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Artificial intelligence in SUS radiology: current landscape, barriers, and integration strategies

Inteligência artificial na radiologia do SUS: panorama atual, barreiras e estratégias de integração

Luis Gustavo Machado Farias[1], Alan Cristian Cordeiro Siqueira[2], Fernanda Marcondes Ribas[2], Kammilly Fernanda Alves dos Santos[3]

ABSTRACT

Introduction: Artificial intelligence (AI) is emerging as a strategic tool for modernizing diagnostic radiology in the Brazilian Unified Health System (SUS), with the potential to improve efficiency, reduce diagnostic delays, and mitigate regional inequalities.

Objective: To critically analyze the available evidence on the use of AI in radiology in Brazil, identifying advances, limitations, and directions for its sustainable implementation.

Method: A narrative review of the literature published between 2018 and 2024 was conducted, including clinical guidelines, systematic reviews, and institutional reports on the direct use of AI, as well as secondary data from DATASUS.

Result: Significant growth in demand for imaging exams in the Unified Health System (SUS) was observed, contrasting with low levels of digitization and connectivity in public facilities. National reports point to gains in efficiency and diagnostic accuracy with the use of AI, although structural barriers, gaps in professional training, and regulatory challenges persist.

Conclusion: The progressive and evidence-driven incorporation of AI into radiology within the Unified Health System (SUS) can promote a structural reconfiguration of diagnostic care, providing that safety, equity, and ethical governance criteria are ensured.

KEYWORDS: Artificial intelligence. Radiology. Health systems. Technological innovation. Brazil.

RESUMO

Introdução: A inteligência artificial (IA) emerge como ferramenta estratégica para modernizar a radiologia diagnóstica no Sistema Único de Saúde, com potencial de aprimorar a eficiência, reduzir atrasos diagnósticos e mitigar desigualdades regionais.

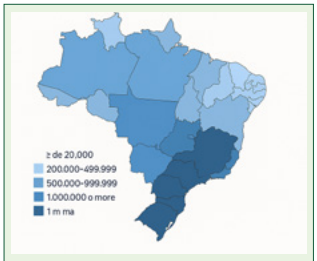
Objetivo: Analisar criticamente as evidências disponíveis sobre o uso da IA na radiologia brasileira, identificando avanços, limitações e direções para sua implementação sustentável.

Método: Realizou-se revisão narrativa da literatura publicada entre 2018 e 2024, incluindo diretrizes clínicas, revisões sistemáticas e relatos institucionais de uso direto de inteligência artificial, além de dados secundários provenientes do DATASUS.

Resultado: Observou-se crescimento expressivo na demanda por exames de imagem no Sistema Único de Saúde, contrastando com baixos níveis de digitalização e conectividade nas unidades públicas. Relatos nacionais apontam ganhos em eficiência e precisão diagnóstica com o uso de inteligência artificial, embora persistam barreiras estruturais, lacunas na formação profissional e desafios regulatórios.

Conclusão: A incorporação progressiva e orientada por evidências da IA na radiologia do Sistema Único de Saúde pode promover reconfiguração estrutural do cuidado diagnóstico, desde que assegurados critérios de segurança, equidade e governança ética.

PALAVRAS-CHAVE: Inteligência artificial. Radiologia. Sistemas de saúde. Inovação tecnológica. Brasil.



SUS imaging exams in 2023

Central Message

Artificial intelligence (AI) has been consolidated as an emerging technology of high complexity in Brazilian radiology, with applications associated with the reduction of morbidity and mortality, optimization of diagnostic flows, and mitigation of operational overload. Its clinical potential stands out especially in populations that are highly dependent on the public imaging network, such as cancer patients, patients with respiratory diseases, and trauma victims. Thus, AI should be seen and understood as a strong collaborator in medical care.

Perspective

In international comparison, although high-income countries have greater technological maturity, the implementation of AI in public health systems in middle-income countries, such as Brazil, still faces structural, regulatory, and formative barriers. In this context, the precise characterization of demand and installed infrastructure is essential to guide public policies, prioritize technological investments, and structure research agendas focused on the national reality.

