

MRI Safety in Resource-Limited Settings: Relevance and Implementation Challenges of International Safety Standards in Cameroon – A Narrative Review

TAYO NGUETSA Marcellin Girez^{1,2*}, KITIO Dresnel Chiline², NGOKA T. Franck² & MBALLA A. Jean Claude³

^{*1}Department of Radiology and Medical Imaging, Green Hope University of Somalia.

²Centre Médical La Cathédrale, Cameroon.

³Faculty of Science, University of Ebolowa, Cameroon

Corresponding Author: TAYO NGUETSA Marcellin Girez

Department of Radiology and Medical Imaging, Green Hope University of Somalia

Email: tmg1989@gmail.com

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Abstract: Background: Magnetic resonance imaging (MRI) is a critical diagnostic modality, yet its availability in Sub-Saharan Africa remains disproportionately low. As countries like Cameroon gradually expand their diagnostic infrastructure often relying on refurbished equipment the implementation of stringent international MRI safety standards becomes increasingly complex.

Objective: This narrative review evaluates the relevance of international MRI safety guidelines (e.g., ACR, IEC, ICNIRP) to the Cameroonian healthcare context, identifies specific implementation barriers, and proposes context-adapted strategies for resource-limited settings.

Methods: Following the Scale for the Assessment of Narrative Review Articles (SANRA) criteria, a comprehensive literature search was conducted across PubMed/PMC, Scopus, and the grey literature of major regulatory bodies (WHO, ICNIRP, IEC, ACR) for publications predominantly between 2015 and 2025. The synthesis focused on safety standards, the health-system context in Cameroon, and the emergence of low-field MRI technologies.

Findings: International standards are biophysically universally applicable but architecturally and economically misaligned with Cameroonian realities. Major implementation challenges include severe shortages of certified Medical Resonance Safety Officers (MRSOs) and medical physicists, inadequate facility space for strict four-zone layouts, reliance on refurbished scanners with outdated safety software, and unreliable power and helium supply chains. Local studies indicate significant gaps in general imaging referral guidelines among clinicians, translating to heightened risks in MRI environments.

Conclusions: Direct transcription of high-income country MRI safety protocols to Cameroon is impractical. A staged, risk-based implementation strategy, integration of safety training into local medical physics curricula, and the adoption of ultra-low-field portable MRI systems offer viable pathways to improve diagnostic equity without compromising patient safety.

Keywords: Magnetic resonance imaging; Patient safety; Sub-Saharan Africa; Cameroon; Health policy; Low-field MRI.

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Introduction

Magnetic resonance imaging (MRI) is an important medical imaging technique that provides detailed images of soft tissues and helps doctors diagnose many diseases without exposing patients to ionizing radiation. Over the past four decades, MRI has become widely used in the diagnosis and management of neurological disorders, musculoskeletal conditions, and cancer. However, access to MRI technology is not the same across the world. High-income countries have many MRI relative to their populations, while Sub-Saharan Africa faces a serious shortage, with fewer than one scanner per million people on average (Anazodo et al., 2022, 2023).

MRI safety is essential because the equipment produces strong magnetic fields and uses different types of energy to create

images (Sammet, 2016; Tsai et al., 2015). The main magnetic field can attract ferromagnetic objects, turning them into dangerous projectiles. Rapidly changing gradient magnetic fields may stimulate peripheral nerves, while the noise produced during scanning can exceed 100 decibels. Radiofrequency (RF) energy can also heat body tissues and cause burns if proper precautions are not taken (Medicines and Healthcare products Regulatory Agency [MHRA], 2021). These risks show the importance of proper safety procedures, controlled access to scanning areas, patient monitoring, and trained staff. Conventional MRI can also be challenging for critically ill patients because they must be transferred from intensive care units to the scanner. During this transfer, intravenous lines may become displaced, and some patients may experience

dangerous increases in intracranial pressure (Algethamy et al., 2015; Lovell et al., 2001; Turpin et al., 2020).

Cameroon, a lower-middle-income country in Central Africa, faces many of the diagnostic imaging challenges found across Sub-Saharan Africa. The country continues to deal with infectious diseases while also experiencing an increasing burden of non-communicable diseases, including stroke and cancer (Anazodo, Adewole, & Dako, 2022). In response to the growing need for diagnostic services, public and private healthcare facilities have gradually acquired more MRI. However, financial limitations mean that some facilities rely on refurbished or second-hand equipment imported from high-income countries (World Health Organization [WHO], 2019).

