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Magnetic Resonance Imaging Safety and Considerations

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Introduction

Magnetic Resonance Imaging (MRI) is a valuable diagnostic tool, but its powerful magnetic field creates serious risks if safety protocols are not followed. This project highlights the importance of strict screening, staff training, and enforcement of safety standards to prevent MR-related accidents and protect patients, MR personnel, other facility employees, and the general public.

What is MRI?

- The magnet is **always on** even when there is no scan in progress. (American College of Radiology, 2024)
- Typical field strengths range from 1.5-3.0 tesla, which is thousands of times stronger than Earth's magnetic field. (Rollins, et al., 2023)
- Strong magnetic fields and radiofrequency (RF) waves create images of internal body structures. (Rollins, et al., 2023)
- The magnetic field extends beyond the scanner room in invisible gauss lines that attract magnetic materials. (American College of Radiology, 2024)
- Ferrous objects (containing iron) can become dangerous projectiles if brought near the magnet. (Medvedkov et al., 2021)
- Strict MRI safety protocols are essential to protect patients, staff, and visitors from injury or equipment damage.

Increasing Safety

- Enforce MRI safety zones and access control.
- Screen all patients and staff.
- Remove all metallic and ferrous objects.
- Use only MR-safe equipment.
- Provide hearing protection during procedures.
- Prevent RF burns by limiting skin-to-skin contact.
- Educate staff regularly on MRI safety.

Risks in MRI include:

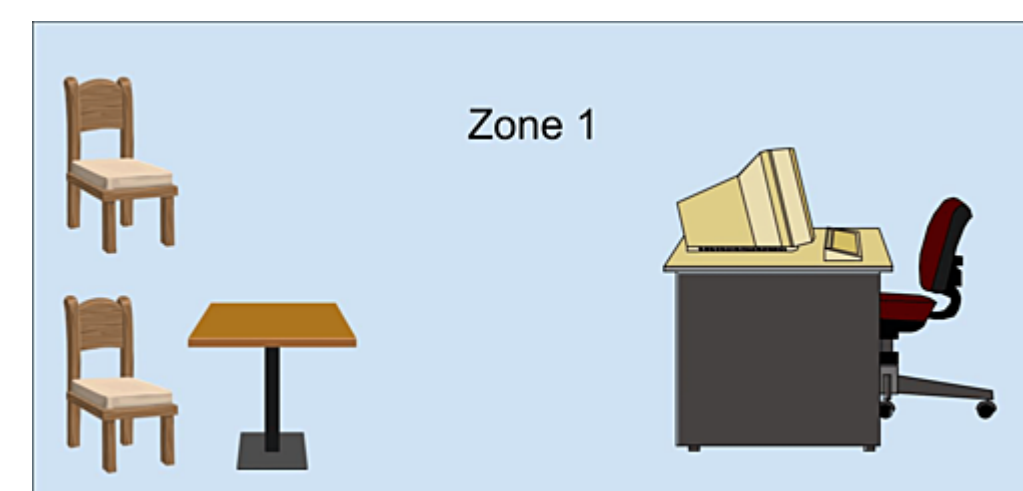
The 3 types of magnetic fields in MR are associated with unique risks

- Main magnetic field B0
 - Ferromagnetic object translation/torque and projectile incidents
- RF field B1
 - Heating and burns
- Time-varying gradient magnetic field
 - Acoustic injury, peripheral nerve stimulation

(American College of Radiology, 2024)

Zone 1

- All areas that are accessible to the general public
- Uncontrolled zone.
 - examples: outside MR department, reception area

