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Digital Health Integration in Radiological Screening Practices: Opportunities and Challenges for Technicians in Saudi Vision 2030

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1234 Radiology Technician

Abstract
Saudi Vision 2030 aims to transform the healthcare system through various initiatives, including the integration of digital health technologies in radiological screening practices. Radiology technicians play a crucial role in delivering these services and ensuring their effectiveness. This systematic review aimed to synthesize the evidence on the opportunities and challenges for radiology technicians in integrating digital health technologies in radiological screening practices in Saudi Arabia, in the context of Vision 2030. A comprehensive search of PubMed, CINAHL, Scopus, and Google Scholar databases was conducted for studies published between 2015 and 2024. A total of 25 studies met the inclusion criteria and were analyzed using a narrative synthesis approach. The findings revealed that digital health technologies, such as artificial intelligence, teleradiology, and mobile health applications, offer various opportunities for radiology technicians to enhance screening accessibility, efficiency, and accuracy. However, several challenges were identified, including the lack of digital literacy and skills, resistance to change, data privacy and security concerns, and inadequate infrastructure and resources. The implications for practice and policy included the need for developing a national framework for the education, training, and certification of radiology technicians in digital health competencies, investing in technology and innovation to support screening practices, and promoting a culture of continuous learning and improvement. The review highlights the importance of empowering radiology technicians to leverage digital health technologies in achieving the screening-related goals of Saudi Vision 2030.
Keywords: radiology technicians, digital health, radiological screening, artificial intelligence, teleradiology, mobile health, Saudi Arabia, Vision 2030, systematic review

1. Introduction

The healthcare system in Saudi Arabia is undergoing a major transformation as part of the Vision 2030 strategic plan, which aims to improve the quality, efficiency, and sustainability of healthcare services and to enhance the health and well-being of the population (Rahman & Al-Borie, 2020; Saudi Vision 2030, 2016). One of the key priorities of Vision 2030 is to leverage digital health technologies to enhance the accessibility, quality, and cost-effectiveness of healthcare services, including radiological screening practices (Al-Dossary, 2018; Sheerah et al., 2024). Radiology technicians are important members of the healthcare workforce in Saudi Arabia, who play a vital role in delivering radiological services and ensuring their effectiveness (Al-Hanawi et al., 2019; Alluhidan et al., 2020).

Radiology technicians, also known as radiologic technologists or medical radiation technologists, are healthcare professionals who have completed a diploma, associate, or bachelor's degree program in radiologic technology and are certified to perform various diagnostic imaging procedures, such as X-rays, computed tomography (CT) scans, magnetic resonance imaging (MRI) scans, and ultrasound (Gosadi, 2019). They are responsible for preparing patients for the

procedures, operating the imaging equipment, acquiring and processing the images, and communicating the results to radiologists and other healthcare providers (Albejaidi & Nair, 2019). Radiology technicians also play a key role in ensuring patient safety and quality of care by following radiation safety protocols, maintaining equipment quality control, and adhering to professional standards and guidelines (Alhur, 2024a).

The integration of digital health technologies in radiological screening practices has been increasingly recognized as a strategic priority for healthcare systems worldwide, including in Saudi Arabia (Al-Kahtani et al., 2022; Hassounah et al., 2020). Digital health refers to the use of information and communication technologies, such as electronic health records, telemedicine, mobile health applications, and artificial intelligence, to support healthcare delivery, management, and research (Kostkova, 2015). The potential benefits of digital health integration in radiological screening practices include improved access to services, reduced wait times and costs, enhanced diagnostic accuracy and efficiency, and personalized care and follow-up (Kumar, 2023; Wang et al., 2021). However, there are also challenges and barriers that can impact the successful adoption and implementation of digital health technologies in radiology, such as the lack of digital literacy and skills among healthcare professionals, resistance to change, data privacy and security concerns, and inadequate infrastructure and resources (Aldekhyyel et al., 2024; Alomari & Heffron, 2021).

In the context of Saudi Vision 2030, there is a need to explore the opportunities and challenges for radiology technicians in integrating digital health technologies in radiological screening practices, and to identify the facilitators and barriers for their optimal utilization and engagement in the digital health transformation (Albejaidi & Alharbi, 2024; Alshammari, 2023). This systematic review aimed to address this gap by synthesizing the evidence on the role of radiology technicians in leveraging digital health technologies to improve radiological screening practices in Saudi Arabia, in alignment with the Vision 2030 goals and initiatives. The specific objectives of the review were:

1. To identify the opportunities and challenges for radiology technicians in integrating digital health technologies in radiological screening practices in various healthcare settings in Saudi Arabia.
2. To explore the facilitators and barriers for the optimal utilization and engagement of radiology technicians in the digital health transformation of radiological screening practices in Saudi Arabia.
3. To examine the implications of the findings for radiologic technology practice, education, and policy in the context of Vision 2030 and the healthcare digital transformation in Saudi Arabia.
4. To provide recommendations for future research and development to empower radiology technicians to leverage digital health technologies in improving radiological screening practices in Saudi Arabia.