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INTRODUCTION

Artificial intelligence (AI) has been consolidated as an emerging technology of high complexity in Brazilian radiology, with applications associated with the reduction of morbidity and mortality, optimization of diagnostic flows, and mitigation of operational overload in the Unified Health System (SUS). Its clinical potential stands out especially in populations that are highly dependent on the public imaging network, such as cancer patients, patients with respiratory diseases, and trauma victims.[1]

The continuous growth in the demand for tests, combined with the pressure for care efficiency, favored the adoption of automated approaches for screening, early detection, and risk stratification, with algorithmic support.[1,2] In recent decades, technical advances have consolidated the feasibility of machine learning applied to medical imaging, highlighting the role of standardized structured data and operational gains in various stages of the diagnostic chain. These elements have supported recommendations from scientific societies and regulatory bodies, such as the Ministry of Health, the Federal Council of Medicine, the World Health Organization, and initiatives of the Brazilian AI Strategy (EBIA).[3]

Despite conceptual and technological advances, important barriers to the practical implementation of AI in the SUS persist — including insufficient infrastructure, absence of specific regulations, and lack of continuous technical training.[4] The low digitization and connectivity of public imaging services, evidenced by official data2, limits the integration of algorithms and compromises the clinical applicability of the available solutions.

This article presents a critical review of the literature on the use of AI in Brazilian radiology, focusing on regional inequalities, installed technological capacity, care impact, and the construction of regulatory frameworks. The analysis seeks to contextualize the current state of scientific evidence, identify areas of uncertainty, and discuss implications for clinical practice, elaboration of guidelines, and definition of priorities in applied research.[5]

METHOD

This review was conducted based on a structured literature search in the PubMed, Crossref (used as an alternative to Embase), Cochrane Library, and LILACS databases, covering publications indexed between 2018 and 2024. The search strategy combined the descriptors "Artificial Intelligence", "Radiology" and "Brazil", selected from the controlled vocabularies MeSH (Medical Subject Headings) and DeCS (Health Sciences Descriptors), associated by Boolean operators (AND/OR), with the objective of maximizing sensitivity and specificity. Specific strategies were adapted according to the syntax of each database.

Randomized clinical trials, meta-analyses, systematic reviews, clinical guidelines issued by recognized scientific societies, as well as observational studies with robust design and clinical applicability, including institutional experiences documented in the context of the SUS, were included. The inclusion criteria included studies published in English or Portuguese, with access to the full text and direct relevance to the application and integration of AI in Brazilian radiology.

Isolated case reports, editorials, duplicate publications, non-systematic narrative reviews, and articles without direct clinical or structural focus were excluded. Study selection was performed independently by 2 reviewers with medical training, with disagreements resolved by consensus. The analysis prioritized evidence of high methodological quality classified according to the GRADE system, whenever available.

The objective was to gather and synthesize recent and relevant recommendations and findings on the adoption of AI in Brazilian radiology, offering critical subsidies to clinical practice, formulation of public policies and strengthening of evidence-based diagnostic infrastructure. This study did not involve experimentation on human beings, nor primary data collection. As this is a literature review with exclusive use of secondary data in the public domain, it is exempt from consideration by the Research Ethics Committee, according to CNS Resolution No. 510/2016.

DISCUSSION

Distribution and demand for imaging tests

The demand for imaging exams in the SUS varies significantly according to the region, socioeconomic profile, and level of urbanization, reflecting inequalities in access, asymmetric distribution of equipment, and digital connectivity, in addition to the availability of qualified professionals and diagnostic support technologies.[6]

In 2023, according to DATASUS data, more than 28 million outpatient imaging exams were performed in Brazil, with a predominance of ultrasounds (19.[3] million), CT scans (3.[1] million) and magnetic resonances (957 thousand).[7] Production is concentrated in states such as São Paulo, Minas Gerais and Rio de Janeiro, while the North and Northeast regions have lower per capita coverage (Figure 1).