Introducing advanced medical equipment into healthcare systems with limited resources can create additional safety challenges. International organisations, including the American College of Radiology (ACR) and the International Electrotechnical Commission (IEC), have developed guidelines and standards to improve MRI safety. The ACR Manual on MR Safety provides recommendations for managing MRI-related risks, screening patients, controlling access to scanning areas, and training staff (American College of Radiology [ACR], 2020). However, implementing these recommendations can be challenging in settings where electricity supply is unreliable, maintenance services are limited, access to liquid helium is difficult, and trained MRI safety personnel are scarce. These challenges are particularly relevant to Cameroon. Previous studies on diagnostic reference levels and imaging referrals in Cameroon have also reported gaps in physicians' knowledge of radiation protection and the appropriate use of diagnostic imaging (Moifo et al., 2014a, 2017a). Although radiation safety has received some regulatory attention, MRI safety remains inadequately addressed in national healthcare policies and regulations.

This narrative review examines MRI safety in Cameroon, focusing on the challenges of implementing international standards in a resource-limited healthcare system. Following the Scale for the Assessment of Narrative Review Articles (SANRA) criteria, the review aims to identify gaps in the existing literature and discuss practical ways to improve MRI safety. Its main objectives are to (1) describe the international MRI safety standards used in clinical practice, (2) assess how these standards can be applied within the Cameroonian healthcare system, (3) identify the infrastructure, training, and organisational challenges that affect their implementation, and (4) recommend evidence-based and locally appropriate strategies to improve MRI safety.

2. Methods

This narrative review was designed and structured in accordance with the SANRA guidelines to ensure methodological rigor, transparency, and a balanced synthesis of the available evidence.

A comprehensive literature search was executed utilizing PubMed and PubMed Central (PMC) as the primary academic

databases. Supplementary searches were conducted across Scopus, Web of Science, and Google Scholar to capture regionally specific journals and engineering publications not indexed in MEDLINE. To capture foundational safety frameworks, a targeted search of grey literature was performed, encompassing publications and technical reports from the WHO, the IEC, the International Commission on Non-Ionizing Radiation Protection (ICNIRP), the ACR, the MHRA, and the US Food and Drug Administration (FDA).

The search strategy utilized a combination of Medical Subject Headings (MeSH) and free-text keywords. Primary search strings included combinations of "Magnetic Resonance Imaging" OR "MRI", "Safety" OR "Standards" OR "Guidelines", "Cameroon" OR "Sub-Saharan Africa" OR "Africa", and "Low-field MRI" OR "Portable MRI" OR "Refurbished Medical Equipment".

Articles published between January 2015 and February 2025 were included to ensure that the review reflects recent technological developments and current international guidelines. Older sources were included only when they provided essential safety standards that remain relevant, such as earlier versions of IEC 60601-2-33. Only articles published in English or French were considered, as these are the official languages of Cameroon and allow the inclusion of medical research from West and Central Africa.

The inclusion criteria covered studies on MRI safety, differences in access to medical imaging worldwide, radiology practices in Sub-Saharan Africa, and the use of imaging technology in resource-limited settings. Studies focusing only on MRI sequence optimisation, diagnostic accuracy without discussing safety, or topics unrelated to the challenges of healthcare in low-resource settings were excluded.

The literature was reviewed in two stages. First, titles and abstracts were screened to identify relevant studies. Next, the full texts of selected articles were assessed for their quality and relevance. The findings were then grouped into four main themes: international MRI safety standards, the healthcare context in Cameroon, challenges to implementing safety measures, and emerging technological solutions. Where studies reported different findings, particularly regarding the cost of safety measures and the diagnostic and safety benefits of low-field MRI systems, the evidence was critically examined to provide a balanced discussion.

3. Overview of International MRI Safety Standards and Guidelines

MRI safety depends on specific safety limits and procedures that protect patients, staff, and the public from the strong electromagnetic fields produced by MRI scanners. These safety guidelines are regularly updated by international technical organisations and professional radiology societies as summarised in Table 1

Table 1: Key international MRI safety standards/guidelines

Issuing Body	Scope & Standard	Main Requirements	Relevance/Applicability in Low-Resource Settings
IEC	IEC 60601-2-33 (Hardware/Biophysics)	Mandates SAR limits, acoustic noise thresholds, and dB/dt controls via 3 operating modes (Normal, 1st Level, 2nd Level).	High relevance. Biophysical limits are absolute. However, older refurbished machines may have uncalibrated or obsolete software requiring manual dosimetry estimation.
ACR	Manual on MR Safety (Architecture/Roles)	Prescribes a 4-zone architectural layout, strict entry controls, and formalized MRMD/MRSD/MRSE hierarchical roles.	Low immediate applicability. Retrofitting existing constrained spaces into 4 zones is rarely feasible. Extreme shortage of medical physicists makes the MRSE role difficult to fill.
ICNIRP	Occupational Exposure Guidelines	Limits occupational static magnetic field exposure to 8 T and advises on movement-induced sensory effects.	Moderate applicability. Protects staff, but requires education on movement near the bore, which is currently lacking in basic radiography training in the region.
ASTM	F2503 Implant Labeling	Classifies devices as MR Safe, MR Conditional, or MR Unsafe, requiring strict verification before scanning.	Severe implementation challenge. Patients frequently lack surgical records for implants, making condition verification nearly impossible without robust national health databases.
ESUR	Contrast Media Guidelines	Details GBCA safety, removes fasting requirements, and outlines renal function testing protocols.	High relevance and highly actionable. Implementing point-of-care creatinine testing can prevent workflow bottlenecks and enhance safety for vulnerable patients.