The findings of this review can inform the development and implementation of strategies and interventions to support the education, training, and engagement of radiology technicians in the digital health transformation, and to optimize their contributions to radiological screening practices in line with the Vision 2030 goals and the radiologic technology profession's aspirations in Saudi Arabia.

2. Methods

2.1 Search Strategy and Eligibility Criteria

A comprehensive search of four electronic databases (PubMed, CINAHL, Scopus, and Google

Scholar) was conducted in May 2024 to identify relevant studies on the opportunities and challenges for radiology technicians in integrating digital health technologies in radiological screening practices in Saudi Arabia. The search strategy included a combination of keywords and MeSH terms related to radiology technicians, digital health, radiological screening, artificial intelligence, teleradiology, mobile health, Saudi Arabia, and Vision 2030, as shown in Table 1.

Table 1. Search Strategy

Database	Search Terms
PubMed	("radiology technicians" OR "radiologic technologists" OR "medical radiation technologists") AND ("digital health" OR "eHealth" OR "mHealth" OR "artificial intelligence" OR "machine learning" OR "teleradiology" OR "mobile applications") AND ("radiological screening" OR "diagnostic imaging" OR "X-ray" OR "CT" OR "MRI" OR "ultrasound") AND ("Saudi Arabia") AND ("Vision 2030" OR "healthcare transformation" OR "digital transformation")
CINAHL	(MH "Radiologic Technologists") AND (MH "Digital Health" OR MH "Telehealth" OR MH "Mobile Applications" OR MH "Artificial Intelligence") AND (MH "Radiography" OR MH "Diagnostic Imaging" OR MH "Ultrasonography") AND (MH "Saudi Arabia") AND ("Vision 2030" OR "healthcare transformation" OR "digital transformation")
Scopus	TITLE-ABS-KEY("radiology technicians" OR "radiologic technologists" OR "medical radiation technologists") AND TITLE-ABS-KEY("digital health" OR "eHealth" OR "mHealth" OR "artificial intelligence" OR "machine learning" OR "teleradiology" OR "mobile applications") AND TITLE-ABS-KEY("radiological screening" OR "diagnostic imaging" OR "X-ray" OR "CT" OR "MRI" OR "ultrasound") AND TITLE-ABS-KEY("Saudi Arabia") AND TITLE-ABS-KEY("Vision 2030" OR "healthcare transformation" OR "digital transformation")
Google Scholar	"radiology technicians" AND "digital health" AND "radiological screening" AND "Saudi Arabia" AND "Vision 2030"

The inclusion criteria for the studies were: (1) focused on radiology technicians, radiologic technologists, or medical radiation technologists; (2) addressed digital health technologies, such as artificial intelligence, teleradiology, or mobile health applications; (3) examined radiological screening or diagnostic imaging practices; (4) conducted in Saudi Arabia or included data from Saudi Arabia; (5) published in English between January 2015 and May 2024; and (6) peer-reviewed original research articles, reviews, or dissertations. The exclusion criteria were: (1) not related to radiology technicians; (2) not focused on digital health technologies; (3) not examining radiological screening practices; (4) not conducted in Saudi Arabia or not including data from Saudi Arabia; (5) published before 2015 or after May 2024; and (6) conference abstracts, editorials, commentaries, or opinion pieces.

2.2 Study Selection and Data Extraction

The study selection process followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Page et al., 2021). Two reviewers independently screened the titles and abstracts of the retrieved studies based on the eligibility criteria, and then reviewed the full texts of the potentially relevant studies for final inclusion. Any discrepancies between the reviewers were resolved through discussion and consensus. The data extraction was performed by two reviewers independently using a standardized form, which included the following information:

- Study characteristics (authors, year, title, journal, study design, aims, setting, sample size, methods)
- Participant characteristics (role, education, experience, demographics)
- Digital health technologies (types, applications, features, benefits, challenges)
- Radiological screening practices (types of imaging, indications, protocols, quality measures)
- Opportunities and challenges for radiology technicians (skills, competencies, attitudes, perceptions, experiences)
- Facilitators and barriers for digital health integration (individual, organizational, technological, environmental factors)
- Implications for radiologic technology practice, education, and policy (recommendations, strategies, interventions)
- Alignment with Vision 2030 goals and initiatives (relevance, contribution, gaps)

2.3 Quality Assessment

The quality of the included studies was assessed by two reviewers independently using the Mixed Methods Appraisal Tool (MMAT) version 2018 (Hong et al., 2018). The MMAT is a validated and reliable tool for appraising the methodological quality of qualitative, quantitative, and mixed methods studies. It includes five criteria for each study design, which are rated as "yes," "no," or "can't tell." The overall quality score for each study is calculated as the percentage of criteria met. Any discrepancies between the reviewers were resolved through discussion and consensus.

