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Digital Health Transformation, Safety Culture Governance, and Quality Performance: The Mediating Role of Employee Engagement in Multi-Specialty Hospitals

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Abstract: **Digital health transformation is seen as a strategic way forward to safer, more efficient and patient-centred care in hospitals; however, it is not well understood how the organisational mechanisms can facilitate the transformation of digital investments into quality performance. The integrated model proposed and validated in this study suggests that digital health transformation positively influences quality performance both directly and indirectly through the variable of employee engagement, while quality governance (safety culture) positively influences the relationship between digital health transformation and employee engagement, and directly influences quality performance. The framework is based on the theories of sociotechnical systems, high-reliability organisations, resource-based view, dynamic capabilities and Donabedian's structure-process-outcome logic. A cross sectional explanatory design was designed with 612 doctors, nurses, allied health professionals, administrators, quality professionals and digitally enabled healthcare professionals of 12 NABH accredited multi-specialty hospitals in India. Constructs were thought of as multi-dimensional organisational capabilities and were measured using multi-item scales which were established and/or derived from the literature. Partial least squares structural equation modelling with 10,000 bootstrap subsamples was used to assess the measurement and structural models. The relationships between digital health transformation and employee engagement ($\beta = .428$, $p < .001$), and between digital health transformation and quality performance ($\beta = .276$, $p < .001$), and between employee engagement and quality performance ($\beta = .357$, $p < .001$) were all positive. In addition to the direct path, a significant indirect path via employee engagement was found ($\beta = .153$, $p < .001$) consistent with complementary partial mediation. Safety culture governance had a positive direct relationship with quality performance ($\beta = .241$, $p < .001$), and a positive relationship between transformation and engagement (interaction $\beta = .124$, $p = .002$). The model explains 41.2% of the variance of engagement and 62.8% of the variance of quality performance. The study contributes an employee-centered perspective of the digital value creation in hospitals and shows that digital capability is related to better quality performance in the context of accountable safety governance. Practical implications are provided for boards of hospitals, quality leaders, digital transformation teams, accreditation and policy makers who would like to leverage technology to align workforce engagement and safety governance.**

Keywords: **Digital health transformation, employee engagement, safety culture governance, quality performance, multi-specialty hospitals, PLS-SEM, India, patient safety.**

1. INTRODUCTION

Whether it is an information technology or health-system strategy question is no longer the issue. Electronic health records (EHRs), clinical decision support, telehealth, analytics, automation, artificial intelligence and interoperable platforms and digital patient interfaces are now being used in clinical and administrative operations in hospitals. But, digitalisation isn't transformation. Transformation implies a series of strategic, governance, workflow, information architecture, workforce capability and organisational routine changes that are designed to change the way value is created and care is delivered via

digital technologies (Agarwal et al., 2010; Vial, 2019; Kraus et al., 2021; Stoumpos et al., 2023). Systematic studies of digital maturity in hospitals also show that the digital maturity transformation is not only about technology, but also about leadership, interoperability, data usage, skills and behaviour and about patient-centred design (Duncan et al., 2022; Cresswell et al., 2025). This broader context is especially pertinent in the context of the hospital setting, where technologies are deeply interdependent with other clinical systems, and where safety, professional judgement and cross-functional co-ordination are not independent of technology performance (Sittig & Singh, 2010; Baxter & Sommerville, 2011).

One process that is missing is that of employee engagement. Engagement is a positive state of work relatedness that is characterized as vigour, dedication and absorption (Schaufeli et al., 2002; Schaufeli et al., 2006). Engagement has been associated with performance and retention and discretionary effort within organisations (Harter et al., 2002; Saks, 2006). In the healthcare industry, a meta-analysis of the literature suggests that work engagement is positively associated with providing quality care to patients (Wee & Lai, 2022) and recent literature reviews indicate that leadership, resources, work design, professional environment and organisational support are important antecedents of work engagement (Aungsuroch et al., 2024). Digital transformation can thus help to improve quality through, amongst other things, timely information for employees, the avoidance of unnecessary friction, the creation of more learning opportunities and by facilitating more meaningful coordination. However, if digital transformation is not accompanied by involvement and capacity development, it can also result in documentation overload and role confusion and resistance to digital transformation (Cresswell & Sheikh, 2013; Gjellebæk et al., 2020). The quality results of transformation should, therefore, be linked to psychological and behavioural factors of the interaction with redesigned work.

This integration is especially pertinent in the Indian context. The objectives of Ayushman Bharat Digital Mission are to create an interoperable, inclusive and secure digital health ecosystem (National Health Authority [NHA], 2026) and the infrastructure, digital readiness, capability and governance of Indian hospitals are highly variable. As per a recent systematic review (Inampudi et al., 2024), technological infrastructure, cost, privacy, data security, skills, communication and implementation constraints are known challenges, which continue to hinder digital transformation in India. Meanwhile, patient-safety studies in India continue to show that there are variations in the scores of the safety-culture dimensions and staff groups (Boora et al., 2021; Tadia et al., 2025). Therefore, the need of the hour is to come up with an explanatory model which can integrate the digital capability, employee responses, safety governance and multidimensional quality performance in Indian multi-specialty hospitals.

