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A critical appraisal of the unmet needs for cross-sectional imaging techniques in Nigeria

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Abstract
Nigeria faces a significant gap in access to cross-sectional imaging techniques such as Computed Tomography (CT) and Magnetic Resonance Imaging (MRI), which are critical for accurate disease diagnosis and management. This review critically examines the unmet needs for these imaging technologies in Nigeria by evaluating peer-reviewed articles, case studies, and national healthcare reports. The review focuses on identifying barriers to access, including infrastructural deficits, lack of trained personnel, and financial constraints that hinder the widespread adoption of CT and MRI in Nigerian healthcare. A comprehensive literature search from 2000-2024 was conducted using various databases and keywords, such as "cross-sectional imaging", "Nigeria healthcare", and "CT and MRI accessibility". The findings underscore the diagnostic and clinical benefits of these imaging modalities, particularly in managing non-communicable diseases and trauma cases, which are on the rise in Nigeria. However, despite technological advancements, the cost and availability of equipment remain limiting factors. This review highlights the need for policy reforms, investments in medical infrastructure, and workforce training to address the growing demand for cross-sectional imaging. Future research should focus on developing cost-effective models and public-private partnerships to bridge the gap, ultimately enhancing patient outcomes and improving healthcare delivery across Nigeria.

Keywords: Cross-sectional imaging, CT scan, MRI, diagnostic barriers, Nigeria

Introduction
Cross-sectional imaging techniques, primarily comprising Magnetic Resonance Imaging (MRI) and Computed Tomography (CT) scans, are cornerstone diagnostic tools in modern medicine [1]. These advanced imaging technologies provide detailed anatomical views of internal organs, tissues, and bones, aiding in the early detection, accurate diagnosis, and effective management of a broad spectrum of diseases. From trauma and oncology to cardiovascular conditions, cross-sectional imaging is indispensable for both acute and chronic care [2-4]. However, despite the critical role these modalities play in improving patient outcomes, access to and utilization of cross-sectional imaging remain limited in many low- and middle-income countries, including Nigeria [5].

MRI uses strong magnetic fields and radio waves to generate high-resolution images, which is especially useful in neurological, musculoskeletal, and soft tissue assessments[1]; on the other hand, CT scans employ X-rays to create cross-sectional images, enabling detailed visualization of bone structures and internal organs. These techniques are not only pivotal in diagnosing conditions but also in guiding treatment decisions, monitoring disease progression, and planning surgical interventions. The absence or underutilization of these technologies significantly impacts the quality of healthcare delivery, contributing to delays in diagnosis, misdiagnosis, and suboptimal treatment outcomes.

In Nigeria, the demand for advanced medical imaging, particularly MRI and CT scans, is growing due to an increasing burden of non-communicable diseases such as cancer, cardiovascular diseases, and neurological disorders [5]. However, the healthcare infrastructure is often inadequate to meet this rising demand. Nigeria's healthcare system, like many in sub-Saharan Africa, faces significant challenges ranging from underfunding, poor infrastructure, and a shortage of healthcare professionals, to uneven distribution of resources across the country.

While tertiary healthcare facilities in major cities may offer MRI and CT services, many rural areas lack access to these essential diagnostic tools, exacerbating health inequities across the countr [5].

The purpose of this review is to critically appraise the unmet needs for cross-sectional imaging in Nigeria, focusing on identifying key gaps in infrastructure, accessibility, affordability, and human resource capacity. This paper aims to highlight the systemic barriers that limit the full integration of MRI and CT scans into routine healthcare services and propose actionable recommendations for addressing these gaps. By examining the current state of cross-sectional imaging in Nigeria, this review underscores the importance of strengthening diagnostic capacity to improve health outcomes and reduce mortality rates, particularly in resource-limited settings. In addressing these challenges, this review contributes to the growing body of evidence calling for targeted policy interventions, increased investment in healthcare infrastructure, and capacity building for medical professionals.

