Physical Environment MRI Safety

Tobias Gilk - Sept 28, 2022

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- Past Member ACR MRI Safety Committee
- Contributing Author 2013 & 2020 ACR MRI Safety Guidance
- Founding Board Member / Past Chair ABMRS
- International Trainer on MRI Safety

ABMRS Content Disclosure

This presentation is not sponsored by or affiliated with the American Board of Magnetic Resonance Safety (ABMRS).

As a member of the the Board of the ABMRS, I am prohibited from speaking on specific examination question content, but permitted to provide education on MRI safety concepts and principles.

This presentation is not an exam preparation for any examination.

Rules of the Road

- Everything on the screen is for you (you can copy or take photos).
- If you have questions, ask!
- If you disagree, please speak up.

Outline

Physical Environment MRI Safety

- Intro
- Magnetic Field Reach
- Zones
- Cryogen Safety
- Novel MRI Systems
- Q & A

Magnetic Field Reach

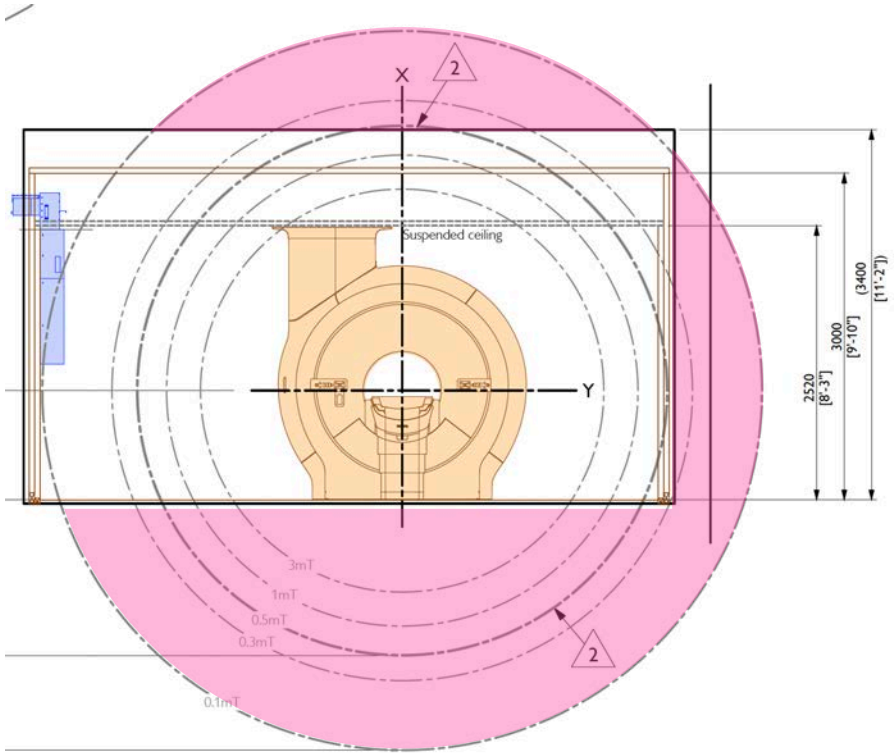
Magnetic Field Reach

Static Field

- In Construction, many construction materials do not contain magnetic fields.
- Steel structures will interact with magnetic fringe field, reshaping it.
- Steel structures can become magnetized, or ‘magnetically contaminated’, which can affect future functions in the space.

Magnetic Field Reach

Static Field



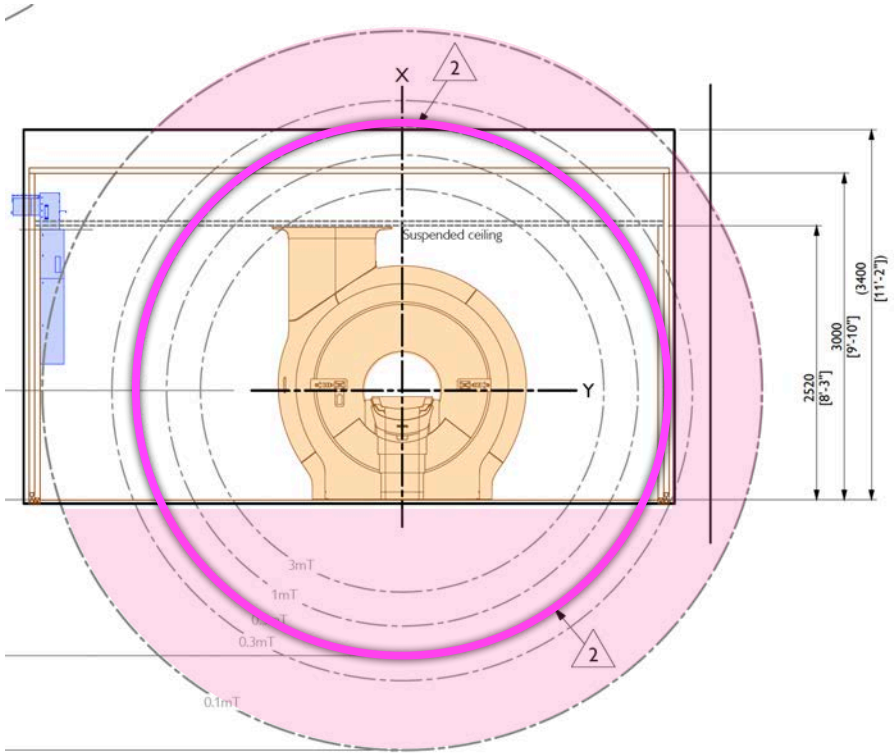
Magnetic Field Reach

9 Gauss (0.9 mT) is the new 5 Gauss (0.5 mT)

- Last month the IEC changed the standard for static field safety for unscreened persons from 5 Gauss (0.5 mT) to 9 Gauss (0.9 mT)
- IEC governs *manufacture* of MRI equipment, but this change has obvious implications for all existing MRIs
- US FDA does not have independent safety standard… they reference IEC
- I understand EU regulation references ICNIRP, so perhaps more steps

