Digital transformation of radiology services in Moroccan public hospitals: drivers and challenges for smart hospital governance

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Abstract

Objectives: This study aims to analyze the drivers and barriers of digital transformation in radiology services within Moroccan public hospitals, identifying conditions necessary to guide these services toward a smart hospital model that enhances efficiency, quality, and governance. **Prior Work:** Previous research has highlighted the global importance of digitalization in healthcare, with radiology being central due to high data dependence and technological complexity. In Morocco, studies focus mostly on broad health system digitalization, with limited attention to public hospital radiology services. **Approach:** A narrative literature review was conducted, integrating academic publications, institutional reports (WHO, OECD, Moroccan Ministry of Health), and national strategic documents. Keywords related to digital health, hospital information systems, radiology services, and smart hospital governance were used to identify relevant sources between 2010 and 2025. The analysis built a conceptual framework linking technological infrastructure, interoperability, governance, workforce capacity, and cybersecurity with digital transformation outcomes. **Results:** The review identified key drivers, including robust infrastructures, interoperable PACS/RIS systems, strategic leadership, and staff training. Major barriers include heterogeneous equipment, system fragmentation, limited digital competencies, financial constraints, organizational resistance, and cybersecurity risks. Moroccan public hospitals show opportunities for modernization, particularly when digitalization is embedded within broader smart government strategies. **Implications:** Effective digital transformation in radiology requires integrated planning, investment in technology and workforce, phased adoption strategies, and robust governance structures. Aligning hospital digitalization with urban and national digital health initiatives can improve efficiency, quality, and patient safety.**Value:** This study provides a foundation for strategic planning and operational guidance to develop “intelligent radiology services” in Moroccan public hospitals, contributing to the broader modernization of healthcare delivery and digital governance.

Keywords: e-health, radiology, hospital governance, performance, smart cities.

1. Introduction

Digital transformation has become a central strategic priority for healthcare systems worldwide. Rapid technological advancements, exponential growth of medical data, and increasing demands for quality, efficiency, and patient safety have driven public healthcare institutions toward "smart hospital" models [1]. These intelligent hospitals rely on interoperable information systems, process digitization, automation, clinical data analytics, and governance strengthened by real-time, reliable information. In Morocco, ICT integration in hospital logistics has enhanced operational efficiency and connected hospital services within broader smart-city frameworks [2]. International organizations emphasize that digitalization is essential for healthcare performance and sustainability [3].

Within this context, radiology services play a critical role in modernizing care pathways. The growing demand for imaging procedures, technological complexity, and centrality of radiological data in diagnostics make digitalization in radiology indispensable. PACS and RIS systems, electronic archiving, interoperability platforms, clinical decision support, and artificial intelligence are key tools for improving speed, diagnostic accuracy, and care coordination [4]. Studies indicate that the performance of imaging services now depends on their digital maturity and integration of digital tools into clinical and administrative workflows [5],[6]. Organizational culture, leadership engagement, and institutional readiness also emerge as critical drivers for successful digital transformation [7], [8].

Despite progress in e-health, digital hospital governance, and digital maturity models, challenges remain. System integration issues, data fragmentation, cybersecurity risks, lack of standardization, and organizational constraints persist [9], [10]. Moroccan hospitals have undertaken efforts to modernize systems and improve information sharing, highlighting the importance of interoperability standards and governance frameworks [11]. The integration of big data, cloud computing, IoT devices, and robust governance structures further supports efficiency and quality improvements in radiology services.

Research specifically addressing the digital transformation of radiology in middle-income countries is limited, particularly in the MENA region. In Morocco, most studies examine health system digitalization broadly, with few focusing on public hospital radiology, a sector facing compounded technological, organizational, and regulatory challenges. Key factors such as digital infrastructure, governance, workforce availability, system maturity, and cybersecurity require further investigation [12].

This study aims to fill these gaps by systematically analyzing the drivers and barriers to digital transformation of radiology services in Moroccan public

hospitals. Its objective is to identify enabling conditions to guide these services toward a smart hospital model capable of supporting modern, efficient, and quality-focused governance, addressing determinants of success, constraints, and contributions of radiology to hospital digitalization.

2. Methodology

2.1.Study approach

This study adopts a narrative literature review to analyze the digital transformation of radiology services in Moroccan public hospitals. By synthesizing academic and institutional literature and contextualizing national health policies, the approach provides an integrative perspective on factors shaping the transition toward smart hospital-aligned imaging services. Relevant studies from SCRD and SCIC journals were included, particularly those addressing digital transformation in developing-country public sectors, healthcare governance, and data security.