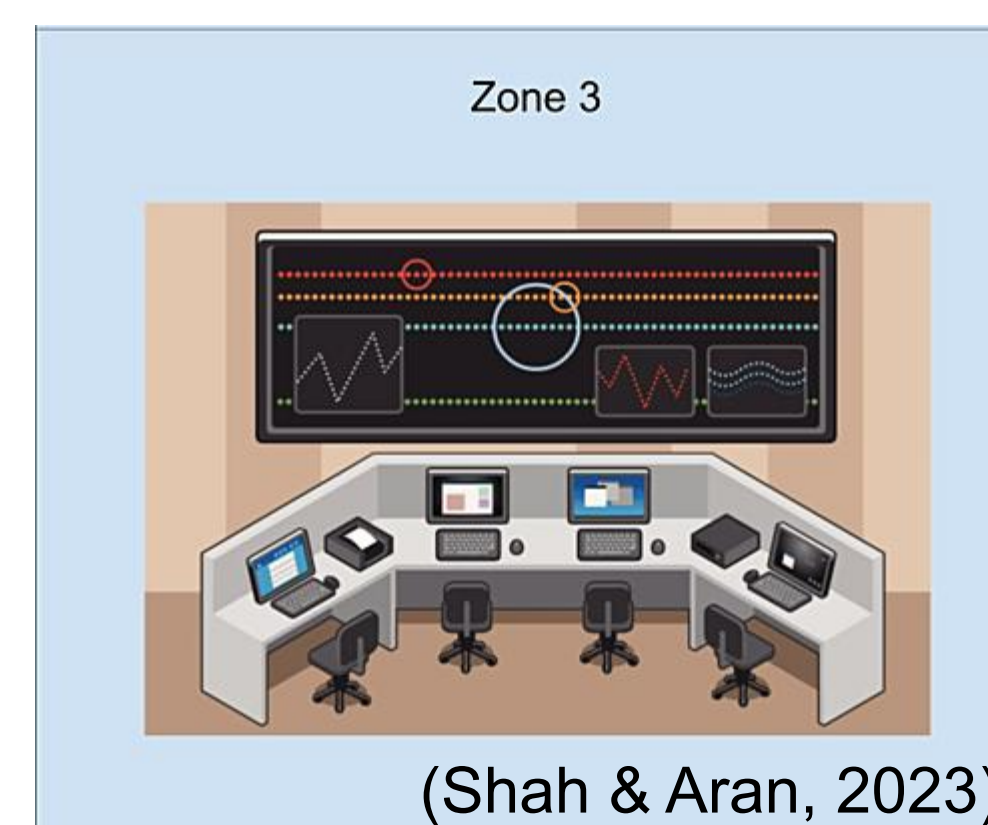


(Shah & Aran, 2023)

(American College of Radiology, 2024)

Zone 3

- Is a controlled access area.
 - Example: Control room
- Only MR personnel have access.
- MR personnel must have direct sight of patient at all times.