Magnetic Field Reach

9 Gauss (0.9 mT) is the new 5 Gauss (0.5 mT)



Magnetic Field Reach

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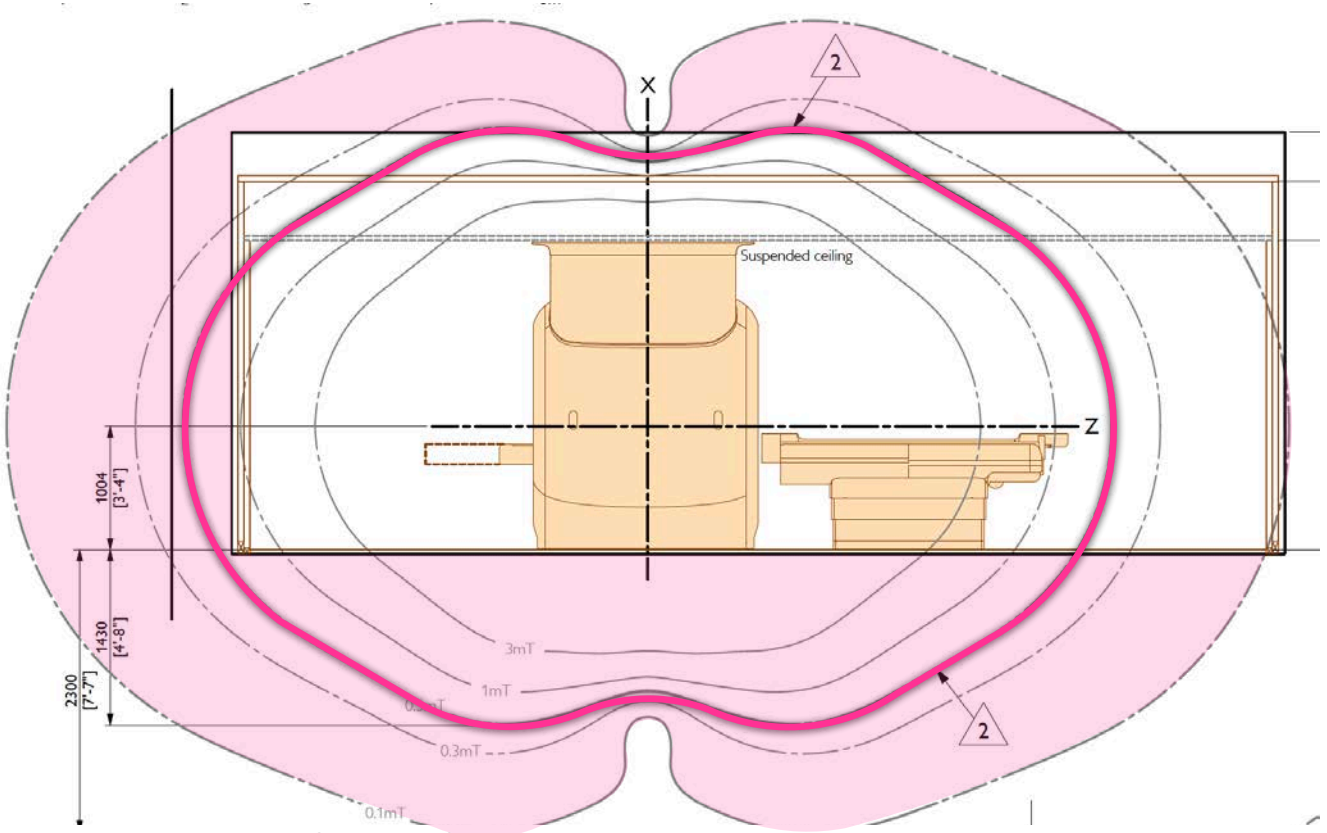


Zones

Zones

What They Are

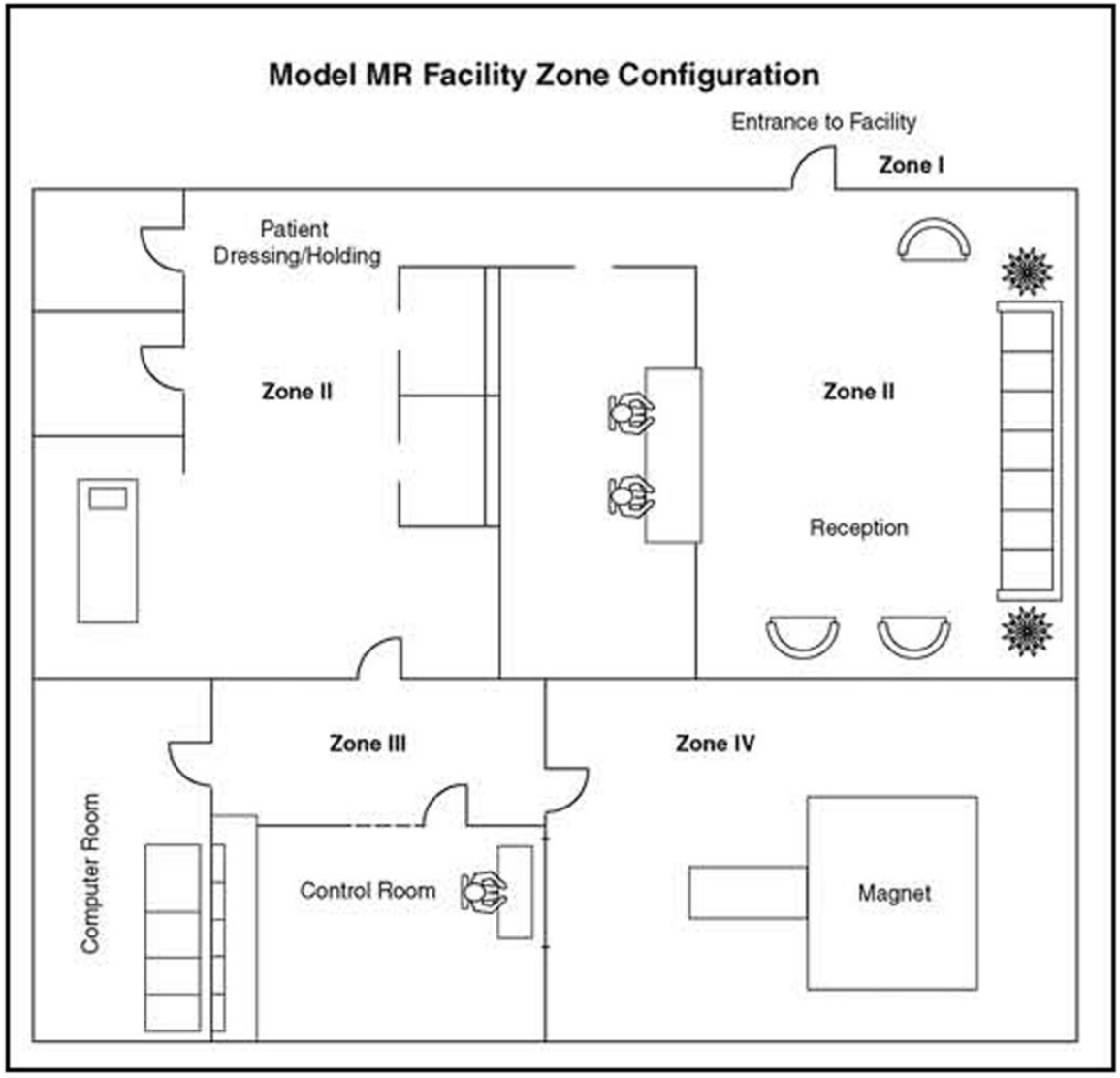
- Zones are MRI-specific hazard areas, going sequentially from ‘No Risk’ to ‘Maximum Risk’