2. REVIEW OF THE EXISTING LITERATURE AND RESEARCH GAPS

Table 1. Thematic synthesis of literature and gaps in the literature

Theme	Representative evidence	What is established	The aim of this study is to address the following gap:
Digital health transformation	Kraus et al. (2021); Duncan et al. (2022); Stoumpos et al. (2023); Snowdon, Hussein, Danforth, et al. (2024); Snowdon, Hussein, Olubisi, et al. (2024); Cresswell et al. (2025)	Maturity is a mix of strategy, interoperability, governance, people and analytics and patient-centred use – the more mature the better the safety and experience.	There is a lack of under-explanation in studies on technology, in terms of employee and governance mechanisms.
Safety culture / governance	Almutairi et al. (2022); Alabdullah & Karwowski (2024); Vibe et al. (2024); Finn et al. (2024); Kyriakeli et al. (2025)	Safety is a common theme throughout, which is led by leadership, teamwork, learning, communication and response to error.	In the case of safety, it is more a climate/culture issue, formal accountability and governance are not as intertwined with digital transformation.
Quality performance	Donabedian (1988), Institute of Medicine (2001), World Health Organization et al. (2018), Snowdon, Hussein, Danforth, et al. (2024), Snowdon, Hussein, Olubisi, et al. (2024).	Quality is multi-dimensional, and is related to structure, process and outcomes.	Many empirical studies have limited endpoints and this limits the interpretation of the performance of organisations.

Employee engagement	Schaufeli et al. (2006); Wee & Lai (2022); Aungsuroch et al. (2024); Luo et al. (2024); Ibrahim et al. (2026)	Care quality is related to engagement which is influenced by job and organisational resources.	There is a lack of regular assessment of digital capability to quality and engagement in the hospital.
Indian hospital context	Boora et al. (2021); Inampudi et al. (2024); Tadia et al. (2025); NHA (2026); NABH (n.d.)	There is varied safety culture, infrastructure, skills and privacy and implementation barriers are developing.	Low level integrated evidence from multi-specialty hospitals with a NABH accreditation.

The authors compiled the information from the literature cited to make up the table.

2.1 Digital Health Transformation

Digital health transformation is often talked about in terms of the technologies themselves – like electronic records, telemedicine, artificial intelligence and patient portals – but this technology-centric approach can mask the organisational capability needed to embed technologies in work. Kraus et al. (2021) showed that there are themes in the research on healthcare transformation, such as operational efficiency, patient-centred models, organisational factors, workforce practices and socio-economic issues. Even as digital applications continue to grow, acceptance and organisational context are still key, as Stoumpos et al. (2023) demonstrate. The synthesis by Duncan et al. (2022) is especially helpful in that it outlines seven dimensions of maturity that are consistent across hospitals: strategy, information-technology capability, interoperability, governance and management, patient-centred care, people and skills and data analytics. Cresswell et al. (2025) show that the interoperability themes that are also converging in national hospital maturity approaches are: interoperability, strategic use and organisational capability. These studies support the notion that transformation is a higher order capability, across the organisation, rather than the number of technologies that are adopted.

2.2 Safety Culture and Safety Culture Governance

The study thus views safety culture governance and safety culture as a perceptual climate as being different. Governance is about systems and processes that ensure that safety expectations become a routine in the organisation: accountability of the board and executive, explicit safety policies, risk controls, compliance systems, incident reporting, learning loops and performance monitoring. High reliability scholarship is what helps to explain this difference. Reliable organisations (Weick et al., 1999; Weick & Sutcliffe, 2007) have the following features: collective mindfulness, sensitivity to operations, reluctance to simplify, preoccupation with failure and resilience. To achieve a high level of reliability in hospitals, it is important to have leadership systems in place that enable learning and disciplined response to weak signals (Chassin & Loeb, 2013; Vogus & Sutcliffe, 2007). Safety-culture interventions that focus on improving teamwork, leadership and just culture have a positive impact on staff outcomes (Finn et al., 2024), and positive hospital safety culture is associated with reduced hospital-acquired conditions and improved value-based purchasing performance (Noghrehchi, Hefner, Stegall, et al., 2024; Noghrehchi, Hefner, & Walker, 2024). Thus, it is assumed that governance will have a direct impact on quality, and will help shape the sense of security, assistance and significance of digital transformation.