Static Magnetic Field (B0) and Projectile Risks

The static magnetic field in modern MRI scanners usually ranges from 1.5 to 3.0 Tesla (T) and remains active even when images are not being taken. It can pull ferromagnetic objects into the scanner, causing serious or fatal injuries (Delfino et al., 2019; Kihlberg et al., 2022). It can also exert force on implanted medical devices, potentially dislodging aneurysm clips or damaging pacemaker leads.

The International Commission on Non-Ionizing Radiation Protection (ICNIRP) recommends a maximum occupational exposure of 8 T under controlled working conditions (Ziegelberger et al., 2009). Although long-term harm remains unproven, moving through strong magnetic field gradients can cause vertigo, nausea, and a metallic taste (MHRA, 2021). As 7 T scanners become more common in research centres, these risks require careful monitoring (Fagan et al., 2021).

Radiofrequency (RF) Fields and Tissue Heating

MRI scanners use radiofrequency (RF) pulses to excite protons in the body. Some of this energy is absorbed by tissues and converted into heat. This is measured as the Specific Absorption Rate (SAR), expressed in watts per kilogram (W/kg). Excessive RF heating can raise body temperature and cause burns (Dempsey et al., 2001). Burns can also occur when metallic fibres in sports clothing form conductive loops (Tokue et al., 2019) or when RF energy interacts with abandoned surgical implant leads (Yao et al., 2021).

The IEC 60601-2-33 standard sets SAR limits and defines three operating modes based on the risk of physiological stress

(IEC, 2010, 2022). Normal Operating Mode limits whole-body SAR to 2.0 W/kg and head SAR to 3.2 W/kg, limiting the rise in core body temperature to 0.5 °C. First Level Controlled Operating Mode allows whole-body SAR up to 4.0 W/kg and requires medical supervision because of the increased risk of physiological stress. Second Level Controlled Operating Mode allows higher exposure levels and is generally reserved for research under appropriate ethical approval (IEC, 2022).

Time-Varying Gradient Fields (dB/dt) and Acoustic Noise

MRI uses gradient coils that rapidly change magnetic fields to create images. These changes can induce electrical currents in body tissues, potentially causing peripheral nerve stimulation (PNS), which may lead to involuntary muscle twitching or pain. The IEC 60601-2-33 standard sets limits on gradient switching to reduce PNS and prevent cardiac stimulation (IEC, 2022).

Rapid gradient switching also produces loud noise as the coils vibrate. Noise levels can exceed 99 dBA and reach 120 dBA in high-field scanners. Patients must use earplugs or specialised headphones during MRI to reduce the risk of temporary or permanent hearing damage (MHRA, 2021).

Implants, Devices, and Contrast Agents

The American Society for Testing and Materials (ASTM) developed the F2503 standard, which classifies medical devices into three categories: *MR Safe*, for items that pose no known hazards in the MRI environment; *MR Unsafe*, for items that may pose risks; and *MR Conditional*, for items that are safe only under specific conditions, such as magnetic field strength and RF exposure (ASTM International, 2020). Before an MRI scan,

patients must be screened carefully, and their medical records checked to confirm whether any implanted device can be scanned safely.

MRI contrast agents, mainly gadolinium-based contrast agents (GBCAs), also require careful consideration. The European Society of Urogenital Radiology (ESUR) provides guidelines for their safe use. Modern macrocyclic GBCAs have a lower risk of nephrogenic systemic fibrosis (NSF) than older linear agents. However, kidney function still needs to be assessed in patients with severe kidney disease (ESUR, 2018). Updated ESUR guidance no longer recommends routine fasting before contrast administration because fasting does not reduce the risk of vomiting and may cause unnecessary discomfort (Barbosa et al., 2018; Hamid et al., 2014; Kim et al., 2018; Li et al., 2018). Concerns about gadolinium accumulation in the brain and bones have also led to recommendations to use these agents carefully, particularly in children, and to consider imaging techniques that do not require gadolinium when appropriate (Wamelink et al., 2024).

Architectural Zoning and Personnel Roles

The ACR Manual on MR Safety establishes the gold standard for facility architecture and personnel hierarchy (ACR,

2020; ACR, 2024). It mandates a strict four-zone layout as shown in Figure 1.