  - Zone 1 - No MRI Function. No MRI-specific Risk.
  - Zone 2 - MRI Function. No MRI-specific Risk.
  - Zone 3 - MRI Function. Moderate MRI-specific Risks.
  - Zone 4 - MRI Scanner Room. Extreme Possible MRI-Specific Risks

Zones

What They Are

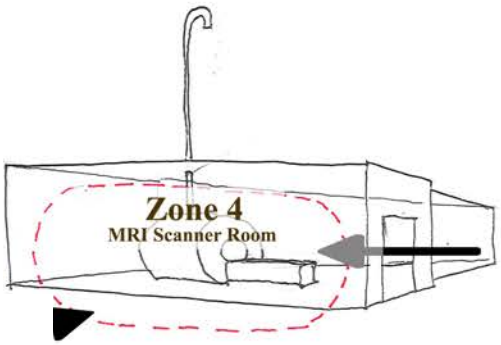
- Zones often shown on floor plan, associated with rooms
- Zone 4 is the only zone defined as a specific room



Zones

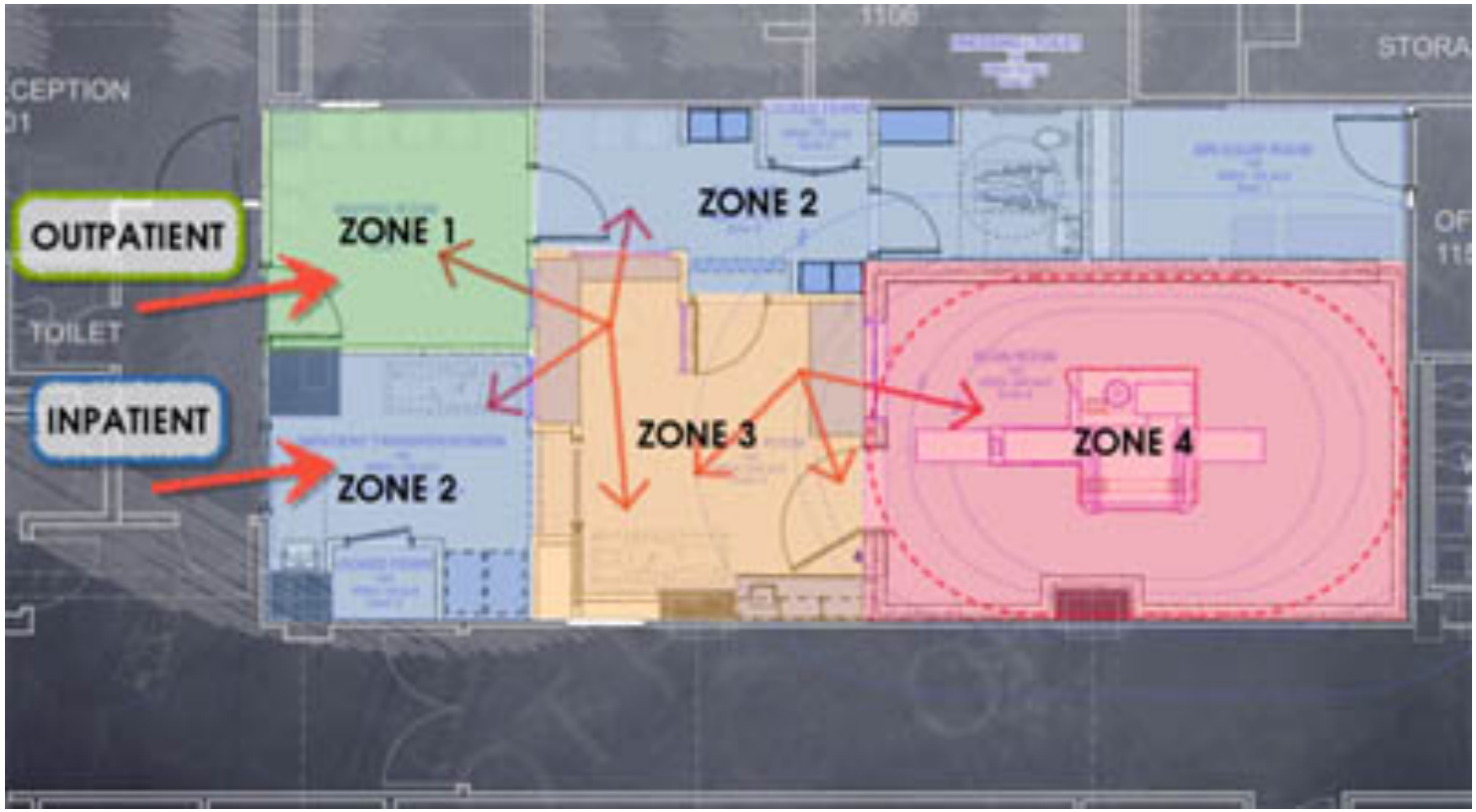
What They Are

- MRI Hazard Designations



Zones

What They Are



Zones

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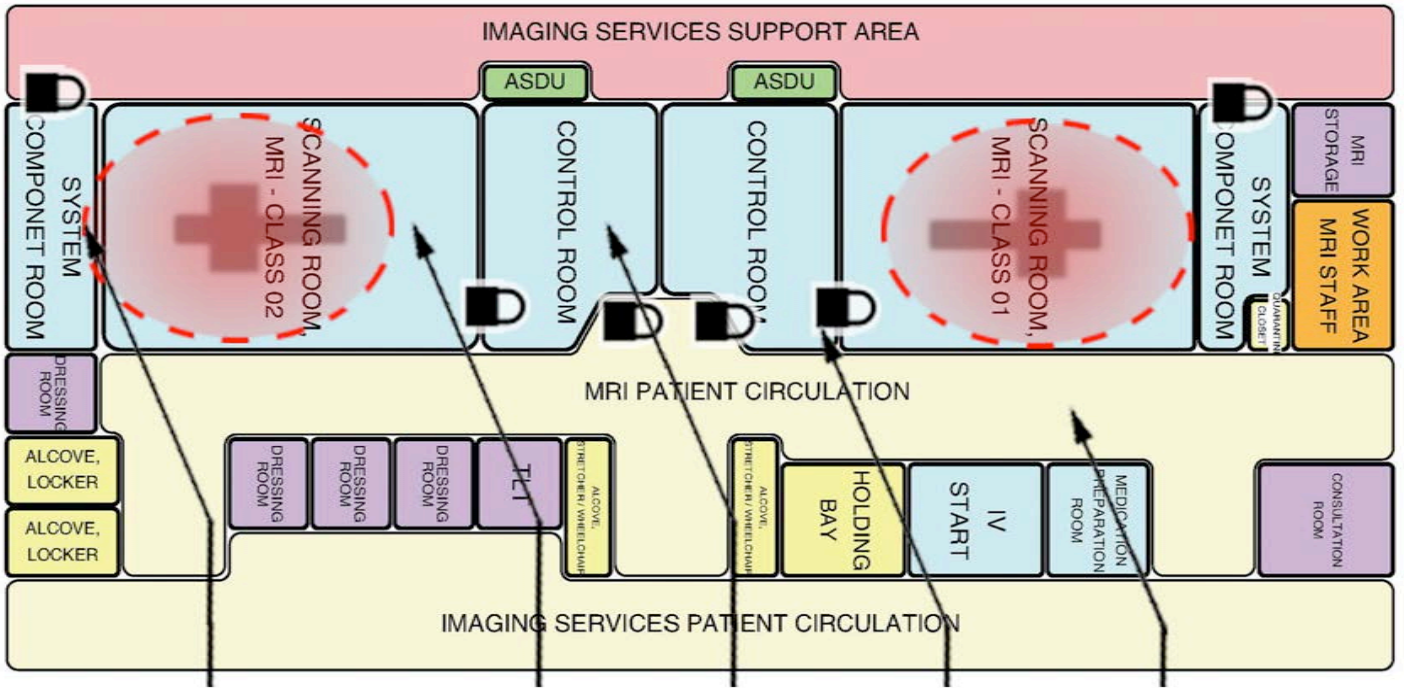


Zone 2:
Unsecured area for patient screening and preparation.

Padlock indicates locked / lockable point of access throughout.

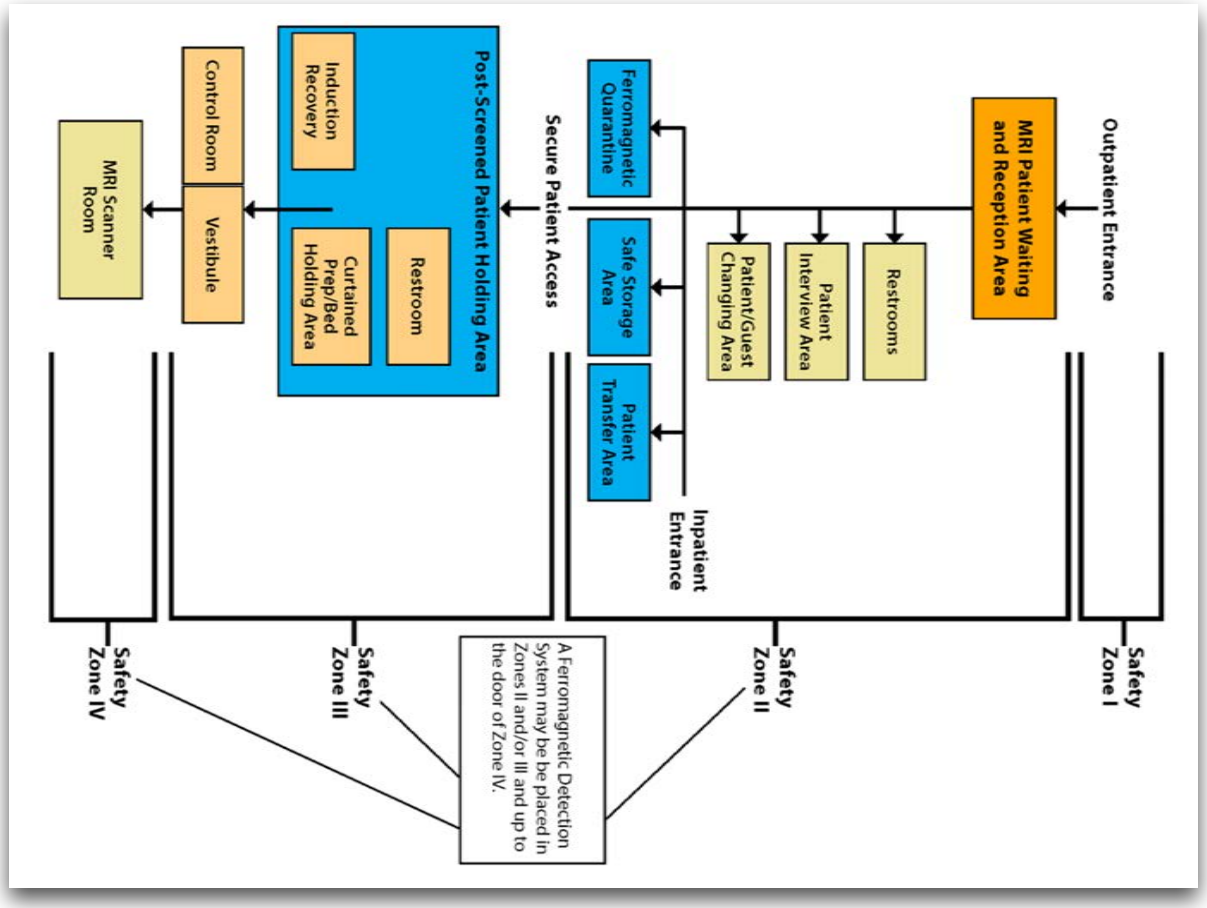
Zone 3:
Direct access to Zone 4 (MRI Scanner Room).