2.3 Quality Performance

Quality in health care has several aspects. Donabedian's (1966, 1988) structure-process-outcome model contributed to the understanding of the importance of organisational conditions, care processes, as well as outcomes, for quality. The Institute of Medicine (2001) later defined high quality care as being safe, effective, patient-centred, timely, efficient and equitable and the World Health Organization, OECD and World Bank (2018) later added quality as a requirement for universal health coverage, which is a system-wide requirement. Patient experience is added to the Triple Aim (Berwick et al., 2008), and population outcomes is added to the Triple Aim to create the Quadruple Aim (Bodenheimer & Sinsky, 2014). However, hospital studies often only track a few clinical outcomes or satisfaction with the hospital. A more general organisational quality construct is used in the present study which includes clinical quality, service quality, patient safety, operational efficiency, patient experience and innovation/organisational effectiveness. This is a reflection of quality of care at the time and a hospital's capacity to continue to improve.

2.4 Employee Engagement

Employee engagement is the behavioural connection between the resources of the organisation and the performance. Kahn (1990) proposed that engagement involves the physical, cognitive and emotional involvement in work roles. Vigour,

dedication and absorption (Schaufeli et al., 2002, 2006) is the most prevalent way of measuring work engagement. Job demands can lead to strain, if they are too high, whereas job resources can lead to a motivational process, which then results in engagement and performance (Bakker & Demerouti, 2007, 2017). The same goes for work in the digital landscape: good systems can be a resource, bad systems can be an additional demand, when it comes to accessing information, coordinating, autonomy and feedback.

The large amount of evidence is complemented by other research. Marques and Ferreira (2020) tell the story of the long journey of digital transformation in the health sector and Kim and Moon (2021) show how safety culture is related to compliance with bloodborne-pathogen prevention. Cultural competency in the hospital is related to the patient-safety culture attributes as shown by Upadhyay et al. (2022) which shows that safety norms are a subset of broader organisational capacities. The selection of digital, cultural and workforce factors as mutually embedded and not separate factors are informed by all of these studies.

2.5 Gaps in the integrated research and Indian context

The evidence when taken together leads to seven gaps. One is that digital transformation and safety culture and quality often are considered in isolation and separately, resulting in disjointed explanations. Second, a significant percentage of digital-health research is direct transformation-performance oriented and the employee mechanism is implicit. Third, safety research is concerned simply with the culture scores, and not the governance systems that have expectations for safety. Fourth, there are many studies on the technology level of digital-health, instead of organisation level maturity. Fifth, the quality of hospital care is often measured by a single or at most, a couple of endpoints, and in reality is multi-dimensional. Sixth, although there has been a major leap towards digitalisation in the healthcare sector in India in terms of policy, there is not much evidence with multi-specialty hospitals that have been NABH accredited. Seventh, there is still a high usage of cross-sectional regression, correlation and descriptive analysis in healthcare research, and mediation, moderation and prediction can be analyzed in a single structural model. The proposed model fills these gaps by providing an explanatory pathway and a governance boundary condition, instead of a new and straightforward technology-performance association.

3. THEORETICAL FOUNDATION AND HYPOTHESIS

No single theory exists that explains this phenomenon of the use of digital technology and employee motivation in relation to the governance of safety and quality of healthcare. The sociotechnical systems theory is therefore adopted as the primary integrating lens, with the high-reliability organisation theory as the lens to explain the safety-governance boundary condition and three additional lenses of resource-based view, dynamic capabilities theory and Donabedian's framework as complementary lenses to the performance.

3.1 Sociotechnical Systems Theory

The theory of sociotechnical systems is based on the idea that the effectiveness of an organisation is reliant on the simultaneous optimisation of social and technical subsystems and not on technology alone (Trist & Bamforth, 1951). This is evident in the current health-informatics applications which embed hardware and software within individuals, processes, workflows, organisational policies and external rules and monitoring processes (Sittig & Singh, 2010; Baxter & Sommerville, 2011). Therefore the digitally mature hospital should be able to create value by using technology in a manner that is appropriate for their professional roles, information needs and collaboration processes. This alignment can lead to higher employee energy and commitment as there is less friction that is avoidable, better visibility of information, learning and improvement, and an increased sense of capability. On the other hand, very advanced systems might not work out due to the fact that they generate unworkable workflows or they decrease expert control. With this as a foundation, digital health transformation will be able to enhance employee engagement.

3.2 Resource Based View (RBV) and Dynamic Capabilities (DC) theories

Continued performance is based on the valuable, rare and difficult to imitate organisational resources as per the resource based view (Barney, 1991). Digital infrastructure is now readily available and will not be enough for sustainable competitive edge. It's the configuration of technology and human capabilities, routines and governance that is important. The dynamic capabilities theory brings in the ability to sense opportunities, seize them and reconfigure resources as environments change (Teece et al., 1997; Teece, 2007). A digital maturity combined with discretional effort and adaptive behaviour from the engaged employees can help hospitals learn quickly, perform analytics, coordinate and redesign processes. So, the digital transformation should have a direct impact on quality – through information and processes – and indirect impact through mobilising an engaged workforce.