Overview of cross-sectional imaging techniques

Cross-sectional imaging techniques are indispensable tools in modern medical diagnostics and treatment planning, providing detailed views of internal structures that are otherwise inaccessible [1]. Two of the most widely used cross-sectional imaging modalities are Magnetic Resonance Imaging (MRI) and Computed Tomography (CT) scans. Both techniques have revolutionized the medical field, allowing for more accurate diagnoses and improved patient outcomes [6, 7]; however, their availability and utilization remain uneven, particularly in resource-limited settings like Nigeria, where challenges in infrastructure, cost, and expertise persist.

Magnetic Resonance Imaging (MRI)

MRI operates on the principle of nuclear magnetic resonance [8]. When a patient is placed inside the MRI scanner, a strong magnetic field aligns the protons in the body's tissues [8]. Radiofrequency pulses are then applied, causing these protons to emit signals as they return to their normal alignment. These signals are captured by the machine and processed to form highly detailed images of the body's internal structures. MRI is especially useful for imaging soft tissues such as the brain, spinal cord, muscles, and joints. It is the gold standard for evaluating neurological disorders, musculoskeletal conditions, and certain cardiovascular abnormalities [9]. In clinical practice, MRI is extensively used in diagnosing conditions like brain tumors, multiple sclerosis, stroke, and ligament or tendon injuries. Its ability to provide high-resolution images without the use of ionizing radiation makes it particularly advantageous in scenarios where repeated imaging is necessary, such as monitoring the progression of chronic diseases.

One of the primary advantages of MRI is its superior contrast resolution, particularly for soft tissues. It is non-invasive and does not involve ionizing radiation, making it safer for repeated use, especially in vulnerable populations such as pregnant women and children. MRI is also highly customizable, allowing for different imaging sequences that can highlight specific types of tissues or abnormalities.

However, MRI has limitations. It is expensive both in terms of equipment and operational costs, which restricts its availability in low-resource settings like Nigeria. The procedure also tends to be time-consuming, requiring patients to remain still for extended periods. Additionally, MRI is contraindicated in patients with certain types of metallic implants, such as pacemakers, due to the strong magnetic fields involved. Its sensitivity to motion can also lead to image degradation, making it less ideal for imaging the abdomen or chest, where organ movement from breathing or digestion can blur the images.

Computed Tomography (CT)

Computed Tomography (CT) uses X-rays to create cross-sectional images of the body [10]. During a CT scan, the patient lies on a table that moves through a circular scanner, which rotates and directs X-rays through the body from various angles. The data from these X-rays are processed by a computer to produce detailed, cross-sectional images. CT scans are particularly useful for visualizing bone structures, detecting cancers, and assessing traumatic injuries. CT has a wide range of applications in emergency medicine due to its speed and ability to quickly assess critical conditions such as internal bleeding, fractures, and acute stroke. It is also commonly used for detecting tumors, lung diseases, and vascular conditions such as pulmonary embolisms. In addition, CT angiography can be used to visualize blood vessels and identify blockages or aneurysms. CT scans offer several advantages, including rapid imaging and the ability to provide detailed images of both bone and soft tissue in a single scan. This makes CT invaluable in emergencies where quick diagnosis is critical. It also allows for three-dimensional reconstructions, aiding in surgical planning and more precise interventions. However, CT has limitations. The most significant drawback is its use of ionizing radiation, which poses a cumulative risk of radiation exposure, especially in cases where multiple scans are required. Although modern CT scanners use lower doses of radiation, the risk remains a concern, particularly for children and young adults. Additionally, while CT provides excellent imaging of bones and dense tissues, its soft tissue contrast resolution is inferior to that of MRI.

