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Strategies for Improving Access and Effectiveness of CT and MRI Imaging Modalities in Low-Middle-Income Countries: A Review

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ABSTRACT

Computed Tomography (CT) and Magnetic Resonance Imaging (MRI) have been gaining global attention in diagnosing non-communicable diseases and improving clinical outcomes. However, significant disparities have been observed in these imaging modalities caused by a lack of or limited access to these devices, financial constraints, infrastructure, and workforce limitations. This review, therefore, examines strategies to improve access and effectiveness of CT and MRI in low- and middle-income countries (LMICs). A scoping review methodology was adopted, involving searches of major databases including PubMed, Scopus, Web of Science, and grey literature, with thematic synthesis used to categorize barriers and proposed solutions. The findings of this study reveal multifaceted challenges across technology, facility, health-system, and patient levels. High acquisition and maintenance costs, unreliable power supply, shortage of trained personnel, weak regulatory frameworks, and inadequate health information systems were identified as key barriers. These factors contribute to equipment downtime, low utilization, long waiting times, and catastrophic out-of-pocket expenditures for patients. Strategic recommendations emphasize innovative financing models, procurement of ruggedized and portable imaging technologies, workforce training, strengthened policy frameworks, improved data systems, and community-level interventions such as mobile imaging services. In conclusion, coordinated multi-level actions are required to break the cycle of under-provision and under-utilization. The study recommends national diagnostic imaging plans, increased funding, regulatory reforms, and expansion of affordable, decentralized imaging services to promote equitable access and improved health outcomes in LMICs.

INTRODUCTION

Modern healthcare has been transformed by advanced medical imaging modalities, especially computed tomography (CT) and magnetic resonance imaging (MRI), which offer non-invasive, high-resolution visualization of internal structures. This is crucial for precise treatment planning, accurate diagnosis, and continuous disease monitoring (Hilabi *et al*., 2023). These technologies greatly improve patient outcomes in a variety of clinical contexts, from neurology to oncology, by making it easier to detect subtle diseases, guiding interventional procedures, and enabling longitudinal assessment of therapy efficacy (Frija *et al*., 2021). Low- and middle-income countries (LMICs) experience severe scarcity, with fewer than one CT scanner and less than one MRI unit per million people, whereas high-income countries (HICs) benefit from widespread availability and high utilization rates of CT and MRI, with about 40 CT scanners and 25–30 MRI units per million population (Jalloul *et al*., 2023; Murali *et al*., 2024). Infrastructure constraints, such as unstable power supplies and maintenance issues, further impede deployment and operating sustainability in resource-constrained areas, exacerbating this striking disparity.

The burden of communicable diseases is decreasing in LMICs, while the prevalence of non-communicable diseases (NCDs), such as cancer, heart disease, and neurological disorders, is rising. These NCDs together account for a growing portion of mortality and morbidity (Konkor and Kuuire, 2023). In addition to being essential for diagnosing and treating these NCDs, such as staging tumors, determining the severity of strokes, and evaluating cardiac abnormalities, CT and MRI are also crucial for dealing with enduring issues like infectious diseases (such as tuberculosis imaging) and trauma-related injuries, which are still common despite urbanization and an increase in traffic (Ahmed *et al*., 2024).

A significant obstacle to attaining equitable healthcare delivery is the lack of access to CT and MRI services in LMICs, which perpetuates cycles of delayed diagnoses, late-stage disease presentations, and subpar health outcomes that disproportionately affect vulnerable populations. In addition to increasing the financial and human consequences of untreated illnesses, this difference highlights the pressing need for focused interventions to bridge personnel, financial, and infrastructure gaps.

Rationale and Significance of the Study

The literature currently available on obstacles to CT and MRI use in low- and middle-income countries (LMICs) is still dispersed, with a large portion of the evidence coming from isolated case studies, country-specific analyses, or focused studies into specific issues like workforce shortages, equipment shortages, or infrastructural constraints. For example, similar studies in Southeast Asia emphasize financial limitations and regulatory gaps, frequently without cross-contextual comparisons that could reveal common patterns or scalable solutions, whereas reports from sub-Saharan Africa highlight power instability and maintenance issues as primary obstacles. This dispersed approach hinders stakeholders' capacity to derive practical insights because prior research has not consistently classified complex obstacles, from technical to economic, and has infrequently incorporated cutting-edge innovations like portable imaging or AI-assisted diagnostics into a coherent story (Gebrewold *et al*., 2025). A consolidated, evidence-based review that unifies these conflicting results, fills in generalizability gaps, and offers a thorough taxonomy of obstacles and related tactics to guide global health priorities is therefore desperately needed.

This study is valuable not only for identifying problems but also for advancing a structured, strategic framework that translates evidence into practical recommendations tailored for diverse actors such as policymakers, hospital administrators, and international health organizations. This framework shifts the discourse from descriptive analyses to implementation-ready roadmaps by proposing prioritized interventions, such as subsidized procurement models, workforce training consortia, and public-private partnerships, with the potential to accelerate equitable access to advanced imaging and reduce the escalating burden of noncommunicable diseases in LMICs. Finally, such a strategy not only improves diagnostic skills and health outcomes, but it also corresponds with SDG 3 by cultivating resilient health systems capable of managing both present inequities and future technological changes.