- **Zone I:** General public access (e.g., standard hospital waiting rooms).
- **Zone II:** Interface area for patient screening and changing, supervised by MR personnel.
- **Zone III:** Strictly controlled access area containing the control room. Access is restricted to authorised personnel and appropriately screened patients under staff supervision.
- **Zone IV:** The scanner room itself, characterized by the highest risk and the presence of the active magnetic field. Only authorised and appropriately screened individuals may enter, and patients must be monitored during examinations. Ferromagnetic objects, such as ordinary oxygen cylinders, scissors, and other unsuitable equipment, can be pulled into the scanner and cause serious injury.

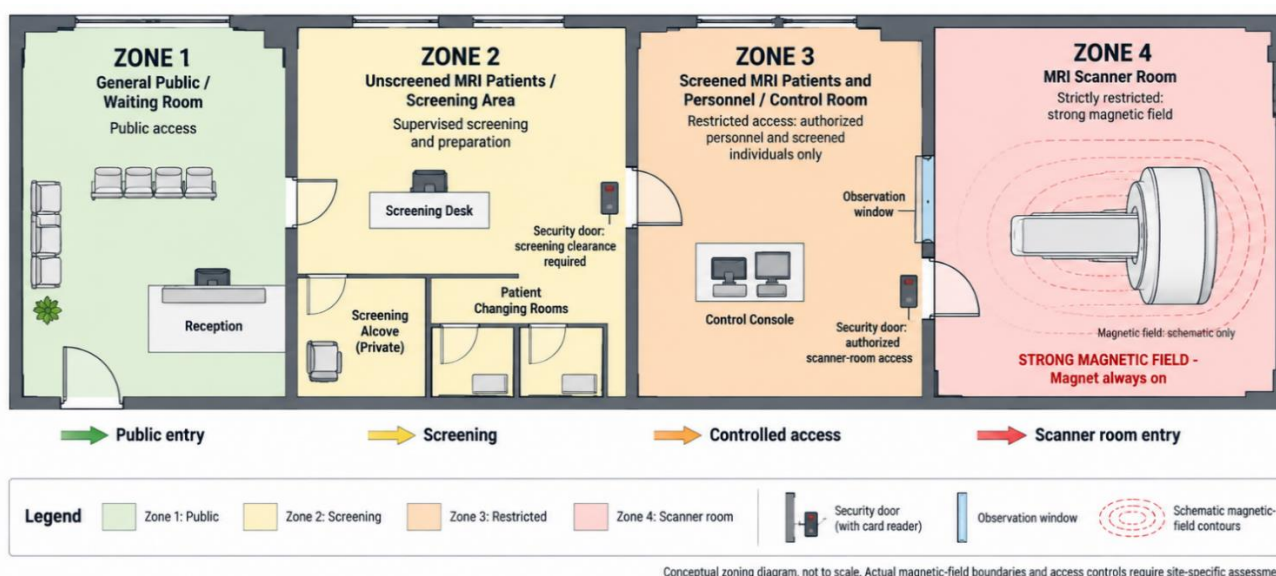


Figure 1: The ACR 4-Zone MRI safety architecture highlighting the progressive restriction of physical access, progressing from the general public (Zone I) to the MR scanner room containing the active magnetic field (Zone IV).

The ACR defines three key roles for managing MRI safety. The MR Medical Director (MRMD) oversees the facility's clinical safety and medical policies. The MR Safety Officer (MRSO), usually a senior radiographer or technologist, manages daily safety procedures and ensures that safety policies are followed. The MR Safety Expert (MRSE), often an MRI physicist, provides technical guidance on complex safety issues, such as scanning patients with implants under special conditions and reducing imaging artefacts (Calamante et al., 2016).

Cryogen and Quench Safety

Superconducting MRI magnets need liquid helium to remain at very low temperatures. If the magnet fails or a patient is trapped in a life-threatening situation, a process called a quench can be used to rapidly reduce the magnetic field. During this process, liquid helium turns into a large volume of gas, which must

be safely released outside the building through specially designed quench pipes. If these pipes fail, helium gas may enter the scanner room, causing suffocation, cold injuries, and dangerous pressure buildup (MHRA, 2021).

MRI Services and Health-System Context in Cameroon

Cameroon's healthcare system is highly centralized, with most advanced medical services concentrated in the major cities of Douala and Yaoundé. The introduction of MRI has been limited by high costs, poor infrastructure, and a shortage of trained professionals.