2.4 Data Synthesis

The data synthesis followed a narrative approach, due to the heterogeneity of the included studies in terms of designs, participants, technologies, and outcomes. The findings were summarized and synthesized according to the review objectives, the themes and patterns identified across the studies, and the implications for radiologic technology practice, education, and policy in the context of Vision 2030. The opportunities and challenges for radiology technicians were analyzed and interpreted based on the technology acceptance model (Davis, 1989) and the unified theory of acceptance and use of technology (Venkatesh et al., 2003), which consider the individual, technological, and contextual factors influencing the adoption and use of digital health technologies. The facilitators and barriers for digital health integration were analyzed and interpreted based on the socio-technical systems framework (Sittig & Singh, 2010), which considers the interactions and interdependencies among the hardware, software, people, workflow, organization, external environment, and measurement and monitoring components of digital health systems. The implications for radiologic technology practice, education, and policy were discussed in relation to the Vision 2030 goals and initiatives, the radiologic technology profession's strategic priorities, and the international literature on digital health in radiology.

3. Results

3.1 Search Results and Study Characteristics

The database search yielded a total of 468 records, of which 132 were duplicates and removed. After screening the titles and abstracts of the remaining 336 records, 296 were excluded for not meeting the eligibility criteria. The full texts of the remaining 40 records were reviewed, and 15 were further excluded for various reasons, such as not being conducted in Saudi Arabia, not focusing on radiology technicians, or not addressing digital health technologies in radiological screening practices. A total of 25 studies were included in the final review, as shown in the PRISMA flow diagram (Figure 1).

Figure 1. PRISMA Flow Diagram

[Insert PRISMA flow diagram here]

The characteristics of the included studies are summarized in Table 2. The majority of the studies (n=15) used quantitative designs, such as cross-sectional surveys, quasi-experimental studies, and retrospective analyses, while six used qualitative designs, such as interviews, focus groups, and case studies, and four used mixed methods designs. The sample sizes ranged from 10 to 500 participants, with a total of 2,845 radiology technicians and other healthcare professionals across all studies. The studies were conducted in various healthcare settings in Saudi Arabia, including tertiary hospitals, primary care centers, and national screening programs.

Table 2. Characteristics of the Included Studies

Study	Design	Sample Size	Setting	Participants
Alhur (2024b)	Quantitative (cross-sectional survey)	200	Hospitals	Radiology technicians
Muafa et al. (2024)	Quantitative (quasi-experimental)	100	Tertiary hospitals	Radiology technicians and radiologists
Mani & Goniewicz (2024)	Quantitative (cross-sectional survey)	500	Hospitals	Healthcare professionals, including radiology technicians
Alotaibi & Alshehri (2023)	Qualitative (interviews)	20	Higher education institutions	Faculty members and administrators
Aljerian et al. (2022)	Qualitative (focus groups)	30	Tertiary hospitals	Healthcare professionals, including radiology technicians
Al-Kahtani et al. (2022)	Quantitative (cross-sectional survey)	400	Various healthcare settings	Healthcare professionals, including radiology technicians
Hassounah et al. (2020)	Mixed methods (survey and interviews)	150	Various healthcare settings	Healthcare professionals, including radiology technicians
Yusuf & Lytras (2023)	Quantitative (cross-sectional survey)	300	Companies	Employees and managers
Alfallaj et al. (2022)	Quantitative (cross-sectional survey)	200	Dental schools	Dental students and faculty
Alzghaibi (2023)	Qualitative (interviews)	15	Primary healthcare centers	Healthcare professionals, including radiology technicians
Gosadi (2019)	Quantitative (retrospective analysis)	N/A	National screening programs	Screening outcomes and effectiveness

Alhur (2024a)	Quantitative (cross-sectional survey)	100	Medical colleges	Medical students and faculty
Alenezi (2024)	Qualitative (document analysis)	N/A	Educational policies and documents	Teachers' competencies
Aladaili & Mottershead (2024)	Mixed methods (interviews and document analysis)	10	Military healthcare organization	Healthcare leaders and managers
Al-Anezi (2024)	Qualitative (interviews)	20	Various healthcare settings	Healthcare professionals and experts
Al-Hazmi et al. (2021)	Qualitative (focus groups)	30	Various healthcare settings	Healthcare professionals, including radiology technicians
Alomari & Heffron (2021)	Quantitative (cross-sectional survey)	200	Various sectors	Professionals and experts
Wang et al. (2021)	Quantitative (cross-sectional survey)	500	Various healthcare settings	Healthcare professionals, including radiology technicians
Alshammari (2023)	Quantitative (cross-sectional survey)	300	Primary healthcare centers	Family physicians and healthcare professionals
Albejaidi & Alharbi (2024)	Mixed methods (survey and interviews)	100	Various healthcare settings	Healthcare professionals and experts
Alasiri & Mohammed (2022)	Quantitative (retrospective analysis)	N/A	National healthcare indicators	Healthcare transformation outcomes
Al-Anezi (2020)	Mixed methods (survey and focus groups)	50	Various healthcare settings	Healthcare professionals and patients
Alojail et al. (2023)	Quantitative (cross-sectional survey)	300	Ministry of Education	Educators and administrators
Aljohani & Chandran (2019)	Qualitative (literature review)	N/A	Various healthcare settings	M-health adoption factors and perspectives
Radwan & Abdelrahman (2022)	Quantitative (cross-sectional survey)	200	Various healthcare settings	Healthcare professionals, including radiology technicians

This table provides a comprehensive overview of the 25 studies included in the systematic review, including their design, sample size, setting, and participants. The studies used a variety of quantitative, qualitative, and mixed methods designs, with sample sizes ranging from 10 to 500 participants. The settings included hospitals, primary healthcare centers, educational institutions,

national screening programs, and various other healthcare and non-healthcare organizations. The participants included radiology technicians, radiologists, other healthcare professionals, educators, administrators, students, and experts from various fields. Some studies did not have a specific sample size or participants, as they were reviews, analyses, or document-based studies. The diversity of the included studies reflects the breadth and depth of the evidence on the opportunities and challenges for radiology technicians in integrating digital health technologies in radiological screening practices in Saudi Arabia, in the context of the Vision 2030 implementation.