Population studies point to a growing trend in the request for highly complex tests, especially among the elderly, cancer patients, and trauma victims, driven by factors such as population aging, expansion of screening programs, and appreciation of early diagnosis.[8] This regional disparity is also evidenced in the absolute volume of tests performed in the SUS (Figure 2).

According to the National Registry of Health Establishments (CNES), only 32.5% of public units with imaging services have computed tomography or magnetic resonance imaging, and less than 24% have integration with archiving and communication systems (PACS/RIS).[2] This technological limitation compromises the feasibility of applying artificial intelligence-based solutions, which require digitized, standardized, and interoperable data.

In international comparison, although high-income countries have greater technological maturity, the implementation of AI in public health systems in middle-

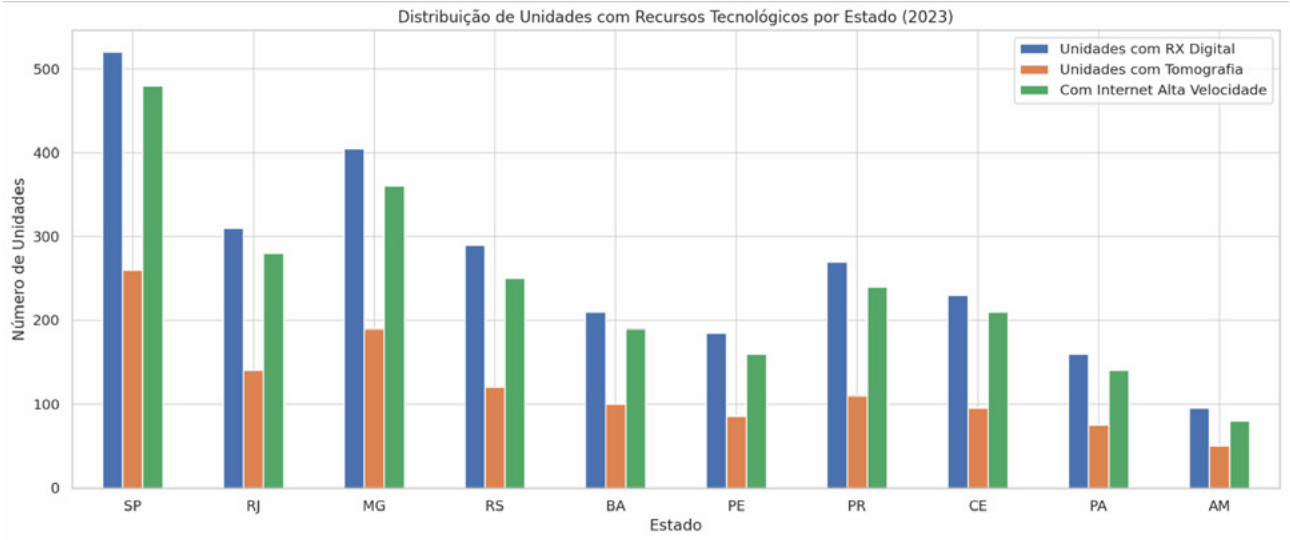

FIGURE 1— Distribution of units with technological resources by Brazilian state (2023). Data from CNES/DATASUS.

