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DIGITAL HEALTH TECHNOLOGY INTEGRATION AND HEALTHCARE MANAGEMENT EFFICIENCY: ORGANIZATIONAL READINESS AND INNOVATION CAPABILITY AS MEDIATORS IN SAUDI HEALTHCARE SYSTEMS
A PLS-SEM Study of the Riyadh Second Health Cluster

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ABSTRACT

Digital health transformation is reshaping healthcare systems globally. Despite substantial investment in digital infrastructure across Saudi Arabia under Vision 2030, empirical evidence linking technology integration to improved healthcare management efficiency remains limited. This study investigates the direct and indirect mechanisms through which digital health technology integration influences healthcare management efficiency, with digital transformation readiness and innovation capability as hypothesized mediators. A cross-sectional quantitative survey was administered to 384 healthcare professionals across hospitals and primary care centers in the Riyadh Second Health Cluster (R2). Validated measurement scales comprising 35 reflective items were employed. Partial Least Squares Structural Equation Modeling (PLS-SEM) was applied using SmartPLS to evaluate both the measurement model (reliability, convergent and discriminant validity) and the structural model (path coefficients, R^2, Q^2, and mediation effects via bootstrapping with 5,000 resamples). Technology integration demonstrated a significant direct positive effect on healthcare management efficiency ($\beta = 0.29$, $p < 0.001$). It also strongly predicted digital transformation readiness ($\beta = 0.63$, $p < 0.001$) and innovation capability ($\beta = 0.58$, $p < 0.001$). Both organizational capabilities significantly enhanced management efficiency (DTR: $\beta = 0.41$, $p < 0.01$; IC: $\beta = 0.37$, $p < 0.01$). Mediation analysis confirmed that both pathways were statistically significant (indirect via DTR: $\beta = 0.15$, $p < 0.001$; indirect via IC: $\beta = 0.11$, $p = 0.002$). The model explained 47% of variance in healthcare management efficiency ($R^2 = 0.47$) with strong predictive relevance ($Q^2 = 0.31$). Digital health technologies alone are insufficient to drive operational improvements. Their impact on healthcare management efficiency is substantially amplified when healthcare organizations cultivate digital transformation readiness and innovation capability. These findings underscore the necessity of holistic, capability-driven digital transformation strategies aligned with Saudi Arabia's Vision 2030 healthcare reform agenda.

KEYWORDS: Digital Health; Health Informatics; Technology Integration; PLS-SEM; Digital Transformation Readiness; Innovation Capability; Healthcare Management Efficiency; Saudi Arabia; Vision 2030.

1. INTRODUCTION

The global healthcare sector is undergoing an unprecedented digital transformation, driven by rapid advances in information and communication technologies and growing demands for more efficient, patient-centered, and evidence-based care delivery. Electronic health records (EHRs), telemedicine platforms, artificial intelligence-assisted clinical decision support systems, and integrated health information exchanges have become foundational elements of modern healthcare infrastructure. These technologies are increasingly recognized for their potential to improve operational coordination, reduce administrative redundancies, strengthen patient safety mechanisms, and support data-driven clinical decision-making across complex healthcare ecosystems.

Recent global health crises, most notably the COVID-19 pandemic, served as powerful catalysts accelerating the shift toward digital health solutions. Healthcare systems that had invested in robust digital infrastructure demonstrated greater resilience, enabling real-time disease surveillance, remote patient monitoring, and rapid clinical communication during periods of extraordinary demand. Despite these advantages, however, a persistent gap has been observed between technology adoption and realized improvements in healthcare management efficiency. A growing body of evidence suggests that the mere implementation of digital tools does not automatically yield operational performance gains; rather, the organizational context within which these technologies are deployed plays a decisive role in determining their impact.

Two organizational capabilities have emerged as particularly critical in this regard: digital transformation readiness and innovation capability. Digital transformation readiness encompasses an organization's preparedness for adopting and leveraging digital technologies, including its technological infrastructure, leadership commitment, workforce competencies, and strategic alignment with digital governance frameworks. Innovation capability, by contrast, refers to an organization's ability to generate, adopt, and operationalize novel solutions in response to evolving healthcare delivery challenges. Together, these capabilities shape whether digital investments are effectively translated into sustainable improvements in healthcare management performance.

Saudi Arabia presents a highly relevant and timely context for examining these relationships. Under the national Vision 2030 Health Sector Transformation Program, the Kingdom has committed to substantial investments in digital health infrastructure, with the explicit goal of modernizing healthcare delivery, improving operational efficiency, and elevating patient care standards across public health institutions. As part of this initiative, regional health clusters, including the Riyadh Second Health Cluster (R2), have been established to integrate digital health systems across networks of hospitals and primary healthcare centers, fostering improved care coordination and resource allocation.

Despite these ambitious reforms, empirical investigation of how digital health technology integration translates into measurable improvements in healthcare management efficiency at the institutional level in Saudi Arabia remains limited. Existing research has predominantly focused on technology adoption patterns, system usability, and healthcare professionals' attitudes toward digital health platforms. Comparatively little attention has been directed toward the organizational mechanisms, specifically the mediating roles of digital transformation readiness and innovation capability, that govern the relationship between technology integration and efficiency outcomes.

Addressing this gap carries both theoretical and practical significance. Theoretically, the study contributes to the literature on healthcare information systems and digital health governance by empirically examining how organizational capabilities mediate the technology-performance relationship within a socio-technical framework. Practically, the findings offer actionable guidance for healthcare policymakers and hospital administrators seeking to design more effective digital transformation strategies, particularly within the Saudi healthcare context.