Sub-Saharan Africa has far fewer than one MRI per million people, and Cameroon faces similar challenges (Anazodo et al., 2022). Most MRI in Cameroon operate at 1.5 T, while some private clinics use older, low-field scanners (0.2–0.5 T) because they are less expensive to purchase and maintain. MRI services are

mainly available in private diagnostic centres and a few hospitals. As a result, people living in rural areas often travel long distances and face high costs to access advanced imaging, which may delay diagnosis until the disease has progressed.

The workforce responsible for MRI services also faces major challenges. Cameroon has a shortage of radiologists, specialist radiographers, and clinical medical physicists. The Federation of African Medical Physics Organizations (FAMPO) has highlighted the shortage of qualified medical physicists across Africa (Trauernicht et al., 2022). Although some African countries offer postgraduate training and clinical placements in medical physics, formal training and accreditation pathways remain limited in many others. This leaves imaging facilities without sufficient expertise to optimize scanning protocols and manage complex safety issues. The International Atomic Energy Agency (IAEA) also emphasizes the importance of education in medical imaging and radiation physics, particularly in low-income settings (Prajogi et al., 2021; Salminen, Izewska, & Andreo, 2005).

In Cameroon, the Radiation Safety and Nuclear Security Authority (ASRAN), formerly known as the National Radiation Protection Agency (ANRP) is responsible for protecting people and the environment from the harmful effects of ionizing radiation, including through equipment quality control and regulatory inspections (Ministry of Scientific Research and Innovation [MINRESI], n.d.). Cameroon's Law No. 2019/012 also establishes a general framework for radiological and nuclear safety, with provisions covering activities involving radioactive materials and devices that emit ionizing radiation (Republic of Cameroon, 2019). Since MRI does not use ionizing radiation, these sources do not establish how MRI-specific safety requirements, such as safety zoning, specific absorption rate (SAR) monitoring, and MR Safety Officer (MRSO) training, are regulated nationally. Further review of the relevant regulations is therefore needed before drawing conclusions about gaps in MRI safety oversight.

Although previous studies in Cameroon have focused on X-rays and CT scans, they provide useful insight into broader imaging safety practices. Surveys have found that physicians' knowledge of radiation protection and imaging referral guidelines is low and limited (Moifo et al., 2017a). Other studies have reported unjustified CT requests, poor understanding of diagnostic reference levels (DRLs), and inadequate clinical justification on imaging request forms (Moifo et al., 2017b; Moifo et al., 2014a, 2014b). Although these findings relate to ionizing radiation, they also highlight gaps in imaging safety education that may affect MRI practice. Limited awareness of imaging guidelines among referring physicians may lead to inadequate screening for MRI contraindications, placing additional responsibility on already overburdened radiographers.

Relevance of International Standards to Cameroon

The physical principles underlying MRI safety remain the same regardless of where the scanner is used. An unverified pacemaker exposed to an MRI scanner's magnetic field may experience movement, malfunction, or heating, depending on the device and scanning conditions (International Electrotechnical Commission [IEC], 2022; Pedrosa et al., 2025). Therefore, international safety standards developed by the IEC and recommendations from the International Commission on Non-Ionizing Radiation Protection (ICNIRP), including guidance on radiofrequency heating, gradient-related nerve stimulation, and occupational exposure to static magnetic fields, remain important for protecting patients and staff (IEC, 2022; International Commission on Non-Ionizing Radiation Protection [ICNIRP], 2009, 2009a). However, the practical application of safety frameworks, such as the American College of Radiology (ACR) four-zone model and the roles of the MR Medical Director (MRMD), MR Safety Officer (MRSO), and MR Safety Expert (MRSE), needs to be considered in the context of Cameroon's healthcare system. The ACR provides recommendations on MRI facility design, controlled access, staff training, and safety responsibilities (Pedrosa et al., 2025). Applying these recommendations may be challenging in settings where infrastructure, funding, and specialist personnel are limited.

For resource-limited public hospitals in Cameroon, renovating existing departments to meet every architectural recommendation of the ACR four-zone model may be difficult because of financial and space constraints. Similarly, access to an MR Safety Expert, often a medical physicist, may be limited where there are few trained specialists and competing clinical demands. Research on medical imaging in sub-Saharan Africa has highlighted broader shortages in imaging resources and specialist capacity (Anazodo et al., 2022).

Therefore, international MRI safety standards remain relevant, but implementing them may require approaches that reflect local resources and infrastructure. The ACR itself describes its manual as a source of recommendations rather than inflexible rules for every practice setting (Pedrosa et al., 2025). Efforts should focus on maintaining essential safety measures while developing practical, locally appropriate ways to apply international guidance.

Implementation Challenges

Providing safe MRI services in Cameroon is challenging due to infrastructure, training, financial, and logistical barriers. Table 2 summarizes these challenges, while a closer analysis highlights the underlying problems.