3.3 High Reliability Organisation Theory and Safety Governance

High-reliability organisation theory helps to understand why the impact of digital transformation on employees needs to change as a result of the strength of safety governance. High-reliability systems focus on attending to failure, on the frontline knowledge, on sensitivity and on resilient responses (Weick et al., 1999; Weick & Sutcliffe, 2007). By communicating the importance of safety, providing non-punitive reporting options, making risk monitoring and responding to concerns public, employees can view digital change as a safer way to work, not monitoring or a heavier workload. Psychological safety can also be used as employees will be more involved if they are able to speak up and learn and error disclosure (Edmondson, 1999). Hence, it is crucial to have a good safety culture governance that can reinforce the positive pathway of digital transformation engagement. Strengthening prevention, learning, accountability and compliance (Singer & Vogus, 2013; Chassin & Loeb, 2013) should also have a direct impact on quality through the same governance practices.

3.4 Donabedian Structure–Process–Outcome Logic

Donabedian's is the final logic that pertains to health care. Digital capability and safety governance are structural domains of the organisation, employee engagement is a process domain influencing the impact of the structures on the delivery of care and quality performance is an outcome domain (Donabedian, 1966, 1988). This structure-process-outcome sequence is not merely a statistical relationship, but theoretically coherent, which is why the mediation hypothesis is. The theories, when put together, imply both direct and indirect effects and the rationale behind the strength of the employee pathway, based on governance.

3.5 Hypotheses and conceptual model

H1: Digital Health Transformation positively affects the Employee Engagement.

H2: Employee Engagement has a positive impact on Quality Performance.

H3: Digital Health Transformation positively affects Quality Performance.

H4: Digital Health Transformation is connected to Quality Performance via Employee Engagement.

H5: Positive relationship between Digital Health Transformation and Employee Engagement is moderated by Safety Culture Governance, such that the relationship will be stronger at higher levels of Safety Culture Governance.

H6: Safety Culture Governance has a positive impact on Quality Performance.

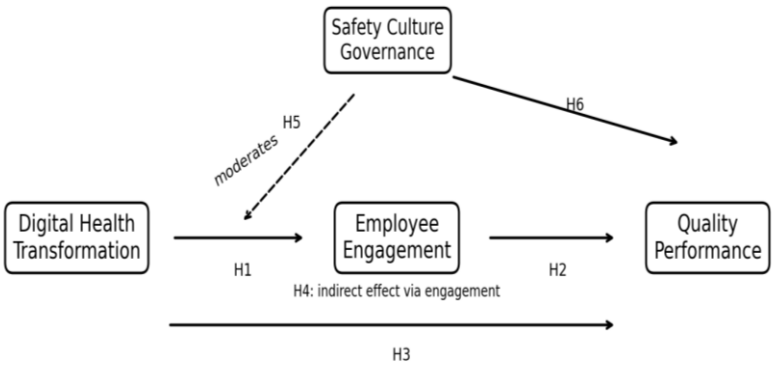


Figure 1. Proposed Conceptual Model

The concepts are based on the sociotechnical systems theory, high-reliability organisation theory, resource-based view, dynamic capabilities theory and Donabedian's framework (Trist & Bamforth, 1951; Barney, 1991; Teece, 2007; Chassin & Loeb, 2013; Donabedian, 1988).

4. METHODOLOGY

4.1 The research design and the setting of the research

A quantitative, cross sectional design was mentioned for multi-specialty hospitals which are accredited with NABH. The hospital was chosen as the context for the organisation and the individual employee as the survey respondent because perceptions of transformation, engagement, governance and quality are experienced in the everyday work of the hospital. To minimize the effect of a local environment, 12 hospitals were spread out in four major urban regions in India. Eligible

respondents were doctors, nurses, allied health professionals, hospital administrators, quality and patient-safety staff and staff members who regularly use digital clinical and/or operational systems. This multiprofessional frame is an effort to move towards a sociotechnical view of transformation, and not just think of digital work as the work of clinicians or IT people.

4.2 The sampling and the respondent profile

Stratified sampling plan has been developed according to the hospital and professional group. Seven hundred questionnaires were allocated, 648 were returned complete or almost complete of which 612 (87.4%) were usable, meeting the predefined data quality criteria. The sample size was greater than the typical power needed for the most complex regression in the model and also was more than the minimum that is generally recommended for stable PLS-SEM estimation (Cohen, 1988; Hair et al., 2022). Lastly, doctors, allied health, administration/quality and digitally enabled support staff were included, as these are the largest continuous user groups (nurses) since the organisation needs to be broad.