MATERIALS AND METHODS

This scoping assessment identifies barriers to CT and MRI use in low- and middle-income countries (LMICs) and makes strategic recommendations. A scoping strategy was developed to accept a wide range of evidence kinds while also completely covering the imaging pipeline. Searches were carried out in PubMed/MEDLINE, Embase, Scopus, Web of Science, CINAHL, and Global Health databases, as well as Google Scholar and grey literature (WHO, World Bank). The keywords included imaging concepts ("CT," "MRI," MeSH equivalents), context ("LMICs," "developing countries"), and barriers ("access," "procurement," "maintenance," "workforce," "cost"). There were no date constraints, although articles from 2019 to October 2025 were preferred.

Inclusion criteria emphasized CT/MRI access in World Bank-classified LMICs; exclusion criteria excluded high-income settings, non-CT/MRI modalities, and purely technical research. Data extraction was carried out using a standardized form that included study specifics, barrier types (financial, infrastructural, human resources, regulatory, and use), and remedies. Thematic synthesis grouped findings into a systematic framework that spans the imaging route.

RESULTS AND DISCUSSION

CT and MRI Density in Low- Middle-Income Countries

The World Health Organization's (WHO 2023) Global Atlas of Medical Devices, which gathers national estimates based on surveys of ministries of health (2020-2021 update), is the source of the statistics on CT (Computed Tomography) and MRI (Magnetic Resonance Imaging) machines. Figure 1 shows the CT and MRI intensity across low-middle-income countries. The UN World Population Prospects provides the population denominators used for per-million rates. Based on Gross National Income (GNI) per capita for FY2025 (using data from 2023), the World Bank classifies low-middle-income countries ($1,146–$4,515) and upper-middle-income ($4,516–$14,005) (World Bank, 2024). Figure 1 displays the CT and MRI machines units per million population, according to the data extracted from the World Health Organization's (WHO 2023) Global Atlas of Medical Devices reports and the World Bank classification of LMICs. The data are organized by density, with Lebanon having the highest density at 3 and 1.2 units per million population in MRI and CT machines, respectively.

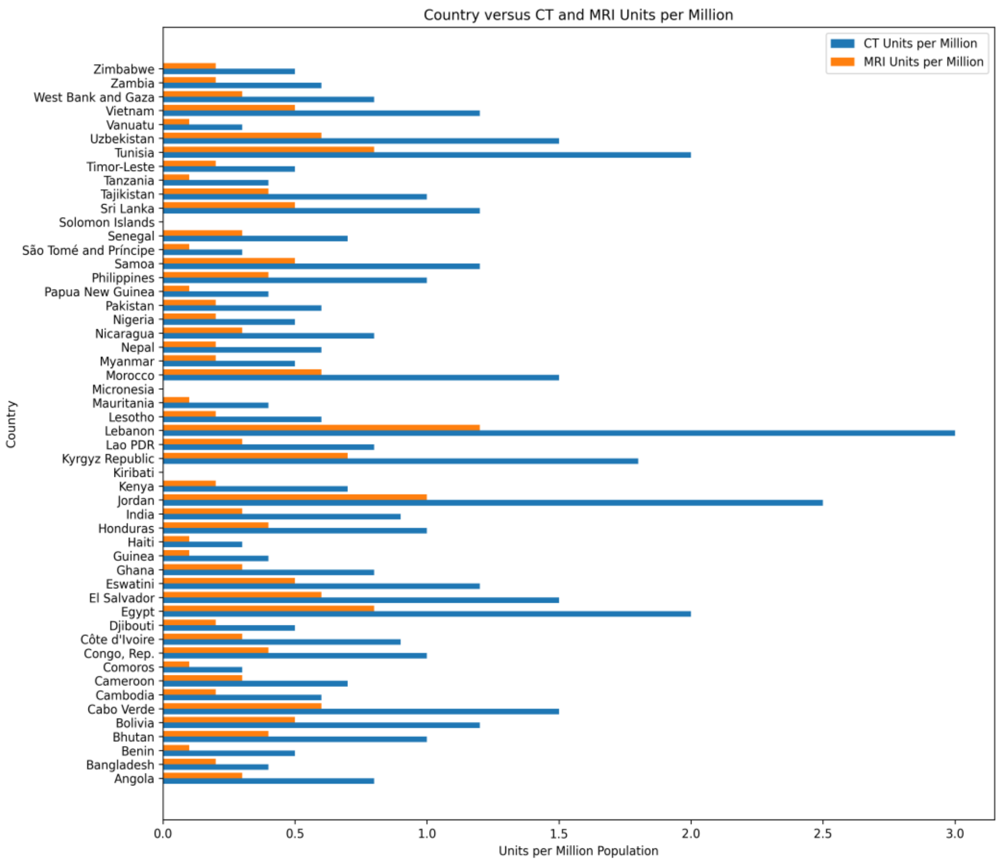

Figure 1: Figure showing CT and MRI intensity across LMICs

The Multifaceted Barriers

The use of computed tomography (CT) and magnetic resonance imaging (MRI) in low- and middle-income countries (LMICs) is hampered by a variety of constraints spanning financial, infrastructural, and human resource domains, significantly limiting diagnostic equality as noncommunicable disease burdens increase. Prohibitive acquisition costs, which frequently surpass national health budgets, along with continuous maintenance charges and a lack of finance methods, prevent procurement and long-term viability, making these technologies unavailable to the majority of the population. Infrastructural constraints, such as unstable power sources, insufficient MRI shielding, and poor transportation logistics, exacerbate the problem by impeding installation and operational reliability in remote or under-resourced areas. Furthermore, severe shortages of qualified radiologists, technicians, and support personnel restrict effective usage and quality assurance, leading to delayed diagnoses and poor patient outcomes. These linked challenges maintain a strong global imaging disparity, necessitating comprehensive policy reforms (Sahu and Madani, 2024).

