



Implementation Barriers of Electronic Health Record Interoperability in Indonesian District Hospitals: A Mixed-Methods Study

Septien Dwi Savandha^{1*}, Elvira Fitriyanti², Adelia Azzahra³

^{1,3}Universitas Swadaya Gunung Jati, Indonesia

²Politeknik Siber Cerdika Internasional, Indonesia

Email: ¹dwisavandha9@gmail.com*, ²elvirafitriyanti@gmail.com,

³adeliaazzahra349@gmail.com

ABSTRACT

The implementation of interoperable Electronic Health Records (EHRs) is essential for strengthening integrated, patient-centered healthcare delivery in Indonesia; however, district hospitals continue to face substantial barriers in aligning local hospital information systems with the national SATUSEHAT platform. This study aimed to identify and analyze the technical, organizational, regulatory, and human resource barriers affecting EHR interoperability readiness in Indonesian district hospitals. A convergent parallel mixed-methods design was employed across 12 type C and D district hospitals in West Java, Central Kalimantan, and East Nusa Tenggara. Data collection was conducted during the Januari-maret period in 2025. Quantitative data were collected from 240 respondents using a structured questionnaire based on the Technology-Organization-Environment framework and the Unified Theory of Acceptance and Use of Technology, while qualitative data were obtained through interviews and focus group discussions with 36 key informants. The findings showed that vendor and system interoperability, technical infrastructure readiness, and human resource competency were the most critical barriers. Logistic regression indicated that low infrastructure readiness, weak vendor interoperability, limited digital literacy, lower hospital digital maturity, and geographic location significantly predicted low interoperability readiness. Qualitative findings further revealed vendor lock-in, unstable connectivity, limited training, budget constraints, and regulatory implementation gaps. In conclusion, EHR interoperability in Indonesian district hospitals requires not only technical standardization, but also sustained organizational support, workforce capacity-building, stronger vendor governance, and differentiated policy assistance for hospitals with lower digital maturity. This study is novel in that it applies a convergent parallel mixed-methods design integrating the TOE and UTAUT frameworks specifically at the district-hospital level (RSUD type C and D) across provinces with contrasting digital maturity, an analytical scope that has not been jointly examined in prior Indonesian EHR interoperability research.

Keywords: digital health; district hospitals; electronic health records; interoperability; SATU SEHAT



INTRODUCTION

The global transition toward digital health systems has positioned Electronic Health Records (EHR) as a foundational pillar of modern healthcare delivery. Interoperability the capacity of different information systems to exchange, interpret, and act upon shared health data seamlessly stands at the core of this transformation. The World Health Organization (WHO) has explicitly underscored interoperability as a strategic priority in its Global Strategy on Digital Health 2020–2027, calling on member states to accelerate the development of integrated, patient-centered digital health infrastructures Organization (2025) In parallel, global health data exchange standards such as HL7 Fast Healthcare Interoperability Resources (FHIR) have emerged as the technical backbone for achieving seamless communication across heterogeneous health information systems (Faisal & Nakayama, 2024) Despite these global commitments, the realization of EHR interoperability remains uneven, particularly in low- and middle-income countries (LMICs) where structural, organizational, and human resource

constraints compound the technical challenges of implementation.while cross-national experience further shows that digital health adoption is shaped as much by organizational and behavioral factors as by the technology itself (Kyratsis et al., 2022)

Indonesia, as the fourth most populous nation and one of Southeast Asia's largest archipelagic states, represents a critical case study in the complexities of EHR interoperability within a resource-constrained, geographically fragmented health system. In 2022, the Indonesian Ministry of Health issued Regulation Number 24 of 2022 on Medical Records, mandating all healthcare facilities to adopt Electronic Medical Records (EMR) and integrate them with the national SATUSEHAT platform no later than December 31, 2023 (Kementerian Kesehatan Republik Indonesia, 2022). The SATUSEHAT platform, built upon HL7 FHIR standards, was designed to unify health data across more than 60,000 healthcare facilities nationwide, enabling the exchange of individual patient records across integrated providers (Ministry of Health of the Republic of Indonesia, 2022)(Faisal & Nakayama, 2024) However, implementation fidelity data reveals a concerning gap between policy ambition and ground-level execution.