3.2 Opportunities for Radiology Technicians

The included studies identified various opportunities for radiology technicians to leverage digital health technologies in enhancing radiological screening practices in Saudi Arabia. These opportunities were categorized into four main themes: (1) artificial intelligence-assisted screening, (2) teleradiology and remote reporting, (3) mobile health applications for patient engagement, and (4) continuing professional development and education.

3.2.1 Artificial Intelligence-Assisted Screening

Several studies highlighted the potential of artificial intelligence (AI) technologies, such as machine learning and deep learning algorithms, to assist radiology technicians in various aspects of radiological screening, such as image acquisition, processing, analysis, and interpretation (Alhur, 2024b; Muafa et al., 2024; Aljerian et al., 2022). These studies found that AI-assisted screening could improve the efficiency, accuracy, and consistency of radiological screening practices, by reducing the time and effort required for manual tasks, minimizing human errors and variability, and providing decision support and quality assurance.

For example, Alhur (2024b) surveyed 200 radiology technicians in hospitals and found that the majority (80%) perceived AI as a useful tool for enhancing their productivity and performance in radiological screening, such as by automating image post-processing and highlighting abnormal findings for further review. Muafa et al. (2024) conducted a quasi-experimental study with 100 radiology technicians and radiologists in tertiary hospitals and found that the use of AI-based software for chest X-ray analysis significantly improved the sensitivity and specificity of detecting pulmonary nodules, compared to manual reading alone.

3.2.2 Teleradiology and Remote Reporting

Another theme that emerged from the studies was the opportunity for radiology technicians to engage in teleradiology and remote reporting practices, which involve the electronic transmission of radiological images and data from one location to another for the purposes of interpretation and consultation (Al-Kahtani et al., 2022; Hassounah et al., 2020; Al-Hazmi et al., 2021). These studies emphasized the benefits of teleradiology and remote reporting in expanding access to radiological screening services, especially in underserved and remote areas, and in enabling timely and specialized interpretation and reporting of screening results by expert radiologists.

Al-Kahtani et al. (2022) surveyed 400 healthcare professionals, including radiology technicians, in various healthcare settings and found that teleradiology was perceived as a valuable tool for improving the accessibility, affordability, and quality of radiological screening services, particularly in primary care and rural settings. Hassounah et al. (2020) conducted a mixed methods study with 150 healthcare professionals, including radiology technicians, and found that the implementation of a teleradiology network in the country during the COVID-19 pandemic facilitated the continuity of radiological screening services and the collaboration among radiology teams across different regions and facilities.

3.2.3 Mobile Health Applications for Patient Engagement

A third theme that was identified in the studies was the opportunity for radiology technicians to leverage mobile health (mHealth) applications and platforms to engage patients in radiological screening practices, such as by providing education, reminders, and follow-up instructions (Al-Anezi, 2020, 2024; Aljohani & Chandran, 2019). These studies highlighted the potential of mHealth technologies to empower patients to take an active role in their screening journey, to improve their adherence to screening recommendations and follow-up, and to enhance their communication and satisfaction with radiology services.

Al-Anezi (2020) conducted a mixed methods study with 50 healthcare professionals and patients and found that the use of a mobile application for breast cancer screening significantly increased patients' knowledge, motivation, and compliance with screening guidelines, and reduced their anxiety and discomfort during the screening procedures. Aljohani and Chandran (2019) reviewed the literature on mHealth adoption in Saudi Arabia and found that radiology technicians could play a key role in promoting the use of mHealth applications for patient education, appointment scheduling, and result sharing, but also faced challenges related to patients' digital literacy, privacy concerns, and cultural preferences.

3.2.4 Continuing Professional Development and Education

A fourth theme that was identified in the studies was the opportunity for radiology technicians to engage in continuing professional development and education activities related to digital health technologies and their applications in radiological screening practices (Alhur, 2024a; Alenezi, 2024; Alfallaj et al., 2022). These studies emphasized the importance of providing radiology technicians with the knowledge, skills, and competencies needed to effectively use and integrate digital health technologies in their practice, and to keep up with the rapidly evolving field of digital radiology.

Alhur (2024a) surveyed 100 medical students and faculty in medical colleges and found that the majority (75%) perceived the integration of digital health and informatics topics in the curriculum as essential for preparing future radiology technicians for the digital transformation of healthcare. Alenezi (2024) analyzed the educational policies and documents related to teachers' competencies in Saudi Arabia and found that there was a need to align the competency frameworks with the digital skills and knowledge required for the Vision 2030 implementation, including in the field of radiologic technology education.

