

Analysis of Factors Influencing Digital Transformation Readiness in Hospitals Using the Organizational Digital Transformation Readiness and TOE Framework

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ABSTRACT

Digital transformation readiness in healthcare extends beyond the availability of technology to the organizational and environmental conditions that shape the implementation of digital solutions in practice. This study aimed to identify and analyze digital transformation readiness components, refine them based on contextual empirical evidence, organize them through the integration of Organizational Digital Transformation Readiness (ODTR) and Technology–Organization–Environment (TOE), and assess stakeholder consensus using the Fuzzy Delphi Method (FDM). A qualitative-dominant sequential design was employed in a single specialized eye hospital involving nine purposively selected participants with domain relevant expertise. Interview data were analyzed using a framework-guided hybrid deductive inductive thematic analysis. The same nine participants subsequently completed the FDM phase; accordingly, FDM was used to assess within-panel stakeholder consensus and refine the candidate components rather than as independent external validation. The analysis produced 23 readiness components, all of which met the predefined FDM consensus criteria and were organized across the Technology (5), Organization (14), and Environment (4) domains. Three context-derived refinements, EM01 Specialty-Specific Features, EM02 Service Continuity, and EM03 Vendor Dependency, were incorporated into the corresponding TOE domains without forming an additional domain. In the context of the specialized eye hospital studied, the findings indicate that digital transformation readiness involves the interrelationship between technological resources and processes, organizational capabilities and governance, human and cultural readiness, and the external digital health environment. The resulting contextual framework provides a traceable structure for understanding and reviewing digital transformation readiness within the organizational setting examined and may support context-sensitive planning for hospital digital transformation.

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1. INTRODUCTION

Digital transformation has become a crucial part of the development of services and operations in healthcare organizations. This transformation is not limited to the implementation of information technology or the conversion of manual processes into electronic systems; it also involves changes in work processes, information management and exchange, user competencies, managerial support, and the organization's ability to integrate technology into clinical and administrative activities. Research on healthcare organizations shows that the use of digital technology interacts with managerial and administrative processes as well as organizational conditions that support its implementation (Mauro et al., 2024). A recent systematic review also indicates that digital readiness in healthcare is related to digital competencies, training, infrastructure, facilitating conditions, and organizational support (Alotaibi et al., 2025). This perspective positions digital transformation readiness as a broader organizational issue than merely the availability of technology.

Digital transformation readiness must therefore be understood as a multidimensional condition. In the healthcare context, Bilgiç and Camgöz Akdağ identified a framework for digital transformation readiness that includes management support, tracking of current status, corporate culture, resource allocation, and service management (Bilgiç & Akdağ, 2021). More recent studies of healthcare leaders

also indicate that digital health readiness is related to the conditions for implementing change, management support, workforce readiness, competencies, resources, and the alignment of technology with work routines (Steenkamp et al., 2025). This literature suggests that a hospital's digital transformation readiness is shaped by the interplay between technological conditions, organizational processes and capabilities, human resources, and the environment in which the transformation takes place.

To obtain a more detailed understanding of organizational readiness, this study draws on the Organizational Digital Transformation Readiness (ODTR) framework and the Technology–Organization–Environment (TOE) framework. ODTR conceptualizes readiness through five dimensions: Technological Resources, Business Processes, Management Capability, Human Capability, and Corporate Culture, thereby providing a granular view of the internal conditions relevant to organizational digital transformation readiness (Michelotto & Joia, 2024). TOE, in contrast, provides a broader organizational-context perspective by distinguishing technological, organizational, and environmental conditions surrounding technology adoption and implementation (Tornatzky & Fleischer, 1990). In healthcare research, the organizational context of TOE has encompassed factors such as organizational readiness, management support, staff capabilities, training, and organizational culture, whereas the environmental context captures external pressure, regulation, support, and interorganizational conditions (Han et al., 2020).

The integration used in this study is therefore complementary and nested rather than a merger of two equivalent theoretical models. ODTR is used to disaggregate internal readiness conditions that would otherwise remain relatively broad within TOE: Technological Resources are situated within the TOE Technology domain, while Business Processes, Management Capability, Human Capability, and Corporate Culture provide finer-grained dimensions within the TOE Organization domain. TOE additionally provides the Environment domain for examining regulatory requirements, external interoperability, external support, and other conditions originating beyond the hospital's internal organizational boundaries. This arrangement addresses complementary analytical needs: ODTR provides internal readiness granularity, whereas TOE preserves the wider technological, organizational, and environmental context in which hospital digital transformation occurs. The integration is therefore used as a nested analytical framework for organizing readiness conditions rather than as a new unified theory or causal model.

For the specific analytical purpose of this study, the two frameworks were therefore not used in isolation. ODTR provides finer differentiation of internal readiness conditions, but it does not offer the same explicit macro-level distinction between internal organizational conditions and external environmental influences. TOE provides this broader contextual distinction, while its Technology and Organization domains operate at a broader level of abstraction than required here to examine business processes, management capability, human capability, and corporate culture. Their combined use was therefore intended to address complementary analytical needs without implying that either framework is theoretically deficient or incomplete.

The relevance of the Environment dimension is increasingly evident in Indonesia's digital health transformation. Regulation of the Minister of Health of the Republic of Indonesia No. 18 of 2022 governs the implementation of the "One Health Data" initiative through the Health Information System (Menteri Kesehatan Republik Indonesia, 2022), while Regulation of the Minister of Health No. 24 of 2022 governs the implementation of Electronic Medical Records at healthcare facilities (Menteri Kesehatan RI, 2022). These implementations are reinforced by the Minister of Health's Circular Letter No. HK.02.01/MENKES/1030/2023, which covers the implementation of EMRs, integration with the SATUSEHAT Platform, and mechanisms for guidance and oversight (Menteri Kesehatan Republik Indonesia, 2023). At the same time, Law No. 27 of 2022 on Personal Data Protection classifies health data and information as a specific category of personal data (Pemerintah RI, 2022). This regulatory framework creates an institutional environment that requires hospitals to address the needs for standardization, interoperability, data integration, data protection, and compliance in the development of digital systems. The relevance of these institutional pressures is also evident in a study of private hospitals in Indonesia that links institutional pressures, dynamic managerial capability, and digital readiness (Tenggono et al., 2024).

These demands for data interoperability, integration, and standardization become increasingly important in the operational context of specialized eye hospitals. Ophthalmology practice has distinctive digital and data management characteristics because clinical services increasingly utilize

various ocular imaging modalities, including fundus photography and optical coherence tomography (OCT), which generate clinical visual data and require integration with patient information and electronic health record systems (Goetz et al., 2025). The literature on ocular imaging indicates that interoperability among imaging devices, image storage systems, and electronic health records remains a critical issue in ophthalmology clinical workflows (Goetz et al., 2025). Developments in imaging standardization also show that OCT, fundus photography, and other retinal imaging modalities can generate data in different formats and across different vendor ecosystems, making the need for harmonization and interoperability increasingly relevant (Gim et al., 2025). These characteristics make eye hospitals an informative context for understanding how digital infrastructure readiness, process integration, user capabilities, organizational governance, and environmental demands interact in a hospital's digital transformation.

Although the literature on digital transformation and digital readiness in healthcare continues to expand, available studies reveal diverse analytical focuses. Some research develops readiness frameworks for healthcare organizations (Bilgiç & Akdağ, 2021; Steenkamp et al., 2025); some emphasize individual capabilities and conditions that support digital readiness (Alotaibi et al., 2025); while other studies employ technological, organizational, and environmental perspectives to understand digital implementation and transformation (Mauro et al., 2024; Tenggono et al., 2024). ODTR provides a specific framework for organizational digital transformation readiness (Michelotto & Joia, 2024), whereas TOE offers a broader framework for analyzing technological, organizational, and environmental contexts (Tornatzky & Fleischer, 1990). Based on this literature review, there remains an empirical gap regarding how detailed readiness components are reflected in hospitals' operational practices and how contextual conditions can lead to adjustments to existing readiness categories. Therefore, this study focuses on examining how these components can be identified and refined based on empirical evidence, and then coherently organized within the ODTR–TOE framework in the context of specialized hospital services.

To address these gaps, this study employs a qualitative approach based on the ODTR–TOE framework to identify and analyze digital transformation readiness components from the experiences and perspectives of hospital stakeholders. This analysis allows for contextual refinement when empirical conditions are not fully represented by the initial categories. The resulting candidate components were then subjected to the Fuzzy Delphi Method (FDM) to obtain stakeholder consensus and support the screening and refinement process. This approach allows the results of the qualitative analysis and stakeholder consensus to be used sequentially in shaping a contextual readiness framework.