Technology and Device-Level Barriers

In low- and middle-income countries (LMICs), advanced imaging modalities like computed tomography (CT) and magnetic resonance imaging (MRI) have enormous potential to improve patient outcomes and diagnostic accuracy. However, a number of obstacles at the technology and device level make it difficult to use them effectively, which exacerbates healthcare inequities. These difficulties, which have their roots in infrastructure and financial restrictions, impede long-term sustainability in addition to limiting deployment and procurement. Recent research highlights the necessity of focused interventions to deal with these problems, in line with more general approaches for fair access in environments with limited resources (Rogers *et al*., 2021).

High Initial Capital Cost

LMIC healthcare systems are heavily burdened financially by the purchase of CT and MRI scanners, with upfront costs for high-end equipment ranging from $1 million to over $3 million per unit, not including ancillary requirements like power stabilization units, shielded rooms, and installation infrastructure (Marey *et al*., 2025). This large capital expenditure frequently surpasses public facility budgets, resulting in underinvestment and a reliance on antiquated or donor-dependent purchases. For example, the lack of imaging resources is severe in many LMICs, with less than one CT scanner per million people compared to 40 in high-income nations. This difference is mostly caused by these exorbitant acquisition costs (Radiological Society of North America [RSNA], 2024). This loop is further sustained by the absence of customized financing methods, since foreign suppliers seldom provide flexible payment plans appropriate for LMIC fiscal realities, which leads to postponed upgrades and protracted diagnostic delays.

High Operational and Maintenance Costs

The continuous operating and maintenance costs of CT and MRI equipment, which include electricity usage, cooling systems, consumables such as contrast agents, and required service contracts, further tax LMIC resources after initial acquisition. These charges can make up as much as 70–80% of an imaging suite's lifetime costs. In off-grid places, unpredictable grid power necessitates expensive backup generators, which increase electricity rates by two to five times. Deferred maintenance brought on by financial constraints causes frequent malfunctions in resource-constrained settings, lowering equipment uptime to as low as 50% in certain facilities. According to recent estimates, annual maintenance fees, which frequently reach $100,000, make these technologies economically unfeasible in the absence of subsidized service agreements. This has led to a shift toward less expensive alternatives, such as ultrasonography, despite their diagnostic limitations (Shem *et al*., 2022).

Lack of Reliable Service Engineering

The severe lack of skilled biomedical engineers and technicians who can perform routine maintenance and repairs, coupled with the exorbitant cost of importing foreign knowledge and the persistent lack of spare parts, is a major barrier to the sustainability of CT and MRI in LMICs. Equipment downtime averages three to six months per incident due to the underdeveloped local engineering capacity, with many nations reporting fewer than one or two specialists per ten million people. Because parts must be purchased globally, service contracts from manufacturers are often prohibitively expensive and logistically difficult due to delays caused by currency fluctuations and customs hurdles. In addition to increasing operating expenses, this engineering shortfall encourages reliance on outside assistance, which impedes the independent execution and scalability of imaging initiatives (Anazodo *et al*., 2023).

Device Suitability and Durability

The harsh environmental conditions common in LMICs, such as voltage fluctuations, extreme heat, dust infiltration, and high humidity, can accelerate component degradation and failure rates by up to 40% (RSNA, 2024). CT and MRI devices, which are primarily designed for stable high-income settings, show poor adaptability to these conditions. For instance, CT scanners experience tube burnout as a result of unstable power sources without surge protection, and MRI systems need steady cooling and shielding that are incompatible with basic facility designs. In rural deployments, where dust and temperature extremes void warranties and make it more difficult to comply with international safety regulations, durability difficulties are especially severe. These discrepancies highlight the need for low-field, ruggedized solutions to close the access gap without sacrificing diagnostic accuracy.

Healthcare Facility-Level Barriers

Systemic flaws that jeopardize patient care and service delivery severely restrict the integration of computed tomography (CT) and magnetic resonance imaging (MRI) at the healthcare facility level in low- and middle-income countries (LMICs). These obstacles, which include a lack of human resources, inadequate education, physical infrastructure constraints, and operational inefficiencies, impede the scaling of sophisticated imaging and sustain diagnostic disparities. According to current research, resolving these facility-specific issues calls for a variety of approaches, such as capacity-building programs and flexible technology solutions, in order to promote sustainable implementation and better access in settings with limited resources (Hricak *et al*., 2021).