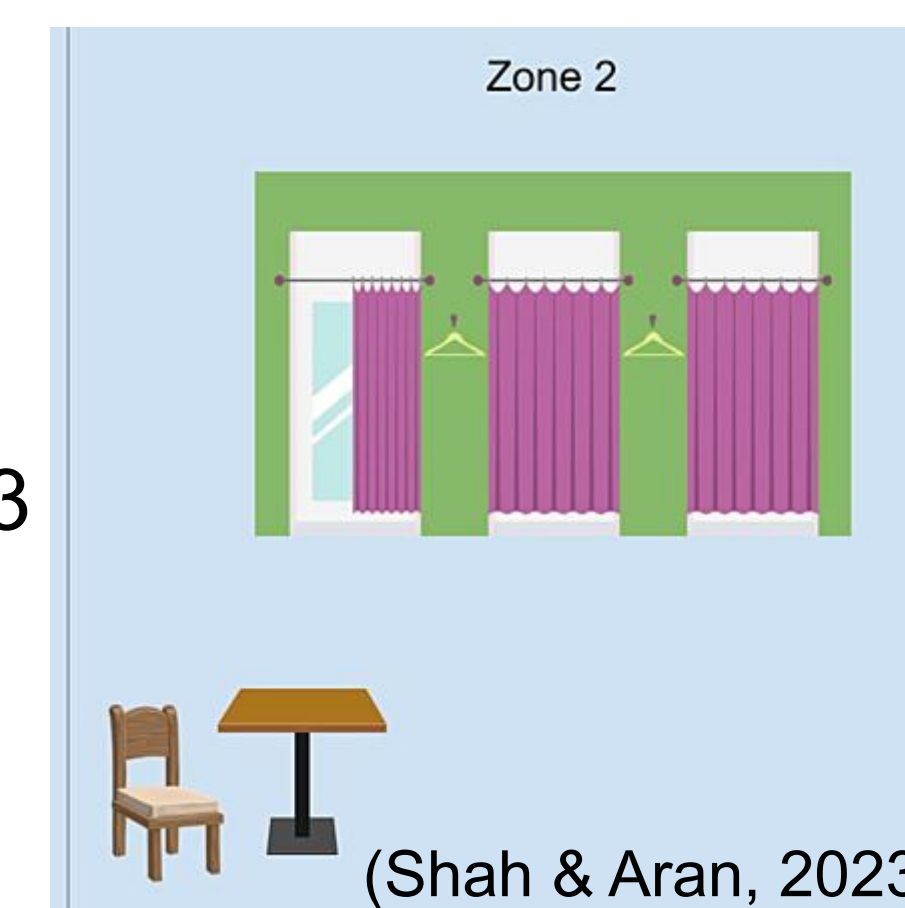


(Shah & Aran, 2023)

(American College of Radiology, 2024)

Zone 2

- Between open accessible zone I and controlled area of zone 3
 - Examples: patient changing and screening areas
- Access is often restricted to MR personnel.

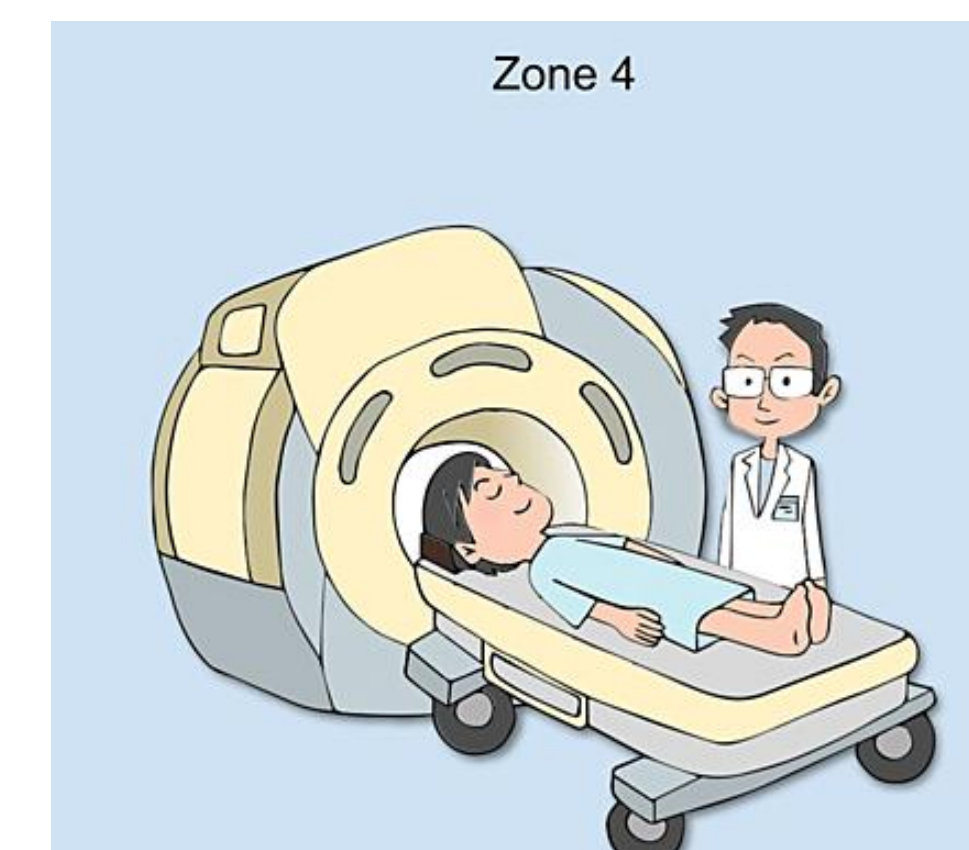


(Shah & Aran, 2023)

(American College of Radiology, 2024)