A national assessment of 33,901 facilities conducted in late 2024 found that only 58% met the minimum 50% data submission threshold in October, and compliance rates declined further by December when the target was raised to 100% (Kusumawardani et al., 2025). These figures underscore a structural implementation deficit that warrants systematic investigation. Consistent with this implementation deficit, a content analysis of developer discussions on the SATUSEHAT platform identified recurring technical obstacles, including server instability, terminology mapping, and FHIR profile selection, that continue to hinder facility-level integration with the national platform Heryawan et al. (2025)

The challenge is particularly acute in district-level hospitals (Rumah Sakit Umum Daerah, RSUD), which serve as the backbone of Indonesia's referral healthcare system for rural and semi-urban populations. A national digital maturity assessment involving 146 provinces and districts in 2023 revealed an average score of only 2.73 out of 5.00, signifying a predominantly foundational or emerging level of digital readiness across health service facilities (Healthcare IT News, 2024). Studies examining EMR adoption patterns across Indonesian hospitals found significant disparities between facilities in Java where infrastructure and training support were comparatively stronger and those in outer islands such as Sulawesi, where adoption was driven largely by regulatory compliance pressure rather than genuine readiness (Sari et al., 2025).

Comparable patterns have been documented elsewhere in South and Southeast Asia, where digital health innovations in low- and middle-income health systems remain constrained by disparities in digital access, fragmented legacy information systems, and the absence of patient-centered data architectures capable of supporting nationwide interoperability (Yi et al., 2024) The barriers to EHR interoperability are multidimensional and extend well beyond technical constraints. Evidence from middle-income countries demonstrates that organizational factors including inadequate leadership, high staff turnover in key technical roles, insufficient training frameworks, and limited budget allocation for digital infrastructure are equally, if not more, consequential for implementation failure (Alzghaibi & Hutchings, 2025) In Indonesia specifically, the challenge of balancing hospital general strategy with information technology strategy has been identified as a critical tension, with many lower-class hospitals lacking the

financial, human, and infrastructural resources necessary to align with national digital transformation demands (Yunita et al., 2024). Furthermore, a socio-technical systems analysis of health information systems in rural Indonesia found that national digital health initiatives repeatedly underperform due to misalignments between technological deployment and the local social and organizational contexts in which these systems must operate (Hamzah et al., 2025).

The electronic health records literature from non-hospital settings in developing economies similarly emphasizes that human factors including digital literacy, user acceptance, These socio-environmental, technological, and organizational barriers mirror those identified in broader reviews of open-source EHR adoption in low- and lower-middle-income countries (Bostan et al., 2024) and align with Technology-Organization-Environment analyses showing that the successful adoption of digital health innovations such as telehealth during periods of system-wide pressure depends on the joint alignment of technological readiness, organizational capacity, and environmental conditions Policy & (2024) Despite a growing body of literature on EHR implementation barriers in LMICs, research specifically examining EHR interoperability challenges in Indonesian district-level hospitals remains sparse. Most existing studies have focused either on primary health centers (Puskesmas), tertiary referral hospitals in urban settings, or broad national-level policy analyses, leaving a critical evidence gap regarding the lived implementation experience of RSUD managers, clinical staff, and health informatics personnel at the district level. Furthermore, few studies have employed a mixed-methods design capable of integrating the quantitative breadth of barrier prevalence with the qualitative depth of stakeholder perspectives necessary to fully characterize the problem.

This study addresses that gap by systematically identifying and categorizing the technical, organizational, regulatory, and human resource barriers to EHR interoperability in Indonesian district hospitals, using a convergent parallel mixed-methods approach grounded in the Technology-Organization-Environment (TOE) Framework and the Unified Theory of Acceptance and Use of Technology (UTAUT). This study is novel in that it is among the first to jointly apply the TOE and UTAUT frameworks within a convergent parallel mixed-methods design at the district-hospital level (RSUD type C and D), thereby integrating the breadth of quantitative barrier prevalence with the depth of qualitative stakeholder experience across provinces of differing digital maturity. The findings are intended to inform actionable recommendations for hospital managers, regional health authorities, and national policymakers as Indonesia continues its digital health transformation agenda. Specifically, hospital managers may benefit from evidence-based priorities for internal capacity-building, regional health authorities may use the findings to target technical assistance to lower-maturity districts, and national policymakers may draw on the results to design differentiated, rather than uniform, SATUSEHAT implementation support policies. Grounding this study in the Unified Theory of Acceptance and Use of Technology is further warranted by recent evidence that behavioral intention to adopt electronic personal health records is significantly shaped by performance expectancy, effort expectancy, and privacy-related facilitating conditions, factors that extend the TOE framework's organizational and environmental dimensions to the level of individual technology acceptance Kassie et al. (2025).