Accordingly, the objectives of this study are: (1) to examine the direct effect of digital health technology integration on healthcare management efficiency; (2) to assess the mediating roles of digital transformation readiness and innovation capability in this relationship; and (3) to provide evidence-based recommendations for advancing digital transformation initiatives in Saudi healthcare institutions. The study employs Partial Least Squares Structural Equation Modeling (PLS-SEM) to test a conceptual model linking digital infrastructure, organizational capabilities, and management efficiency outcomes among healthcare professionals in the Riyadh Second Health Cluster.

2. CONCEPTUAL FRAMEWORK AND HYPOTHESIS DEVELOPMENT

2.1 Theoretical Foundation

This study draws upon socio-technical systems (STS) theory as its overarching theoretical

foundation. STS theory posits that organizational performance emerges from the dynamic interdependence between technological infrastructure and human and organizational elements. In healthcare settings, this implies that the effectiveness of digital health systems is jointly determined by the technical quality of the systems themselves and the organizational environment in which they are embedded, encompassing workforce competencies, leadership orientation, institutional culture, and strategic governance.

This theoretical lens is particularly well-suited to the study of digital health transformation, where technologies such as EHRs, clinical decision support systems, and telemedicine platforms are deeply embedded in complex clinical and administrative workflows. Consistent with STS theory, this study proposes that technology integration serves as the technical dimension, while digital transformation readiness and innovation capability represent the complementary organizational dimensions. It is the interplay of these dimensions that ultimately determines whether digital investments yield improvements in healthcare management efficiency.

The socio-technical perspective also informs the choice of mediation analysis as a primary analytical strategy. Rather than examining technology integration as a direct, independent driver of efficiency, the study conceptualizes organizational capabilities as essential enabling conditions that shape the magnitude and sustainability of technology-driven performance improvements.

2.2 Technology Integration and Healthcare Management Efficiency (H1)

Technology integration is defined in this study as the degree to which digital tools and information systems are systematically incorporated into healthcare clinical and administrative operations. This encompasses EHRs, digital communication platforms, clinical decision support systems, and telemedicine applications. A well-integrated digital health ecosystem enables healthcare providers to access real-time clinical information, streamline patient flow management, reduce service duplication, and allocate resources more effectively across facilities.

The extant literature consistently demonstrates that technology integration is positively associated with healthcare management efficiency. Digitally integrated systems reduce administrative burden, enhance cross-departmental communication, and support evidence-based decision-making at both clinical and managerial levels. When digital tools are seamlessly embedded into existing workflows, healthcare organizations can realize meaningful improvements in operational efficiency, patient safety, and service quality.

H1: Technology integration has a significant positive direct effect on healthcare management efficiency.

2.3 Technology Integration and Digital Transformation Readiness (H2)

Digital transformation readiness captures an organization's capacity to prepare for, manage, and sustain digital change. This capacity encompasses adequate technological infrastructure, digitally literate and trained workforce, supportive leadership, and coherent digital governance structures. Healthcare organizations that actively pursue technology integration typically invest in the organizational conditions necessary to support this integration, including workforce development programs, digital governance frameworks, and leadership engagement in digital strategy formulation.

This relationship is reciprocally reinforcing: investment in technology integration stimulates organizational readiness by creating new demands for digital competency and institutional support, while higher levels of readiness facilitate more comprehensive and effective technology integration. Prior research suggests that establishing digital infrastructure tends to trigger broader organizational transformations that build digital transformation capability over time.

H2: Technology integration has a significant positive effect on digital transformation readiness.

2.4 Digital Transformation Readiness and Healthcare Management Efficiency (H3)

Digital transformation readiness directly influences an organization's capacity to derive operational benefits from its digital investments. Readiness-mature healthcare institutions are characterized by committed digital leadership, well-equipped technological infrastructure, and a workforce equipped with the skills to leverage digital systems effectively in clinical and administrative workflows. These attributes enable organizations to embed digital technologies deeply within routine operational processes, eliminating redundancies, improving clinical communication, and enhancing patient management outcomes.

Organizations with higher levels of digital transformation readiness are better positioned to implement digital tools coherently, sustain adoption over time, and scale digital initiatives across

institutional boundaries. This translates into measurable improvements in healthcare management efficiency, including faster clinical decision cycles, more effective resource utilization, and improved coordination across care teams.

H3: Digital transformation readiness has a significant positive effect on healthcare management efficiency.

2.5 Innovation Capability and Healthcare Management Efficiency (H4)

Innovation capability reflects an organization's sustained ability to generate, adopt, and operationalize new ideas, processes, or technologies in ways that enhance service delivery and organizational performance. In healthcare settings, innovation capability empowers institutions to redesign clinical workflows, develop novel digital health applications, and continuously adapt technological solutions to evolving operational needs and local contextual conditions.

Organizations with strong innovation capabilities are also more resilient in overcoming barriers to technology implementation, possessing the organizational agility to identify and resolve workflow disruptions, engage stakeholders effectively, and sustain momentum through the inherent challenges of digital transformation. Empirical evidence consistently identifies innovation-oriented organizational cultures as key determinants of successful digital transformation and superior operational performance in healthcare systems.

H4: Innovation capability has a significant positive effect on healthcare management efficiency.

2.6 Mediating Role of Digital Transformation Readiness (H5)

Digital transformation readiness is hypothesized to mediate the relationship between technology integration and healthcare management efficiency. Healthcare organizations that integrate digital technologies typically develop readiness capabilities in parallel, including workforce training, infrastructure investment, and digital leadership engagement. These readiness capabilities, in turn, provide the institutional foundations necessary for effective utilization of digital systems in operational practice.

This mediated pathway reflects a theoretically coherent mechanism: technology integration creates the impetus and institutional context for building digital readiness, which subsequently enables organizations to extract greater efficiency benefits from their digital investments. Partial mediation is expected, as direct effects of technology integration on efficiency are also anticipated.