RQ1. What factors or components play a role in digital transformation readiness at the hospitals studied, based on an analysis within the ODTR–TOE framework?

RQ2. How can these readiness factors or components be refined based on empirical evidence and stakeholder consensus, and organized into a contextual readiness framework within the ODTR–TOE structure?

This study aims to identify and analyze the components of digital transformation readiness in the hospitals under study, conduct contextual refinement based on empirical evidence, organize these components within the ODTR–TOE framework, and obtain consensus-based refinement of the candidate components. Academically, this study contributes through the integrated empirical application of ODTR and TOE, contextual assessment and refinement of existing readiness categories, and analytical clarification regarding the relationship between internal organizational readiness and environmental conditions in the context of hospital digital transformation. Practically, the resulting contextual readiness framework provides a structure for hospital management to identify areas of readiness requiring attention and can serve as a basis for setting priorities for process improvement, capability development, digital governance, and technology investment planning aligned with the organization's needs.

2. METHOD

2.1 Study Design and Setting

This study employed a qualitative-dominant sequential design to identify and refine the components of digital transformation readiness in specialized eye hospitals. The study was conducted in two sequential phases: qualitative analysis based on interviews and the Fuzzy Delphi Method (FDM) for consensus-building, screening, and refinement of candidate components (Hidayat &

Lawahid, 2020; Ishikawa et al., 1993). The FDM was not positioned as an independent external validation because the FDM panel consisted of the same participants as those in the interview phase. The study was not designed to test causal relationships or produce statistical generalizations.

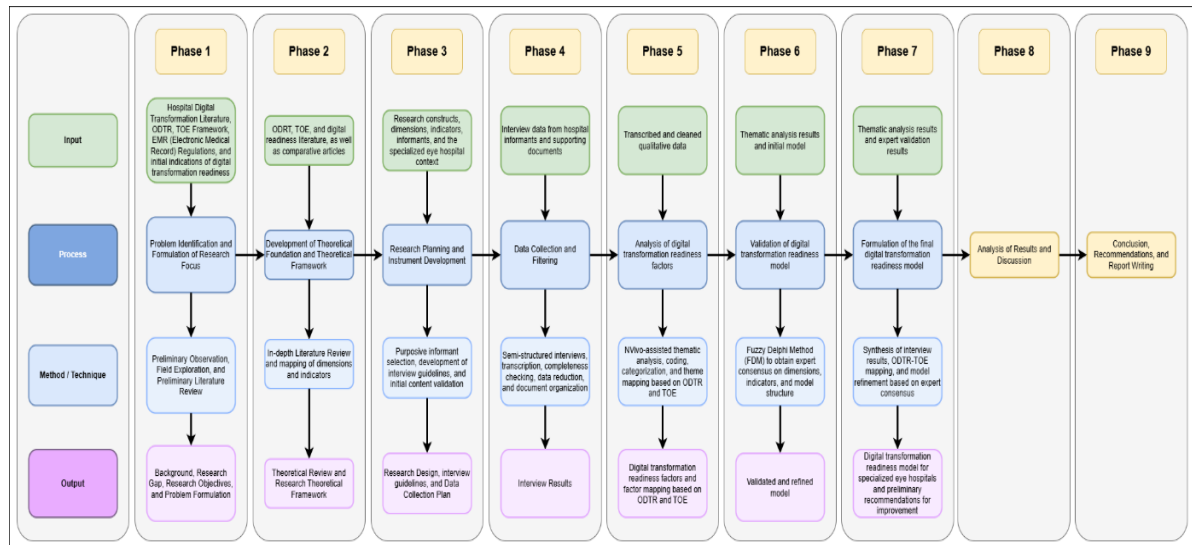


Figure 1. Research and Analysis Flowchart

2.2 Systematic Literature Review and Initial Framework Development

A Systematic Literature Review (SLR) was conducted to identify literature-derived dimensions, factors, and indicators relevant to digital transformation readiness and to develop the preliminary analytical framework used in the qualitative phase. The review procedure was informed by the systematic literature review guidance of Kitchenham and Charters (Kitchenham & Charters, 2007), while the study-selection process was reported using the PRISMA 2020 flow diagram (Page et al., 2021). Literature searches were conducted using Scopus, PubMed, Garuda, and the ScienceDirect and Emerald platforms. A conceptual Boolean search strategy combining terms related to digital transformation, readiness, organizational context, healthcare, hospitals, and TOE was adapted to the syntax of each source. The core search string was: ("Digital transformation" OR "Digital health" OR "mHealth") AND ("Readiness" OR "Organizational readiness" OR "Digital readiness") AND ("Organization" OR "Government" OR "Healthcare" OR "Hospital" OR "TOE"). The review included publications from 2021 to 2026. Studies were considered for inclusion when they were peer-reviewed, available in full text, relevant to organizational or healthcare digital transformation readiness, reported dimensions, factors, indicators, constructs, or comparable analytical concepts applicable to readiness assessment, and provided sufficient methodological information to support traceable extraction and interpretation of the reported readiness-related constructs.

The initial search identified 650 records. After removal of 230 duplicates using mendeley, 420 unique records remained for title and abstract screening. Of these, 335 records were excluded based on the predefined title and abstract screening criteria, leaving 85 reports for full-text retrieval; all 85 reports were successfully retrieved. Full-text eligibility assessment excluded 57 reports: 28 did not provide readiness-related dimensions, factors, indicators, or comparable analytical constructs; 19 addressed contexts or sectors outside the review scope; and 10 did not provide sufficient methodological information on study design, data sources or sampling where applicable, and analytical procedures to support traceable extraction of readiness-related constructs. Consequently, 28 studies were included in the final synthesis. The study-selection process is summarized in the PRISMA flow diagram in Figure 2.

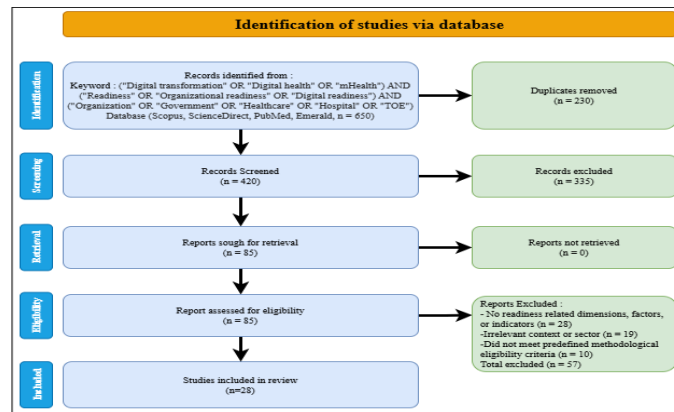


Figure 2. PRISMA Flow Diagram of the Study-Selection Process for the Systematic Literature Review

Data extraction focused on readiness-related dimensions, factors, constructs, and indicators reported in the 28 included studies. Extracted concepts were compared according to their substantive definitions rather than terminology alone. Concepts with substantially overlapping meanings were consolidated under a common preliminary indicator, whereas conceptually distinct constructs were retained separately. The resulting concepts were then organized using the nested ODTR–TOE analytical structure. Internally oriented readiness concepts were mapped according to their substantive locus to Technological Resources, Business Processes, Management Capability, Human Capability, or Corporate Culture, while externally oriented conditions were organized within the TOE Environment context. The number of preliminary indicators was not predetermined. Rather, the final set of 21 indicators resulted from the extraction, comparison, consolidation of substantively overlapping concepts, retention of conceptually distinct constructs, and subsequent mapping to the nested ODTR–TOE analytical structure. These 21 indicators constituted the literature-derived analytical starting framework for the subsequent qualitative analysis. Relevant Indonesian regulatory documents were used as supplementary contextual and normative sources for Environment-related indicators and were not counted among the 28 peer-reviewed studies included through the SLR selection process.

2.3 Analytical Framework

The analytical framework was operationalized as a nested analytical arrangement using the Technology–Organization–Environment (TOE) and Organizational Digital Transformation Readiness (ODTR) frameworks. TOE served as the macro-level organizing structure for locating readiness conditions within technological, organizational, and environmental contexts (Tornatzky & Fleischer, 1990), while ODTR provided finer differentiation of internal readiness through Technological Resources, Business Processes, Management Capability, Human Capability, and Corporate Culture (Michelotto & Joia, 2024).