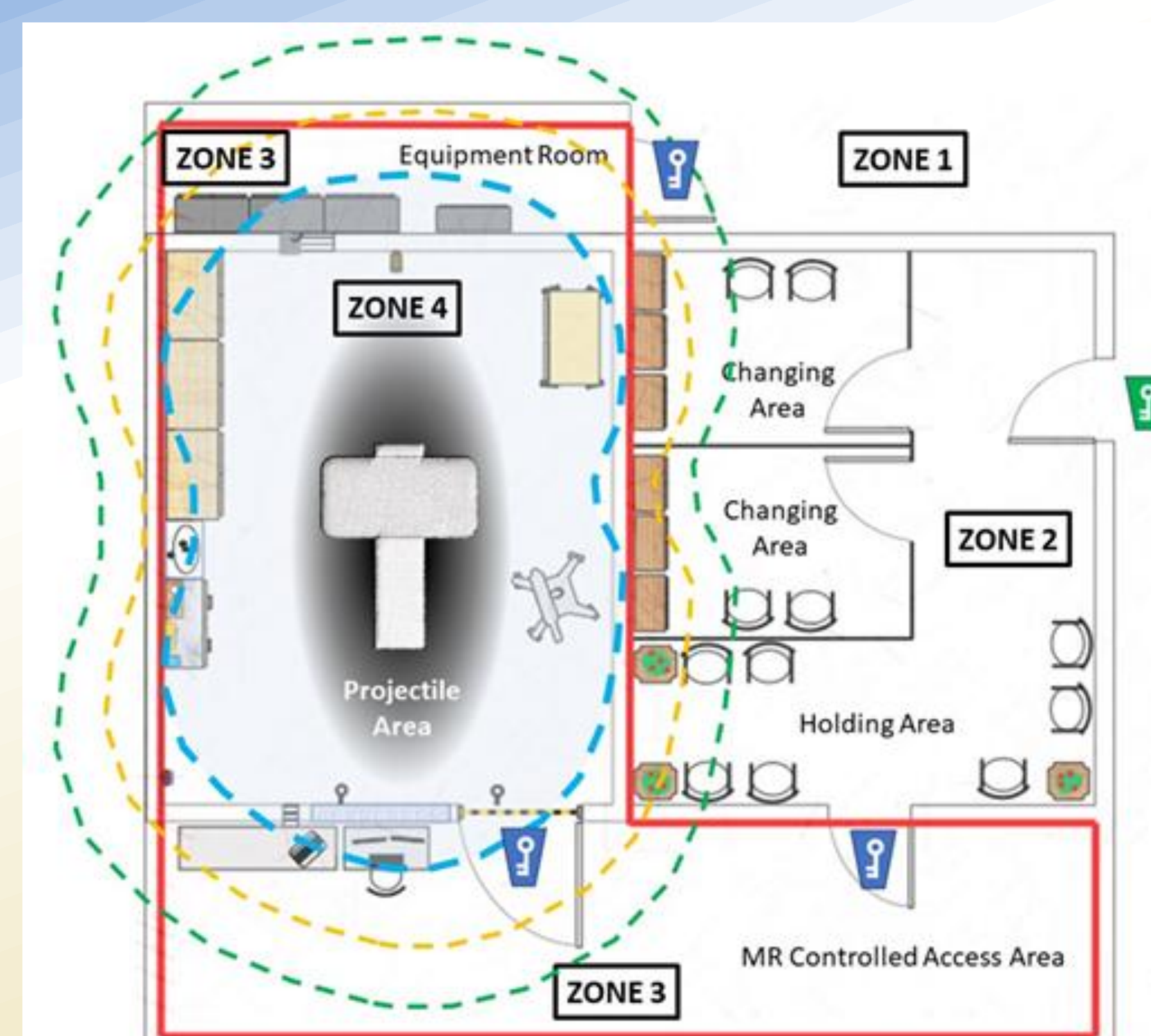
Zone 4

- Is a controlled access area.
- Only MR personnel have access.
 - Example: magnet room
- Must have a sign displayed saying "magnet is always on".



(Shah & Aran, 2023)

(American College of Radiology, 2024)



-  = Restricted access (Recommended)
-  = Restricted access (optional)
-  = MR Controlled Access Area
-  = Projectile Area
-  = MR Environment
-  = 9 Gauss line
-  = 5 Gauss line
-  = 3 Gauss line

Depictions of "MR Controlled Access Area," "MR Environment," and "Projectile Area" as they relate to the 4-zone model (American College of Radiology, 2024)

Screening

- All needing to enter Zone III must first pass an MR safety screening process that includes a written form and verbal interview.