Current status of cross-sectional imaging in Nigeria

Cross-sectional imaging techniques, particularly Magnetic Resonance Imaging (MRI) and Computed Tomography (CT), play a crucial role in modern medical diagnostics and treatment planning [11]. Despite their importance, the availability, accessibility, and utilization of these technologies in Nigeria remain limited. The distribution of MRI and CT facilities in Nigeria is marked by significant inequities, with a concentration of these resources in urban centers and tertiary healthcare facilities, leaving rural areas underserved [12, 13]. According to recent surveys, MRI and CT scanners are disproportionately available in cities such as Lagos, Abuja, and Port Harcourt, where most of Nigeria's tertiary and teaching hospitals are located.[14]. Studies have found that of about 60 MRI machines currently operational in Nigeria, over 80% are located in the southern part of the country, with the majority in private facilities [15, 16]. Similarly, the distribution of CT scanners follows this pattern, with less than 10% of all CT machines located in northern states, where healthcare infrastructure is generally weaker [17].

This uneven distribution reflects a broader issue of healthcare inequality, as patients in rural areas must often travel long distances to access imaging services [13]. The

limited number of MRI and CT machines, coupled with Nigeria's large population, creates a significant supply-demand gap. Ogbole *et al*. highlighted that even in urban centers, the ratio of MRI machines to the population is far below the global standard, with one MRI machine serving nearly one million people in some regions [18]. This is in stark contrast to high-income countries, where the ratio is typically one MRI machine for every 38,000 people [14].

Geographic disparities are a significant barrier to equitable access to cross-sectional imaging in Nigeria [14, 16]. While patients in cities like Lagos and Abuja have relatively easier access to MRI and CT facilities, those in remote and rural areas face substantial obstacles [15]. Studies have shown that rural patients often have to travel many kilometers to access a facility with MRI or CT services, leading to delays in diagnosis and handling [19-21]. This strikingly affects emergency cases, where timely imaging could be life-saving. Moreover, the infrastructure challenges in rural areas, including unreliable electricity and poor transportation networks, further complicate access. Many rural healthcare centers cannot house and operate cross-sectional imaging equipment [15, 22]. Even when mobile imaging units are available, as some pilot programs have attempted, maintenance and operational costs have proven unsustainable without significant government investment or external support.

The utilization of MRI and CT scans in Nigeria lags behind global standards, reflecting both the shortage of equipment and the financial barriers faced by patients [20, 23]. Studies have examined the utilization of imaging services in several Nigerian teaching hospitals and found that even when MRI and CT scanners were available, they were often underused [11, 24]. The studies attributed this underutilization to high costs, lack of insurance coverage, and a general lack of awareness among healthcare providers and patients about the benefits of these imaging modalities. In many public hospitals, the waiting time for MRI or CT scans can exceed two weeks, which further discourages their use [13]. Several factors contribute to the underutilization of MRI and CT scans in Nigeria. The high cost of these imaging services is a major barrier [11]. A single MRI scan can cost between ₦80,000 and ₦200,000 (Approximately USD 50 to 125 USD), which is prohibitively expensive for many Nigerians, especially in the absence of comprehensive health insurance coverage [25]. Available evidence shows that only 5% of Nigerians have health insurance that covers advanced imaging techniques, leaving the majority to pay out-of-pocket for these services [26, 27].

In addition to financial barriers, there is a shortage of skilled professionals to operate MRI and CT machines [5, 11]. Nigeria has fewer than 300 certified radiologists, most of whom are concentrated in urban areas; the lack of training opportunities and continuous professional development for radiologic technologists further limits the capacity to fully utilize the existing imaging equipment [28]. This shortage of trained personnel often leads to longer wait times and limits the hours of operation for MRI and CT facilities, thereby reducing their overall utilization. Another critical issue is the lack of awareness and referrals from primary care physicians [28]. Many healthcare providers in Nigeria are either unfamiliar with or lack confidence in the appropriate use of MRI and CT imaging [29].

The core areas of unmet needs: Nigeria faces significant unmet needs in cross-sectional imaging, particularly in the areas of infrastructure, financial access, human resources, and public awareness [28]. Addressing these issues is essential to bridging the gap in healthcare service delivery, improving diagnostic capacity and ultimately enhancing patient outcomes. Despite recent efforts to improve healthcare infrastructure, systematic reviews and original articles indicate that significant challenges remain in terms of availability, affordability, and utilization of MRI and CT imaging services [12].