Zone 4:
MRI Scanner Room.

Zone 3:
Potentialy dangerous magnetic fields may extend into adjacent rooms on same floor, and vertically into rooms above and below.

Zones

What They Are



Zones

Signage

Zones

Signage

Zones

Signage

Zones

Signage

Zones

Door to Zone 4

- Door to Zone 4 is the *absolute last chance* to catch hazard items


MRI
IN USE
DANGER!
MRI
ZONE IV
Screened MRI Patients Under Constant Direct
Supervision of Trained MRI Personnel Only
MAGNETOM
3T

Zones

Door to Zone 4

FULL STOP/FINAL CHECK

A "full stop and final check" performed by the MRI technologist is recommended to confirm the satisfactory completion of MR safety screening for the patient, support equipment, and personnel immediately prior to crossing from Zone III to Zone IV. The purpose of this final check is to confirm the patient's identification, ensure that all screening has been appropriately performed, and ensure that there has been no change in patient and/or equipment status while in Zone III.

https://www.acr.org/-/media/ACR/Files/Radiology-Safety/MR-Safety/Manual-on-MR-Safety.pdf

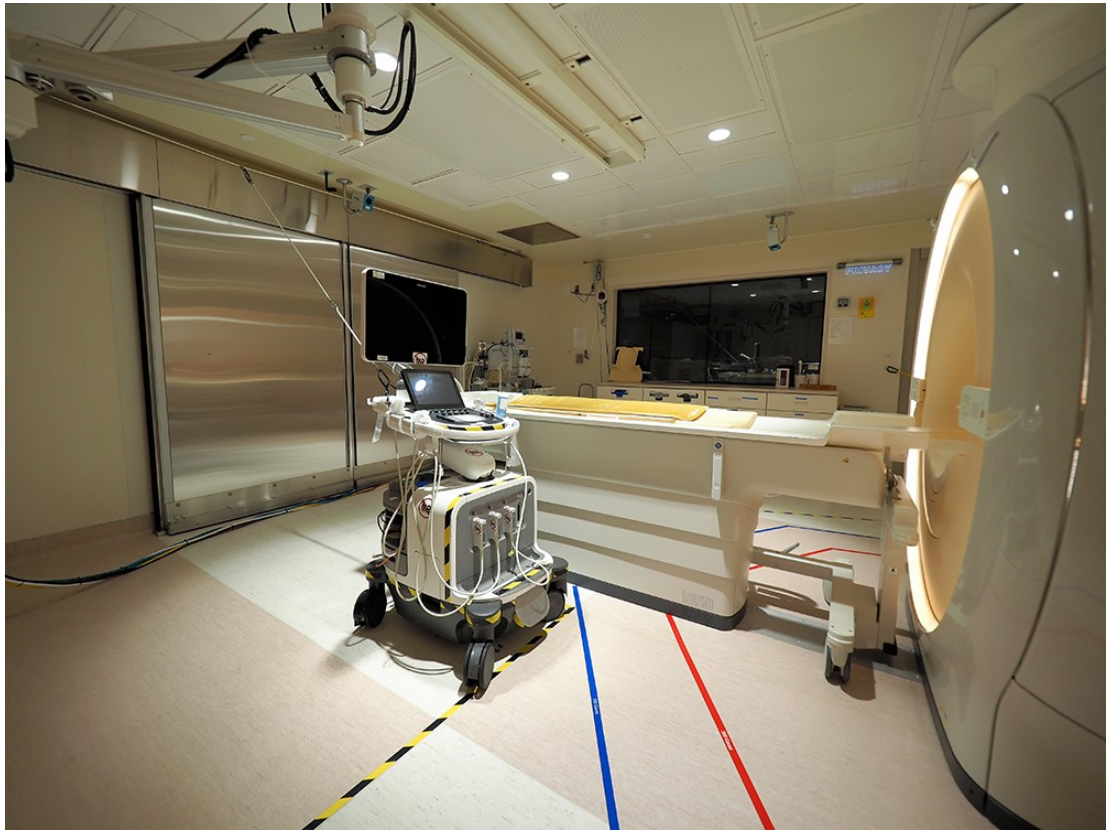
Zones

Tethers

When supporting the use of non-MR Conditional portable equipment outside the MRI Scanner Room (Zone 4), such as horizontal patient transfer devices, infusion pumps, or patient monitors, planners shall provide anchoring tether-points to allow each individual portable piece of non-MR Conditional equipment to be tethered to prevent its inadvertent introduction into the MRI Scanner Room.