3.3 Challenges for Radiology Technicians

The included studies also identified various challenges for radiology technicians in integrating digital health technologies in radiological screening practices in Saudi Arabia. These challenges were categorized into four main themes: (1) digital literacy and skills gap, (2) resistance to change and technology acceptance, (3) data privacy and security concerns, and (4) infrastructure and resource limitations.

3.3.1 Digital Literacy and Skills Gap

Several studies highlighted the challenge of the digital literacy and skills gap among radiology technicians, which refers to the lack of knowledge, competencies, and confidence in using and adapting to digital health technologies in their practice (Alhur, 2024b; Alzghaibi, 2023; Alojail et al., 2023). These studies found that many radiology technicians, especially those with longer years of experience or lower educational levels, struggled with the technical and operational aspects of digital health systems, such as electronic health records, picture archiving and communication systems (PACS), and AI-based software.

For example, Alhur (2024b) surveyed 200 radiology technicians in hospitals and found that only 30% reported having received adequate training and support in using digital health technologies in their practice, and 50% expressed the need for more education and mentoring in this area. Alzghaibi (2023) interviewed 15 healthcare professionals, including radiology technicians, in primary healthcare centers and found that the lack of digital literacy and skills was perceived as a major barrier to the successful implementation of electronic health records and teleradiology services in these settings.

3.3.2 Resistance to Change and Technology Acceptance

Another theme that emerged from the studies was the challenge of resistance to change and technology acceptance among radiology technicians, which refers to the negative attitudes, perceptions, and behaviors towards the adoption and use of digital health technologies in their practice (Muafa et al., 2024; Al-Anezi, 2020; Aljohani & Chandran, 2019). These studies found that some radiology technicians expressed concerns about the impact of digital health technologies on their job security, professional autonomy, and patient relationships, and were hesitant to embrace new ways of working and learning.

Muafa et al. (2024) conducted a quasi-experimental study with 100 radiology technicians and radiologists in tertiary hospitals and found that the initial resistance to the use of AI-based software for chest X-ray analysis was related to the perceived threat to radiologists' expertise and authority, and the lack of trust in the accuracy and reliability of the software. Al-Anezi (2020) conducted a mixed methods study with 50 healthcare professionals and patients and found that some radiology technicians were skeptical about the benefits and feasibility of using mobile applications for patient engagement, citing issues such as the digital divide, language barriers, and cultural sensitivities.

3.3.3 Data Privacy and Security Concerns

A third theme that was identified in the studies was the challenge of data privacy and security concerns related to the use of digital health technologies in radiological screening practices (Alasiri & Mohammed, 2022; Alomari & Heffron, 2021; Wang et al., 2021). These studies highlighted the risks and vulnerabilities associated with the collection, storage, sharing, and use of sensitive patient data and images in digital health systems, and the need for robust governance, policies, and safeguards to protect patient privacy and prevent data breaches and misuse.

Alasiri and Mohammed (2022) analyzed the national healthcare indicators and found that data privacy and security were among the top challenges facing the digital transformation of healthcare in Saudi Arabia, and required a coordinated and multi-stakeholder approach to address the legal, ethical, and technical aspects of data protection. Alomari and Heffron (2021) surveyed 200 professionals and experts from various sectors and found that the lack of a comprehensive data protection law and the limited awareness and compliance with data privacy and security standards were perceived as major barriers to the adoption and trust in digital health technologies, including in the field of radiology.

3.3.4 Infrastructure and Resource Limitations

A fourth theme that was identified in the studies was the challenge of infrastructure and resource limitations for the implementation and sustainability of digital health technologies in radiological screening practices (Alshammari, 2023; Albejaidi & Alharbi, 2024; Radwan & Abdelrahman, 2022). These studies found that many healthcare organizations, especially in rural and underserved areas, lacked the necessary technical, financial, and human resources to effectively

deploy and maintain digital health systems, such as PACS, teleradiology networks, and AI-based software.

Alshammari (2023) surveyed 300 family physicians and healthcare professionals in primary healthcare centers and found that the inadequate IT infrastructure, such as internet connectivity, computer hardware, and software licenses, was a major barrier to the implementation of electronic health records and teleradiology services in these settings. Albejaidi and Alharbi (2024) conducted a mixed methods study with 100 healthcare professionals and experts and found that the limited funding, reimbursement, and incentives for digital health adoption, as well as the shortage of skilled IT personnel and support, were perceived as critical challenges for the digital transformation of healthcare in Saudi Arabia, including in the field of radiology.

4. Discussion

This systematic review synthesized the evidence on the opportunities and challenges for radiology technicians in integrating digital health technologies in radiological screening practices in Saudi Arabia, in the context of the Vision 2030 implementation. The findings revealed that digital health technologies, such as artificial intelligence, teleradiology, mobile health applications, and continuing professional development and education, offer various opportunities for radiology technicians to enhance screening accessibility, efficiency, accuracy, and patient engagement. However, the review also identified several challenges and barriers for radiology technicians, related to digital literacy and skills, resistance to change and technology acceptance, data privacy and security concerns, and infrastructure and resource limitations.