H5: Digital transformation readiness significantly mediates the relationship between technology integration and healthcare management efficiency.

2.7 Mediating Role of Innovation Capability (H6)

Innovation capability is similarly hypothesized to mediate the technology integration-efficiency relationship. Digital technologies expand the opportunity space for organizational innovation by providing new data sources, communication channels, and process automation capabilities. However, organizations can only capitalize on these opportunities if they possess the capacity to innovate, including the ability to redesign workflows, experiment with new digital health delivery models, and foster collaborative problem-solving among multidisciplinary clinical and administrative teams.

Without adequate innovation capability, digital technologies may remain underutilized or poorly adapted to local operational realities. Conversely, organizations with high innovation capability can translate digital investments into sustained operational improvements, creating a virtuous cycle of digital adoption and performance enhancement.

H6: Innovation capability significantly mediates the relationship between technology integration and healthcare management efficiency.

2.8 Conceptual Model

Consistent with the foregoing hypotheses, the study proposes a theoretically grounded structural model in which technology integration influences healthcare management efficiency both directly (H1) and indirectly via digital transformation readiness (H5) and innovation capability (H6). The model also captures the effects of technology integration on both mediators (H2, implicit in H5) and the direct contributions of each mediator to efficiency outcomes (H3, H4). The conceptual framework is illustrated in Figure 1.

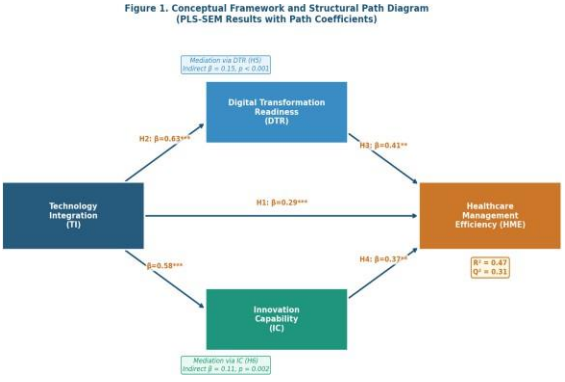

Figure 1. Conceptual Framework and PLS-SEM Structural Path Diagram with Empirical Path Coefficients

3. METHODOLOGY

3.1 Research Design

This study employs a quantitative cross-sectional survey design to examine the hypothesized structural relationships among technology integration, digital transformation readiness, innovation capability, and healthcare management efficiency. Cross-sectional quantitative designs are widely used in healthcare management and health information systems research, enabling systematic testing of theoretical models and statistical estimation of relationships between latent constructs.

The proposed conceptual model was tested using Partial Least Squares Structural Equation Modeling (PLS-SEM), implemented in SmartPLS 4.0. PLS-SEM is particularly appropriate for studies involving complex models with multiple interrelated latent constructs and mediating pathways, and is especially well-suited to exploratory and predictive research objectives. It has been extensively applied in digital health and healthcare management research, offering robust handling of small-to-medium sample sizes relative to covariance-based SEM alternatives.

3.2 Study Setting and Population

The study was conducted across institutions affiliated with the Riyadh Second Health Cluster (R2), Saudi Arabia, a major integrated healthcare network established under the Vision 2030 Health Sector Transformation Program. The cluster encompasses King Fahad Medical City (KFMC), Prince Mohammed Bin Abdulaziz Hospital (PMAH), Al-Yamamah Hospital, and numerous primary healthcare centers (PHCs). These institutions collectively represent a sophisticated digital health ecosystem, relying extensively on EHRs, hospital information systems, and integrated digital management platforms.

The study population comprised healthcare professionals from clinical, administrative, and digital health roles who interact with digital healthcare technologies as part of their routine practice. Based on official statistics from the Saudi Ministry of Health and Riyadh Second Health Cluster, the total eligible workforce comprised approximately 7,819 professionals, distributed across four professional categories: Allied Health Professionals (38.32%), Physicians (34.19%), Nursing Staff (25.28%), and Health Informatics Specialists (2.21%).

3.3 Sampling Strategy and Sample Size

A stratified purposive sampling approach was employed to ensure representation from all key professional groups engaged in healthcare delivery and digital health system utilization. Sample size was determined using the Krejcie and Morgan (1970) formula applied to the total population of 7,819, yielding a minimum required sample of 367 respondents at a 95% confidence level and a 5% margin of error. A total of 402 questionnaires were returned (response rate: 87.4%), of which 384 valid responses were retained following data screening for completeness and quality.

3.4 Measurement Instrument

Data were collected using a structured, self-administered questionnaire comprising 45 items organized into five sections. Measurement items for the four latent constructs (technology integration, digital transformation readiness, innovation capability, and healthcare management efficiency) were adapted from established, previously validated scales in the digital health and organizational innovation literature. All construct items were measured using a five-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree).

A pilot study was conducted among 50 healthcare professionals from the R2 cluster prior to full-scale data collection. Cronbach's alpha values for all constructs ranged from 0.79 to 0.85, and all Content Validity Indices (CVI) exceeded the acceptable threshold of 0.80, confirming satisfactory reliability and content validity of the measurement instrument.

3.5 Analytical Approach

Data analysis followed the two-step PLS-SEM approach recommended by Hair et al. (2021). In Step 1, the measurement model was assessed for indicator reliability (outer loadings > 0.70), internal consistency reliability (Cronbach's alpha and composite reliability > 0.70), convergent validity (AVE > 0.50), and discriminant validity (Fornell– Larcker criterion and Heterotrait–Monotrait [HTMT] ratio < 0.85). In Step 2, the structural model was evaluated through path coefficients (β), bootstrapping with 5,000 resamples for significance testing, coefficient of determination (R^2), Stone– Geisser predictive relevance (Q^2), and mediation analysis via indirect effect estimation.