For this study, the mapping between ODTR and TOE was based on the substantive locus of each construct rather than on an assumption of theoretical equivalence. Technological Resources were situated within the TOE Technology domain, whereas Business Processes, Management Capability, Human Capability, and Corporate Culture were situated within the TOE Organization domain because they concern internal organizational processes, capabilities, resources, and patterns of coordination. Conditions originating primarily beyond the hospital's organizational boundary, including regulatory requirements, external-system integration, external support, and other external conditions relevant to digital transformation, were examined within the TOE Environment domain. These placements do not imply construct equivalence between the ODTR dimensions and the TOE contexts; rather, they indicate the primary analytical locus under which each readiness dimension was examined in this study. This mapping therefore provided a nested analytical structure in which TOE defined the broader contextual domains and ODTR provided greater analytical resolution for internal readiness.

The nested structure was used as a guiding analytical scaffold rather than as an exhaustive or immutable classification scheme. Initial literature-derived indicators guided the deductive component of the analysis, while the hybrid deductive–inductive approach allowed empirical evidence to refine indicator definitions, boundaries, and component placement when the initial categories did not adequately represent the observed context (Proudfoot, 2023). Context-derived components were therefore assigned to Technology, Organization, or Environment according to their substantive core

rather than being forced into the original ODTR categories. Accordingly, the framework was used for analytical organization and interpretation and was not treated as a causal model, a weighting structure, or a new unified theory..

2.4 Participants and Sampling

Nine participants ($n = 9$) were selected through purposive sampling to represent managerial, technical, clinical, health-information, and administrative perspectives relevant to hospital digital transformation (Campbell et al., 2020). Participants represented hospital management, information technology, medical records, medical and nursing services, refraction services, registration, pharmacy, and financial administration. For the FDM phase, expert eligibility was determined using predefined, study-specific criteria established before final panel screening and questionnaire distribution. Substantive eligibility required participants to: (1) have at least five years of relevant professional experience in hospital services, management, information technology, medical records or data management, clinical care, pharmacy, or administrative workflow; (2) have documented direct involvement in the hospital's digital transformation, including SIMRS/RME implementation or use, digital workflow, governance, system integration, evaluation, training, or related support; (3) possess knowledge and experience in at least one substantive area relevant to the readiness framework; and (4) have current contextual knowledge of hospital workflows and/or digital-system use within their professional area. The five-year threshold was applied as a study-specific screening criterion rather than as a universal Delphi/FDM standard. The use of explicit professional-experience and topic-relevance criteria is consistent with purposive expert selection in Delphi and FDM studies (Beiderbeck et al., 2021; Niederberger & Spranger, 2020; Selvaraju & Nik Hisamuddin, 2024).

Procedural eligibility additionally required participants to be willing and available to complete the FDM assessment and to provide individual judgments without direction from supervisors, peers, or other panel members. Relevant organizational roles and prior participation in the qualitative interview phase were documented separately and were not, by themselves, treated as evidence of expertise. Supporting characteristics, such as cross-unit digital decision exposure and relevant professional education or training, were considered complementary evidence rather than mandatory eligibility requirements. All nine participants included in the FDM panel met the substantive eligibility criteria. Their professional experience ranged from 8 to 23 years, and each had been involved in or had contributed to the hospital's digital transformation since January 2020. Table 1 summarizes their organizational roles, professional experience, and substantive relevance to digitalization. Accordingly, the FDM panel was treated as a group of stakeholders with domain-relevant expertise in the organizational context under study, rather than as a statistically representative or independent external expert panel.

Table 1. Participant Characteristics and Basis of Domain-Relevant Expertise

Code	Position / Role	Professional Experience	Role-Relevant Involvement in Hospital Digitalization	Relevant Subject-Matter Knowledge and Current Contextual Experience
N1	Director	23 years	Strategic oversight of hospital digitalization, including policy direction, implementation monitoring, and resource allocation	Hospital management, digital strategy, organizational governance, and resource decision-making
N2	Head of Information Technology	11 years	Direct responsibility for digital infrastructure, database and server management, system integration, maintenance, and technical coordination	Information technology, system integration, infrastructure, interoperability, and technical system management
N3	Head of Medical Records	9 years	Direct involvement in the transition from conventional records to EMR and in digital health-information management	Medical records, EMR implementation, diagnostic coding, data management, documentation standards, and data governance
N4	Ophthalmologist	15 years	Sustained role-relevant involvement in EMR-supported ophthalmology workflows, including clinical documentation and digital handling of examination information	Ophthalmology clinical workflow, digital clinical documentation, system usability in practice, and specialty-specific information requirements
N5	Head of Nursing	10 years	Direct involvement in supervising digital nursing workflows, EMR-related documentation, and adaptation of nursing processes to digital systems	Nursing workflow, clinical documentation, user adaptation, workflow supervision, and operational experience with digital

Code	Position / Role	Professional Experience	Role-Relevant Involvement in Hospital Digitalization	Relevant Subject-Matter Knowledge and Current Contextual Experience
N6	Head of Refraction Services	13 years	Direct involvement in supervising the recording and transfer of ophthalmic examination and refraction data into the electronic medical record	systems Ophthalmic examination workflow, refraction data, device-generated clinical information, specialty-specific workflow, and EMR use
N7	Head of Registration	9 years	Direct involvement in supervising digital registration, demographic data processing, insurance-related processes, and electronic queue management	Patient registration workflow, digital administrative processes, insurance-platform interaction, data correction processes, and operational system use
N8	Head of Pharmacy	8 years	Direct involvement in supervising electronic prescribing, digital medication workflows, inventory systems, and related billing processes	Pharmacy workflow, e-prescribing, medication information management, inventory processes, external-platform interaction, and inter-unit coordination
N9	Head of Cashier Services	12 years	Direct involvement in supervising digital billing processes, insurance-platform interaction, and administrative completion of patient-service workflows	Billing workflow, insurance-platform interaction, administrative data processing, inter-unit coordination, and digital completion of patient-service processes

2.5 Data Collection

Primary data were collected through semi-structured interviews with nine participants. The interviews were used to explore experiences and perceptions regarding technological readiness, organizational processes, management and human resource capabilities, organizational culture, and the external environment. The semi-structured approach allowed the interview focus to be maintained while providing room to explore relevant issues that arose during the data collection process (Adeoye-Olatunde & Olenik, 2021). Interview transcripts were used as primary evidence, while NVivo supported the organization, coding, classification, and retrieval of data (Allsop et al., 2022; Mortelmans, 2024; Priyanti et al., 2020). The FDM instrument was subsequently developed from candidate components that had passed through qualitative synthesis and the Decision Log. Thus, FDM was used to evaluate candidates derived from the qualitative phase and not to independently formulate initial factors.

2.6 Qualitative Data Analysis and Component Development

Interview data were analyzed using a hybrid deductive–inductive framework-guided thematic analysis (Proudfoot, 2023). The deductive approach used TOE and ODTR as conceptual guides, while the inductive approach allowed patterns and refinements to emerge from empirical evidence. NVivo was used as analysis software and was not treated as a research method (Allsop et al., 2022; Mortelmans, 2024; Priyanti et al., 2020). At the node level, evidence was examined based on conceptual coherence, variation, boundaries, and potential overlap. Coding frequency was not used as the sole measure of a theme's importance; theme development considered the coherence and relevance of patterns to the research questions (Braun & Clarke, 2020). The Decision Log served as a pre-FDM analytical gate to document decisions regarding the retention, refinement, merging, or exclusion of analytical units. This process yielded 23 candidate components for the FDM phase.

2.7 Fuzzy Delphi Consensus Phase

The Fuzzy Delphi Method (FDM) was used to assess stakeholder consensus and refine the 23 candidate components generated through the preceding qualitative analysis. The FDM panel consisted of the same nine participants who had contributed to the interview phase. This overlap was consistent with the intended function of the second phase, which was to examine structured agreement among stakeholders with domain-relevant expertise regarding the analytically derived candidate components, rather than to provide independent external validation of the qualitative findings (Beiderbeck et al., 2021; Ishikawa et al., 1993; Niederberger & Spranger, 2020).