The lack of sufficient MRI and CT facilities is one of the most significant barriers to accessing cross-sectional imaging in Nigeria [30]. According to Udunna and Gouveia, Nigeria's current capacity for MRI and CT machines is grossly inadequate for its population, with less than one machine available per million people in many states [16]. This shortage is exacerbated by the fact that most facilities are located in major urban centers, leaving rural areas severely underserved. Findings have shown that of Nigeria's 36 states, nearly half have only one functional MRI or CT machine, often located in tertiary hospitals, leaving a vast population without local access to essential diagnostic services [15, 31]. The lack of reliable technical support and maintenance for MRI and CT machines further compounds the infrastructural challenge [14]. There is evidence that many MRI and CT machines in public hospitals remain out of service for extended periods due to technical breakdowns and the unavailability of spare parts [32, 33]. These issues are particularly acute in government hospitals, where budgetary constraints limit the ability to perform routine maintenance or hire qualified technical personnel. Findings reveal that more than 30% of imaging equipment in West African hospitals was non-operational at any given time due to technical failures and the lack of skilled personnel to repair them [34, 35].

The high cost of MRI and CT scans represents a major barrier to their utilization [25]. While cross-sectional imaging is essential for diagnosing conditions such as cancer, cardiovascular disease, and neurological disorders, its cost remains prohibitively high for most Nigerians; with private facilities charging even higher [25]. For CT scans, the cost is slightly lower but still unaffordable for the majority of the population, particularly those in rural and low-income settings [28]. This financial burden often results in delayed diagnosis and treatment, particularly for conditions that require regular imaging follow-up, such as cancer or stroke. Nigeria's National Health Insurance Authority (NHIA) provides limited coverage for advanced diagnostic imaging, with many patients having to pay out-of-pocket for MRI and CT scans [27]. As a result, many patients forego recommended imaging procedures due to the cost, leading to poorer health outcomes.

In addition**,** the shortage of trained radiologists and radiologic technologists is a critical challenge facing cross-sectional imaging in Nigeria [36, 37]. With fewer than 300 certified radiologists for a population of over 200 million, the country lacks the human resources needed to utilize its imaging infrastructure. Adequately [38]. Most radiologists are concentrated in major cities, leaving rural areas severely underserved [38]. This shortage not only limits access to imaging services but also contributes to delays in diagnosis and misinterpretation of results. A study reported that in many secondary healthcare facilities, non-specialists such as general practitioners or nurses are often tasked with

operating complex imaging equipment, leading to suboptimal image quality and potential diagnostic errors [39]. Limited awareness among healthcare providers and patients about the benefits and appropriate use of MRI and CT imaging is another major challenge [40]. Many primary care physicians and specialists are either unaware of or lack confidence in the diagnostic value of cross-sectional imaging, leading to fewer referrals [30, 40]. Misconceptions about cross-sectional imaging technologies are prevalent among the general public, contributing to underutilization [41]. A 2022 study by Okon *et al*. found that many patients feared that exposure to MRI or CT scans could lead to adverse health effects, such as cancer, due to radiation exposure [42].

Recommendations

The unmet needs in cross-sectional imaging techniques such as MRI and CT scans in Nigeria present significant challenges to healthcare delivery, patient outcomes, and equity. Addressing these issues requires a multifaceted approach involving policy reforms, infrastructural investments, enhanced training programs, and community engagement. To address the disparity in access to MRI and CT services, the Nigerian government and healthcare policymakers must develop and implement targeted policies. The National Health Insurance Authority (NHIA) needs to expand its coverage to include advanced imaging services such as MRI and CT scans. Moreover, the government should prioritize healthcare spending in underserved regions, particularly rural areas where access to diagnostic services is limited. Policies that incentivize private sector investment in healthcare infrastructure, including tax breaks and public-private partnerships, could stimulate the establishment of more MRI and CT facilities outside major urban centers. There is strong evidence that public-private partnerships have been successful in expanding healthcare access in other sectors and could be replicated for cross-sectional imaging [43, 44].