Table 2: Implementation challenges in Cameroon mapped to evidence-based, context-appropriate solutions

Challenge	Evidence / Source	Proposed Solution	Responsible Stakeholder
Inadequate space for strict ACR 4-Zone architectural layouts	ACR Guidelines	Implement visual floor markings and physical stanchions as "soft zones." Prioritize the acquisition of permanent-magnet ULF-MRI systems that do not require complex zoning.	Hospital Administration; Radiology Department Heads

Frequent power grid failures risking equipment damage	LMIC context reviews	Mandate robust Uninterruptible Power Supplies (UPS) dedicated solely to the MRI cooling and gradient systems.	Ministry of Public Health; Facility Management
High cost and shortage of liquid helium for cooling/quench recovery	Global helium shortage analyses	Transition procurement strategies toward sealed-system "helium-free" MRI technology or permanent magnet low-field scanners.	National Procurement Agencies; Imaging Investors
Lack of trained MR Safety Officers (MRSOs) and Experts (MRSEs)	FAMPO workforce data, Moifo et al.	Integrate localized MR safety modules into national radiographer curricula. Establish a national tele-consultation network for complex implant queries.	Medical Societies (FAMPO); Academic Institutions
Patient screening failures due to language/literacy barriers	Health literacy barriers in neuroimaging	Develop pictorial, multi-lingual audio-visual screening tools. Conduct mandatory verbal interviews by trained radiographers rather than relying on written forms.	Clinical Radiographers; Radiology Nursing Staff
Unknown safety status of implants due to missing medical records	ASTM F2503, Refurbished tech risks	Implement a "when in doubt, keep them out" policy. Utilize point-of-care ultrasound or localized X-ray to attempt basic identification of metallic implants before MRI.	Referring Physicians; MR Radiographers

Infrastructure, Power, and Cooling

MRI, especially high-field systems, need a stable power supply and reliable cooling. However, many cities in Sub-Saharan Africa experience frequent power cuts and voltage fluctuations. Without proper backup systems, these interruptions can damage important scanner components (Anazodo et al., 2022).

MRI with 1.5 T magnets require liquid helium to maintain their superconducting state. Global helium shortages can increase costs and make supplies difficult to obtain, particularly in resource-limited settings. If a magnet loses its superconducting state during an emergency, replacing the lost helium can place a heavy financial burden on a hospital. These costs may create concerns about initiating an emergency quench, even when patient safety is at risk. Furthermore, an improperly designed or installed quench pipe can allow helium gas to enter the scanning room, creating risks of asphyxiation and cold-related injuries (MHRA, 2021; ACR, 2020)

Equipment Donation and Refurbished Scanners

A large proportion of MRI scanners in lower-middle-income countries are refurbished or donated (Shukla et al., 2023). Although this helps improve access to MRI services, it can also create safety concerns. Some refurbished scanners may have incomplete maintenance records, missing manufacturer manuals, or outdated software that limits safety monitoring.

Safety accessories, such as MRI-compatible monitoring cables, insulating pads, and non-magnetic fire extinguishers, may also be missing. Without appropriate precautions, the risk of patient burns and other MRI-related injuries may increase. In addition, service providers maintaining these scanners may lack access to specialised manufacturer tools for calibration, potentially affecting scanner performance and compliance with established MRI safety requirements (IEC, 2022).

Training, Credentialing, and the Safety Hierarchy

A lack of formal training and certification in MRI safety is an important challenge. Without a clear certification pathway, hospitals may lack designated Magnetic Resonance Safety Officers

(MRSOs) or Magnetic Resonance Safety Experts (MRSEs). Radiographers may have general radiography training but limited specialised knowledge of MRI safety, including the effects of radiofrequency (RF) energy and magnetic-field gradients.

This problem may be compounded by gaps in referring physicians’ knowledge of imaging guidelines. A study in Cameroon reported gaps in clinicians’ knowledge of medical imaging prescriptions and referral guidelines (Moifo et al., 2017a). If information about a pacemaker or other potentially unsafe implant is missing from a referral, the radiographer must identify the risk before scanning. Patients with pacemakers that are not approved for MRI require careful assessment and appropriate safety procedures before an examination can proceed (ACR, 2024). These challenges highlight the need for better communication between referring physicians and radiographers, along with specialised MRI safety training and clear screening procedures.

Screening Practices: Language, Literacy, and Documentation

International guidelines recommend careful patient screening before MRI to identify potential risks, including implants and metallic foreign bodies. In Cameroon, language differences and limited health literacy may make this process more difficult. Although French and English are the official languages, many local languages are spoken across the country. Patients may struggle to understand medical terms such as “aneurysm clip,” “shrapnel,” or “implanted neurostimulator” on screening forms. Using simple language and conducting verbal screening in a language the patient understands can help reduce misunderstandings and improve MRI safety (Al-Naser and Tafti, 2026).