Importantly, interview responses were not transferred directly into the FDM instrument. Before entering the FDM phase, the qualitative evidence underwent coding, node-level evidence assessment, overlap and boundary review, domain synthesis, and documentation through the Decision Log. The candidate components presented to the panel therefore represented analytical syntheses

across the qualitative evidence rather than verbatim restatements of individual participants' previous responses. Panel members then provided individual assessments of these candidate components according to the predefined FDM procedure. These analytical and procedural steps were intended to provide separation between evidence generation and consensus assessment; however, they do not eliminate the methodological implications of using the same participants across both phases. Because the panel members evaluated components that were partly derived from their earlier accounts, the possibility of confirmation bias or circular reinforcement cannot be excluded. Accordingly, the FDM findings in this study are interpreted as context-bounded, within-panel stakeholder consensus and refinement. They are not interpreted as independent confirmation, external validation, or evidence that the resulting components are generalizable beyond the organizational context examined.

Assessments were conducted using a five-point Likert scale and subsequently converted into Triangular Fuzzy Numbers (TFN) (m_1, m_2, m_3) following the predefined FDM procedure (Hidayat & Lawahid, 2020).

Table 2. Likert Scale and Triangular Fuzzy Number (TFN) Conversion

Response Option	Likert Scale	Fuzzy Scale (l, m, u)
Strongly Agree	5	(0.60, 0.80, 1.00)
Agree	4	(0.40, 0.60, 0.80)
Uncertain / Moderately Agree	3	(0.20, 0.40, 0.60)
Disagree	2	(0.00, 0.20, 0.40)
Strongly Disagree	1	(0.00, 0.00, 0.20)

Fuzzy values are aggregated at the item level. Panel agreement is evaluated using the threshold distance:

$$d(\tilde{m}, \tilde{n}) = \sqrt{\frac{(m_1 - n_1)^2 + (m_2 - n_2)^2 + (m_3 - n_3)^2}{3}}$$

For each component, the panel-agreement percentage was calculated based on the number of panelists whose individual threshold distance satisfied $d \leq 0.2$. Following Hidayat and Lawahid (2020), the agreement percentage was calculated as:

$$\text{Panel Agreement (\%)} = \frac{n_{d \leq 0.2}}{N} \times 100$$

where $n_d \leq 0.2$ denotes the number of panelists whose individual threshold distance for a component was $d \leq 0.2$, and N denotes the total number of panelists. In this study, $N=9$; therefore, agreement by eight of nine panelists corresponded to 88.89%, reported as 89% after rounding, whereas agreement by all nine panelists corresponded to 100%. A component satisfied the panel-agreement criterion when the resulting percentage exceeded 75% (Hidayat & Lawahid, 2020).

A component was considered to have reached consensus when the item-level threshold value satisfied $d \leq 0.2$ and the panel-agreement percentage exceeded 75%. Defuzzification was then performed using:

$$A_{max} = \frac{m_1 + m_2 + m_3}{3}$$

with the criteria $A_{max} > 0.5$ (Ahmad et al., 2025; Hidayat & Lawahid, 2020). A combination of the criteria $d \leq 0.2$, consensus $>75\%$, and fuzzy scores > 0.5 is also used in contemporary FDM implementations (Ahmad et al., 2025). The value A_{max} is not treated as an empirical measure of importance among components. Components that meet the criteria are reported as having reached consensus or being retained based on FDM.

3. RESULT AND DISCUSSION

3.1 Initial Literature-Derived Dimensions and Indicators

The literature-based framework development process described in Section 2.2 resulted in 21 preliminary indicators of digital transformation readiness. The indicators were derived through the extraction, comparison, and conceptual consolidation of readiness-related constructs identified across the studies included in the SLR, supplemented where relevant by Indonesian regulatory documents used as contextual and normative sources. The resulting concepts were subsequently organized within the nested ODTR–TOE analytical structure. Five ODTR dimensions Technological Resources,

Business Processes, Management Capability, Human Capability, and Corporate Culture were used to organize internally oriented readiness indicators, while externally oriented conditions were organized within the TOE Environment domain. The resulting 21 indicators constituted the literature-derived analytical starting framework for the qualitative phase and are presented in Table 3.

Table 3. Dimensions and Preliminary Indicators of Digital Transformation Readiness.

No.	Dimension	Indicator	Sources
1	Technological Resources	System Availability	(Alwali et al., 2025; Bilgiç & Akdağ, 2021; Handrean et al., 2024; Michelotto & Joia, 2024; Nurfadhila et al., 2026; Steenkamp et al., 2025; Stoumpos et al., 2023; Wahyudin et al., 2024)
2	Technological Resources	Data Integration	(Abdelsalam, 2025; Bilgiç & Akdağ, 2021; Fitria et al., 2026; Mauro et al., 2024; Nurfadhila et al., 2026; Wahyudin et al., 2024)
3	Technological Resources	Data Security	(Abdelsalam, 2025; Stoumpos et al., 2023; Wahyudin et al., 2024)
4	Technological Resources	System Reliability	(Abdelsalam, 2025; Boruga et al., 2026; Jeilani & Hussein, 2025)
5	Business Processes	Digital Workflow	(Bilgiç & Akdağ, 2021; Mauro et al., 2024; Michelotto & Joia, 2024; Sjöberg et al., 2026)
6	Business Processes	Process Fit	(Aliu et al., 2025; Boruga et al., 2026; Naeem et al., 2024; Sjöberg et al., 2026; Steenkamp et al., 2025)
7	Business Processes	Process Structuring	(Aliu et al., 2025; Bilgiç & Akdağ, 2021; Handrean et al., 2024; Jeilani & Hussein, 2025; Matthews & Burgess, 2025; Michelotto & Joia, 2024; Steenkamp et al., 2025)
8	Management Capability	Management Support	(Bilgiç & Akdağ, 2021; Kludacz-Alessandri et al., 2025; Michelotto & Joia, 2024; Naeem et al., 2024; Steenkamp et al., 2025)
9	Management Capability	Digital Strategy	(Aliu et al., 2025; Alshehri et al., 2026; Bilgiç & Akdağ, 2021; Lutfiani et al., 2025; Michelotto & Joia, 2024; Steenkamp et al., 2025; Tenggono et al., 2024)
10	Management Capability	Resource Capacity	(Bilgiç & Akdağ, 2021; Matthews & Burgess, 2025; Mauro et al., 2024; Steenkamp et al., 2025)
11	Management Capability	Governance	(Abdelsalam, 2025; Bilgiç & Akdağ, 2021; Lim et al., 2025; Mauro et al., 2024; Michelotto & Joia, 2024; Stoumpos et al., 2023; Wahyudin et al., 2024)
12	Human Capability	Digital Competence	(Bilgiç & Akdağ, 2021; Lutfiani et al., 2025; Michelotto & Joia, 2024; Naeem et al., 2024; Nurfadhila et al., 2026; Steenkamp et al., 2025; Stoumpos et al., 2023; Tenggono et al., 2024)
13	Human Capability	Human Resource Development	(Al-shammari & Alzghoul, 2026; Bilgiç & Akdağ, 2021; Mohamed et al., 2026; Steenkamp et al., 2025)
14	Human Capability	User Adaptation	(Abdelsalam, 2025; Aliu et al., 2025; Alwali et al., 2025; Nurfadhila et al., 2026; Steenkamp et al., 2025)
15	Corporate Culture	Digital Culture	(Aliu et al., 2025; Handrean et al., 2024; Lim et al., 2025; Lutfiani et al., 2025; Michelotto & Joia, 2024; Nurfadhila et al., 2026; Steenkamp et al., 2025)
16	Corporate Culture	Knowledge Sharing	(Al-shammari & Alzghoul, 2026; Bilgiç & Akdağ, 2021; Michelotto & Joia, 2024; Mohamed et al., 2026; Steenkamp et al., 2025; Wahyudin et al., 2024)
17	Corporate Culture	Inter-unit Collaboration	(Bilgiç & Akdağ, 2021; Kludacz-Alessandri et al., 2025; Mauro et al., 2024; Steenkamp et al., 2025; Wahyudin et al., 2024)
18	Environment Readiness	Regulatory Compliance	(Abdelsalam, 2025; Alshehri et al., 2026; Lutfiani et al., 2025; Menteri Kesehatan RI, 2022; Tenggono et al., 2024; Wahyudin et al., 2024)
19	Environment Readiness	External Integration	(Ayaz et al., 2021; Fitria et al., 2026; Haleem et al., 2021, 2022; Menteri Kesehatan RI, 2022)
20	Environment Readiness	Data Protection	(Haleem et al., 2021, 2022; Keshta & Odeh, 2021; Pemerintah RI, 2022)
21	Environment Readiness	External Support	(Jeilani & Hussein, 2025; Mauro et al., 2024; Naeem et al., 2024)

The 21 preliminary indicators were used to guide the deductive component of the qualitative analysis, while their definitions, boundaries, and empirical relevance remained open to refinement through the interview evidence. The analytical process therefore allowed contextual patterns not sufficiently represented in the literature-derived framework to be identified, while also permitting potential overlap and insufficient empirical distinctiveness among the preliminary indicators to be examined. Accordingly, the 21-indicator structure was treated as an analytical starting point rather than imposed as the final empirical structure.