Another critical policy intervention is the establishment of standardized protocols for maintaining imaging equipment. There is a pressing need for the Nigerian Ministry of Health to enforce regular maintenance and quality checks for MRI and CT machines, particularly in public hospitals, where breakdowns and delays in repairs are common. A national imaging quality assurance program could ensure that machines are functioning optimally, thereby reducing diagnostic delays and improving patient outcomes. To achieve this, the Nigerian government should allocate a greater percentage of its healthcare budget to the procurement of diagnostic equipment. Additionally, international donors and development partners could play a significant role in funding imaging equipment in low-resource settings. Several countries in sub-Saharan Africa have successfully collaborated with global organizations to expand healthcare infrastructure [45], and similar partnerships could be beneficial for Nigeria. Furthermore, addressing the infrastructural challenges requires the establishment of specialized imaging centers in tertiary hospitals.

In addition, building more specialized centers that can handle high patient volumes and complex cases would significantly improve diagnostic efficiency and patient outcomes. The shortage of trained radiologists and radiologic technologists is a major contributor to the underutilization of MRI and CT services in Nigeria; strengthening training and continuing professional development (CPD) programs for healthcare professionals is critical. To address this, the government, in collaboration with academic institutions and professional bodies, should establish more training programs focused on cross-sectional imaging. Scholarships and grants for radiology students could help attract more professionals to the field. Online and distance-learning courses, which have proven effective in other low-resource settings, could provide continuous education for radiologists and radiologic technologists in remote areas. These programs should focus on the latest advances in MRI and CT technologies, proper interpretation of images, and equipment maintenance to ensure high-quality diagnostic services. In addition, partnerships with international universities and radiology departments could facilitate knowledge exchange and capacity building. Some countries in sub-Saharan Africa have implemented twinning programs, where radiologists from high-income countries train local professionals in advanced imaging techniques. These collaborations could improve the skills of Nigerian radiologists, ensuring that they are equipped to operate sophisticated imaging equipment and interpret results accurately. Public awareness and education are also essential for promoting the appropriate use of MRI and CT imaging services.

Public education campaigns are needed to inform both healthcare providers and patients about the importance, safety, and benefits of MRI and CT scans. Awareness initiatives should focus on demystifying these technologies, explaining when they are necessary, and alleviating fears about radiation exposure, especially in the case of CT scans. Furthermore, such programs should highlight that MRI, unlike CT, does not involve radiation and is safe for a wide range of patients. This effort should be paired with educational materials for healthcare professionals to ensure proper referral practices and encourage the appropriate utilization of imaging technologies, particularly in rural and underserved regions.

Conclusion

This review highlights the critical unmet needs in cross-sectional imaging in Nigeria, specifically focusing on infrastructure, financial barriers, human resources, and public awareness. The limited availability of MRI and CT facilities, geographic disparities, and high costs of imaging services significantly impede timely diagnosis and appropriate medical care. The shortage of trained radiologists and radiologic technologists, coupled with insufficient opportunities for continuous professional development, further exacerbates these challenges. Additionally, widespread public misconceptions about imaging technologies and limited awareness among healthcare providers hinder the appropriate utilization of these essential diagnostic tools.

Therefore, this review calls on all stakeholders, including government bodies, healthcare policymakers, international partners, and professional organizations, to prioritize investments in cross-sectional imaging infrastructure, expand training opportunities for healthcare professionals, and implement policies that enhance affordability and access to imaging services. These efforts must be paired with community outreach initiatives to raise public awareness about the importance of MRI and CT imaging in

timely disease detection and management. Addressing these unmet needs is essential for improving healthcare outcomes and building a more equitable healthcare system in Nigeria.

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Not available.

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