Incomplete medical records can create further challenges. For example, a patient who underwent surgery many years ago may know that they have a metal pin in their leg but may not have the records needed to identify the implant and confirm its MRI safety conditions. The ACR recommends identifying implants and checking the manufacturer’s safety conditions before scanning. When an implant cannot be identified, the decision to proceed requires an appropriate risk assessment rather than assuming that the implant is safe (ACR, 2024). These challenges highlight the

importance of clear communication, reliable screening procedures, and appropriate implant assessment, particularly when patients have travelled long distances or spent significant amounts of money to access MRI services.

Contrast Media Safety and Renal Function Assessment

Safe use of gadolinium-based contrast agents (GBCAs) requires assessing kidney function using estimated glomerular filtration rate (eGFR) to reduce the risk of nephrogenic systemic fibrosis (NSF) (ESUR, 2018). In Cameroon, delays in obtaining laboratory results may cause patients to miss MRI appointments. Limited access to rapid point-of-care testing can also make it difficult to complete safety checks on time.

ESUR guidelines recommend assessing kidney function before administering gadolinium-based contrast agents to reduce the risk of nephrogenic systemic fibrosis (NSF) (ESUR, 2018). In Cameroon, delays in laboratory testing may cause missed MRI appointments, while limited access to rapid testing can make these safety checks difficult to complete on time.

Strategies, Recommendations and Policy Options

Addressing these challenges requires a flexible approach to MRI safety rather than a simple pass-or-fail system. Cameroon needs practical, step-by-step safety measures that suit local resources while maintaining essential safety standards.

Promoting Ultra-Low-Field and Portable MRI

One promising approach is the use of ultra-low-field (ULF) and portable MRI (pMRI) systems. These scanners operate at low magnetic field strengths, such as 0.064 T, and can use permanent magnets instead of superconducting magnets. This reduces the need for liquid helium and complex cooling systems, making them more suitable for settings with limited infrastructure (Prabhat et al., 2021; Sheth et al., 2020).

Portable MRI systems may be easier to install in emergency departments, intensive care units, and rural clinics because they generally require less specialised infrastructure than conventional high-field scanners (Mazurek et al., 2021). Exploring local assembly and maintenance could further improve access to neuroimaging in Cameroon (Obungoloch et al., 2023). However, low-field MRI does not eliminate the need for safety screening, and unidentified implants must still be assessed before scanning.

Although ULF MRI provides lower image resolution than conventional 1.5 T systems, studies suggest that it may help identify important conditions, including intracerebral haemorrhage, hydrocephalus, and midline shift, particularly when rapid imaging is needed (Sheth et al., 2022).

Enhancing Education and Regional Collaboration

MRI safety training should be adapted to local needs rather than relying only on international guidelines. African organisations such as the Consortium for Advancement of MRI Education and Research in Africa (CAMERA) and FAMPO could help develop training programmes that address the challenges faced by healthcare professionals in the region (Anazodo et al., 2022).

In Cameroon, the Ministry of Public Health could include MRI safety training in national radiographer education programmes. A central support network, with a qualified MRI Safety Expert (MRSE) based in Yaoundé or Douala, could provide remote advice to radiographers in rural hospitals about complex cases, such as patients with implants. Artificial intelligence (AI) could also help prioritise abnormal scans and improve workflow where trained staff are limited (Anazodo, Adewole, & Dako, 2022).

Adapting Screening and Procurement Practices

To address language and literacy barriers, MRI screening should include visual aids and culturally appropriate materials rather than relying solely on written forms. Digital tools with audio translations in widely spoken local languages, such as Fulfulde, Ewondo, and Duala, could help patients understand screening questions. Point-of-care creatinine testing could also provide faster kidney function results, reducing delays and supporting safer contrast administration in accordance with ESUR guidelines (Corbett et al., 2020). A complete context-adapted workflow integrating these strategies is illustrated in Figure 2.

At the policy level, Cameroon should strengthen regulations for importing refurbished medical equipment. Following relevant WHO guidance, all imported MRI scanners should undergo independent quality assurance testing before clinical use to verify their safety and performance (Shukla et al., 2023). Importers should also be required to provide original manufacturer safety manuals, maintenance records, and initial staff training to support safe operation.