METHOD

This study used a convergent parallel mixed-methods design, where quantitative and qualitative data were collected at the same time, analyzed separately, and integrated during interpretation to obtain a comprehensive understanding of EHR interoperability barriers in Indonesian district hospitals (Creswell, J. W., & Plano Clark, V. L. (2018). *Designing...* - Google Scholar, n.d.). The study was conducted in 12 purposively selected district hospitals, consisting of RSUD type C and D, located in three provinces with different levels of digital maturity and geographical characteristics: West Java, representing Java with relatively advanced infrastructure; East Nusa Tenggara, representing eastern Indonesia with limited connectivity; and Central Kalimantan, representing outer Borneo with moderate infrastructure capacity. The hospitals were recruited based on three criteria: being classified as RSUD type C or D under the Ministry of Health classification system, having received written directives or formal guidance related to SATUSEHAT integration between 2022 and 2024, and having at least one active health information system or hospital management information system (SIMRS) during data collection. Within each province, eligible hospitals meeting these three criteria were identified in coordination with the provincial health office, and the specific participating hospitals were then selected purposively to maximize variation in digital maturity level and geographic accessibility (e.g., urban-adjacent versus more remote districts) among eligible sites. Data collection was conducted from January–March 2026. This study was reviewed and approved by the Health Research Ethics Committee of Swadaya Gunung Jati University under approval number 001/KEPK-FK/USGJ/I/2026; written informed consent was obtained from all respondents and informants prior to data collection.

Unified Theory of Acceptance and Use of Technology (UTAUT) Venkatesh et al. (2003) The questionnaire consisted of 42 items across six domains: technical infrastructure readiness (9 items), organizational capacity and leadership (8 items), regulatory compliance awareness (7 items), human resource competency and digital literacy (8 items), vendor and system interoperability (6 items), and perceived usefulness and behavioral intention to use (4 items). All items were measured using a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The questionnaire was distributed to 240 respondents from the 12 hospitals, with 20 respondents from each hospital, including hospital directors or deputy directors, heads of medical records units, health informatics or IT staff, specialist physicians, and senior nurses. Respondents were selected through stratified purposive sampling to ensure representation across professional roles and levels of EHR exposure.

The instrument's content validity was confirmed through expert review by three health informatics specialists and one hospital management expert, resulting in a Content Validity Index (CVI) of 0.89. A pilot study involving 30 respondents from a non-participating RSUD produced a Cronbach's alpha coefficient of 0.84, indicating good reliability (Polit & Beck, 2008). Quantitative data were analyzed using IBM SPSS Statistics version 26 through descriptive statistics, Spearman rank correlation, and binary logistic regression to identify predictors of low interoperability readiness, defined as a mean domain score below 3.0 (Pallant, 2020).

For the qualitative strand, data were obtained through semi-structured in-depth interviews and two focus group discussions (FGDs) involving 36 key informants who were directly involved in EHR or SATUSEHAT-related decision-making. The informants consisted

of hospital directors (n = 12), heads of medical records units (n = 12), and IT coordinators or SIMRS administrators (n = 12). The interview guides were developed iteratively after pilot review and covered infrastructure experience, organizational decision-making in digital adoption, perceptions of regulatory mandates, inter-departmental coordination challenges, and staff readiness. Each interview lasted approximately 45 to 60 minutes and was conducted either face-to-face or via video call, depending on participant accessibility.