Workforce Shortages

The use of CT and MRI in LMIC institutions is severely limited by a widespread lack of specialist personnel, with serious shortages of medical physicists, radiologists, and radiographers/technologists compromising both equipment operation and image interpretation. The radiologist-to-population ratio is less than two per million in many LMICs, while it is above 100 in high-income nations. This results in overworked personnel and delayed diagnosis, which can cause wait times to exceed several weeks (Parag and Hardcastle, 2022). Brain drain, the migration of experts to cities or overseas, makes this shortage worse and makes rural facilities more vulnerable. The lack of medical physicists, who are crucial for dosimetry and quality assurance, increases the likelihood of subpar imaging procedures and radiation safety failures because facilities frequently operate without specific responsibilities. In addition to reducing scanner utilization rates, which are often below 30%, these staffing gaps also increase diagnostic errors, highlighting the necessity of focused recruitment and retention initiatives to increase facility-level capacity.

Inadequate Training and Continuing Education

Inadequate initial and continuing training programs for CT and MRI operations and interpretation exacerbate labor shortages by depriving facility staff of the skills necessary to fully utilize these technologies in LMICs. Because advanced imaging modalities are not emphasized in formal radiology education, technologists must rely on ad hoc learning, which jeopardizes scan quality and patient safety. Limited access to workshops, simulation tools, or international certifications further hinders continuing education, especially in distant places where participation is discouraged by travel expenses. According to recent surveys, more than 60% of LMIC radiographers claim they have not received enough practical training for MRI sequences, which results in underutilization and increased picture artifact rates. In order to empower facility teams and improve interpretive accuracy, localized, hybrid education models are required. While virtual training systems show promise as scalable solutions, their adoption is hindered by bandwidth limitations (Ogbole *et al*., 2023).

Infrastructural Deficits

Infrastructural deficiencies at the facility level, such as unstable electrical power, limited physical space, and poor internet access, constitute significant barriers to reliable CT and MRI adoption in LMICs. Up to 70% of rural facilities experience power instability, resulting in frequent scanner downtime and the need for expensive uninterruptible power supplies that strain budgets. Space limits in overcrowded hospitals can lead to suboptimal installations, such as unshielded MRI rooms that risk interference or safety breaches, while dust and humidity accelerate device deterioration. Teleradiology, a critical workaround for expert consultations, is hampered by unreliable broadband, with connectivity rates in Sub-Saharan Africa falling below 50%, delaying remote readings and fragmenting care pathways. These deficiencies combine to diminish operational efficiency, with facilities reporting average downtimes of 20-40%, highlighting the importance of modular, low-infrastructure designs in strategic upgrades for robust imaging environments (Miranda-Schaeubinger *et al*., 2022).

Inefficient Workflow and Referral Systems

In LMIC facilities, where fragmented procedures result in redundant testing, drawn-out patient journeys, and underutilized resources, the effectiveness of CT and MRI services is further diminished by their ineffective integration into larger clinical workflows and referral networks. Referral systems frequently lack standard operating procedures, which leads to improper imaging requests that overload scanners and increase expenses without producing a diagnosis. Seamless operations are hampered by bureaucratic obstacles in equipment maintenance and procurement, and the lack of electronic health records makes it difficult for hospitals to share images, which promotes care delivery silos. Due to transportation obstacles, rural sites in hub-and-spoke architectures experience "screen-and-refer" inefficiencies that prolong turnaround times to days or weeks. To integrate imaging as a fundamental element of prompt, patient-centered care in LMICs, these systems must be streamlined via digital interoperability and protocol-driven routes (DeStigter *et al*., 2021).

Health System and Policy-Level Barriers

The adoption and use of computed tomography (CT) and magnetic resonance imaging (MRI) in low- and middle-income countries (LMICs) is hampered at the health system and policy level by long-standing structural flaws that go beyond specific facilities, such as financial shortfalls, bureaucratic roadblocks, data silos, and the lack of unified strategic frameworks. These obstacles support a vicious circle of underfunding and unequal access, wherein illnesses that can be detected by early imaging have greater rates of morbidity and mortality due to diagnostic delays. Recent data highlights the importance of policy changes, such as improved public funding and simplified laws, in removing these barriers and facilitating the scale deployment of advanced imaging services (Fleming *et al*., 2021).

Financial Barriers

Systemic financial restrictions, which include inadequate government funding for healthcare infrastructure, limited insurance coverage for modern diagnostics, and high out-of-pocket costs that discourage patient uptake, severely restrict the integration of CT and MRI in LMICs. Due to competing priorities like infectious disease control, public health budgets in many LMICs devote less than 5% to diagnostics, with imaging modalities like CT and MRI receiving negligible shares. As a result, per capita spending on radiology services is less than \$1 per year, compared to over \$200 in high-income settings. A single MRI scan can cost two to five times the monthly family income in sub-Saharan Africa, where low insurance penetration, typically less than 20%, shifts the price to patients, forcing them to skip care and rely on symptomatic management (Ussi and Mtenga, 2025). Even while donor support is sporadic, it doesn't cover ongoing expenses, which emphasizes the need for creative financing methods like pooled regional funds to reduce these financial disincentives and encourage fair use.