2.2.Type of study

The work is designed as a narrative review focused on digitalization of radiology services, hospital governance, and digital transformation models in healthcare. Grey literature, including institutional reports (WHO, OECD, Moroccan Ministry of Health), national strategic documents, and professional publications, was incorporated to reflect the specificities of Moroccan public hospitals and their technological integration.

2.3.Sources and document search strategy

The literature search spanned 2010–2025 across databases such as PubMed, Scopus, Web of Science, Google Scholar, and relevant African and Maghreb platforms. SCRD group journals (SCRD, SCIC) were explored for studies on healthcare data security, smart hospital systems, and organizational readiness. Keywords were applied in French, English, and occasionally Arabic, combining terms such as digital health, e-health, hospital information systems, radiology services, PACS, RIS, smart hospital, interoperability, data security, digital maturity, public hospitals, Morocco.

Inclusion criteria: publications from 2010–2025 in French or English providing theoretical or empirical insights on digitalization, medical imaging systems, hospital governance, or health technologies. Priority was given to low- and middle-income countries and public hospital contexts. Excluded were studies irrelevant to digital hospital systems or focusing exclusively on private-sector environments.

Selection occurred in three stages: title screening, abstract review, and full-text analysis. An analytical matrix categorized publications by dimensions such as digital infrastructure, radiology information systems, governance models,

interoperability, security, innovation adoption, workforce competencies, and national strategies for digital health transformation.

2.4.Analysis and conceptual framework

Analysis of selected documents informed a conceptual framework of key determinants for digital transformation in radiology. Dimensions included technological infrastructure, system interoperability, hospital governance and leadership, cybersecurity, workflow integration, and staff competencies.

Where relevant, digital maturity models were applied to assess hospitals' progress and identify development needs. This framework guided the narrative synthesis linking facilitators and barriers of digitalization to hospital governance, contextualized within Moroccan public healthcare settings.

3. Results

3.1.General overview of existing research

International research on digital transformation in healthcare shows substantial scientific production over the past decade, driven by the rapid evolution of digital technologies, the expansion of hospital information systems, and growing expectations regarding quality and efficiency of care [13], [14]. Recent studies emphasize the increasing integration of advanced digital tools such as AI, digital twins, and multimedia reporting in radiology, reflecting a shift toward highly automated diagnostic workflows [15], [16]. Most publications stem from Europe, North America, and Asia, with emerging contributions from developing countries engaged in the modernization of public hospital infrastructure [17]. Radiology-focused research is particularly abundant, reflecting the centrality of medical imaging in diagnostic pathways and the specialty's strong dependence on digital systems [18], [19], [20].

The literature consistently highlights major benefits of digitalization, including improved access to imaging, reduced diagnostic errors, enhanced workflow efficiency, increased data security, and seamless integration with electronic medical records [21]. PACS and RIS remain the technological backbone of radiology, while AI applications continue to expand in diagnostic assistance and workflow optimization [22], [23].

However, challenges persist, especially in contexts with fragmented infrastructures or heterogeneous equipment, which complicates the implementation of harmonized digital ecosystems [24]. In the MENA region, research is more limited, although recent studies address interoperability issues, governance concerns, and digital adoption barriers in public hospitals [17], [25].

3.2.Drivers supporting the digital transformation of radiology services

The literature identifies several key drivers supporting the digital transformation of radiology services. Operational gains, such as faster image processing, reduced waiting times, improved diagnostic reliability, and more efficient care pathways, remain central [18], [17]. Interoperability between PACS, RIS, hospital information systems, and electronic medical records enables seamless data exchange, enhances clinical communication, and reduces unnecessary repeat examinations [26] [27].

Institutional leadership also emerges as a major driver. Studies highlight the role of committed governance that develops strategic digital visions, ensures resource allocation, promotes international standards, and fosters innovation across departments [28], [13], and readiness of public authorities to implement strategic changes, as observed in smart-government initiatives leveraging AI [1]. Successful adoption is strongly associated with the availability of skilled personnel, biomedical engineers, IT specialists, and radiology technicians trained in digital workflows [16], [21].

Furthermore, robust infrastructures and digital maturity models are essential for assessing organizational readiness and guiding digital transformation [29]. When infrastructure is stable and staff adequately trained, radiology departments demonstrate greater capacity to incorporate innovation and improve performance [15].

3.3.Challenges and barriers to digital transformation in public hospitals

Despite significant benefits, several barriers hinder digital transformation, especially in public hospitals and middle-income countries. Interoperability issues, including incompatible systems, lack of standardization, and outdated equipment, are among the most frequently cited obstacles [24]. Such fragmentation impedes communication, slows workflows, and increases error risk.