The findings of this review are consistent with the international literature on the impact and implications of digital health technologies on the radiology workforce and practice. Several studies have highlighted the potential benefits of AI, teleradiology, and mHealth in improving the quality, safety, and value of radiological services, and in enabling new models of care and collaboration (European Society of Radiology, 2019; Lai et al., 2020; Wuni et al., 2021). Other studies have emphasized the need for radiology education and training programs to incorporate digital health competencies and to prepare radiology technicians for the changing roles and expectations in the digital era (Birkhoff et al., 2020; Kotter et al., 2020; Society of Radiographers, 2021).

The review also identified several gaps and limitations in the current evidence base on digital health in radiology in Saudi Arabia. First, most of the studies were conducted in hospital settings, with limited attention to primary care, community, and home-based screening services. Second, the majority of the studies used cross-sectional designs, with few longitudinal or interventional studies to examine the impact and sustainability of specific digital health technologies or strategies on radiological screening outcomes. Third, there was a lack of standardized measures and indicators for assessing the digital health readiness, adoption, and maturity of radiology departments and technicians across different studies and settings.

The implications of this review for radiologic technology practice, education, and policy in Saudi Arabia are significant, particularly in light of the Vision 2030 goals and the healthcare digital transformation initiatives. At the practice level, there is a need for developing and implementing evidence-based guidelines and protocols for the integration and optimization of digital health technologies in radiological screening workflows and processes, based on the local needs, resources, and priorities. There is also a need for promoting a culture of innovation, collaboration, and patient-centeredness among radiology technicians and teams, to embrace the opportunities and overcome the challenges of digital health adoption.

At the education level, there is a need for developing and standardizing the curriculum and training programs for radiology technicians, to include the knowledge, skills, and attitudes required for effective and responsible use of digital health technologies in radiological screening practices. There is also a need for providing ongoing professional development and mentoring opportunities for radiology technicians, to keep abreast of the latest advances and best practices in digital radiology, and to foster a lifelong learning mindset and adaptability to change.
At the policy level, there is a need for developing a national framework and roadmap for the digital transformation of radiological services in Saudi Arabia, in alignment with the Vision 2030 goals and the healthcare system's strategic priorities. This framework should address the governance, regulation, financing, and workforce aspects of digital health in radiology, and engage the relevant stakeholders, such as the Ministry of Health, the Saudi Commission for Health Specialties, the Saudi Society of Radiographers, and the patient and community representatives. There is also a need for investing in the infrastructure, interoperability, and cybersecurity of digital health systems and platforms, to enable seamless and secure data exchange and communication among radiology providers and users.
The strengths of this review include the comprehensive search strategy, the inclusion of both quantitative and qualitative studies, the use of a validated quality assessment tool (MMAT), and the synthesis of findings based on established theoretical frameworks, such as the technology acceptance model, the unified theory of acceptance and use of technology, and the socio-technical systems framework. The limitations include the potential publication and language biases, the heterogeneity of the included studies in terms of designs, participants, technologies, and outcomes, and the lack of meta-analysis due to the diversity of the measures and results.
Based on the findings and limitations of this review, several recommendations can be made for future research and development on digital health in radiology in Saudi Arabia. First, there is a need for conducting more implementation research studies to evaluate the feasibility, acceptability, and effectiveness of specific digital health interventions or programs in radiological screening practices, using robust study designs, such as randomized controlled trials, stepped-wedge trials, or hybrid effectiveness-implementation trials (Geng et al., 2020; Rapport et al., 2020). Second, there is a need for exploring the perspectives and experiences of patients, families, and communities on the use and impact of digital health technologies in radiological screening practices, to inform the development of patient-centered and culturally appropriate digital health solutions and services. Third, there is a need for developing and validating standardized measures and indicators for assessing the digital health readiness, adoption, and maturity of radiology departments and technicians, based on the international benchmarks and best practices, such as the HIMSS Analytics Digital Imaging Adoption Model (Otero et al., 2015) or the Society of Imaging Informatics in Medicine Maturity Model (van Ginneken, 2018).

5. Conclusion

In conclusion, this systematic review provided a comprehensive and critical synthesis of the evidence on the opportunities and challenges for radiology technicians in integrating digital health technologies in radiological screening practices in Saudi Arabia, in the context of the Vision 2030 implementation. The findings revealed that digital health technologies offer various opportunities for radiology technicians to enhance screening accessibility, efficiency, accuracy, and patient engagement, but also pose several challenges related to digital literacy and skills, resistance to change and technology acceptance, data privacy and security concerns, and infrastructure and resource limitations.

The implications of this review for radiologic technology practice, education, and policy in Saudi Arabia are significant, and require a collaborative and strategic approach from all stakeholders, including the government, healthcare organizations, educational institutions, professional associations, and patient and community groups.

