Vol. 1(1), November 2024, pp. 41-44 Radiance NEWSLETTER

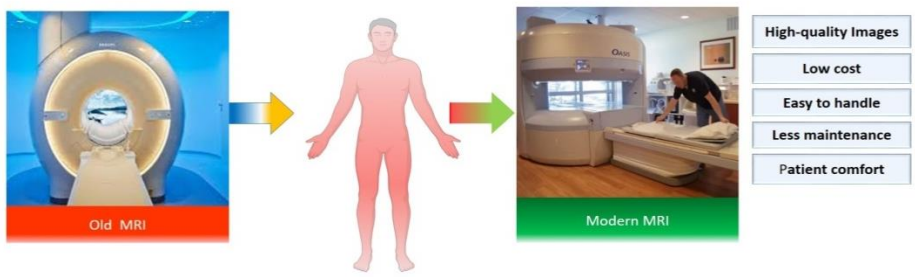
# Scientific and Economic Impact of MRI Technology in Modern Healthcare: Advantages and Implications

Dinoop K, Chief Minister's Nava Kerala Postdoctoral Fellow, Inter University Centre for Social Science Research and Extension, Mahatma Gandhi University, Kottayam, Kerala, India 686 560 , dinoop@mgu.ac.in, http://orcid.org/0000-0002-5083-4754

Athulya M, School of Chemical Sciences, Mahatma Gandhi University, Kottayam, Kerala, India- 686 560.
athulyajyothishkumar@gmail.com

Jibin K P, Senior Researcher, School of Chemical Sciences, Mahatma Gandhi University, Kottayam, Kerala, India- 686 560 jibin@mgu.ac.in , https://orcid.org/0000-0002-4274-605X

## Graphical Abstract




## Introduction

Advancement of new Magnetic Resonance Imaging (MRI) technologies has significantly increases the precision in medical technology (1). However, integrating these innovations into global healthcare systems presents notable economic challenges. The MRI market, projected to grow from USD 7.08 billion in 2024 to USD 12.51 billion by 2033, with a Compound Annual Growth Rate (CAGR) of 6.53%, this segment underscores the increasing preference for patient-friendly imaging solutions. Leading companies like Siemens Healthineers, GE Healthcare and Philips dominate this arena, collectively holding over 70% of the market share. Their leadership is bolstered by pioneering high-field MRI systems and advanced imaging software, setting benchmarks in diagnostic capabilities. Annual increases of 10% to 15% in new product launches highlight on-going R&D efforts, fueling innovations such as faster imaging sequences and enhanced spatial resolution, crucial for functional and molecular imaging applications (2).

The competitive landscape of the MRI market is characterized by relentless technological advancements and strategic initiatives among key players. Siemens Healthineers, GE Healthcare and Philips continue to drive innovation, leveraging their extensive R&D

investments to maintain leadership and meet evolving healthcare demands. These advancements not only elevate diagnostic precision but also foster competitive differentiation, compelling firms to continually enhance product portfolios and geographic presence through mergers and partnerships (1, 3).

**Modernization in Medical Imaging**

New MRI technologies encompass innovations such as higher magnetic field strengths, faster imaging sequences, improved spatial resolution and enhanced functional imaging capabilities. These advancements promise better diagnostic accuracy, reduced scan times and expanded applications in areas like neuroimaging, oncology and cardiovascular medicine (3). The economic implications of adopting new MRI technologies, however, span beyond the initial costs of acquisition.

**Types of MRI and its importance**

MRI equipment are of various types, some of the types commonly used are.

1. C**losed MRI;** the traditional MRI machine where the patient is placed inside a large tube-like structure surrounded by a strong magnet. It provides high-quality images.
2. **Open MRI; d**esigned to be more spacious and open on the sides, suitable for patients who are claustrophobic or larger individuals.
3. **High-field MRI;** machines have a stronger magnetic field and produce the highest quality images commonly used for the imaging of brain, spine, joints and soft tissues..
4. **Low-field MRI;** machines have a weaker magnetic field which is used in certain situations where high-field MRI is not suitable.
5. **Wide-bore MRI;** machines have a wider opening (bore) which can help accommodate larger patients and reduce feelings of claustrophobia.
6. **Extremity MRI;** smaller MRI machines designed specifically for imaging parts of the body such as the hand, wrist, foot or knee.
7. **Functional MRI (fMRI);** used to measure brain activity by detecting changes associated with blood flow. It is used primarily for research and specialized clinical applications (3).

**Advancement in MRI**

1. **3 Tesla (3T) MRI: A** high-field MRI scanner with a magnetic field strength of 3 Tesla, offering improved spatial resolution and signal-to-noise ratio. In this equipment magnetic field strength is double the strength of the traditional 1.5 Tesla MRI scanners. Advantages of 3T MRI are i**mproved image quality**, e**nhanced spatial resolution, shorter scan times. It is u**seful for functional fMRI studies, c**linical applications** and p**atient comfort (4).**
2. **Open-Bore MRI**: Combining the spaciousness with the high-quality imaging capabilities of closed-bore systems, open-bore MRI machines feature a wider and shorter bore, which can enhance the patient comfort at the same time providing excellent image quality. Advantages of Open-Bore MRI are s**pacious design, improved patient experience, accessibility, high-quality Images, versatility** and **pediatric and geriatric imaging.**