Zones

Tethers



Cryogen Safety

Cryogen Safety

Cryogens and Superconductivity

- MRIs Are Electromagnets
  - Superconductivity reduces electrical consumption (reduces operational cost)
  - Superconductivity only available at super-cold temperatures
  - Liquid Helium boiling temperature -269° C

Cryogen Safety

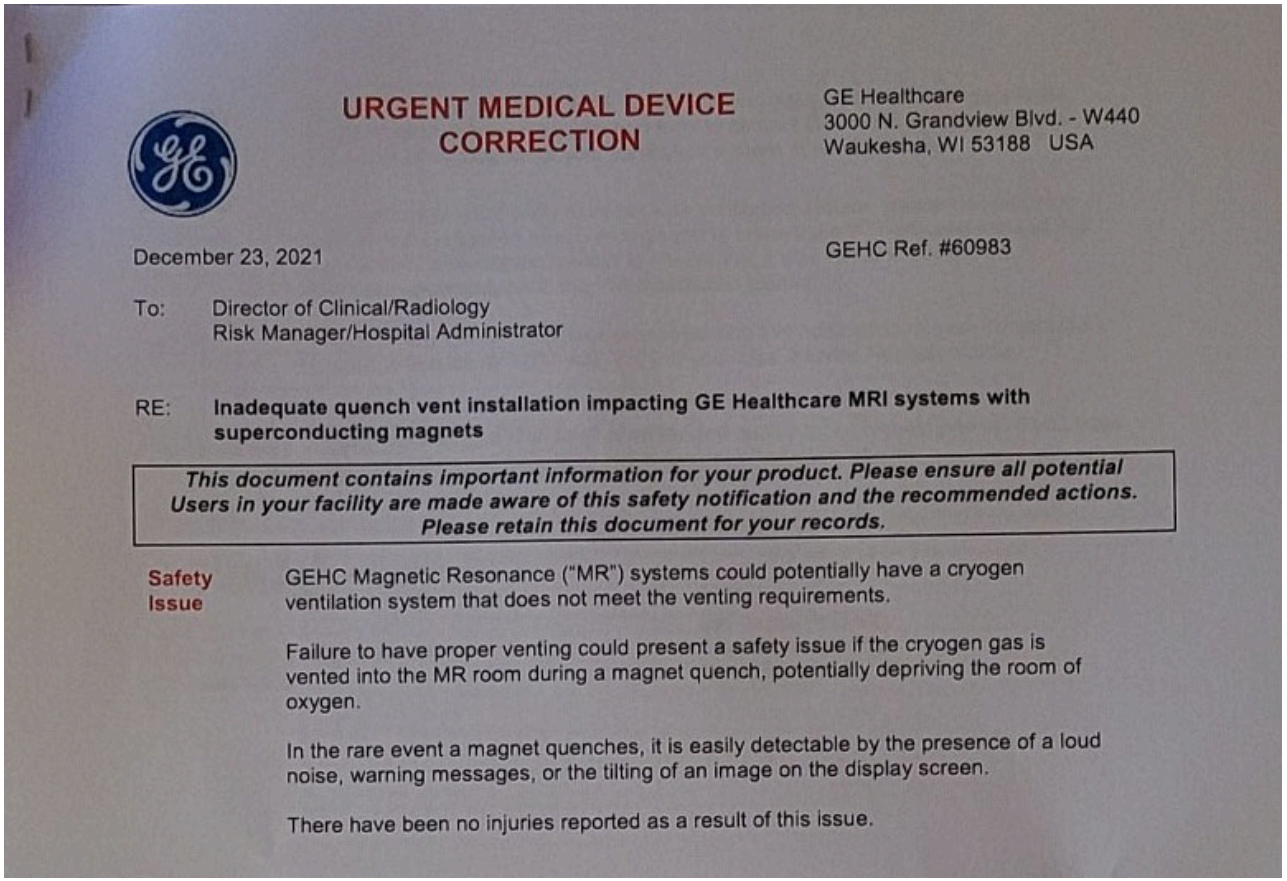
Quench vs. EPO

- Superconducting MRI Systems Typically Have 2 Emergency Features…
  - Emergency Power Off (EPO)
  - Quench Button

Cryogen Safety

- A Large Majority of MRI Systems Are Superconducting & Require Cryogens
- A Few Newer Superconducting Magnets Do NOT Require Quench Pipes
- The Following Relates To Systems WITH Quench Pipes

Cryogen Safety



URGENT MEDICAL DEVICE CORRECTION

GE Healthcare
3000 N. Grandview Blvd. - W440
Waukesha, WI 53188 USA

December 23, 2021

GEHC Ref. #60983

To: Director of Clinical/Radiology
Risk Manager/Hospital Administrator

RE: **Inadequate quench vent installation impacting GE Healthcare MRI systems with superconducting magnets**

This document contains important information for your product. Please ensure all potential Users in your facility are made aware of this safety notification and the recommended actions. Please retain this document for your records.

Safety Issue

GEHC Magnetic Resonance ("MR") systems could potentially have a cryogen ventilation system that does not meet the venting requirements.

Failure to have proper venting could present a safety issue if the cryogen gas is vented into the MR room during a magnet quench, potentially depriving the room of oxygen.

In the rare event a magnet quenches, it is easily detectable by the presence of a loud noise, warning messages, or the tilting of an image on the display screen.

There have been no injuries reported as a result of this issue.