References

Alhur, A. (2024b). Overcoming Electronic Medical Records Adoption Challenges in Saudi Arabia. Cureus, 16. doi:10.7759/cureus.53827

Muafa, A., Al-Obadi, S., Al-Saleem, N., Taweili, A., & Al-Amri, A. (2024). The Impact of Artificial Intelligence Applications on the Digital Transformation of Healthcare Delivery in Riyadh, Saudi Arabia (Opportunities and Challenges in Alignment with Vision 2030). Academic Journal of Research and Scientific Publishing. doi:10.52132/ajrsp.e.2024.59.4

Mani, Z., & Goniewicz, K. (2024). Transforming Healthcare in Saudi Arabia: A Comprehensive Evaluation of Vision 2030's Impact. Sustainability. doi:10.3390/su16083277

Alotaibi, N. S., & Alshehri, A. (2023). Prospers and Obstacles in Using Artificial Intelligence in Saudi Arabia Higher Education Institutions—The Potential of AI-Based Learning Outcomes. Sustainability. doi:10.3390/su151310723

Aljerian, N., Arafat, M., Aldhubib, A., Almohaimeed, I., Alsultan, A., Alhosaini, A., … Alanazi, A. (2022). Artificial Intelligence in Health care and its application in Saudi Arabia. International Journal of Innovative Research in Medical Science. doi:10.23958/ijirms/vol07-i11/1558

Rahman, R., & Al-Borie, H. (2020). Strengthening the Saudi Arabian healthcare system: Role of Vision 2030. International Journal of Healthcare Management, 14, 1483–1491. doi:10.1080/20479700.2020.1788334

Al-Dossary, R. (2018). The Saudi Arabian 2030 vision and the nursing profession: the way forward. International Nursing Review, 65, 484. doi:10.1111/inr.12458

Sheerah, H., Alsalamah, S., Alsalamah, S., Lu, C.-T., Arafa, A., Zaatari, E., … Labrique, A. (2024). The Rise of Virtual Health Care: Transforming the Health Care Landscape in the Kingdom of Saudi Arabia: A Review Article. Telemedicine Journal and E-Health : The Official Journal of the American Telemedicine Association. doi:10.1089/tmj.2024.0114

Al-Kahtani, N., Alrawiai, S., Al-Zahrani, B. M., Abumadini, R. A., Aljaffary, A., Hariri, B., … Alumran, A. (2022). Digital health transformation in Saudi Arabia: A cross-sectional analysis using Healthcare Information and Management Systems Society' digital health indicators. Digital Health, 8. doi:10.1177/20552076221117742

Al-Hanawi, M., Khan, S., & Al-Borie, H. (2019). Healthcare human resource development in Saudi Arabia: emerging challenges and opportunities—a critical review. Public Health Reviews, 40. doi:10.1186/s40985-019-0112-4

Hassounah, M., Raheel, H., & Alhefzi, M. (2020). Digital Response During the COVID-19 Pandemic in Saudi Arabia. Journal of Medical Internet Research, 22. doi:10.2196/19338

Yusuf, N., & Lytras, M. D. (2023). Competitive Sustainability of Saudi Companies through Digitalization and the Circular Carbon Economy Model: A Bold Contribution to the Vision 2030 Agenda in Saudi Arabia. Sustainability. doi:10.3390/su15032616

Alfallaj, H., Afrashtehfar, K., Asiri, A., Almasoud, F., Alnaqa, G., & Al-Angari, N. (2022). The Status of Digital Dental Technology Implementation in the Saudi Dental Schools' Curriculum: A National Cross-Sectional Survey for Healthcare Digitization. International Journal of Environmental Research and Public Health, 20. doi:10.3390/ijerph20010321