3.2 Thematic Analysis and Empirical Refinement

The qualitative analysis involved nine participants representing managerial, technology and data-management, clinical, and administrative perspectives. The 21 literature-derived indicators were

examined through coded interview evidence, overlap and boundary review, domain synthesis, and Decision Log documentation. Twenty indicators were retained or conceptually refined, while ER20 Data Protection was not retained as a standalone empirical component because the evidence did not support a sufficiently distinct substantive core. Three context-derived components EM01 Specialty-Specific Features, EM02 Service Continuity, and EM03 Vendor Dependency emerged through the inductive component of the analysis, resulting in 23 candidate components for FDM assessment.

A total of 485 coded references were recorded across the 23 candidate components (Table 4). Because a single evidence unit could support more than one component, this count does not represent 485 unique quotations. Reference and participant counts were used only to describe evidence distribution and not to indicate component importance or strength of influence.

Table 4. Distribution of Evidence Across the 23 Candidate Components

No.	Domain	Code	Final Component	References	Informants
1	Technology	TR01	System Availability	10	6
2	Technology	TR02	Data Integration	47	9
3	Technology	TR03	Data Security	20	7
4	Technology	TR04	System Reliability	25	9
5	Technology	EM01	Specialty-Specific Features	41	9
6	Organization	BP05	Digital Workflow	12	7
7	Organization	BP06	Process Fit	26	8
8	Organization	BP07	Process Structuring	36	9
9	Organization	EM02	Service Continuity	28	8
10	Organization	MC08	Management Support	7	4
11	Organization	MC09	Digital Strategy	9	3
12	Organization	MC10	Resource Capacity	8	4
13	Organization	MC11	Governance	40	8
14	Organization	HC12	Digital Competence	10	7
15	Organization	HC13	Human Resource Development	9	6
16	Organization	HC14	User Adaptation	29	9
17	Organization	CC15	Digital Culture	22	7
18	Organization	CC16	Knowledge Sharing	10	6
19	Organization	CC17	Inter-unit Collaboration	30	9
20	Environment	ER18	Regulatory Compliance	9	3
21	Environment	ER19	External Integration	31	7
22	Environment	ER21	External Support	13	6
23	Environment	EM03	Vendor Dependency	13	5

Technological Resources

Evidence regarding Technological Resources indicates that the existence of a system does not always equate to having sufficient technology to meet all transformation needs. From a strategic perspective, Director [N1] explained that information systems were already in use before the implementation of RME became more intensive, but the available technology faced limitations as the organization's needs evolved. He stated, "Our system is still simple, and for current needs, it is indeed quite limited." At the same time, he emphasized that development is carried out in line with the organization's capabilities: "We're also implementing it in phases, including through collaboration with vendors, to ensure it remains within the hospital's budgetary constraints."

This perspective was clarified by the Head of IT [N2], who stated, "The system we're using is indeed quite old; it's still based on Visual FoxPro. It actually still functions for day-to-day operations, but because it's so old, developing it isn't as easy as with newer systems." This evidence forms the basis for refinement TR01: the technology is available and can still support operations, but its adequacy for further development must be distinguished from its mere existence. In TR02, "Data Integration," evidence emerged across nearly all working groups. The Head of IT [N2] explained, "At this eye hospital, there are still several diagnostic devices that are not directly connected to the RME. As a result, examination results still have to be entered or uploaded manually by staff." He also cited OCT, fundus photography, and several other devices as examples of integration needs that are not yet directly available.

From the perspective of data and medical records, the Head of Medical Records [N3] stated that "examination results from OCT or fundus imaging still need to be uploaded one by one to the RME." He emphasized that this process requires verification because manual data transfer creates the possibility of selecting or uploading the wrong data during peak service hours. At the operational level, Nurse [N5] explained, "We review the results from the device or the printout, then enter the

necessary numbers into the RME.” The same situation was observed among optometrists. Optometrist [N6] said, “Since the devices aren’t integrated yet, I still have to enter everything one by one from the examination results.” When asked to identify the issue that most burdens her work, she emphasized, “In my opinion, the most burdensome task is manually entering examination results from the devices into the RME.”

This evidence indicates that the integration gap is primarily component-specific. Some internal workflows are already digital, so the findings do not support the claim that the hospital system as a whole is not integrated. Analytical refinement therefore limits TR02 to Data Integration, modules, and devices, while connectivity with SATUSEHAT or insurer portals is addressed under ER19. For TR03 Data Security, the evidence covers account settings, role-based access rights, credentials, account usage controls, backups, and safeguards. The Head of Medical Records [N3], for example, explained, “We also monitor access rights to ensure that each staff member can only access data relevant to their duties.” This evidence supports the existence of technical and operational security mechanisms but is not used to assess the overall security level of the system or compliance with all data protection obligations.

In TR04 System Reliability, variations in informants’ experiences indicate that issues do not occur constantly. A nurse [N5] stated, “The system is often slow during peak hours, especially around 9 to 11 a.m.” She explained that under certain conditions, the data-saving process can experience long loading times or even connection timeouts. The optometrist [N6] described a consistent pattern: “The system sometimes takes a long time to load, especially during peak hours.” However, they distinguished this from the manual data entry challenges experienced with nearly every patient. From an administrative perspective, the Head of Registration [N7] said that the system “sometimes feels slower in the morning when patients arrive all at once,” while the Head of Pharmacy [N8] noted that under normal conditions the system is quite helpful, but begins to feel slow when the service load increases. The Head of Cashier [N9] also described slowdowns during peak hours when data from the previous unit is not immediately available.

Therefore, TR04 more accurately describes intermittent or situational performance degradation rather than continuous system unreliability. The analysis also yielded EM01 Specialty-Specific Features as a contextual refinement. The most direct evidence comes from the needs of ophthalmology documentation. An ophthalmologist [N4] stated, “In ophthalmology, we often need to sketch the location of an abnormality or explain its position in detail. In the current system, most fields are still text columns, so it’s not very flexible for such needs.” Elsewhere, the Ophthalmologist [N4] explained, “Much of our work is visual in nature. Sometimes it’s faster for me to simply mark an image of the eye than to have to explain everything in writing.” He added that such options are not yet available in the system currently in use. Evidence from data managers supports this pattern. The Head of Medical Records [N3] explained that during the RME migration, the hospital needed to adapt “the format of eye examinations, medical histories, and documentation requirements—which are indeed different from those of general hospitals.” Thus, EM01 is not merely a generic workflow mismatch, but rather a system requirement to represent the information and clinical workflows specific to ophthalmology.

The findings regarding EM01 are insufficient to be generalized as a universal problem across all specialty hospitals. However, the ophthalmology-specific literature points to similar issues. Sanders et al. found that documentation of ophthalmological examinations in electronic systems has distinct characteristics compared to paper-based documentation, including regarding the representation of clinical findings. Logeswaran et al. also emphasized the importance of user-centered EHR design in ophthalmology because this specialty has specific workflow and usability demands. A study by Pandit and Boland on DICOM integration in eye examinations showed that integrating data from diagnostic devices can reduce the need for manual entry or correction. These findings are consistent with the relevance of EM01 and TR02 in the context of this study, but they do not establish EM01 as a universal factor across all specialty hospitals (Sanders et al., 2013).

Analytically, EM01 contributes by broadening the interpretation of “Technological Resources”: readiness is not sufficiently assessed by the mere presence of a system, but also by the extent to which technology can accommodate the information structures and clinical activities that characterize the services under study.

Business Processes

In Business Processes, evidence shows that workflow digitization can occur alongside additional tasks or the use of non-digital media under certain conditions. In BP05 Digital Workflow, an Ophthalmologist [N4] explained that before a patient enters the doctor's office, some assessment results are already available in the RME: "Some of the data is also entered into the RME before the patient enters my office." In the next stage, the diagnosis and electronic prescription can be forwarded to other units if the system is functioning normally. In the Pharmacy, the Head of Pharmacy [N8] explains, "As soon as the doctor finishes sending the electronic prescription, it usually appears on the pharmacy computer within a few moments." This indicates the existence of a digital handover across service stages, although it does not mean the entire workflow is fully paperless or seamless.