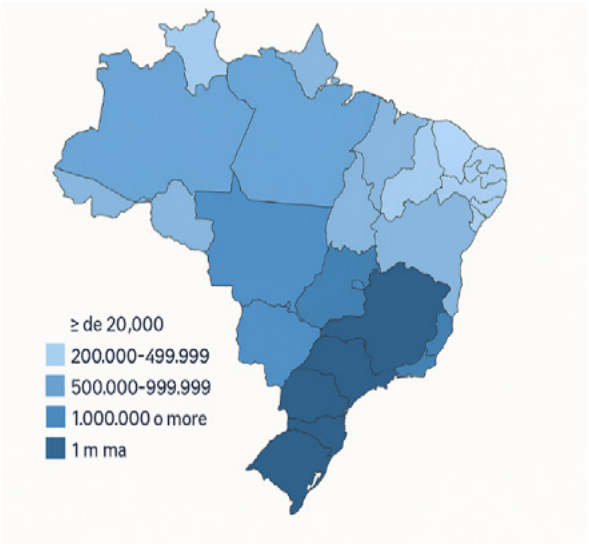

FIGURE 2 — Volume of imaging exams performed in the SUS by Brazilian state in 2023. Data from SIA/SUS.

income countries, such as Brazil, still faces structural, regulatory, and formative barriers. In this context, the precise characterization of demand and installed infrastructure is essential to guide public policies, prioritize technological investments, and structure research agendas focused on the national reality.

Architecture and operation of AI systems in radiology

The application of AI in radiology involves the interaction between supervised algorithms, convolutional neural networks, and large volumes of labeled medical data, with the aim of automating tasks such as detection, segmentation, screening, and diagnostic classification of images.[5] Systems operate through organized pipelines that connect image acquisition, digital preprocessing, and diagnostic inference based on previously trained models.

The effectiveness of these algorithms depends on elements such as the standardization of images (e.[9,] in DICOM format), the curation of balanced datasets, and the integration with archiving and communication systems (PACS/RIS). This set allows a structured processing chain, with extraction of characteristics, visual normalization and association with previous clinical findings. Convolutional neural networks stand out in this process for their ability to identify complex patterns, with cross-validation based on image banks annotated by experts.[5]

Recent evidence highlights the role of approaches such as transferred learning, supervised fitting, and hybrid models (ensembles) in performing specific tasks, such as screening for pulmonary nodules, osteoarticular fractures, and mammographic lesions.[3] These advances have allowed the development of systems with performance comparable to that of experienced radiologists, especially in the prioritization of critical examinations.

In addition to diagnosis, these algorithms contribute to the monitoring of operational indicators — such as average time to issue reports, error rate, and rework — and enable clinical decision support tools with the potential to personalize care flows.[9] By intervening in critical stages of the diagnostic process, AI acts as a complementary instrument to medical practice, whose safety and applicability depend on factors such as algorithmic transparency, data traceability, and continuous validation in real clinical contexts.

Evolution of AI-mediated diagnostic imaging criteria, methods and systems in the Brazilian and international context

Diagnostic imaging in Brazil is based on the integration of clinical findings, laboratory tests, and methods such as radiography, computed tomography, magnetic resonance imaging, and digital mammography. These procedures follow care protocols defined by institutions such as the Brazilian College of Radiology, the American College of Radiology, and the World Health Organization.[10] Diagnostic criteria recommend the identification of radiological patterns associated with the clinical context, often complemented by confirmatory tests or repeat examinations.

The request and prioritization of tests consider clinical-epidemiological factors, such as age, cancer

history, chronic diseases, and risk exposures. In groups of greater vulnerability, structured algorithms — such as BI-RADS, Lung-RADS, and probability scales — have been progressively incorporated into clinical practice, with good results in stratification and automated imaging screening.

In recent years, visual biomarkers and computational algorithms have been integrated into the diagnostic routine with the support of AI. This has allowed automated triage, reduction of interobserver variability, and prioritization of emergency reports.[9] Tools based on convolutional neural networks have been applied in the detection of pulmonary nodules, occult fractures, intracranial hemorrhages, and changes in bone density, with performance similar to that of experienced radiologists.