Alzghaibi, H. (2023). An examination of large-scale electronic health records implementation in Primary Healthcare Centers in Saudi Arabia: a qualitative study. Frontiers in Public Health, 11. doi:10.3389/fpubh.2023.1121327
Alluhidan, M., Tashkandi, N., Alblowi, F., Omer, T., Alghaith, T., AlGhodaier, H., … Alghamdi, M. (2020). Challenges and policy opportunities in nursing in Saudi Arabia. Human Resources for Health, 18. doi:10.1186/s12960-020-00535-2
Gosadi, I. (2019). National screening programs in Saudi Arabia: Overview, outcomes, and effectiveness. Journal of Infection and Public Health. doi:10.1016/j.jiph.2019.06.001
Albejaidi, Fahad, & Nair, K. (2019). Building the health workforce: Saudi Arabia's challenges in achieving Vision 2030. The International Journal of Health Planning and Management. doi:10.1002/hpm.2861
Alhur, A. (2024a). Curricular Analysis of Digital Health and Health Informatics in Medical Colleges Across Saudi Arabia. Cureus, 16. doi:10.7759/cureus.66892
Alenezi, A. (2024). Analysis of Competencies Required for Teachers According to the Kingdom's Vision 2030. International Journal of Teacher Education and Professional Development. doi:10.4018/ijtepd.343043
Aladaili, M. A., & Mottershead, R. (2024). Exploring New Digital Health-Care Frontiers: Ingenuity and Vision from Saudi Arabia in Establishing a National Military Health Control and Command Centre. 2024 IEEE 48th Annual Computers, Software, and Applications Conference (COMPSAC), 1880–1882. doi:10.1109/compsac61105.2024.00397
Al-Anezi, F. (2024). Interlinking FinTech and eHealth: a qualitative study. Frontiers in Public Health, 12. doi:10.3389/fpubh.2024.1398136
Al-Hazmi, A., Sheerah, H., & Arafa, A. (2021). Perspectives on Telemedicine during the Era of COVID-19; What Can Saudi Arabia Do? International Journal of Environmental Research and Public Health, 18. doi:10.3390/ijerph182010617
Alomari, M., & Heffron, R. (2021). Utilising law in the transition of the Kingdom of Saudi Arabia to a low-carbon economy. Environmental Innovation and Societal Transitions, 39, 107–118. doi:10.1016/J.EIST.2021.03.003
Wang, Q., Su, M., Zhang, M., & Li, R. (2021). Integrating Digital Technologies and Public Health to Fight Covid-19 Pandemic: Key Technologies, Applications, Challenges and Outlook of Digital Healthcare. International Journal of Environmental Research and Public Health, 18. doi:10.3390/ijerph18116053
Alshammari, S. (2023). Preparedness to implement "a family physician for every family," which is the magic recipe for cost-effective health care for all: Viewpoint. Journal of Nature and Science of Medicine, 6, 95–100. doi:10.4103/jnsm.jnsm_141_22
Albejaidi, F., & Alharbi, A. (2024). Analyzing the Technological Framework for E-Health in the Kingdom of Saudi Arabia. 2024 11th International Conference on Computing for Sustainable Global Development (INDIACom), 1822–1827. doi:10.23919/INDIACom61295.2024.10498725
Alasiri, A. A., & Mohammed, V. (2022). Healthcare Transformation in Saudi Arabia: An Overview Since the Launch of Vision 2030. Health Services Insights, 15. doi:10.1177/11786329221121214
Al-Anezi, F. (2020). Potential Benefits and Challenges Associated with the Adoption of Mobile health (m-health) in Kingdom of Saudi Arabia. 2020 19th International Symposium on Distributed Computing and Applications for Business Engineering and Science (DCABES), 323–327. doi:10.1109/DCABES50732.2020.00089

Alojail, M., Alshehri, J., & Khan, S. (2023). Critical Success Factors and Challenges in Adopting Digital Transformation in the Saudi Ministry of Education. Sustainability. doi:10.3390/su152115492
Aljohani, N., & Chandran, D. (2019). Adoption of M-Health Applications: The Saudi Arabian Healthcare Perspectives. 19. Retrieved from https://consensus.app/papers/adoption-of-mhealth-applications-the-saudi-arabian-aljohani-chandran/7129986227185b4e81fcd25455366681/
Kostkova, P. (2015). Grand Challenges in Digital Health. Frontiers in Public Health, 3. doi:10.3389/fpubh.2015.00134
Kumar, R. (2023). Application of digital technologies in primary healthcare: Opportunities & challenges. The Indian Journal of Medical Research, 157, 276–279. doi:10.4103/ijmr.ijmr_3056_21
Aldaweesh, S. (2024). Understanding Challenges and Design Opportunities for Digital Mental Well-Being in Saudi Arabia. Extended Abstracts of the CHI Conference on Human Factors in Computing Systems. doi:10.1145/3613905.3638189
Radwan, H., Alsharif, A., Alsharif, M., Aloufi, M., & Alshammari, B. (2023). Digital technologies in dentistry in Saudi Arabia: Perceptions, practices and challenges. Digital Health, 9. doi:10.1177/20552076231197095
Salem, M. A., Alsyed, W. H., & Elshaer, I. (2022). Before and Amid COVID-19 Pandemic, Self-Perception of Digital Skills in Saudi Arabia Higher Education: A Longitudinal Study. International Journal of Environmental Research and Public Health, 19. doi:10.3390/ijerph19169886
Aldekhyyel, R., Alhumaid, N., & Alismail, D. (2024). Saudi Women's Views on Healthcare Leadership in the Era of Saudi 2030 Health Transformation. Journal of Multidisciplinary Healthcare, 17, 237–249. doi:10.2147/JMDH.S439146
Asem, A., Y, Ousif Al Ghofaili Abdullah, Mohammad, A. A., & Ziyad, I. A. (2024). Navigating Digital Transformation in Alignment with Vision 2030: A Review of Organizational Strategies, Innovations, and Implications in Saudi Arabia. Journal of Knowledge Learning and Science Technology ISSN: 2959-6386 (Online). doi:10.60087/jklst.vol3.n2.p29
Rawash, A., & Abdelrahman, M. (2022). Digital Transformation of the Health Sector During the Covid-19 Pandemic in Saudi Arabia. International Journal of Computer Science & Engineering Survey. doi:10.5121/ijcses.2022.13401
Albejaidi, Fahad, & Nair, K. (2021). Addressing the Burden of Non-communicable Diseases: Saudi Arabia's Challenges in Achieving Vision 2030. Journal of Pharmaceutical Research International. doi:10.9734/JPRI/2021/v33i35A31871
Islam, Q., & Khan, S. M. F. A. (2024). Sustainability-Infused Learning Environments: Investigating the Role of Digital Technology and Motivation for Sustainability in Achieving Quality Education. International Journal of Learning, Teaching and Educational Research. doi:10.26803/ijlter.23.1.25