Cryogen Safety

Cryogen Safety

Cryogen Safety

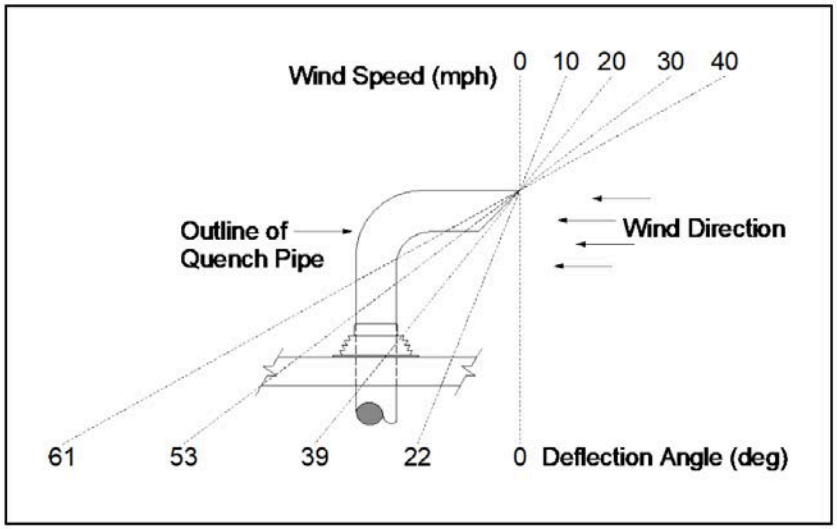


Figure 2.7.3.3-1: Diagrammatic illustration of how wind-driven rain can defeat a 90° quench pipe discharge with 45° chamfered end. (Image used with permission from RAD-Planning)

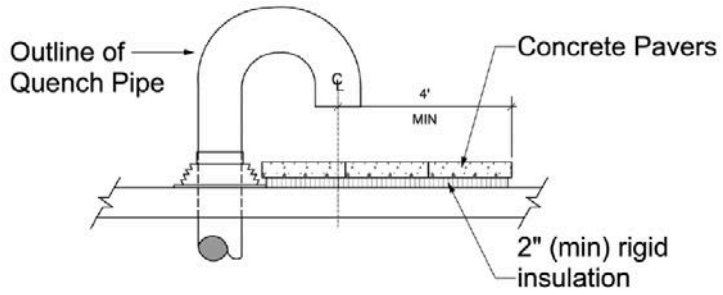


Figure 2.7.3.3-4: Diagrammatic illustration of a sacrificial roof protection assembly. (Image used with permission from RAD-Planning)

Cryogen Safety

Cryogen Safety

Cryogen Safety

Magnet Room Door Swing

- I was one of the loudest voices demanding out-swinging MRI room doors (in the 90's / early 00's)
- This was when most RF doors were 'finger' or 'friction-fit' doors
- Hospital design standards increased requirements for latching doors
- MRI manufacturers began recommending / requiring passive pressure relief systems

Cryogen Safety

Magnet Room Door Swing

Although it can provide a degree of redundancy, it should be noted that, even with an exhaust fan, designing the door to Zone IV to swing outward is not, by itself, an appropriate means of pressure relief. In a severe positive-pressure situation, unlatching an outward-swinging door might permit the door to burst open with tremendous pressure, potentially injuring person(s) opening the door. If employed as the only means of pressure equalization, an outward-swinging door may actually introduce new hazards to any person attempting to open the door to a pressurized magnet room from the outside.

https://www.cfm.va.gov/til/dGuide/dgImaging.pdf

Cryogen Safety

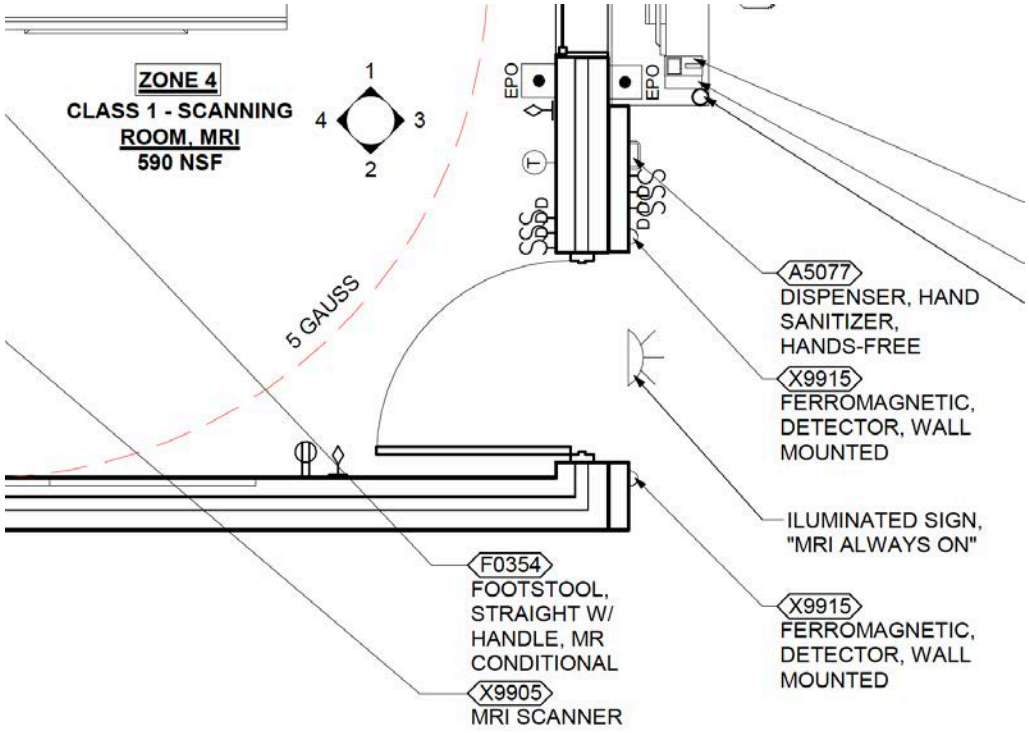
Magnet Room Door Swing

Once provided with appropriate pressure equalization and emergency exhaust, magnet room door-swing direction and design should be left to the discretion of a facility and their design professionals.