3.6 Ethical Considerations

The study was conducted in accordance with the ethical principles of the Declaration of Helsinki. All participant involvement was entirely voluntary. Respondents were fully informed of the study's purpose prior to questionnaire completion. All responses were anonymized, and no personally

identifiable information was collected or retained. Data were used exclusively for academic research purposes.

4. RESULTS

4.1 Sample Characteristics

Of 460 questionnaires distributed, 402 were returned (response rate: 87.4%), and 384 valid responses were retained for analysis. The sample comprised Allied Health Professionals (n = 138; 35.9%), Physicians (n = 128; 33.3%), Nurses (n = 101; 26.3%), and Health Informatics Specialists (n = 17; 4.5%). The sample composition closely mirrors the professional distribution of the R2 workforce, supporting the representativeness of the study sample. Figure 2 presents the demographic profile of respondents.

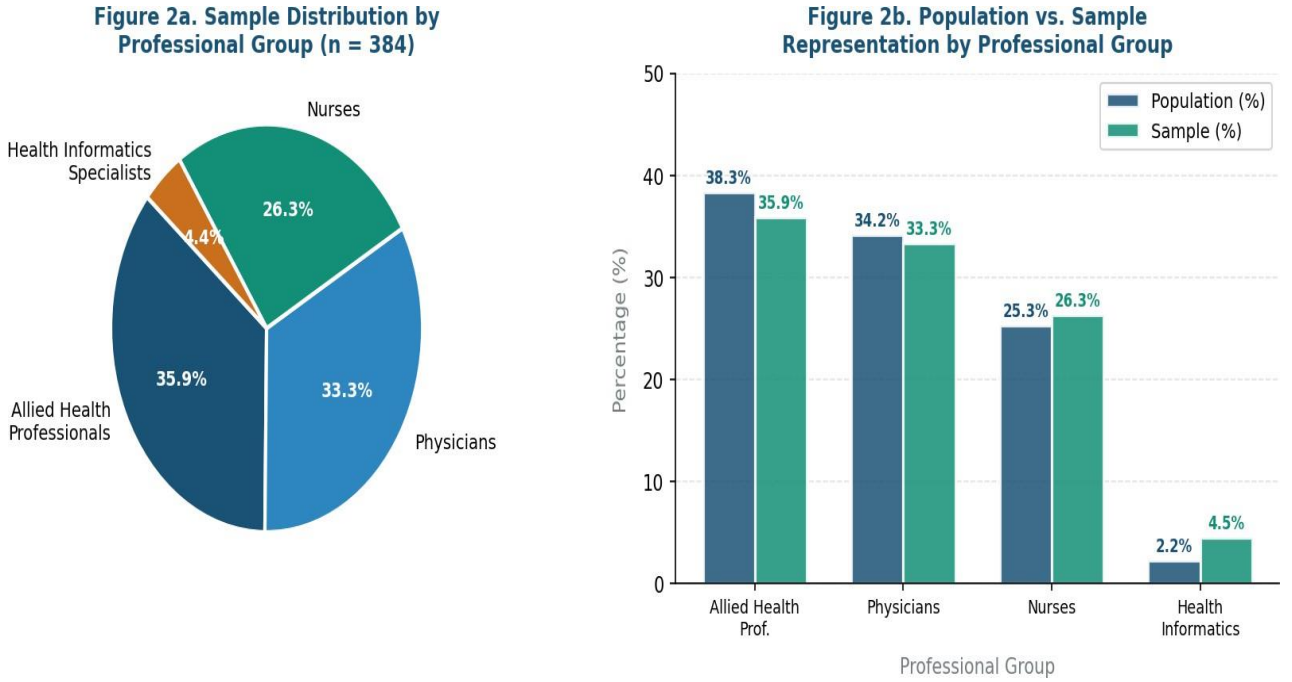

Figure 2. Demographic Profile: (a) Sample Distribution by Professional Group; (b) Population vs. Sample Proportional Representation

Table 1. Demographic Characteristics of Respondents (n = 384)

Professional Group	Frequency	Percentage (%)
Allied Health Professionals	138	35.9%
Physicians	128	33.3%
Nurses	101	26.3%
Health Informatics Specialists	17	4.5%
Total	**384**	**100.0%**

4.2 Measurement Model Evaluation

The measurement model was assessed systematically across four key psychometric criteria: indicator reliability, internal consistency reliability, convergent validity, and discriminant validity. All constructs met or exceeded established thresholds on each criterion, supporting the adequacy of the measurement model as a foundation for structural model analysis.

Indicator Reliability

All factor loadings exceeded the recommended threshold of 0.70, ranging from 0.70 to 0.91 across constructs, indicating that each indicator shared a substantial proportion of variance with its respective latent construct.

Internal Consistency Reliability

Cronbach's alpha coefficients ranged from 0.88 to 0.91, and composite reliability (CR) values ranged from 0.90 to 0.93, all exceeding the minimum acceptable threshold of 0.70. These results confirm strong internal consistency across all constructs.

Convergent Validity

Average Variance Extracted (AVE) values for all constructs exceeded the recommended threshold of 0.50 (range: 0.56–0.63), indicating that each construct accounts for a majority of the variance in its indicators. The combined measurement model results are presented in Table 2 and Figure 3.