4.3 Measurement

Table 2. Operationalise and create Measurement Basis

Construct / role	Dimensions	Principal measurement basis	Format
Digital Health Transformation IV (higher-order)	Digital strategy & governance, IT capability & interoperability, analytics/decision support, workflow integration, people/digital capability.	Duncan et al. (2022); Cresswell et al. (2025); Snowdon, Hussein, Danforth, et al. (2024); Werner et al. (2023)	5-point agreement; 20 items
Employee Engagement (Mediator)	Vigour; dedication; absorption	Schaufeli et al. (2002, 2006)	7-point frequency (0–6); 9 items
Safety Culture Governance (Moderator/direct antecedant)	Leadership responsibilities, safety policies and monitoring, reporting and learning, risk/compliance governance.	AHRQ (2019); Chassin & Loeb (2013); Singer & Vogus (2013); NABH (n.d.)	5-point agreement; 16 items
Quality Performance (DV – higher order)	Clinical/service quality, patient safety, operational efficiency, patient experience, innovation/organisational effectiveness.	According to Donabedian (1988), Institute of Medicine (2001), World Health Organization et al. (2018), Snowdon, Hussein, Olubisi, et al. (2024)	5-point agreement; 20 items

Adapted from Duncan et al. (2022), Schaufeli et al. (2006), AHRQ (2019), Donabedian (1988), Cresswell et al. (2025) and other sources.

4.4 Data analysis

SmartPLS 4 was selected because this is an explanatory-predictive study, the presence of higher order constructs, mediation and moderation and the lack of multivariate normality. A disjoint two-stage approach was used for measuring the higher order constructs, following the guidance of hierarchical-component (Becker et al., 2012; Hair et al., 2022). Indicators loadings, Cronbach's alpha, rho_A, composite reliability and average variance extracted (Fornell & Larcker, 1981) were used to measure the reflective measurement quality. The heterotrait-monotrait ratio (Henseler et al., 2015) was used for the assessment of the discriminant validity. VIFs for full-collinearity were also calculated as a diagnostic test of the potential common-method bias, but it should be noted that this test cannot prove that there is no method effects (Kock, 2015). For structural estimates 10,000 bootstrap subsamples were used. Mediation was interpreted based on the bootstrapped indirect effect, rather than causal-steps logic (Preacher & Hayes, 2008; Nitzl et al., 2016; Hayes, 2018). Moderation term was estimated by a two-stage estimation. To comply with current PLS-SEM guidelines (Hair et al., 2019; Hair et al., 2022; Shmueli et al., 2019), R2, Stone-Geisser's Q2, SRMR and PLSpredict were reported. The 10-fold cross validation and 10 repetitions of PLSpredict were performed. The measurement invariance was firstly examined by using the MICOM procedure before performing the multi-group analysis by professional grouping by using the permutation method.

5. RESULTS

5.1 Sample characteristics

Table 3. Respondent Profile (n = 612)

Characteristic	Category	n	%
Gender	Women	342	55.9
	Men	270	44.1
Professional group	Doctors	140	22.9
	Nurses	236	38.6
	Allied health	96	15.7
	Administration/quality	88	14.4
	IT-enabled/other healthcare staff	52	8.5
Healthcare experience	< 5 years	156	25.5
	5–10 years	214	35.0
	> 10 years	242	39.5
Use of core digital systems, every day	Yes	420	68.6
	No / intermittent	192	31.4
Hospital tenure	< 3 years	178	29.1
	3–7 years	249	40.7
	> 7 years	185	30.2

Source: Authors' analysis.

Table 4. Results of the descriptive statistics and the latent-variable correlations are reported.

Construct	Mean	SD	1	2	3	4
Digital Health Transformation	3.72	0.61	1.00			
Employee Engagement	3.79	0.66	.70	1.00		
Safety Culture Governance	3.68	0.63	.72	.77	1.00	
Quality Performance	3.81	0.58	.70	.74	.71	1.00

Source: Authors' analysis. Means and standard deviations are scores for constructs which are not standardised: Employee Engagement scores are on a 0-6 frequency range and other constructs scores are on a 1-5 agreement range. Correlations are correlations between latent variables which have been standardised.

5.2 Measurement model

Measurement model revealed the recommended levels of reliability and convergent-validity. The standardised indicator loadings ranged from .698 to .884, with only a few being slightly below .70, but still retained as the reliability of the constructs and AVE were still acceptable. Cronbach's alpha ranged from .887 to .921, rho_A from .892 to .925, composite reliability from .916 to .943, and AVE from .622 to .735. The VIFs were less than 3.3 (the diagnostic cut-off for full-collinearity) and ranged between 2.07 and 2.58. These values do not indicate the absence of common-method bias, but do decrease the worry of severe common-method contamination. Table 5 and 6 showed that all the HTMT values were below .85 indicating the discriminant validity, ranging from .776 to .824. Also, the second stage loadings and collinearity of the reflective-reflective higher order Digital Health Transformation and Quality Performance constructs were acceptable.

Table 5. Reliability, convergent validity and collinearity assessment.

Construct	Loading range	α	rho_A	CR	AVE	Full collinearity VIF
Digital Health Transformation	.706–.862	.912	.918	.931	.662	2.31
Employee Engagement	.721–.884	.887	.892	.916	.685	2.07
Safety Culture Governance	.698–.873	.921	.925	.943	.735	2.44
Quality Performance	.704–.851	.904	.911	.929	.622	2.58

Source: Authors' analysis. Cronbach's alpha (α), composite reliability (CR) and average variance extracted (AVE).