Cybersecurity and data protection challenges are also critical, particularly given the sensitivity of radiological data and the rise of cyberattacks on hospitals [30]. This aligns with broader concerns raised in cyberbiosecurity literature about the vulnerabilities of digitized biomedical data and the need for robust protection frameworks [23]. Compliance issues further complicate the environment. Organizational resistance to change, reinforced by insufficient training, limited digital skills, and the perception of increased workload, remains a persistent barrier [21], [31].

Financial and material constraints also play a determining role: aging infrastructures, limited budgets, difficulties with maintenance, and inequalities between rural and urban facilities [17]. Moreover, the scarcity of studies on digital

radiology in developing contexts restricts the applicability of Western models to resource-limited settings [28], [22].

3.4.Implications for the Moroccan context

The literature indicates that Morocco's digital transformation of radiology services is shaped by both promising opportunities and persistent structural constraints. The country has articulated a clear political commitment to digital health, supported by national reforms, digital governance strategies, and modernization initiatives in public hospitals [32].

However, the challenges highlighted in the literature closely mirror realities in Moroccan public hospitals: heterogeneous radiological equipment, limited interoperability, reliance on aging infrastructures, shortages of specialized digital competencies, and the need for strengthened digital governance [17]. Cybersecurity and data protection are particularly pressing concerns [30], [31].

These findings support the development of a conceptual framework tailored to Morocco, integrating governance, infrastructure, human resources, interoperability, security, and organizational models. Recent evidence indicates that ICT-enabled hospital logistics can serve as a critical lever to optimize operations, facilitate data flows, and align hospitals with smart-city initiatives [2]. Such a framework can guide the evolution toward an "intelligent radiology service" that improves care quality, strengthens hospital performance, and aligns with the national vision for a modern digital healthcare system [7], [15], [21], highlighting that hospital digital transformation should be considered within a broader urban and public governance strategy.

4. Discussion

The literature shows that the digital transformation of radiology services is driven by technological, organizational, and institutional factors, yet it faces significant obstacles, particularly in public hospitals in middle-income countries such as Morocco [13], [17]. Key drivers include reliable digital infrastructures, adoption of interoperable systems (PACS, RIS, electronic medical records), process standardization, strong institutional leadership, and staff training [18], [33] These elements facilitate operational efficiency, faster image processing, improved diagnostic quality, interdepartmental coordination, and data security [10], [23].

Barriers remain substantial: system fragmentation, heterogeneous equipment, financial and material constraints, organizational resistance, limited digital skills, and cybersecurity risks [24], [30]. These challenges are compounded by the scarcity of local publications, which limits the applicability of international models to Moroccan public hospitals [21].

The analysis indicates that realizing the benefits of digitalization requires coordinated efforts, including investments in infrastructure, workforce capacity building, phased adoption strategies, and governance improvements [28]. Strategic directions to support transformation include:

- Strengthening digital leadership and governance, with clear strategies and performance monitoring.
- Investing in infrastructure and interoperability, standardizing systems, and centralizing radiological data.
- Training staff to develop digital competencies and a culture of cybersecurity.
- Implementing phased adoption through pilot projects and continuous evaluation.
- Ensuring robust data protection aligned with national and international standards.

A governance model for an "intelligent" radiology unit can be structured around five pillars: infrastructures and technologies; governance and leadership; interoperability and data flows; skills development; and data security and compliance [34], [35]. Embedding hospitals within broader smart government frameworks ensures that digitalization contributes to institutional and urban service modernization [1]. Aligning radiology digitalization with urban digital health strategies supports integrated, data-driven medical services and reinforces hospital performance [7], [8]. Effective digital transformation requires a holistic approach that balances technological investments, organizational readiness, workforce capacity, and governance. When well implemented, it can optimize processes, improve care quality, and integrate hospitals into the broader vision of smart healthcare and public service modernization.

5. Conclusion

The digital transformation of radiology services in Moroccan public hospitals represents a major opportunity to modernize healthcare and improve quality and efficiency [17], [21]. Successful implementation relies on robust infrastructures, interoperability, strategic leadership, staff training, and standardized practices [18], [23].

Significant challenges remain, including system fragmentation, skill shortages, resistance to change, financial constraints, and cybersecurity risks [30]. Overcoming these barriers requires an integrated, progressive approach combining technological investments, capacity building, adapted governance, and continuous monitoring of performance indicators [28].

Embedding radiology digitalization within broader smart government strategies ensures alignment with urban digital health initiatives, supporting efficiency, quality, and public value [1], [7], [8]. Future local research, including case studies, qualitative and quantitative assessments, evaluation of digital maturity models, governance, and interoperability, is needed to consolidate a strategic and operational framework for sustainable digital transformation in Moroccan public hospitals [20].

Advancing toward an “intelligent radiology service” model can optimize hospital processes, enhance care quality, strengthen safety, and contribute to the modernization of Morocco’s healthcare system.

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