(American College of Radiology, 2024)

APPENDIX 3: Safety Screening Form for MR Procedures

Date: _____ Name (first middle last): _____
 Female [] Male [] Age: _____ Date of Birth: _____ Height: _____ Weight: _____

1. Why are you having this examination (medical problem)? _____ YES NO

2. Have you ever had an MRI examination before and had a problem? _____
 If YES, please describe: _____

3. Have you ever had a surgical operation or procedure of any kind? _____
 If YES, list all prior surgeries and approximate dates: _____

4. Have you ever been injured by a metal object (foreign body) (e.g., bullet, MR, shrapnel)? _____
 If YES, please describe: _____

5. Have you ever had an injury from a metal object in your eye (metal shavings, metal shavings, other metal objects)? _____
 If YES, did you seek medical attention? _____
 Describe what was found: _____

6. Do you have a history of kidney disease, asthma, or other allergic respiratory disease? _____
 If YES, please list drugs: _____

7. Do you have any drug allergies? _____
 If YES, please list drugs: _____

8. Have you ever received a contrast agent's (not dye) used for MRI, CT, or other x-ray or study? _____
 If YES, please describe: _____

9. Have you ever had a x-ray dye or magnetic resonance imaging (MRI) contrast agent allergic reaction? _____
 If YES, please describe: _____

10. Are you pregnant or suspect you may be pregnant? _____

11. Are you breast feeding? _____

12. Date of last menstrual period: _____ Post-menopausal? _____

(Kanal et al., 2020)

Implant Safety



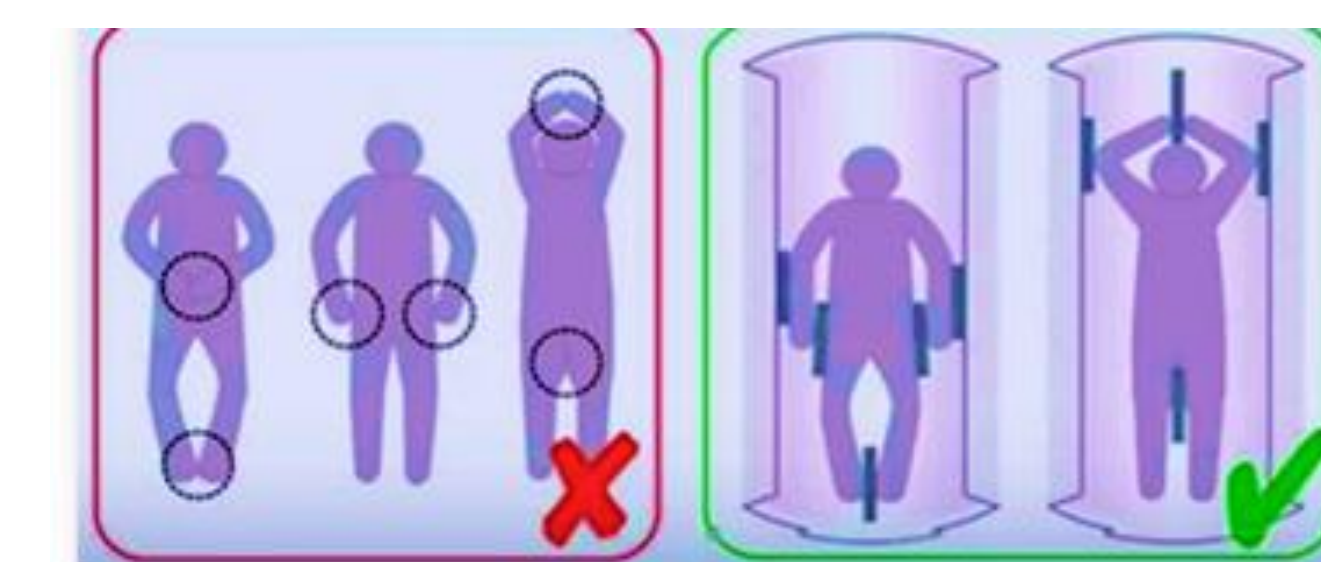
- (A) MR Safe, items that pose no known risk or hazard in the MRI environment.
- (B) MR Conditional, implants and devices demonstrate no hazard in the MRI environment, but only when prescribed conditions for safe use are adhered to.
- (C) MR Unsafe, implants and devices should never be brought into the MRI environment.