Regulatory and Importation Hurdles

The lack of CT and MRI equipment in LMICs is made worse by regulatory complexity and importation bottlenecks. Long customs clearances, high medical device tariffs (which can reach 10–30% in some areas), and inconsistent certification standards cause deployments to be delayed by 6–12 months and raise costs by up to 50%. These obstacles are caused by non-tariff barriers like arbitrary inspections, complex bureaucratic procedures that are prone to corruption, and fragmented national regulations that categorize imaging equipment under general import duties rather than critical health commodities. High spare part costs deter maintenance in nations like Nigeria and India, making imported scanners unusable in a matter of years. Access might be accelerated by harmonizing laws through WHO-guided frameworks, but this policy inertia is sustained by a lack of political prioritization, which hinders the timely expansion of imaging capabilities.

Weak Health Information Systems

The lack of national imaging registries, established data protocols, and interoperable electronic records impedes resource allocation and outcome monitoring, and the fragility of health information systems in LMICs compromises evidence-based planning for CT and MRI services. Unreliable utilization indicators, such as scanner occupancy rates and diagnostic yields, are produced by fragmented data gathering, which is frequently manual and facility-specific. This leads to ineffective investments and redundant efforts across regions. The lack of centralized databases in more than 70% of LMICs prevents epidemiological analyses that are necessary to prioritize high-burden diseases like cancer or stroke, where optimal imaging could prevent 20–30% of premature deaths. To produce useful insights and promote accountability in the growth of imaging programs, digital health architectures, including cloud-based registries, must be strengthened (Mollura *et al*., 2020).

Absence of National Diagnostic Imaging Plans

The majority of LMICs lack comprehensive national diagnostic imaging strategies, which constitutes a fundamental policy gap in the absence of workforce development, equitable distribution, and locally relevant technology integration roadmaps. In the absence of such planning, imaging programs continue to be ad hoc, donor-driven, and urban-focused, with less than 10% of accessible scanners located in rural areas, although making up 60–80% of the population. The mismatch between local policies and global health targets, including Sustainable Development Goal 3, is a clear indication of this strategic weakness. As of 2024, no LMIC has a master plan specifically for imaging, which has caused progress toward universal health care to stop. Developing these strategies through multi-stakeholder cooperation could include performance standards, phased investments, and legislative changes, eventually turning obstacles into chances for improved access and systemic resilience (Shah *et al*., 2021).

Patient and Community-Level Barriers

In low- and middle-income countries (LMICs), patient and community-level barriers are the greatest direct obstacles to CT and MRI utilization. Individual circumstances combine with more general systemic injustices to prevent timely access and participation in sophisticated imaging treatments. Vulnerable communities are disproportionately affected by these issues, which result in late-stage presentations and less-than-ideal health outcomes. These issues include physical inaccessibility, economic destruction, cultural reluctance, and lengthy delays. Overcoming these obstacles requires community-centered initiatives, such as mobile imaging units and awareness campaigns, based on qualitative and epidemiological evidence. These interventions must be in line with strategy guidelines for equitable implementation and improved diagnosis pathways (Chitekwe, 2022).

Geographical and Transportation Barriers

Patients' access to CT and MRI facilities in LMICs is severely restricted by remote locations and inadequate infrastructure. Long travel times to urban imaging centers, often more than 100–200 km in rural areas, combined with deteriorating road networks and unreliable public transportation, make the trip difficult and dangerous. Because there are few or no ambulances in Tanzania due to fuel shortages and maintenance problems, stroke survivors often have to travel for several hours on pothole-filled roads in makeshift vehicles like motorcycles or oxcarts, delaying vital neuroimaging by hours or days (Michael *et al*., 2025). Comparably, only around 25% of people in Southern African contexts may obtain advanced imaging or neurosurgery services in less than two hours, which exacerbates disparities for rural communities that have to avoid under-equipped district hospitals in order to receive tertiary care. The potential of low-field, portable MRI devices to decentralize services and reduce such access gaps is highlighted by the fact that these geographical obstacles not only increase indirect costs but also increase dangers during transit (Arnold *et al*., 2023).

Financial Catastrophe

For LMIC patients, the direct and indirect costs of CT and MRI scans cause financial disasters. Out-of-pocket expenses, which frequently account for 40–60% of household income, compel trade-offs between diagnostics and necessities, resulting in debt cycles and postponed care. In Tanzania, a single CT scan for stroke evaluation can cost up to 600,000 Tanzanian shillings (about $220 USD), making it expensive without insurance. As a result, many people choose not to get tested at all or sell assets like livestock to pay the costs (Michael *et al*., 2025). Up to 100 million households in larger LMIC settings experience catastrophic health spending each year due to high scan costs, transportation costs, and lodging costs. Limited national health insurance coverage (such as Tanzania's NHIF, which excludes the majority of MRIs) further exacerbates disparities. Innovations in low-field MRI promise cost reductions to less than $500 per scan, but in the absence of subsidized models, these financial hurdles continue to prevent necessary imaging, especially for low-income and immigrant communities.

Long Waiting Times

The confluence of upstream impediments results in long wait times for CT and MRI services in low- and middle-income countries, where accumulated delays, from referral logistics to scan scheduling, can last weeks or months, undermining clinical usefulness and patient trust. Financial permissions for insured MRIs or CTs add days of bureaucracy to Tanzanian facilities, while transportation failures extend pre-hospital intervals beyond therapeutic windows for illnesses like as stroke, resulting in permanent sequelae. For example, wait times for neuroimaging in West Africa are 2-4 weeks due to high demand against a shortage of machines, which disproportionately affects rural patients who come late because of travel restrictions. In addition to impairing results, these delays, which are typically 20–50% longer in LMICs than in high-income settings, also encourage avoidance behaviors. To shorten timeframes and maintain community trust in diagnostic routes, strategic proposals include tele-imaging and triage techniques (Mehtar, 2019). All barriers previously stated are hereby summarised in Table 1 with their key supporting evidence from previous literature.