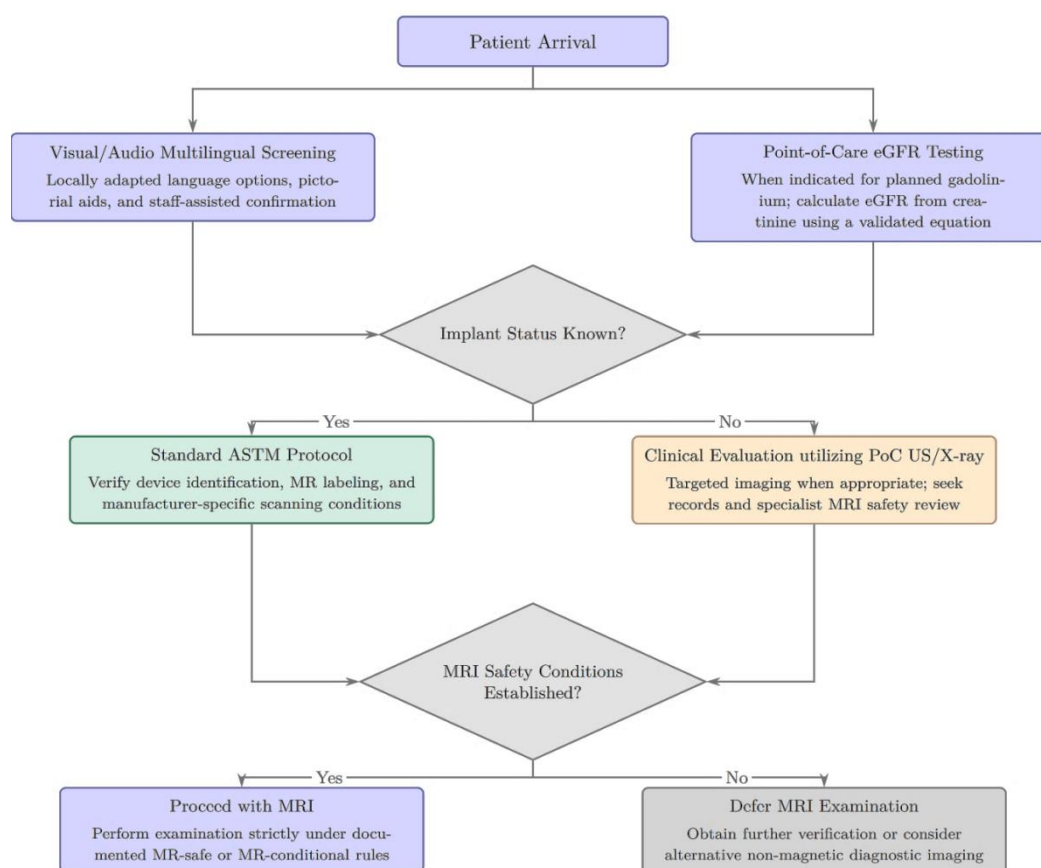


Figure 2: Proposed context-adapted MRI safety screening workflow for resource-limited settings. The pathway integrates multilingual audio-visual aids for low-literacy populations, point-of-care renal testing to prevent workflow bottlenecks, and a risk-stratified approach for managing patients with unverified implants.

Limitations of this review

This narrative review is subject to several limitations. First, there is limited published evidence specifically documenting MRI safety incidents, near-misses, and facility-level compliance with safety standards in Cameroon. Therefore, some aspects of the discussion draw on studies of general radiography and computed tomography safety in the region, as well as broader evidence from Sub-Saharan Africa. These findings provide useful context but may not fully reflect the specific challenges of MRI safety in Cameroon. Second, although the literature search was structured using the SANRA guidelines, the narrative review approach may be subject to selection bias and does not provide the same level of reproducibility as a systematic review. Finally, low-field and portable MRI technologies are evolving rapidly. New evidence may change current understanding of their clinical applications, safety requirements, and suitability for resource-limited settings, potentially influencing the recommendations presented in this review.

Conclusion

The global expansion of MRI technology offers opportunities to improve access to diagnostic imaging, but patient safety must remain a priority. Although international standards, such as IEC 60601-2-33, establish important safety requirements, their implementation must consider the healthcare infrastructure, resources, and workforce available in Cameroon. International guidance, including ACR recommendations, should therefore be

applied in ways that address local constraints without compromising essential safety principles.

The findings of this review highlight several challenges that may affect MRI safety in Cameroon, including limited data on safety incidents, concerns about refurbished equipment, language barriers during patient screening, and gaps in specialised safety training. Addressing these challenges requires a context-specific approach that combines regional MRI safety education, stronger regulation and quality assurance for imported scanners, and improved screening and communication procedures. Low-field and portable MRI systems may also offer opportunities to expand access where conventional MRI infrastructure is difficult to maintain, although their clinical capabilities and safety requirements must be carefully considered.

Ultimately, improving MRI safety in Cameroon requires balancing international safety standards with practical local needs. Strengthening regulatory oversight, developing appropriate training pathways, and evaluating technologies suited to resource-limited settings can support safer and more equitable access to MRI services while maintaining patient protection as a fundamental priority.

Declarations

Ethics approval and consent to participate: Not applicable (narrative review of published literature).

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Consent for publication: Not applicable.

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