These resources have been progressively incorporated into automated clinical flows, both in the public and private sectors. In Brazil, multicenter studies conducted in university hospitals have shown that the use of diagnostic algorithms reduced response time by up to 32% and increased accuracy in priority cases.[5]

The current integration of AI in clinical-radiological flows in Brazil, its practical applications, adopted conducts, emerging protocols, and clinical decision support

The integration of AI into clinical-radiological flows in Brazil requires a multimodal and progressive approach, which combines diagnostic technology, integrated care protocols, and continuous professional training. These strategies aim to improve operational efficiency, reduce the time to issue reports, minimize rework, and expand access to exams in areas with limited coverage.[11]

Emerging guidelines from the Brazilian College of Radiology and pilot projects conducted by the Ministry of Health recommend that the adoption of AI systems occur in a staggered manner, based on the degree of digitalization of the unit, local epidemiological profile, and type of examination.[12] University hospitals and public referral services have been using validated algorithms for automated screening in chest exams, mammography, and cranial CT scans in emergency contexts as a front line.

These tools have been supported by evidence from cohort studies and experiences with robust technical validation, especially in institutions with academic-technological partnerships. In the absence of adequate infrastructure or internal technical support, viable alternatives include remotely assisted reports, cloud-based systems, or partnerships with regional support centers.[13]

Structuring interventions — such as continuous training of radiologists[4], standardization of care protocols, and modernization of the technology park with a focus on connectivity and image curation — are essential for the effective application of AI. These actions are especially relevant in overloaded outpatient units, places without specialists, and regions with poor digital infrastructure.

New trends and technologies

Recent advances in applied research, multicenter simulations, and clinical validations have been transforming the integration of AI into radiological practice, with a special impact in the context of the SUS. The incorporation of deep learning algorithms, automated segmentation, and preclassification by neural networks has enabled the development of emerging diagnostic platforms, predictive models, and high-sensitivity screening strategies — especially in outpatient settings with high demand and shortage of specialists.[14]

Controlled clinical trials conducted in Brazilian university hospitals have demonstrated the effectiveness of algorithms to detect pulmonary nodules and fractures in tomography and radiography scans, with satisfactory performance in at-risk populations, such as the elderly, cancer patients, and victims of traumatic brain injury.[5]

Among the innovations with the greatest potential impact, the following stand out: automated screening platforms integrated with PACS, already implemented in experimental clinical settings; risk prediction models with continuous learning capacity; and validated operational protocols for application in mammography and cranial tomography, with gains in response time and reduction of pending reports.

These solutions, validated in different outpatient settings, have already demonstrated a measurable impact on diagnostic efficiency and clinical prioritization (Table 1).

Recent updates from the Brazilian College of Radiology, in line with guidelines from the American College of Radiology and the Food and Drug Administration (FDA), recommend the assisted use of AI in screenings, with a requirement for mandatory local validation and human supervision in final reports.[15]

Structural barriers, methodological uncertainties and controversies about validation, regulation and applicability of AI in diagnostic imaging in the Brazilian public sector

Despite recent advances in the integration of AI into diagnostic imaging, critical gaps persist that hinder its consolidation in the Brazilian public sector. Among the main obstacles are the scarcity of randomized controlled trials with multicenter validation, the absence of long-term data on real clinical impact, and the lack of external validations in small units, which limits the extrapolation of the available evidence (Table 2).[16]

In the regulatory field, there is still no consensus regarding the degree of acceptable autonomy for diagnostic algorithms, nor on the obligation of review by human radiologists in all cases. International guidelines, such as those of the FDA and the American College of Radiology, contrast with the Brazilian scenario, which lacks clear regulations by the Federal Council of Medicine and the National Health Surveillance Agency, reflecting different interpretations of safety, legal liability, and auditability criteria.[17]

In addition, public units in the North and Northeast regions remain underrepresented in AI validation

TABLE 1 — Recent innovations in radiological diagnosis with AI – Brazil

Innovation / Technology	Clinical Application	Current Status
AI for Fracture Detection	Orthopedic X-ray in the emergency department	Validated pilot study5
AI-Automated Triage	Digital mammography	University Hospital Experience
Prioritization platform	Urgent CT scans (stroke, trauma)	Workflow data in SUS hospitals
Automated image curation	Urgent CT scans (stroke, trauma)	Cohort studies and local validation