In BP06 System Alignment, the Ophthalmologist [N4] stated, "In my opinion, it's not yet fully aligned with the ophthalmologist's examination workflow." He explained that some rarely used menus are in easily accessible locations, while information that's used more frequently actually requires navigating to different pages. A nurse [N5] noted, "In RME, some of the data is actually in different menus, so we have to switch between tabs and save the information multiple times." Meanwhile, the Optometrist [N6] said, "The sequence still doesn't fully follow my examination workflow." According to them, the actual workflow proceeds from old glasses, autorefraction, visual acuity, to subjective examination, but the column arrangement in the RME does not always follow that sequence.

Thus, BP06 indicates a partial workflow-system mismatch, not a complete system mismatch. In BP07 Process Organization/Redundancy, evidence across administrative units reveals a more consistent pattern. The Head of Registration [N7] explained, "The insurance portal isn't connected to the hospital system, so staff have to enter data in two places." Regarding medication services, the Head of Pharmacy [N8] stated, "The SIMRS isn't connected to the respective insurance portals. So even though the prescription has been entered into the system, the data still has to be retyped into the insurance portal." From the service checkout point, the Head of Cashier [N9] said, "Because our system isn't yet connected to the insurance portal, staff still have to retype the same data into that portal." He explained that patient identification, diagnosis, procedures, and even cost details already present in the SIMRS still need to be transferred for the insurance claims process. The convergence of N7, N8, and N9 indicates that BP07 is not merely the experience of a single unit. However, this pattern remains limited to specific workflows and is not intended to suggest that the entire hospital process is redundant. The analysis also yielded EM02 Service Continuity. The difference from BP07 lies in the function of the actions. In EM02, manual processes or deferred input are primarily used to maintain service when digital functions are disrupted. An Ophthalmologist [N4] said, "If the system happens to be slow or experiencing an error, I usually write out a manual prescription first so the patient doesn't have to wait too long." A Nurse [N5] described the process more explicitly: when data cannot be saved immediately, examination results are temporarily recorded on paper. She explained, "Once the system is back to normal, we re-enter that data. So the work ends up being done twice."

The same approach was observed with the Optometrist [N6], who stated, "If the system is loading or experiencing issues during peak patient hours, I also revert to manual record-keeping so patients can still see the doctor." In administrative services, the Head of Registration [N7] also explained that patients who need to be seen immediately can be prioritized, while administrative tasks are completed later. The Head of Pharmacy [N8] mentioned the existence of backup procedures in case the system malfunctions to ensure that medication services do not stop. Thus, EM02 represents an operational continuity response, not formal business continuity maturity, disaster recovery, or automatic failover. The patterns BP06 and BP07 show that digital implementation does not automatically eliminate workflow inconsistencies or additional work. This is consistent with the literature on digital health readiness, which identifies the alignment of technology with work routines and an organization's ability to manage process changes as critical components of readiness (Bilgiç & Akdağ, 2021; Proudfoot, 2023; Steenkamp et al., 2025). In the context of this study, these findings are more granular because system misalignments, repetitive tasks, and continuity responses can be distinguished as separate functions. EM02 also indicates that manual actions cannot automatically be labeled as digitization failures. In some situations, such practices serve as temporary operational mechanisms to prevent service interruptions. However, the existence of these mechanisms should not be used to imply that business continuity processes are mature or standardized.

Management Capability

In the Management Capability domain, most of the evidence comes from actors responsible for decision-making, technology management, and data oversight. This is consistent with the nature of the construct being assessed and does not indicate that factors mentioned by only three or four informants are less important. In MC08 Managerial Support, Director [N1] described his involvement through monitoring the progress of implementation, budget decisions, oversight of resource needs, and coordination with vendors. He stated that his focus was on ensuring the digital transformation process continued without disrupting services. Regarding MC09 Digital Strategy, Director [N1] explained, "Developing this system requires significant costs, while the hospital's capabilities must also be taken into account. So, we are indeed implementing it in phases." This statement indicates prioritization and phasing but is not used as evidence of a formal transformation roadmap or KPIs.

In MC10 Internal Resource Capacity, Director [N1] also mentioned limitations in IT capacity: "Our IT team is still very small, yet they must support system development while also handling day-to-day operational needs." The Head of IT [N2] confirmed that internal work encompasses not only servers and networks but also communication with users, resolving daily issues, and coordinating development with vendors. This evidence supports the relative limitations of internal capacity, not a complete lack of resources. At MC11 Digital Governance, the evidence demonstrates mechanisms for monitoring, authorization, verification, and corrective actions. The Head of Medical Records [N3] explained, "The medical records team routinely checks the completeness of medical record entries, reminds doctors if any data is still missing, and ensures that the data submitted is accurate." In the administrative unit, the Head of Registration [N7] noted that certain corrections cannot be made by all staff: "Staff typically do not have access to make further changes, so I log in using my department head account so the data can be corrected."

The Head of Pharmacy [N8] also described the process controls when data is inconsistent: "We do not process the prescription immediately. We put it on hold temporarily, then we confirm with the clinic." This evidence demonstrates tangible governance functions, but it is insufficient to establish a specific level of governance maturity. These findings are consistent with the literature on ODTR and digital health transformation readiness, which identifies management support, resources, strategic direction, and governance as critical components of organizational readiness (Alotaibi et al., 2025; Bilgiç & Akdağ, 2021; Pemerintah RI, 2022; Steenkamp et al., 2025). However, this study suggests that these four aspects should not be treated as a single, homogeneous management construct. Actual management support does not automatically indicate the existence of a formal strategy; a phased strategy does not automatically indicate sufficient resources; and the presence of monitoring or authorization does not automatically indicate governance maturity. This distinction helps ensure that interpretations of readiness remain more granular.

Human Capability

In the area of Human Capability, evidence shows that the ability to use technology and the process of adapting to technology are two related but not identical concepts. From a management perspective, Director [N1] provided important qualifying evidence by stating, "The biggest challenge right now isn't that employees are unwilling to change. On the contrary, they've already been trying to follow the existing processes." This statement preempts the interpretation that all implementation obstacles stem from user resistance. The Head of IT [N2] also noted, "RME is still relatively new, so it will take time for doctors and staff to get used to using the system in their daily work."

Among clinical users, Ophthalmologist [N4] acknowledged that "the adaptation process isn't exactly easy right away." However, he also explained the benefits of RME, particularly because patient histories can be retrieved more quickly compared to having to wait for physical files to be located. A nurse [N5] described the transition period by stating, "Even now, we're still in the adjustment phase. Sometimes there are feature updates, menu layout changes, or adjustments between modules." The optometrist [N6] also noted, "When we first switched to RME, it did take some getting used to. We were previously accustomed to writing down examination results by hand, but now we have to type them into the computer."

In the administrative group, the Head of Registration [N7] explained that almost all processes now use the system, although work on two platforms still occurs. The Head of Pharmacy [N8] described the situation as a "transition period" because electronic prescriptions and paper prescriptions are still being used simultaneously. The Head of Cashier [N9] noted that at the beginning of

implementation, users had to adjust from the habit of reading paper files, but “now they’re much more accustomed to it.” This pattern supports the distinction between HC12 Digital Competence, HC13 Digital Capability Development, and HC14 User Adaptation. HC12 describes the operational capabilities already possessed at the time of the study; HC13 represents mechanisms for building or strengthening those capabilities; while HC14 describes the journey of adjustment and habituation.

These findings are consistent with digital readiness studies that position competencies, capacity development, and the ability to change as components of readiness for transformation (Bilgiç & Akdağ, 2021; Gim et al., 2025; Pemerintah RI, 2022; Steenkamp et al., 2025). However, research evidence indicates that adaptation difficulties cannot be treated as synonymous with low competence or resistance. A user may have been able to routinely perform RME at the time of the study but still have experienced significant difficulties adapting in the early stages. Therefore, HC14 is better understood as a trajectory of adjustment rather than a static user characteristic.