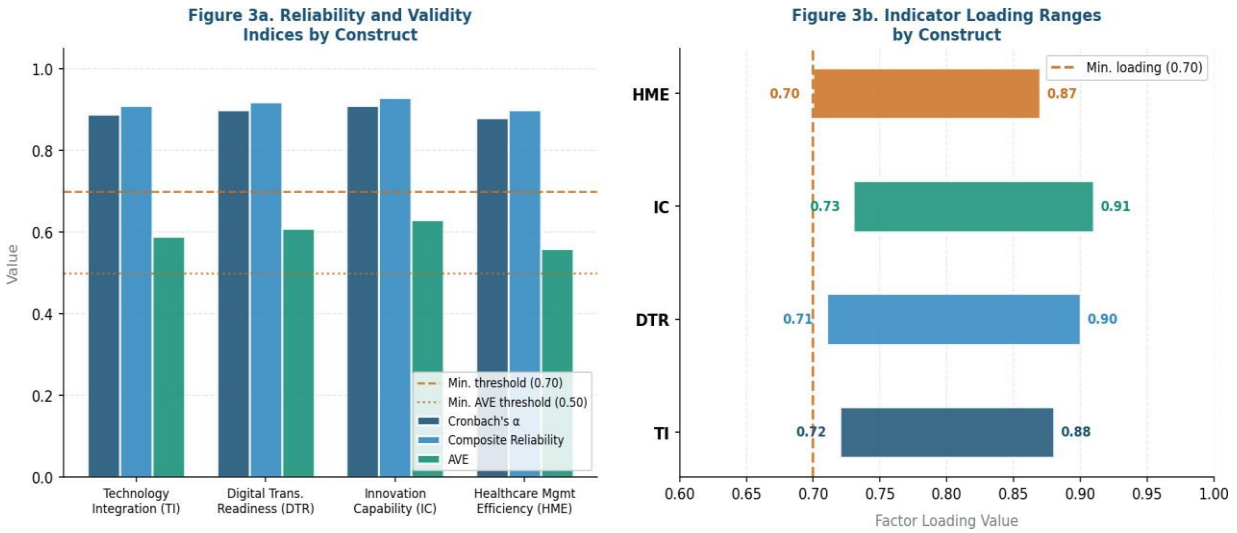

Figure 3. Measurement Model Results: (a) Reliability and Validity Indices by Construct; (b) Indicator Loading Ranges

Table 2. Measurement Model Results: Reliability and Convergent Validity

Construct	Items	Loading Range	Cronbach's α	CR	AVE
Technology Integration (TI)	8	0.72–0.88	0.89	0.91	0.59
Digital Transformation Readiness (DTR)	9	0.71–0.90	0.90	0.92	0.61
Innovation Capability (IC)	8	0.73–0.91	0.91	0.93	0.63
Healthcare Management Efficiency (HME)	10	0.70–0.87	0.88	0.90	0.56

Note: CR = Composite Reliability; AVE = Average Variance Extracted. All values meet recommended thresholds: loadings > 0.70; α and CR > 0.70; AVE > 0.50.

4.3 Discriminant Validity

Discriminant validity was assessed using both the Fornell–Larcker criterion and the Heterotrait–Monotrait (HTMT) ratio. As shown in Table 3 and Figure 6, the square root of AVE for each construct exceeded its highest inter-construct correlation, confirming adequate discriminant validity per the Fornell–Larcker criterion. Furthermore, all HTMT ratio values were below the recommended cutoff of 0.85 (range: 0.63–0.72), providing additional confirmation that the constructs are empirically distinct from one another.

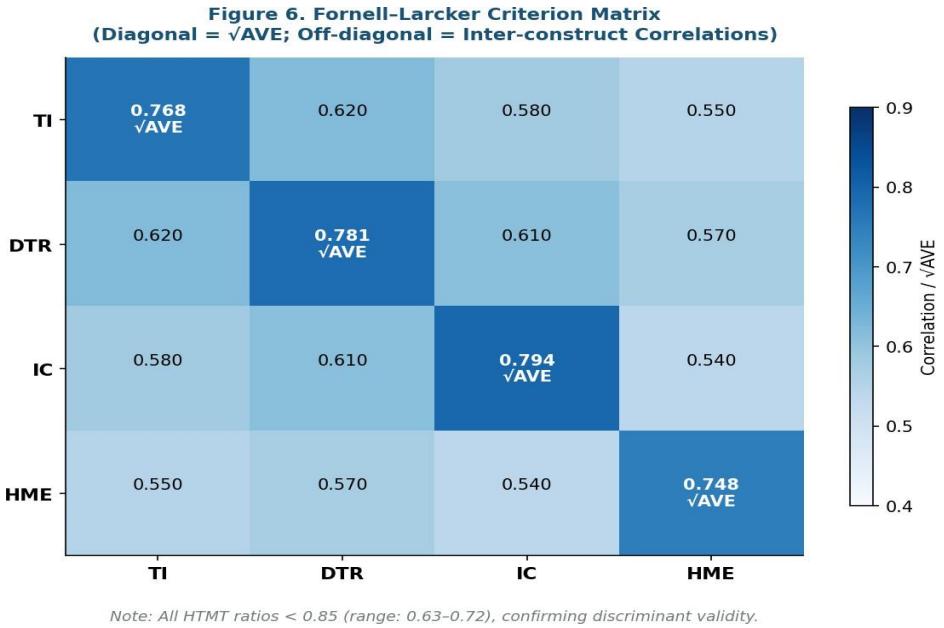

Figure 6. Fornell–Larcker Criterion Matrix (Diagonal = √AVE; Off-diagonal = Inter-construct Correlations; HTMT range: 0.63–0.72)

Table 3. Fornell–Larcker Criterion Matrix

Construct	TI	DTR	IC	HME
Technology Integration (TI)	**0.768***	0.620	0.580	0.550
Digital Transformation Readiness (DTR)	0.620	**0.781***	0.610	0.570
Innovation Capability (IC)	0.580	0.610	**0.794***	0.540
Healthcare Management Efficiency (HME)	0.550	0.570	0.540	**0.748***

** Diagonal values represent $\sqrt{AVE}$. All HTMT values < 0.85 (range: 0.63–0.72). Abbreviations: TI = Technology Integration; DTR = Digital Transformation Readiness; IC = Innovation Capability; HME = Healthcare Management Efficiency.*

4.4 Structural Model Results

Following confirmation of measurement model adequacy, the structural model was estimated to examine the hypothesized relationships among constructs. Path coefficients, t-statistics, and p-values were derived from bootstrapping with 5,000 resamples. The results are presented in Table 4 and Figure 4.