Table 6. HTMT Discriminant-Validity Matrix

Construct	1	2	3	4
Digital Health Transformation	—			
Employee Engagement	.778	—		
Safety Culture Governance	.791	.824	—	
Quality Performance	.776	.816	.798	—

Source: Authors' analysis. All of the HTMT ratios are less than .85.

5.3 Structural model with hypotheses

The structural model showed that it had a significant explanatory power (R2 = .412 for Employee Engagement and R2 = .628 for Quality Performance). Digital Health Transformation was positively associated with Employee Engagement (β = .428, t = 10.62, p < .001) which supported H1. The results showed that Employee Engagement had a positive relationship with Quality Performance (β = .357, t = 8.44, p < .001) and thus, H2 was supported. The direct path from Digital Health Transformation to Quality Performance also was positive (β = .276, t = 6.51, p < .001), supporting H3. In line with the hypothesis, Safety Culture Governance was found to be directly and positively related with Quality Performance (β = .241, t = 5.98, p < .001) to support H6. It was also part of the main effect on engagement that was required to estimate a moderated relationship and was positive (β = .219, p < .001). The model was found to have an SRMR of .054 and Q2 values of .268 (engagement) and .401 (quality performance), indicating the predictive relevance.

Table 7. Structural model with hypotheses was developed to answer the research questions.

Hyp.	Path	β	SE	t	p	95% CI	Decision
H1	DHT → Employee Engagement	.428	.040	10.62	<.001	[.350, .503]	Supported
H2	Employee Engagement has a positive impact on Quality Performance.	.357	.042	8.44	<.001	[.273, .438]	Supported
H3	DHT → Quality Performance	.276	.042	6.51	<.001	[.192, .356]	Supported
H5	DHT × SCG → Employee Engagement.	.124	.039	3.17	.002	[.048, .199]	Supported
H6	SCG → Quality Performance	.241	.040	5.98	<.001	[.162, .320]	Supported
Control	SCG → Employee Engagement	.219	.040	5.44	<.001	[.140, .297]	—

Source: Authors' analysis based on 10,000 bootstrap subsamples. p < .01; p < .001.

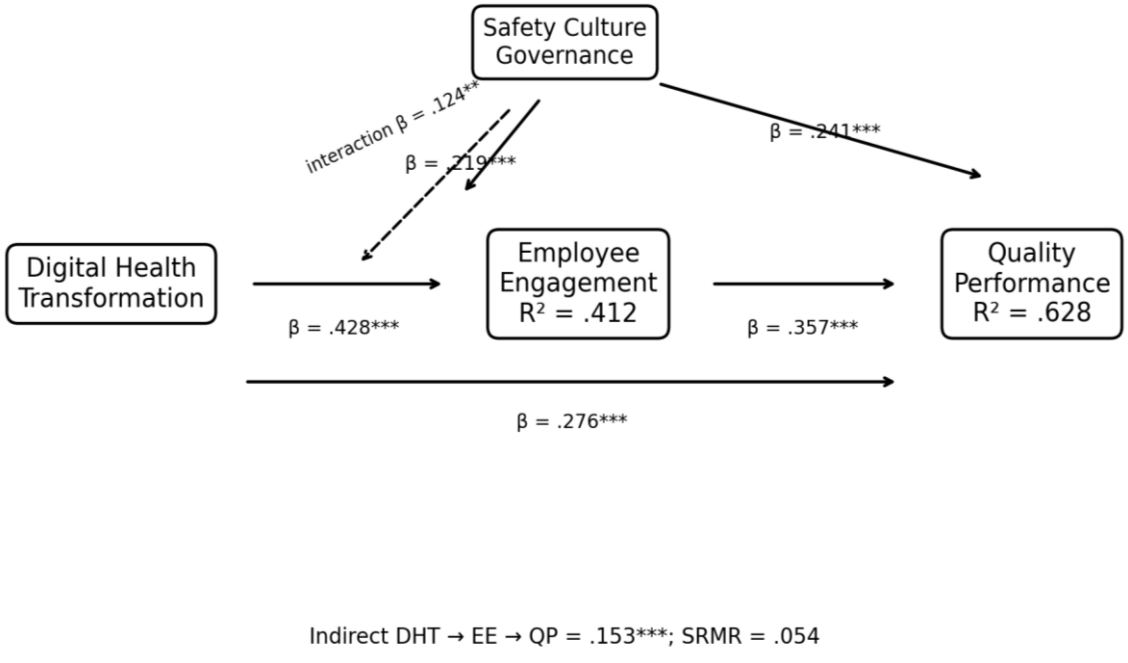


Figure 2. standardised structural model

Source: Authors' analysis. DHT = Digital Health Transformation; SCG = Safety Culture Governance; p < .001; p < .01.