Corporate Culture

In Corporate Culture, evidence emerges through shared routines, practices of mutual assistance, and cross-unit coordination. In CC15 Digital Culture, evidence shows that the use of the system has become part of the routine for a number of units, although manual work methods still persist in certain situations. This is not automatically interpreted as resistance, as some manual practices also serve as a response to the system’s limitations. In CC16 Knowledge Sharing, staff described practices of mutual assistance when other users encountered difficulties using the system’s menus or features. These practices demonstrate informal knowledge exchange, but they are not sufficient to conclude that the hospital has a mature knowledge management system.

In CC17 Interdepartmental Collaboration, forms of coordination can be observed directly. The Head of Registration [N7] explained that she frequently coordinates with the outpatient clinics and medical records department when patient data or conditions require cross-unit resolution. In the Pharmacy, the Head of Pharmacy [N8] stated, “If there are discrepancies in the data between the outpatient clinics and the pharmacy, we do not process the prescription immediately. We put it on hold temporarily, then confirm with the outpatient clinic.” At the Cashier’s Desk, the Head of Cashier Services [N9] explained, “If even a single piece of data is missing or incorrect, we cannot correct it ourselves at the cashier’s desk. We must contact the clinic or pharmacy so the data can be corrected first.”

This evidence demonstrates actual cross-unit collaboration, but it is not used to assert that such collaboration is formal, mature, or fully institutionalized. This finding reinforces the importance of distinguishing between individual adaptation, knowledge exchange, and cross-unit coordination. The ODTR literature identifies corporate culture as one dimension of transformation readiness (Alotaibi et al., 2025), while digital health research also emphasizes the importance of a culture of change and collaborative work (Bilgiç & Akdağ, 2021; Steenkamp et al., 2025). In the context of this study, digital culture is more reliably identified through recurring patterns of collaborative work than through personal attitudes. Meanwhile, cross-unit coordination indicates organizational support for digital work but is not used as a sole indicator of cultural maturity.

Environment Readiness

Under Environment Readiness, evidence shows that hospitals interact with regulatory requirements, external platforms, and external actors involved in system development. Regarding ER18 Regulatory Compliance, Director [N1] explained, “Hospitals are already required to implement Electronic Medical Records and integrate them with SATUSEHAT. So, whether we like it or not, we also have to adapt.” The Head of IT and the Head of Medical Records provided evidence regarding the technical implementation of these requirements. The Head of IT [N2] stated, “For SATUSEHAT, we cannot connect directly from our existing system, so we are still using a bridging mechanism provided by the vendor.” Thus, ER18 represents regulatory alignment and implementation requirements, not evidence that all regulatory requirements have been met. In ER19 External Integration, the clearest evidence emerged regarding SATUSEHAT and the insurer’s platform. The Head of Registration [N7] explained that the insurance portal has not yet been integrated with the RME, so the process is carried out on two systems. The Head of Pharmacy [N8] noted that although prescriptions are available in the SIMRS, staff still have to re-enter the data into the insurance portal. The Head of Billing [N9]

described a similar process regarding patient identification, diagnoses, procedures, cost details, and approval numbers.

These findings form the basis for distinguishing ER19 from TR02. TR02 pertains to Data Integration, whereas ER19 pertains to data exchange with institutions or platforms outside the hospital. In ER21 External Support, vendor involvement can take the form of technical support, maintenance, coordination, or escalation. However, the analysis showed that not all relationships with vendors can be adequately described as “support.” This led to the identification of EM03 Vendor Dependency. The Head of IT [N2] explained directly, “If there is a need for changes, feature additions, or specific fixes, we cannot handle them on our own right away. We have to convey the needs to the vendor and then wait for the development process.” He also stated that most system development still requires vendor involvement.

From a management perspective, the Director [N1] noted, “Development also still depends on the vendor. So if there are changes or obstacles that require adjustments, the hospital cannot act on its own immediately.” The Head of Medical Records [N3] provided corroborating evidence: “Almost every system change or feature addition must go through the vendor.” He explained that new requirements from the hospital as well as changes to SATUSEHAT usually need to be relayed through IT to the vendor. The convergence of N1–N3 supports EM03 as “selective vendor reliance” that is, dependence on vendors for specific technical actions, rather than total outsourcing or comprehensive organizational dependence. TOE literature identifies external environmental conditions, external support, institutional pressures, and relationships with the technology ecosystem as part of the context of digital adoption and transformation (Michelotto & Joia, 2024; Pemerintah RI, 2022; Tornatzky & Fleischer, 1990). The research findings refine these categories by showing that external support and external dependency are not always the same phenomenon. Vendors can serve as a source of technical support in ER21, but when certain modifications or developments cannot be carried out independently, the relationship takes on a different character and is more accurately represented as EM03. Since the evidence indicates reliance only on specific functions, the term “selective vendor reliance” is more appropriate than “total vendor dependency.”

ER20 Data Protection was included among the initial literature-derived indicators, but it was not retained as an independent empirical component after node-level and overlap/boundary evaluation. Initial coding recorded five references across four of the nine informants. This decision was based on empirical distinctiveness rather than conceptual importance. The available evidence did not form a sufficiently coherent and distinct substantive pattern separate from related security and governance functions. Evidence concerning access rights, account controls, backups, and safeguarding was more directly represented under TR03 Data Security, whereas evidence concerning monitoring, responsibility, authorization, and accountability was more appropriately represented under MC11 Governance. This analytical redistribution should not be interpreted as equating data protection with data security or governance, nor as implying that data protection is unimportant. Rather, within this dataset, data protection-related evidence was expressed primarily through security and governance mechanisms and did not support a sufficiently distinct standalone empirical component. Data protection therefore remains a relevant contextual consideration in interpreting digital transformation readiness, even though ER20 was not advanced to the FDM stage as an independent component.

3.3 Fuzzy Delphi Method Analysis

Following qualitative analysis and the pre-FDM analytical review, 23 candidate readiness components were assessed using the Fuzzy Delphi Method (FDM). The panel comprised the same nine participants who had participated in the interview phase; accordingly, the results reported in this section represent consensus within the same stakeholder/expert panel rather than independent external validation. Based on the aggregated FDM calculations, the overall threshold value was $d = 0.074$, with an overall panel agreement of 98%. At the item level, agreement ranged from 89% to 100% after rounding. All 23 candidate components satisfied the predefined acceptance criteria of $d \leq 0.2$, panel agreement greater than 75%, and a defuzzified value $A_{max} > 0.5$. Consequently, all 23 components were retained in the final contextual readiness structure, as shown in Table 5.

The retention of all 23 candidates indicates that the panel reached consensus on the candidate set that had already undergone qualitative evidence assessment, conceptual boundary review, overlap assessment, and Decision Log screening before entering the FDM phase. Because the same participants contributed to both the qualitative evidence and the subsequent FDM assessment, this

result should not be interpreted as independent confirmation of the qualitative findings or as external validation of the resulting framework. Rather, it represents context-bounded stakeholder consensus on the relevance and retention of the analytically derived components within the organizational setting examined. The variation in defuzzified scores was used only as part of the predefined FDM decision procedure and was not interpreted as an empirical hierarchy of component importance. Accordingly, components meeting the acceptance criteria were treated as retained components without inferring that a higher fuzzy score represented greater substantive importance to digital transformation readiness.

Table 5. Results of the Fuzzy Delphi Method

No.	Code	Component	Threshold	Percentage	Fuzzy Score	Decision
1	TR01	System Availability	0.060	89%	0.778	Retained
2	TR02	Data Integration	0.000	100%	0.800	Retained
3	TR03	Data Security	0.151	100%	0.689	Retained
4	TR04	System Reliability	0.000	100%	0.800	Retained
5	BP05	Digital Workflow	0.158	89%	0.644	Retained
6	BP06	Process Fit	0.000	100%	0.800	Retained
7	BP07	Process Structuring	0.000	100%	0.800	Retained
8	MC08	Management Support	0.106	100%	0.756	Retained
9	MC09	Digital Strategy	0.136	100%	0.667	Retained
10	MC10	Resource Capacity	0.000	100%	0.800	Retained
11	MC11	Governance	0.106	100%	0.644	Retained
12	HC12	Digital Competence	0.136	100%	0.667	Retained
13	HC13	Human Resource Development	0.136	100%	0.733	Retained
14	HC14	User Adaptation	0.000	100%	0.800	Retained
15	CC15	Digital Culture	0.136	100%	0.733	Retained
16	CC16	Knowledge Sharing	0.136	100%	0.733	Retained
17	CC17	Inter-unit Collaboration	0.060	89%	0.622	Retained
18	ER18	Regulatory Compliance	0.060	89%	0.622	Retained
19	ER19	External Integration	0.000	100%	0.800	Retained
20	ER21	External Support	0.106	100%	0.756	Retained
21	EM01	Specialty-Specific Features	0.106	100%	0.756	Retained
22	EM02	Service Continuity	0.000	100%	0.600	Retained
23	EM03	Vendor Dependency	0.106	100%	0.556	Retained

The fact that no candidates were eliminated during the FDM phase indicates that substantive refinement of the candidate set had primarily taken place during the preceding qualitative analysis phase. The FDM then yielded stakeholder consensus on 23 components that had passed the evidence evaluation, conceptual boundary review, and Decision Log.