Technology integration demonstrated a significant positive direct effect on healthcare management efficiency (β = 0.29, t = 4.87, p < 0.001), supporting H1. Technology integration also exerted strong positive effects on digital transformation readiness (β = 0.63, t = 12.31, p < 0.001; H2) and innovation capability (β = 0.58, t = 10.74, p < 0.001). Furthermore, digital transformation readiness (β = 0.41, t = 6.53, p < 0.01; H3) and innovation capability (β = 0.37, t = 5.89, p < 0.01; H4) each demonstrated significant positive effects on healthcare management efficiency.

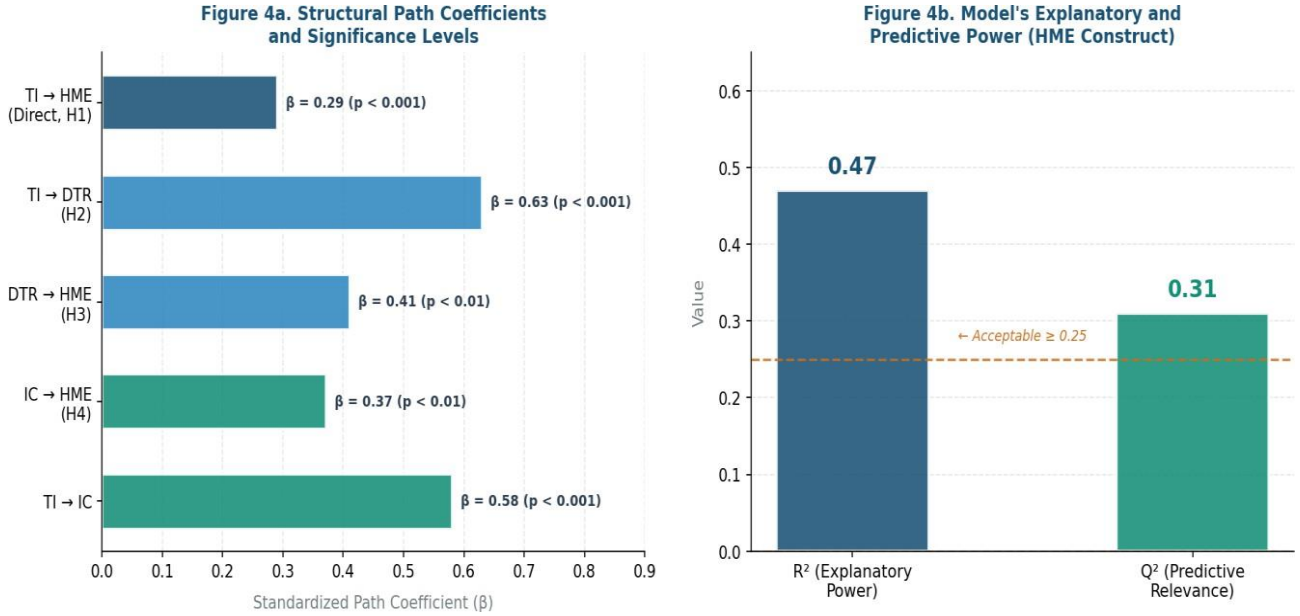

Figure 4. Structural Model Results: (a) Path Coefficients and Significance Levels; (b) Model Explanatory and Predictive Power

Table 4. Structural Model Path Coefficients (Bootstrapping, 5,000 Resamples)

H	Structural Path	β	t-Value	p-Value	Decision
H1	TI → HME (Direct)	0.29	4.87	< 0.001	**Supported**
H2	TI → DTR	0.63	12.31	< 0.001	**Supported**
H3	DTR → HME	0.41	6.53	< 0.01	**Supported**
H4	IC → HME	0.37	5.89	< 0.01	**Supported**
—	TI → IC	0.58	10.74	< 0.001	**Supported**

Note: β = standardized path coefficient; TI = Technology Integration; DTR = Digital Transformation Readiness; IC = Innovation Capability; HME = Healthcare Management Efficiency.

4.5 Explanatory Power and Predictive Relevance

The structural model explained 47% of the variance in healthcare management efficiency (R^2 = 0.47). This level of explanatory power substantially exceeds the commonly cited acceptable threshold of $R^2 \geq 0.25$ for behavioral and organizational research (Chin, 1998), indicating strong model fit and practical significance. The Stone–Geisser predictive relevance statistic (Q^2 = 0.31) exceeded zero, confirming that the structural model demonstrates meaningful predictive relevance for the endogenous construct of healthcare management efficiency.

4.6 Mediation Analysis

Mediation analysis was conducted using bootstrapping procedures (5,000 resamples) to estimate and test the statistical significance of the indirect effects of technology integration on healthcare management efficiency through the two proposed mediators. The results are summarized in Table 5 and Figure 5.

