding the fundamentals of MRI among the professions. Nurses and anesthesiology technicians on the other hand were found to have relatively lower levels of knowledge in this area. The result also suggests that it is essential for all professionals involved in MRI procedures to actively acquaint themselves with the necessary preparations for MRI procedures. Additionally, individuals with 9-11 years of clinical experience demonstrate a greater level of basic MRI knowledge when compared to other groups. The amount of clinical experience plays a role in shaping one's level of knowledge, and there is a direct relationship between the two. This result further indicates that as individuals gain more years of experience in a clinical setting, their knowledge tends to grow proportionately.

Moreover, it is worth noting that anesthesiology technicians displayed a moderate level of knowledge regarding MRI safety, whereas doctors exhibited a high level of knowledge in this area. Anesthesiology technicians further acknowledged their complete lack of knowledge regarding the prohibition of running emergency codes inside the MRI room. On the other hand, nurses are not knowledgeable about the MRI Zones, further indicating that they are clueless about MRI scanners being inside Zone IV. When grouped according to professions, it is further revealed that there is a significant difference in their basic knowledge of MRI. The study's results suggest a

possible intervention to improve MRI safety knowledge among anesthesiology technicians and nurses: the implementation of customized educational programs designed specifically for their needs. These programs would aim to enhance their understanding and awareness of MRI safety protocols and procedures.

The study also concluded that there is no correlation between profession, years of clinical experience, and level of education in terms of the level of knowledge on MRI safety. There is a negative correlation between profession and the level of education, which indicates that when one of the variables changes, the other variable will also change in the opposite direction. Furthermore, the study suggests that there is a significant difference in the level of knowledge on MRI safety when grouped according to the profession. A conclusion section must be included and should clearly indicate the advantages, limitations, and possible applications of the paper. Although a conclusion may review the main points of the paper, do not replicate the abstract as the conclusion. A conclusion might elaborate on the importance of the work or suggest applications and extensions.

Finally, the findings of this study indicated that basic knowledge of MRI and level of knowledge of MRI safety are not significantly correlated. In other words, respondents who have a good grasp of the basic principles and concepts of MRI may not necessarily demonstrate a higher level of knowledge in terms of safety protocols, precautions, and potential risks involved in MRI scans. This finding suggests that factors beyond basic knowledge, such as specific training programs, ongoing education, or dedicated safety training, may be necessary to ensure a comprehensive understanding and adherence to MRI safety guidelines.

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