Table 1: Multifaceted Barriers to CT and MRI Adoption in LMICs

Level	Barrier	Key Supporting Evidence from the Literature
Technology and Device-Level	High Initial Capital Cost	Costs between $1 and $3 million per unit, including ancillary infrastructure; in many LMICs, this is less than 1 CT per million, whereas in HICs, it is 40 per million (Marey *et al*., 2025; RSNA, 2024).
	High Operational and Maintenance Costs	70–80% of lifetime expenditures; yearly service contracts around $100,000; uptime in certain facilities as low as 50% (Shem *et al*., 2022).
	Lack of Reliable Service Engineering	Three to six months of downtime per event; fewer than one or two specialists per ten million people; costly contracts for imported components and services (Anazodo *et al*., 2023)
	Device Suitability and Durability	Devices made for HIC conditions have failure rates of about 40% because of dust, heat, humidity, and power fluctuations (RSNA, 2024).
Healthcare Facility-Level	Workforce Shortages	<2 radiologists per million (compared to >100 in HICs); scanner usage is frequently less than 30%; there is a significant lack of technologists and physicists (Parag and Hardcastle, 2022; Hricak *et al*., 2021).
	Inadequate Training and Continuing Education	Inadequate MRI training, ad hoc learning, and restricted access to workshops and certification are reported by more than 60% of radiographers (Ogbole *et al*., 2023).
	Infrastructural Deficits	Up to 70% of remote facilities experience power instability; average downtime is 20–40%; teleradiology is hampered by inadequate connectivity (Miranda-Schaeubinger *et al*., 2022).
	Inefficient Workflow and Referral Systems	Inadequate SOPs, disjointed documentation, bureaucratic hold-ups, and rural "screen-and-refer" turnaround times of days to weeks (DeStigter *et al*., 2021).
Health System and Policy-Level	Financial Barriers	Diagnostics receives less than 5% of the health budget; radiology spending is less than $1 per capita annually (compared to more than $200 in HICs); out-of-pocket expenses are often 2–5 times monthly income (Ussi and Mtenga, 2025; Fleming *et al*., 2021).
	Regulatory and Importation Hurdles	Non-tariff barriers and corruption are prevalent, with tariffs ranging from 10 to 30%, delays of 6 to 12 months, and expenses of around 50% (paper gives Nigeria/India instances).
	Weak Health Information Systems	Evidence-based planning and resource allocation are hampered by the lack of centralized databases and registries in over 70% of LMICs (Mollura *et al*., 2020).
	Absence of National Diagnostic Imaging Plans	According to statistics from 2024, no LMIC has a comprehensive master plan; imaging is still donor-driven, ad hoc, and oriented toward cities (Shah *et al*., 2021).

Patient and Community-Level	Level Geographical and Transportation Barriers	Traveling more than 100–200 km is typical; only around 25% of people in some areas have access to advanced imaging in less than two hours; delays are lethal for stroke Arnold *et al*., (2023) and Michael *et al*., (2025)
	Financial Catastrophe	OOP accounts for 40–60% of household income; in Tanzania, a single CT costs about $220 USD, forcing millions of people into catastrophic spending each year (Michael *et al*., 2025).
	Long Waiting Times	Weeks to months for scans; 20–50% longer than HICs; pre-hospital + bureaucratic delays beyond therapeutic windows (e.g., stroke) (Mehtar, 2019).

Strategic Recommendation for Improving the Equitable Distribution

Interpretation and Interrelationship of Barriers

The initial purchase of scanners is directly restricted by financial limitations at the health-system level (high capital expenditures, insufficient public budgets, limited insurance coverage, and high out-of-pocket charges), which also compel institutions to forgo costly service contracts or replacement parts. This results in frequent malfunctions and extended equipment downtime (often 3–6 months per occurrence) due to neglected or missing maintenance (device-level barrier). In turn, downtime decreases the availability of scanners, resulting in lengthy patient wait times (weeks to months), which deters referrals, lowers overall utilization rates (typically below 30–50%), and leaves the already limited trained workforce underutilized or overworked when machines are in use. Underinvestment is sustained by low utilization, which further justifies constrained future budgetary commitments.

Inadequate shielding, heat, dust, and unstable power are examples of infrastructure deficiencies that exacerbate the issue. Financially strapped facilities cannot afford good installations or strong power stability, which can accelerate device deterioration and failure rates by up to 40%. Financial strains are further increased as a result of increased maintenance expenses and downtime. The delivery of equipment and spare parts is delayed by 6 to 12 months and costs are increased by up to 50% due to weak regulatory frameworks and importation barriers, which exacerbate sustainability problems at the device and financial levels.