Digital transformation readiness was confirmed as a significant partial mediator of the technology integration–efficiency relationship (indirect β = 0.15, t = 3.94, p < 0.001), supporting H5. Similarly, innovation capability significantly mediated this relationship (indirect β = 0.11, t = 3.18, p = 0.002), supporting H6. The coexistence of significant direct and indirect effects indicates partial mediation through both organizational capability pathways.

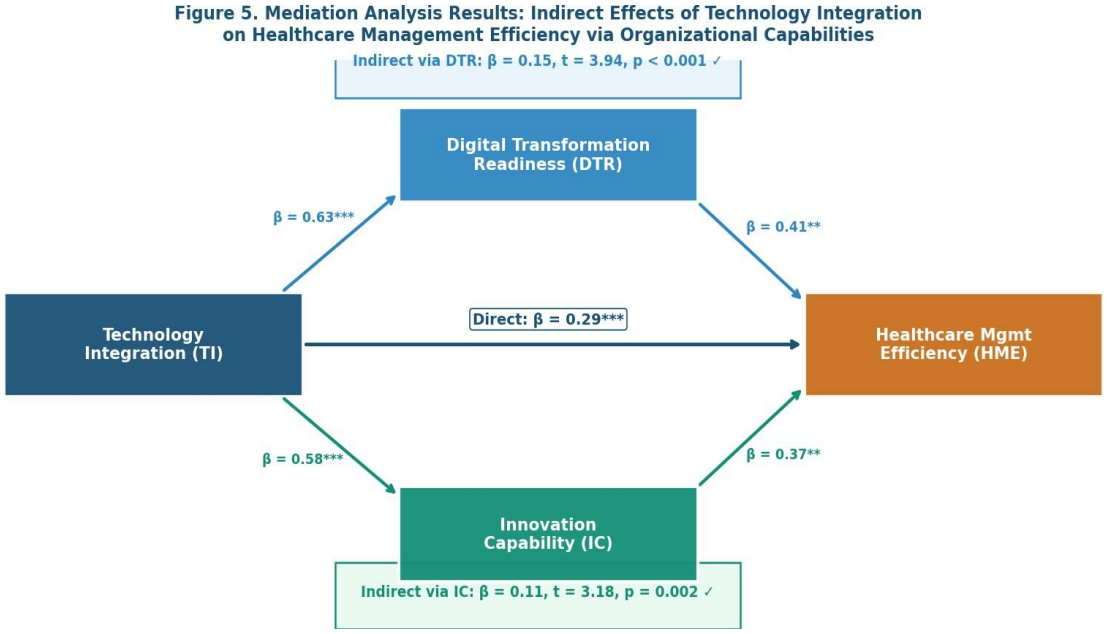

Figure 5. Mediation Analysis: Indirect Effects of Technology Integration on Healthcare Management Efficiency via Organizational Capabilities

Table 5. Mediation Analysis Results (Indirect Effects, Bootstrapping 5,000 Resamples)

H	Indirect Path	β	t-Value	p-Value	Decision
H5	TI → DTR → HME	0.15	3.94	< 0.001	Supported
H6	TI → IC → HME	0.11	3.18	0.002	Supported

Note: Both mediations are partial (significant direct path also retained). TI = Technology Integration; DTR = Digital Transformation Readiness; IC = Innovation Capability; HME = Healthcare Management Efficiency.

5. DISCUSSION

5.1 Interpretation of Structural Relationships

The findings confirm that technology integration exerts a significant positive direct effect on healthcare management efficiency, as hypothesized. This result is consistent with a substantial body of international evidence demonstrating that the systematic incorporation of digital health systems, including EHRs, clinical decision support tools, and telemedicine platforms, meaningfully enhances operational coordination, reduces administrative burden, and supports evidence-based decision-making in healthcare organizations. In the Saudi context, where significant investments have been directed toward digital health infrastructure under Vision 2030, this finding validates the operational rationale for these investments, confirming that technology integration yields tangible efficiency gains at the institutional level.

Technology integration also demonstrated strong positive effects on both digital transformation readiness (β = 0.63) and innovation capability (β = 0.58). These findings suggest that healthcare institutions engaged in active digital technology integration simultaneously build the organizational capabilities needed to sustain and deepen digital transformation. The particularly strong effect on digital transformation readiness indicates that technology integration serves as a powerful organizational catalyst, creating institutional demand for digital competency development, infrastructure investment, and leadership

engagement in digital governance, processes that collectively elevate an organization's capacity for further digital transformation.

Digital transformation readiness and innovation capability each demonstrated significant independent contributions to healthcare management efficiency. Readiness-mature organizations are better equipped to embed digital systems within routine clinical and administrative workflows, enabling more effective utilization of digital health platforms and translating technology adoption into measurable operational improvements. High-innovation organizations, in turn, possess the organizational agility to adapt digital technologies to local operational realities, redesign workflows around new digital capabilities, and sustain continuous improvement in healthcare delivery models.

5.2 Mediating Roles of Organizational Capabilities

The mediation analysis offers important insights into the mechanisms through which digital transformation produces efficiency gains in healthcare settings. The finding that both digital transformation readiness and innovation capability partially mediate the technology integration–efficiency relationship carries significant theoretical and practical implications.

From a theoretical perspective, these results reinforce the core proposition of socio-technical systems theory: that the performance impact of technological change depends fundamentally on the alignment between technical systems and organizational elements. Technology integration alone, in the absence of supporting organizational capabilities, produces suboptimal efficiency outcomes. It is the organizational capacity to prepare for, manage, and innovate around digital technologies that transforms technological investment into operational improvement.

From a practical perspective, the mediation findings imply that healthcare organizations must pursue a dual strategy: investing not only in digital infrastructure but also in the organizational capabilities that enable effective utilization of that infrastructure. Programs that develop digital leadership, strengthen workforce digital competencies, establish robust digital governance frameworks, and cultivate innovation-oriented organizational cultures are essential complements to technology investment in any comprehensive digital transformation strategy.