TABLE 2 — Key recommendations for diagnostic AI - Context and limitations

Technical Axis	Recommended Intervention	Conduct in Doubtful Cases	Recomendação Atual
AI Diagnostics	Autonatized screening with local validation	Expert review before the final report	Pilot studies in university hospitals1
PACS Integration	Partial integration with human supervision	Internal protocols	Isolated institutional experiences17
Regulation and standardization	Lack of regulatory consensus in Brazil	Divergences between CFM, ANVISA and FDA	Need for clear regulation
Population inclusion	Representation of vulnerable populations	Low generalization to the North/Northeast	Evaluations concentrated in the Southeast region18
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studies, compromising the applicability of technological solutions in contexts with limited infrastructure, low connectivity, and scarcity of qualified professionals. Populations such as indigenous people, riverside dwellers, pregnant women, and patients with multiple comorbidities are also rarely included in the datasets used to train the algorithms currently available.[18]

From an operational point of view, the dependence on high-cost technologies, the heterogeneity in the structuring of images (DICOM, PACS) and inequalities in access to servers and networks widen the distance between the technical production of centers of excellence and their implementation in the daily life of the SUS. Recognizing these gaps is essential to guide public policies based on real-world evidence and foster more inclusive clinical and technological research, aligned with the structural demands of the Brazilian health system.

The analysis of the available evidence on the adoption of AI in diagnostic imaging in the SUS points to significant advances in different domains, with emphasis on automated screening, increased efficiency in diagnostic flows, and clinical decision support in complex exams, such as tomography and mammography.[19]

There is consensus among national and international guidelines — such as those of the Brazilian College of Radiology and the American College of Radiology — regarding the assisted and supervised use of AI. This position is supported by multicenter studies, workflow analyses and institutional validations.[3]

However, uncertainties persist regarding the applicability of these technologies in contexts with limited infrastructure, reduced interoperability, and lack of validation in small units. The literature lacks methodologically robust studies that evaluate clinical impact in environments with low technological density and in the long term.

Although the effectiveness of AI is well demonstrated in hospitals with advanced digital integration, its adoption in peripheral units of the SUS, especially in primary care and in regions with low connectivity or lack of specialists, has not yet been sufficiently proven.[20]

In addition, there are divergences between international regulatory frameworks — such as the FDA and EMA — and the lack of clear regulations in Brazil, which generates uncertainties about minimum safety criteria, technical responsibility, and validation requirements.

These factors reinforce the urgency of fostering multicenter research with regional diversity, studies based on real-world evidence, cost-effectiveness analyses, and continuing education programs. Such measures are essential to ensure that technological advances translate into concrete, equitable and sustainable improvements in diagnostic imaging in the public health system.

CONCLUSION

The critical analysis of the evidence on the adoption of AI in Brazilian radiology highlights the importance of a structured care approach, guided by evidence and supported by carefully incorporated technological innovations. The consolidation of AI as a diagnostic support tool represents a relevant functional advance, with the potential to reduce regional inequalities, improve triage, and increase the effectiveness of imaging care in the SUS.[21] However, the diversity of care models, inequalities in infrastructure, and the complexity of local contexts require a continuous process of monitoring implementation, reviewing algorithmic robustness, and periodically updating clinical protocols. The effective adoption of these technologies requires constant professional qualification, investments in interoperability, data curation, and ethical validation. In this context, revisions such as this are strategic tools to guide public policies, update clinical guidelines, and support institutional decisions. They contribute to safer, more equitable, and evidence-based medical practice — one that balances technological innovation with operational feasibility and patient care centricity.

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Authors' contributions

Luis Gustavo Machado Farias - Conceptualization, Writing (original draft)
Alan Cristian Cordeiro Siqueira - Formal Analysis, Supervision
Fernanda Marcondes Ribas – Research, Writing (proofreading and editing)
Kammilly Fernanda Alves dos Santos - Supervision, Methodology

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