Inadequate training and a lack of workers are closely related to the aforementioned cycles at the facility level. Insufficient financing results in a lack of training opportunities and competitive pay, which causes brain drain and overwork current employees. Frequent machine outages reduce opportunities for practical training, increase skill gaps, degrade image quality, and increase diagnostic errors, all of which further erode system trust and lower demand. Ad hoc, urban-biased deployment and policy neglect are sustained by inadequate health information systems and the lack of national imaging plans.

Lastly, obstacles at the patient and community levels close the loop: long wait times, catastrophic costs (a single scan costs two to five times monthly income), and geographic inaccessibility combine to delay care until diseases manifest late, increasing morbidity and supporting the idea that costly imaging is "unnecessary" in settings with limited resources. The political and financial deprioritization of imaging in national budgets is strengthened by this low demand. Table 2 depicts that the barriers are interrelated and consistent across low- and middle-income countries.

In conclusion, a self-sustaining loop of under-provision and under-use is created by financial obstacles, which are the main cause of issues with infrastructure, technology, human resources, operations, and eventually patient access.

Table 2: Comparison with Existing Literature, Consistency of Barriers across LMIC Regions

Barrier Category	Findings in the Provided Chapter	Comparison with Broader Literature (2019–2025)	Consistency Across Regions
High capital and operational costs	$1–3M+ per scanner; maintenance ~70–80% of lifetime cost;	Highly consistent (WHO 2021; Hricak *et al*., Lancet Oncology 2021)	Universal in Sub-Saharan Africa, South Asia, Latin America, Southeast Asia
Maintenance and service engineering	Downtime 3–6 months; scarce local engineers; expensive imported contracts	Consistent (Anazodo *et al*., 2023; Mollura *et al*., RAD-AID 2020–2024 reports)	Strongest in Africa and rural Asia; slightly better in urban Latin America and middle-income Asia
Device durability and suitability	Designed for HIC environments; 40% higher	Consistent (RSNA global reports 2024; Arnold *et al*.,	Universal; repeatedly cited as a rationale for low-field/portable MRI development

	failure in heat/dust/power fluctuations	low-field MRI studies 2023–2025)	
Workforce shortages and training	60% radiographers report inadequate MRI training	Highly consistent (Parag and Hardcastle 2022; Ogbole *et al*., Nigeria 2023; WFPI/ISR surveys)	Most severe in Africa; moderate in Latin America and Asia; brain drain affects all regions
Infrastructural deficits (power, space, internet)	70% rural facilities have unstable power; teleradiology is limited by <50% broadband in the USA	Very consistent (Miranda-Schaeubinger *et al*., 2022; WHO Essential Diagnostics List updates)	Power/internet is worst in SSA and South Asia; space issues are common everywhere
Regulatory and importation hurdles	6–12 month delays; 10–30% tariffs; up to 50% cost inflation	Consistent (Fleming *et al*., 2021; African and Asian case studies 2023–2025)	Strongest in Africa (Nigeria, Tanzania) and parts of South Asia; less severe in Latin America
Weak health information systems	>70% LMICs lack centralized registries; hampers evidence-based planning	Consistent (Mollura *et al*., 2020; WHO digital health reports 2022–2024)	Universal limitation; some progress in middle-income countries (e.g., India, Brazil)
Absence of national imaging plans	No LMIC has a comprehensive imaging master plan as of 2024	Consistent (Shah *et al*., 2021; WHO/IAEA surveys 2023)	Universal gap; a few countries (e.g., Rwanda, Ghana) are beginning to draft plans
Geographical and financial access for patients	Scans cost 2–5× monthly income; travel >100–200 km common; catastrophic expenditure	Highly consistent (Michael *et al*., Tanzania 2025; Ussi and Mtenga 2025; broader LMIC cancer/stroke studies)	Most extreme in rural SSA; also significant in rural Asia and Latin America
Long waiting times	Weeks to months; worsened by downtime and referral inefficiencies	Consistent (Mehtar 2019; recent West and East Africa studies 2023–2025)	Universal in public sector facilities across all LMIC regions

Technology and Device-Level Recommendations

Policymakers and procurement agencies should support creative financing options such equipment leasing, pay-per-use plans, public-private partnerships (PPPs), and pooled regional procurement funds in order to address high capital costs, extended downtime, and environmental unsuitability. These approaches, which have been successfully tested in African radiology programs, share risk, match payments with utilization, and guarantee manufacturer skin-in-the-game for maintenance while cutting initial expenditures by 40–60% (RAD-AID International, 2025). Governments and donors must simultaneously push for the purchase of ruggedized, LMIC-appropriate equipment, especially portable, low-field (<0.5 T) MRI systems that run on regular power outlets, don't require cryogenic cooling, and can withstand dust and heat fluctuations. These systems should demonstrate uptime >90% in actual Malawian deployments as opposed to <60% for conventional systems (Jones *et al*., 2025; Chetcuti and Chilungulo, 2025). In order to reduce downtime from months to days and develop technical sovereignty, it is crucial to establish local and regional service centers in conjunction with accredited training programs for biomedical engineers, including train-the-trainer models.