3.4 Final Readiness Framework

Based on the thematic analysis, conceptual refinement process, and within-panel consensus obtained through the Fuzzy Delphi Method, this study developed a Contextual Digital Transformation Readiness Framework that organizes hospital digital transformation readiness components within the TOE structure. The final framework comprises 23 components, as presented in Figure 3.

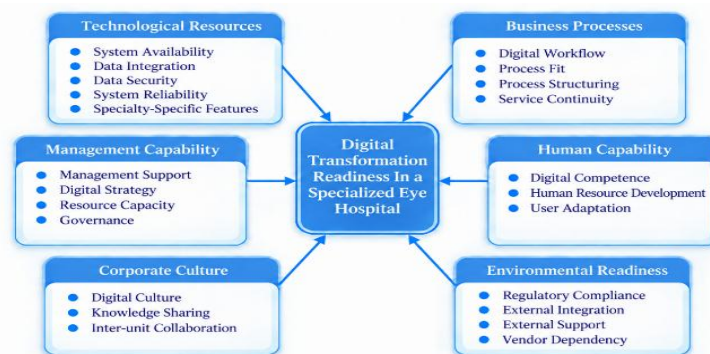


Figure 3. Digital Transformation Readiness Framework

The framework was developed through a sequential refinement process. The literature review initially identified 21 indicators that served as the analytical starting framework. Interview analysis then examined the adequacy of the empirical evidence, conceptual coherence, and potential overlap and boundaries among the indicators. This process generated 24 analytical decision records. Twenty

initial indicators were retained or refined, whereas ER20 Data Protection was not retained as an independent empirical component because the available qualitative evidence did not support a sufficiently distinct substantive core separate from related security and governance functions. This decision concerned the empirical distinctiveness of ER20 within the present dataset and should not be interpreted as diminishing the conceptual or regulatory relevance of data protection. At the same time, three context-derived refinements were identified: EM01 Specialty-Specific Features, EM02 Service Continuity, and EM03 Vendor Dependency. These analytical decisions resulted in 23 candidate components, all of which subsequently met the predefined FDM consensus criteria within the study panel.

Structurally, the 23 components are organized across the three TOE domains. The Technology domain comprises five components under Technological Resources: TR01 System Availability, TR02 Data Integration, TR03 Data Security, TR04 System Reliability, and EM01 Specialty-Specific Features. The Organization domain comprises 14 components distributed across Business Processes, Management Capability, Human Capability, and Corporate Culture. The Environment domain comprises four components: ER18 Regulatory Compliance, ER19 External Integration, ER21 External Support, and EM03 Vendor Dependency. Thus, the final structure consists of five Technology components, fourteen Organization components, and four Environment components. The three context-derived components were not treated as additional domains because their substantive meanings could still be coherently organized within the existing TOE structure. EM01 was positioned within Technology because it represents the ability of digital systems to accommodate ophthalmology-specific information and workflow requirements. EM02 was positioned within Organization, specifically Business Processes, because it reflects operational responses used to maintain service continuity when digital functions are disrupted. EM03 was positioned within Environment because it reflects reliance on vendor involvement for particular technical modifications or developments when internal autonomy is limited. These placements illustrate how context-specific evidence can refine component-level interpretation without requiring the addition of a new macro-level domain beyond TOE.

In practical terms, the framework may provide a structured basis for preliminary internal reflection or readiness review by drawing attention to technological conditions, workflow alignment, organizational capabilities, governance, user competence and adaptation, organizational culture, external interoperability, and context-specific technical requirements. Its use at this stage should therefore be understood as a contextual analytical structure rather than as a standardized or externally validated assessment instrument. Further operationalization and independent testing would be required before the framework could be used for formal comparative assessment across hospitals. The framework remains specific to the organizational context examined in this study. The 23-component structure is not intended as a causal or predictive model, a hierarchy of factor importance, or an externally validated instrument for hospital comparison. Its principal contribution lies in the traceable analytical progression from literature-derived indicators and qualitative evidence, through component refinement and documented analytical decisions, to stakeholder consensus within the study panel. Accordingly, the framework should be interpreted as a context-bounded representation of digital transformation readiness rather than as evidence of universal applicability.

4. CONCLUSION

This study indicates that digital transformation readiness in the specialized eye hospital examined is a multidimensional condition that extends beyond technological availability alone. The resulting contextual framework comprises 23 readiness components organized across the three macro-level TOE domains: Technology (5 components), Organization (14 components), and Environment (4 components). Within this structure, the ODTR dimensions provide greater granularity for examining technological resources, business processes, management capability, human capability, and corporate culture. All 23 candidate components generated through the qualitative analytical process met the predefined FDM consensus criteria within the study panel.

The analysis also identified three context-derived refinements. EM01, Specialty-Specific Features, reflects the need for digital systems to accommodate ophthalmology-specific information structures, visual or anatomical documentation, laterality, and clinical workflows. EM02, Service Continuity, represents operational responses such as temporary manual or hybrid procedures and deferred digital completion used to maintain services when digital functions are disrupted. EM03,

Vendor Dependency, reflects selective reliance on vendors for particular technical modifications, developments, or corrective actions when internal capacity to act independently is limited. These refinements were incorporated into the corresponding TOE domains rather than treated as additional macro-level domains. The findings therefore illustrate how context-specific empirical evidence can refine component-level interpretations while retaining TOE as the broader organizing structure and ODTR as a source of internal readiness granularity. Practically, the resulting Contextual Digital Transformation Readiness Framework may provide a structured basis for preliminary internal reflection and readiness review by drawing attention to technological conditions, workflow alignment, organizational capabilities, governance, user competence and adaptation, organizational culture, external interoperability, and context-specific technical requirements. At its current stage, however, the framework should be treated as a contextual analytical structure rather than as a standardized, predictive, or externally validated assessment instrument.

The findings should be interpreted in light of several methodological boundaries. The study was conducted at a single specialized eye hospital with nine participants, and the same participants contributed to both the qualitative interview and FDM phases. Although the candidate components underwent qualitative synthesis, evidence assessment, conceptual boundary and overlap review, and Decision Log screening before being evaluated through FDM, using the same participants across both phases may have increased the possibility of confirmation bias or circular reinforcement because panel members assessed components partly derived from their earlier accounts. Consequently, the FDM results represent context-bounded, within-panel stakeholder consensus and refinement rather than independent confirmation or external validation of the qualitative findings. In addition, evidence concerning technical conditions was derived primarily from stakeholder experiences and perceptions rather than independent technical measurements or system logs.

These methodological characteristics limit the basis for statistical or universal generalization and instead support a context-sensitive interpretation of the findings. Future research should examine the framework using an independent expert panel, include hospitals with different service profiles and organizational settings, and, where relevant, combine stakeholder assessments with objective technical evidence. Such work would help determine which components remain applicable across contexts and which are specific to the organizational and clinical setting examined in this study. Overall, the study provides a traceable contextual account of digital transformation readiness in a specialized hospital by linking literature-derived readiness concepts, empirical stakeholder evidence, analytical refinement, and within-panel consensus.

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interest related to this research or its publication.

DATA AVAILABILITY

The data underlying this study were generated through interviews with research participants and the subsequent qualitative analysis and Fuzzy Delphi Method (FDM) process. Due to the confidential nature of the interview data and the research context, the underlying data are not publicly available. Data supporting the findings of this study may be made available by the corresponding author upon reasonable request, subject to confidentiality, ethical considerations, and applicable institutional restrictions.

AUTHOR CONTRIBUTIONS

Andiky Vicky Handayana Putra : Conceptualization; Methodology; Investigation; Data Curation; Formal Analysis; Fuzzy Delphi Method; Writing, Original Draft; Visualization. **Ryan Randy Suryono** : Conceptualization; Methodology; Supervision; Validation; Writing, Review & Editing. **Damayanti** : Methodology; Supervision; Validation; Writing, Review & Editing.

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