5.4 Mediation, moderation and predictive robustness

The specific indirect link between Digital Health Transformation and Quality Performance via Employee Engagement was β = .153 (t = 6.62, p < .001; 95% bootstrap CI [.113, .198]). The direct link was also important and was in the same direction as the pattern, which is indicative of complementary partial mediation and hence H4 is supported. The Digital Health Transformation × Safety Culture Governance interaction was a positive predictor of Employee Engagement (β = .124, t = 3.17, p = .002), thus supporting H5. Simple-slope estimates indicated that the range of the transformation-engagement relationship was .31 to .43 to .55 from low to mean to high governance, respectively. Moderate out of sample predictive performance was obtained with lower RMSE when compared with PLSpredict for 16 out of 20 quality indicators when compared to the benchmark linear-model. MICOM confirmed all of the measurement-invariance conditions for the comparison of the professional groups. The multi-group permutation test showed one slight difference – the transformation-engagement path was stronger for nurses/allied health staff than doctors (Δβ = .126, p = .041); the other focal paths did not differ significantly.

Table 8. Moderation and Conditional Moderation Effects.

Test	Effect	β / slope	t	p	95% CI	Interpretation
H4: Indirect effect	DHT → EE → QP	.153	6.62	<.001	[.113, .198]	Complementary partial mediation
Conditional slope	DHT → EE at low SCG (-1 SD)	.310	5.11	<.001	[.193, .426]	Positive
Conditional slope	DHT at mean SCG	.428	10.62	<.001	[.350, .503]	Positive
Conditional slope	DHT → EE at high SCG (+1 SD)	.550	9.37	<.001	[.435, .663]	Stronger positive

Note: Bootstrapped indirect effects and simple slopes (at ±1SD of Safety Culture Governance) were used to derive these values.

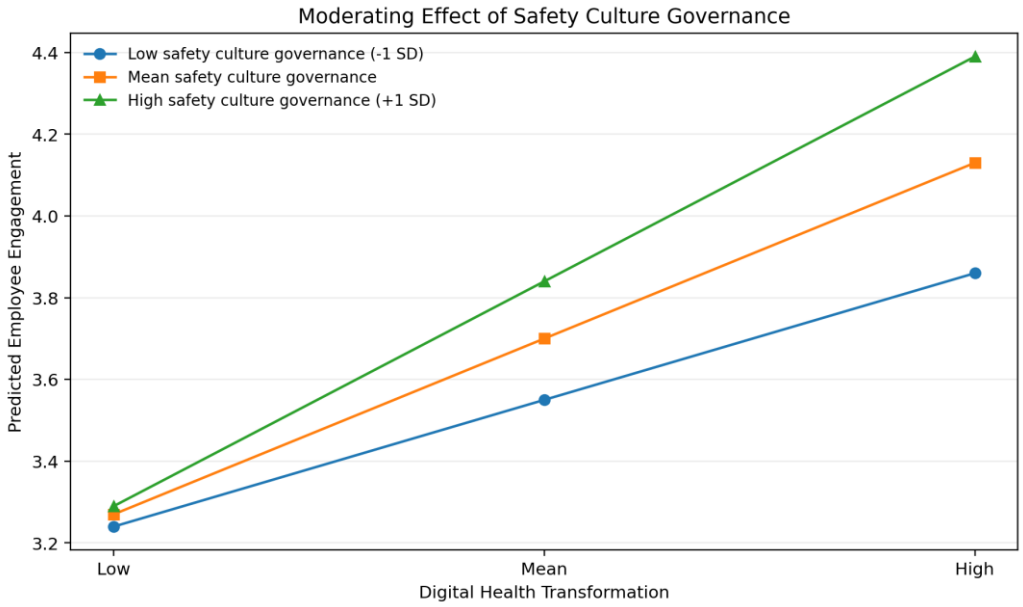


Figure 3. Moderating Effect of Safety Culture Governance on the Digital transformation – Engagement Relationship

Source: Authors' analysis. Simple slopes of standardised interaction model.

Table 9. Predictive and Robustness Checks are performed to check the robustness of the forecast.

Indicator	Outcome / comparison	Result	Interpretation
R^2	Employee Engagement	.412	41.2% of variance explained
R^2	Quality Performance	.628	62.8% of variance explained
Q^2	Employee Engagement	.268	Predictive relevance
Q^2	Quality Performance	.401	Predictive relevance
SRMR	Overall model	.054	Below .08 guideline
PLSpredict	Quality indicators	The 16/20 indicators have an RMSE lower than the LM benchmark.	Moderate predictive performance as compared to LM benchmark.
MGA	Nurses/allied to doctors: DHT→EE	Δβ=.126; p=.041	One small group difference
MGA	Other focal paths	p>.05	the other focal paths did not differ significantly.
MICOM	Professional-group comparison	MICOM confirmed all of the measurement-invariance conditions for the comparison of the professional groups.	MGA interpretation supported

Source: Authors' analysis. MGA = multi-group analysis, RMSE = root mean square error, LM = linear-model benchmark.