3. **Silent MRI**: Designed to reduce the noise levels typically associated with MRI scans, silent MRI technology utilizes advanced acoustic engineering and modified sequences to make the scanning experience quieter for patients. This can improve patient comfort and reduce the need for sedation, especially in pediatric and anxious patients. Benefits of Silent MRI are n**oise reduction, acoustic engineering, patient experience, clinical applications, quality imaging, and increased accessibility.**
4. **Portable MRI**: These compact MRI systems are designed for mobility and can be transported to different locations within a hospital or even to remote settings such as field hospitals or rural clinics. Benefits of portable MRI are m**obility and flexibility, point-of-care imaging, accessibility, patient comfort and safety, quality imaging, emergency and disaster response, research and exploration and veterinary medicine.**
5. **Cardiac MRI**: Useful for more precise imaging of the heart and its blood vessels, allowing detailed assessment of heart function, perfusion and viability. Advantages of cardiac MRI are d**etailed visualization, functional assessment, tissue characterization, perfusion Imaging and non-invasiveness.**
6. **Ultra-High Field MRI (7T and Beyond)**: These MRI scanners have even stronger magnetic fields (7 Tesla and higher), offering unprecedented resolution for imaging small anatomical structures and enhancing the capabilities of research and clinical studies in neuroscience, oncology and musculoskeletal imaging. Advantages of Ultra-High Field MRI are i**mproved spatial resolution**, e**nhanced tissue contrast**, **fMRI capabilities, spectroscopy and metabolite imaging, quantitative imaging of biomarkers, n**euroimaging and musculoskeletal imaging.
7. **Interoperative MRI (iMRI)**: Integrated within surgical suites, iMRI allows real-time imaging during surgery. It enables surgeons to assess tumor resection margins, guide procedures more accurately and verify outcomes immediately. It potentially improves the surgical outcomes and reduce the need for repeat surgeries. Advantages of intraoperative MRI are **Real-Time imaging, enhanced surgical precision, intraoperative planning and guidance, minimization of reoperations, integration with navigation systems and neurosurgical applications (5).**

**Economic Considerations**

The acquisition and implementation of new MRI technologies pose substantial economic challenges to healthcare providers. State-of-the-art MRI systems, equipped with advanced functionalities, come with a significant price tag, representing a considerable upfront investment (3). Beyond purchase costs, installing these sophisticated systems requires specialized infrastructure and trained personnel, further escalating initial capital expenditures. These financial burdens create barriers for many healthcare facilities looking to enhance diagnostic capabilities, complicating the efforts to upgrade or expand their imaging capabilities (6).

Operational costs for new MRI technologies extend well beyond the acquisition costs, constituting an ongoing financial commitment. Regular maintenance is costly due to the intricate nature of system components, while keeping up with technological advancements

necessitates frequent software and hardware upgrades. Continuous training of staff is essential to ensure proficiency in using the latest MRI features, adding another layer of expense. Collectively, these operational costs underscore the need for meticulous financial planning and resource allocation to sustain advanced MRI technology in healthcare settings.

Market dynamics are further shaped by fierce competition among manufacturers driving innovation in MRI technology. While this competition fosters advancements that enhance diagnostic capabilities, it also influences pricing strategies, posing challenges for healthcare providers evaluating new investments. Regulatory considerations, including approval processes and compliance with safety standards add additional layers of complexity to the adoption of advanced MRI technologies (6, 7).

In sum up, the economic implications of advancing medical imaging, particularly with the introduction of New MRI technologies, highlight both opportunities and challenges for healthcare systems worldwide. These technologies promise enhanced diagnostic capabilities and potential cost savings through improved patient management but require significant initial investments, ongoing operational expenses and careful implementation strategies. Achieving a balance between technological advancement, financial sustainability and equitable healthcare delivery is crucial. As healthcare providers and policymakers navigate the complexities of integrating New MRI technologies into clinical practice, continuous research, economic analysis and policy development will be essential. Proactive management of economic challenges and strategic innovation will enable healthcare systems to maximize the benefits of advanced medical imaging, ultimately improving patient care and outcomes on a broader scale.

**References**

1. Sima, D. M.; Esposito, G.; Van Hecke, W.; Ribbens, A.; Nagels, G.; Smeets, D. Health Economic Impact of Software-Assisted Brain MRI on Therapeutic Decision-Making and Outcomes of Relapsing-Remitting Multiple Sclerosis Patients—A Microsimulation Study. *Brain Sci.*2021, *11* (12), 1570.
2. Magnetic Resonance Imaging (MRI) Market Size to Achieve USD 12.51 Bn by 2033; *GlobeNewswire*, September 9, 2024. https://www.globenewswire.com/news-release/2024/09/09/2942995/0/en/Magnetic-Resonance-Imaging-MRI-Market-Size-to-Achieve-USD-12-51-Bn-by-2033.html.
3. World Health Organization. *Medical Devices: Managing the Mismatch: An Outcome of the Priority Medical Devices Project*; World Health Organization: Geneva, 2010.
4. Chen, X.; Qu, L.; Xie, Y. A Paired Dataset of T1- and T2-Weighted MRI at 3 Tesla and 7 Tesla. *Sci. Data*2023, *10*, 489. https://doi.org/10.1038/s41597-023-02400-y.
5. Moser, E. Ultra-High-Field Magnetic Resonance: Why and When? *World J. Radiol.*2010, *2* (1), 37–40. https://doi.org/10.4329/wjr.v2.i1.37. PMID: 21160738; PMCID: PMC2999312.
6. Scotland, G.; Bryan, S. Why Do Health Economists Promote Technology Adoption Rather Than the Search for Efficiency? A Proposal for a Change in Our Approach to Economic Evaluation in Health Care. *Med. Decis. Mak.*2017, *37* (2), 139–147.
7. Glied, S.; Smith, P. C., Eds. *The Oxford Handbook of Health Economics*; Oxford University Press: Oxford, 2013.