Healthcare Facility-Level Recommendations

Human resources and infrastructure limitations should be given top priority in facility-level interventions through aggressive workforce scaling and skill development. Regional certification centers, task-shifting to radiographers for fundamental sequences, and hybrid (virtual + hands-on) training curricula must be funded by national programs. Research indicates that structured programs enhance scan quality and utilization by 60–80%. To avoid unstable broadband while allowing expert oversight, facilities should implement teleradiology networks with cloud-based PACS and low-infrastructure technologies (low-field/portable MRI, solar-compatible power systems, containerized imaging suites). In order to reduce scanner overload and eliminate incorrect requests, standardized clinical decision support tools and electronic referral processes must be used. Pilots in East Africa have demonstrated 30–45% reductions in wait times and unnecessary tests.

Health System and Policy-Level Recommendations

In order to develop and finance national diagnostic imaging programs, which are currently lacking in all LMICs as of 2024–2025, systemic transformation requires political commitment. These initiatives, which are based on effective national cancer plans in Rwanda and Ghana, must include specific goals for scanner density, workforce ratios, rural coverage, and phased low-field MRI rollout. Regulatory harmonization can reduce costs by 30–50% and deployment delays by 6–12 months by eliminating or lowering tariffs on imaging equipment and replacement parts, expediting approvals for ruggedized technologies, and implementing WHO prequalification-like programs. To produce trustworthy utilization statistics and support ongoing investment, health ministries should require interoperable health information systems with national imaging registries and cloud repositories. To avoid catastrophic costs, innovative insurance models that cover advanced imaging and budgetary reallocation toward diagnostics (aiming for >8% of health expenditure) are essential.

Patient and Community-Level Recommendations

Governments and non-governmental organizations should expand mobile and portable low-field MRI units to provide services within two hours of 80% of the population in order to lessen geographic isolation and financial catastrophe. Early deployments in Africa and Asia have demonstrated significant reductions in travel burden and late-stage presentations. The implementation of microfinance-linked payment plans, community health insurance expansion, and subsidized or tiered pricing models is necessary to keep out-of-pocket expenses below 10% of household income; stroke programs have shown a 40–60% increase in utilization. It has been demonstrated that community awareness campaigns utilizing mobile applications, radio, and community health professionals, along with triage procedures that give priority to urgent cases, foster trust and shorten wait times from weeks to days.

Implications for Policy and Practice

Governments should develop and fund comprehensive national diagnostic imaging programs with clear targets for scanner density, workforce ratios, rural coverage, and a phased low-field MRI rollout, while also harmonizing regulations, eliminating imaging equipment and parts tariffs, and reallocating at least 8% of health budgets to diagnostics and universal coverage for advanced imaging. NGOs and international agencies (WHO, IAEA, RAD-AID, donors) should prioritize funding and scaling ruggedized, portable/low-field MRI units, regional service/training hubs, innovative financing models (leasing, pay-per-use, PPPs), and community-based insurance/microfinance schemes that keep out-of-pocket costs to less than 10% of household income. To reduce wait times and unnecessary scans by 30-45%, hospital administrators must aggressively invest in workforce training (regional certification, task shifting, hybrid curricula), teleradiology networks with cloud PACS, solar-compatible infrastructure, and standardized referral/decision-support tools, as well as actively adopt low-field and containerized systems that achieve >90% uptime in resource-constrained settings. Collectively, all stakeholders must disrupt the self-reinforcing cycle of under-provision and under-use by viewing diagnostic imaging as a necessary, high-return investment rather than a luxury.

Limitations of this Study

The study's scoping review strategy, which relies on published information from 2019 onward, runs the risk of publication bias by underreporting failures or bad outcomes in CT/MRI use in LMICs, thereby skewing findings toward positive examples. Heterogeneity within research, such as differences in technique, regional focus (e.g., Sub-Saharan Africa vs. Southeast Asia), and detail levels, can lead to discrepancies in synthesis and make uniform comparisons difficult. Generalizability is constrained due to varied LMIC environments, such as economic, infrastructural, cultural, and epidemiological differences, which may reduce guideline applicability without local modifications.

CONCLUSION

This study highlights the complex challenges limiting access to CT and MRI services in low- and middle-income countries (LMICs). The findings show that high acquisition, operation, and maintenance costs make advanced imaging technologies difficult to sustain, leading to inadequate infrastructure, insufficient workforce development, and frequent equipment breakdowns. These problems are compounded by unreliable power supply, a shortage of biomedical engineers, weak health policies, and poor diagnostic planning systems, all of which reduce service efficiency and quality. At the patient level, long travel distances, high out-of-pocket expenses, and prolonged waiting times often delay diagnosis and treatment, particularly for conditions such as cancer and stroke. Consequently, a cycle of underfunding, poor equipment utilization, and limited access persists, reinforcing the perception that advanced imaging is a luxury rather than a healthcare necessity. Addressing these interconnected barriers through coordinated investments in financing, infrastructure, workforce training, and policy development is essential for improving diagnostic services, strengthening health systems, reducing health inequalities, and advancing universal health coverage in LMICs.

To improve CT and MRI access in LMICs, the study suggests a multi-level approach: at the technology level, it advocates for innovative financing and robust, portable equipment; at the facility level, it supports human resources, teleradiology, and streamlined workflows; and at the policy level, it enacts national imaging plans, tariff reductions, and stronger data systems. In order to include imaging in universal health care, it simultaneously urges politicians and international players to enhance funding allocation, scale proven technologies, and promote collaboration. It also calls for the deployment of mobile units and financial protection for patients.

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