6. DISCUSSION

The results support the hypothesis that the value of the digital is not only technical, but also organisational and behavioural in hospitals. The positive direct relationship between Digital Health Transformation and Quality Performance aligns with recent evidence at the hospital level demonstrating a relationship between digital maturity and improved safety grades, reduced adverse events and a better patient experience (Snowdon, Hussein, Danforth, et al., 2024; Snowdon, Hussein, Olubisi, et al., 2024). But the mediation result does include an important explanatory element. The indirect association

through engagement was standardised and was β = .153, indicating that part of the association between digital transformation and quality performance was mediated by the vigour and dedication and absorption in digitally enabled work of employees. This is in line with the sociotechnical systems theory which states that the technical and social systems need to be optimised at the same time to improve the performance of the system (Trist & Bamforth, 1951; Sittig & Singh, 2010). It is also not limited to the current engagement-quality association (Wee & Lai, 2022) but considers engagement as an internal response to the organisation's digital capability.

Both direct and contingent roles for Safety Culture Governance. It directly correlates to quality, and positive safety culture and reduced hospital-acquired conditions (HACs) and improved value-based purchasing metrics have been found (Noghrehchi, Hefner, Stegall, et al., 2024; Noghrehchi, Hefner, & Walker, 2024). To top it off, governance strengthened the Digital Health Transformation → Employee Engagement relationship. Digital change is more likely to be embraced by employees when safety is perceived as a priority, leaders are held accountable for their actions, incident reporting is protected, risks are monitored and learning is based on mistakes. From an HRO perspective, governance is the process of making weak signals 'talkable' and corrective actions 'legitimate' (Weick & Sutcliffe, 2007; Chassin & Loeb, 2013) through ongoing behaviours in the organisation. This is also congruent with thinking in the context of psychological-safety: If the environment is one in which people feel free to express their views and learn from others without being blamed, then they will work harder (Edmondson, 1999).

7. CONTRIBUTIONS AND IMPLICATIONS

7.1 Managerial implications

Digital transformation must be a clinical-organisational programme, not an IT implementation and must be managed by hospital leaders. Boards and executive teams should set goals for transformation in terms of quality, shared responsibility for digital, clinical and quality leaders, and monitor workforce response to transformation goals and milestones. Digital programmes need to involve co-design with frontline users, allow for protected training time, have digital champions, and have workflow redesign and rapid feedback. Vigour, dedication or perceived usability should be used as leading indicators: if the vigour, dedication or perceived usability decreases during the implementation then it is likely that the job demands are exceeding the resources available as a result of the technical change.

7.2 Consequences for Safety governance and accreditation

Safety governance should be integrated in the programme governance from the beginning, as a part of the digital programme. New systems must be pre-implemented hazard analysis, have clearly defined escalation pathways, audit trails, non-punitive incident reporting and post-implementation surveillance and explicit ownership of digital safety risks. Digital incidents and near misses should be part of quality committees, just as any other clinical incidents, to ensure that hazards associated with the use of technology are also part of the learning system. For NABH accredited hospitals, this can be a way to link transformation with the existing accreditation requirements, as opposed to a parallel digital governance. Accreditation bodies can also encourage maturity indicators that reflect the capability of leadership and interoperability, as well as workforce and learning, not just hardware and software.

8. THIS RESEARCH HAS ITS LIMITATIONS AND MORE RESEARCH IS NEEDED.

There are a number of restrictions that can be considered as interpretation. Cross sectional design offers a theoretically consistent relationship, but does not offer evidence of temporal causality, longitudinal or stepped implementation studies should focus on whether there is a temporal relationship between the changes in digital maturity and the engagement and quality gains. There are some common-method risk even after procedural steps and collinearity checks are performed, if only one source (self-report) is used to measure variables. There is also potential for the self-reported organisational quality to not align with the audited clinical measures and future studies should seek to correlate the measures in the survey with infection rates, medication events, readmission rates, waiting times, patient-experience scores and operational data. Respondents were concentrated in 12 hospitals; the primary PLS-SEM was at the individual level; future multilevel models need to differentiate between within hospital and between hospital effects. Professions and hospitals are included in the sample but it would be useful to have a larger sample of professions and hospitals to enhance generalisability. Future research can be conducted to determine if the moderated mediation is present between digital literacy, leadership style, professional autonomy and burnout and/or technology complexity. Finally, future studies should, if possible, compare results derived from PLS-SEM to those of longitudinal CB-SEM and causal-inference designs that have measurement and data structures that enable comparisons.

9. CONCLUSION

It's not just about technology and digital health transformation is correlated with hospital quality. The findings show that there are two parallel paths: a direct path, which goes through digitally enabled processes; and an indirect path, which goes through employee engagement. Safety culture governance is linked to quality performance, and improves the employee pathway. The managerial implication in the center is integration in the case of multi-specialty hospitals. Digital strategy should be thought of as a single operating system for quality, workforce engagement and safety governance should be as well. This employee first and governance sensitive view is a better understanding of how digital maturity can become a reliable clinical and organisational performance in the hospital.

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