(Shellock et al., 2022)

RF Burns

- The radiofrequency field (B1) is used to excite the patient's tissues and produce the MR signal for image acquisition.
- Responsible for the highest number of reported adverse injuries, burns.
- Skin to skin contact and contact with conductive materials inside the bore can lead to RF burns.
- leads or cables should not directly contact the skin
- Pads with at least 1cm thickness should be used anywhere skin-to-skin contact or skin-to-bore contact would occur.
- Patients should be changed into MR-safe gowns.

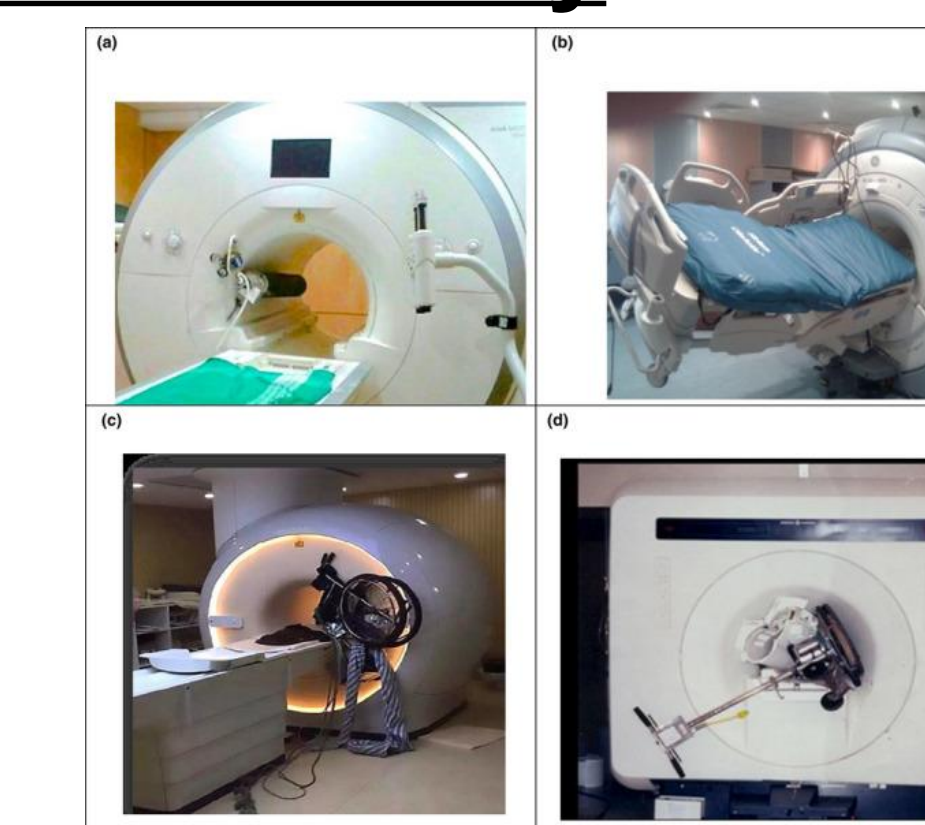
(American College of Radiology, 2024)



(Medvedkov et al., 2021)

Projectile Accidents & Auditory Considerations

- Measures to take to prevent projectile risks
 - Examples: use ferromagnetic detection and screen everyone
- Noise is generated from the switching of the gradient fields
- Use auditory protection



Examples of projectile accidents in the MRI environment: (A) oxygen cylinder, (B) stretcher bed, (C) wheelchair, (D) floor buffer (Shellock et al., 2022)

Conclusion

MRI is a powerful diagnostic tool, but its benefits can only be realized when strict safety protocols are upheld. Even a single lapse in screening, training, or zone enforcement can have devastating consequences. Ongoing education, vigilance, and adherence to established safety standards are essential to protect patients, staff, and the public, ensuring that MRI remains both effective and safe.