https://www.cfm.va.gov/til/dGuide/dgImaging.pdf

Cryogen Safety

Magnet Room Door Swing



Cryogen Safety

If Your Magnet Has A Quench Pipe…

… The scanner room should also have

- An Exhaust Fan
- An Overpressure Relief

Novel MRI Systems

Novel MRI Systems

Pediatric Population MRI Safety Benefits

- TEXT
- TEXT

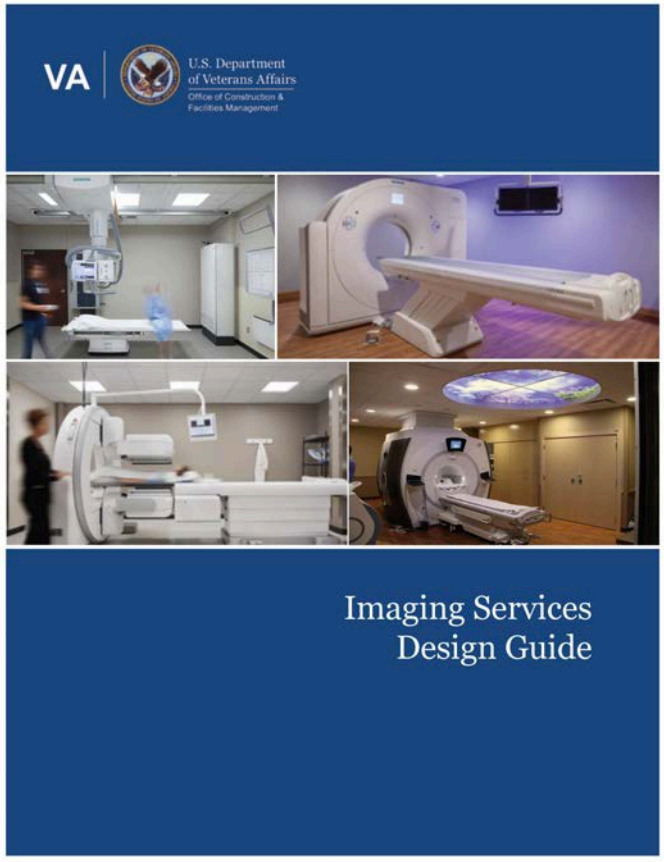
Novel MRI Systems

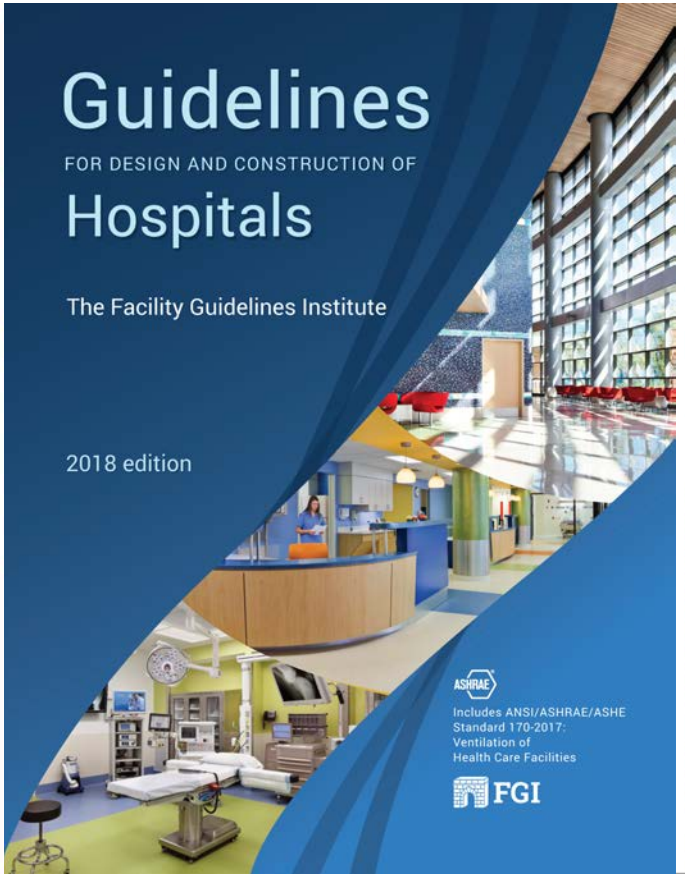
Pediatric Population MRI Safety Benefits

- TEXT
- TEXT

Resources

Resources





MR Imaging Safety
Siting and Zoning Considerations

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KEYWORDS

• MR imaging • Safety • Zones • Standards • Practice • Physical environment • Construction • Renovation

KEY POINTS

- In the past 20 years, MR imaging seems to have steadily produced increasing risk of harm. By contrast, safety initiatives have substantially reduced risk of harm from ionizing radiation usage in diagnostic settings.
- MR imaging safety, as an initiative, has suffered from the absence of formal standards of training or implementation.
- Physical environment MR safety (PEMS) has a significant potentiating capability for clinical and operational safety practices, when effectively integrated. When executed poorly, PEMS initiatives can actively undermine clinical and operational safety practices.
- Although several PEMS initiatives are only practical as a part of a major capital project, many PEMS improvements can be implemented without meaningful interruption to MR imaging patient care services.

INTRODUCTION/BACKGROUND

MR imaging safety, as a discipline, has been poorly formed in practice. With neither radiologists nor MR imaging technologists having formal curriculum in MR imaging safety as a part of their professional education, and with scant licensure or accreditation standard requirements for MR imaging safety that directly combat the sources of MR imaging harm, the structure and practice of MR imaging safety has developed in an alarmingly ad hoc manner, particularly when contrasted with contemporary practices for ionizing radiation safety. In this regard, MR imaging safety has become a victim of its own marketing.

In the past decade, alone, the stochastic risk from diagnostic exposure to ionizing radiation has fallen significantly due to concerted safety efforts on multiple fronts, although very small numbers of deterministic radiation burns continue to occur. It seems that the improvements in radiograph-based imaging technology coupled with practice changes inspired by programs such as "Image Gently" and "Image Wisely" have made marked improvements in the safety of diagnostic modalities that use ionizing radiation.

By contrast, technological improvements in MR imaging over the past 20 years have largely increased risk concerns (eg, more powerful magnetic fields, greater radiofrequency (RF) power, increased slew rates), and there have been no comparable public awareness campaigns for MR imaging to identify or reduce risks or to better report the adverse events that do occur. In this timeframe, MR imaging–classified adverse event report rates to the US Food and Drug Administration (FDA) have accelerated faster than the number of examinations performed.[1] Said plainly, the data suggest that, unlike diagnostic radiography, we are injuring more MR imaging patients today than we were 20 years ago (Fig. 1).

When we adjust our focus from the macro to the individual practitioner, we see enormous variability

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Q&A

Thank You

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