5.3 Theoretical Contributions

This study makes several theoretical contributions to the literature on digital health transformation and healthcare management. First, by empirically demonstrating that digital transformation readiness and innovation capability mediate the technology-efficiency relationship, the study extends existing digital transformation theory by identifying the specific organizational mechanisms through which technological investments are converted into operational performance improvements. This advances understanding beyond simplistic technology-adoption models and toward a more nuanced, capability-contingent conception of digital transformation.

Second, the study contributes to healthcare information systems research by validating and extending a socio-technical conceptual model in a complex real-world healthcare setting. The integrated framework linking technology integration, organizational capabilities, and management efficiency provides a theoretically grounded and empirically tested roadmap for studying digital health transformation across different institutional and national contexts.

Third, the application of PLS-SEM in a large-scale cross-sectional survey of Saudi healthcare professionals demonstrates the methodological utility of this approach for examining complex structural relationships in digital health research, contributing to the growing literature on quantitative methods in health informatics.

5.4 Practical Implications

The findings carry several actionable implications for healthcare administrators, policymakers, and digital health strategists, particularly within the Saudi Vision 2030 context.

First, healthcare organizations must recognize that digital technology investment, while necessary, is insufficient on its own to drive operational efficiency improvements. Realizing the full potential of digital health investments requires intentional organizational development efforts that cultivate digital transformation readiness, including workforce training programs, digital governance frameworks, and committed leadership engagement with digital reform agendas.

Second, fostering innovation capability should be treated as a strategic priority in digital transformation programs. This can be achieved through mechanisms such as establishing dedicated digital innovation units, incentivizing cross-disciplinary collaboration between clinical and IT professionals, creating safe spaces for workflow experimentation, and institutionalizing processes for capturing and scaling locally effective digital health

innovations.

Third, for policymakers implementing Vision 2030 healthcare reforms, the findings underscore the importance of aligning large-scale digital infrastructure investments with complementary workforce development and organizational learning initiatives. National and cluster-level digital transformation programs are more likely to achieve their intended efficiency objectives when they are designed as integrated capability-building programs rather than technology deployment exercises.

6. CONCLUSION

This study examined the direct and indirect effects of digital health technology integration on healthcare management efficiency within the Riyadh Second Health Cluster, Saudi Arabia. Employing PLS-SEM with a sample of 384 healthcare professionals, the analysis demonstrated that technology integration significantly and positively influences healthcare management efficiency both directly and indirectly through the mediating organizational capabilities of digital transformation readiness and innovation capability. All six hypotheses received empirical support. The structural model explained 47% of the variance in healthcare management efficiency and demonstrated strong predictive relevance.

These findings underscore a central and practically important conclusion: digital health technologies, while essential enablers of modern healthcare delivery, are not sufficient by themselves to produce sustainable improvements in healthcare management efficiency. Their impact is substantially amplified, and more reliably realized, when healthcare organizations proactively develop the organizational readiness and innovation capabilities needed to leverage digital investments effectively. This capability-contingent model of digital health transformation offers a theoretically grounded and empirically validated framework for guiding both research and practice in this rapidly evolving field.

The study contributes to the growing literature on digital health systems and medical informatics by providing rigorous structural evidence of the organizational mechanisms through which digital investments are translated into management efficiency outcomes. It also provides actionable guidance for healthcare administrators and policymakers pursuing digital transformation under the Saudi Vision 2030 healthcare reform agenda, emphasizing the necessity of holistic, capability- driven approaches to digital health transformation.

7. LIMITATIONS AND FUTURE RESEARCH

This study has several limitations that should be acknowledged. First, the cross-sectional research design precludes causal inference regarding the temporal dynamics of the relationships examined. Future longitudinal studies are needed to track how digital transformation capabilities and efficiency outcomes evolve over time within healthcare organizations.

Second, the study sample was drawn exclusively from institutions affiliated with the Riyadh Second Health Cluster, limiting the generalizability of findings to other regional health clusters or international healthcare systems. Future research should replicate and extend the study across multiple Saudi health clusters and in comparative international contexts to evaluate the generalizability of the proposed framework.

Third, the study relies exclusively on self-reported survey data, which is subject to potential response bias and common method variance. Future studies would benefit from triangulating survey data with objective operational performance indicators, administrative healthcare data, and qualitative institutional case studies.

Finally, future research should explore additional moderating and mediating variables that may influence the technology-efficiency relationship, including digital leadership styles, organizational culture dimensions, patient engagement in digital health platforms, and national regulatory environments. The development and validation of more granular measurement instruments for digital transformation readiness and innovation capability in healthcare-specific contexts would also strengthen future empirical work in this domain.

Declarations

Ethics Approval and Consent to Participate

This study was conducted in accordance with the ethical principles of the Declaration of Helsinki. approved by the Institutional Review Board of King Fahad Medical City, Riyadh, Saudi Arabia (IRB Ref: KFMC-26-077E). Participation was entirely voluntary. All respondents were informed of the study's objectives prior to questionnaire completion. All responses were anonymized, and no personally identifiable information was collected or retained. Data were used exclusively for academic research purposes.

Author Contributions

Conceptualization: Adel N. Alanazi, Akram A. A. Abdulsamad; Methodology: Adel N. Alanazi; Formal Analysis: Adel N. Alanazi; Writing – Original Draft: Adel N. Alanazi; Writing – Review & Editing: Akram A. A. Abdulsamad; Supervision: Akram A. A. Abdulsamad. All authors approved the final manuscript.

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Data Availability

The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

Competing Interests

The authors declare no competing interests.

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