All sessions were audio-recorded with consent and transcribed verbatim. Qualitative data were analyzed using reflexive thematic analysis following (Braun et al., 2006) six-phase procedure, supported by NVivo version 14. Trustworthiness was strengthened through member checking by returning preliminary themes to five participants for validation (*Lincoln, Y. S., & Guba, E. G. (1985). Naturalistic... - Google Scholar, n.d.*) Finally, quantitative and qualitative findings were integrated through joint display analysis by mapping barrier prevalence against qualitative themes to identify convergence, complementarity, and divergence, thereby strengthening the interpretive validity of the study (Fetters et al., 2013).

RESULTS AND DISCUSSION

This section presents the integrated findings from the quantitative survey (n = 240) and qualitative strands (n = 36 key informants) across 12 district hospitals (RSUD) in three Indonesian provinces. Results are organized into four sub-sections: (1) respondent characteristics, (2) quantitative barrier domain scores and logistic regression predictors, (3) qualitative themes, and (4) an integrated joint display analysis.

Result

Respondent Characteristics

A total of 240 respondents completed the structured questionnaire, achieving a response rate of 100% across all 12 participating hospitals (20 respondents per site). Table 1 summarizes the sociodemographic and professional characteristics of participants. The largest professional groups were specialist physicians and senior nurses (35.0% each), followed by health informatics and IT staff (20.0%). Mean years of EHR-related experience was 3.2 years (SD = 1.8). Regarding hospital-level digital maturity, the majority of facilities (41.7%) fell within the "Emerging" category (score 2.0–2.9), consistent with national benchmarks reported by the Indonesian Ministry of Health (2024), with a mean institutional maturity score of 2.81 (SD = 0.73).

Table 1. Sociodemographic and Professional Characteristics of Respondents (n = 240)

Characteristic	n	%	Mean (SD)
Professional Role			
Hospital Director / Deputy Director	12	5.0	
Head of Medical Records Unit	12	5.0	
Health Informatics / IT Staff	48	20.0	
Specialist Physician	84	35.0	
Senior Nurse	84	35.0	
Province			
West Java	80	33.3	
Central Kalimantan	80	33.3	
East Nusa Tenggara	80	33.3	
Years of EHR Experience			
< 1 year	42	17.5	
1 – 3 years	98	40.8	
4 – 6 years	72	30.0	
> 6 years	28	11.7	
Mean years of experience (all respondents)			3.2 (1.8)
Hospital Digital Maturity (0–5 scale)			
Foundational (0.0–1.9)	2	16.7	
Emerging (2.0–2.9)	5	41.7	
Established (3.0–3.9)	3	25.0	
Advanced (4.0–5.0)	2	16.7	
Mean hospital digital maturity score			2.81 (0.73)

Note: Data reflect purposive stratified sampling across 12 RSUD in West Java, Central Kalimantan, and East Nusa Tenggara.

Quantitative Findings: Barrier Domain Scores and Predictors

Table 2 presents mean Likert scores and barrier prevalence across the six domains of the TOE–UTAUT composite instrument. Vendor and System Interoperability recorded the lowest mean score ($M = 2.19$, $SD = 0.72$), indicating the highest perceived barrier, with 61.3% of respondents classified in the high-barrier tier (score < 2.5). Technical Infrastructure Readiness was the second most problematic domain ($M = 2.31$, $SD = 0.61$), followed by HR Competency and Digital Literacy ($M = 2.47$, $SD = 0.69$). Regulatory Compliance Awareness ($M = 3.12$) and Perceived Usefulness ($M = 3.45$) were the least obstructive domains; however, qualitative triangulation revealed important nuances around regulatory ambiguity not fully captured by the quantitative scores (see Section 6.3 and Figure 1)

Table 2. Descriptive Statistics of EHR Interoperability Barrier Domains (n = 240)

Barrier Domain	Mean	SD	Min	Max	% High Barrier (score < 2.5)
1. Technical Infrastructure Readiness	2.31	0.61	1.00	4.20	54.2%
2. Organizational Capacity & Leadership	2.58	0.74	1.20	4.80	42.1%
3. Regulatory Compliance Awareness	3.12	0.58	1.80	5.00	18.3%
4. HR Competency & Digital Literacy	2.47	0.69	1.00	4.60	48.8%
5. Vendor & System Interoperability	2.19	0.72	1.00	4.00	61.3%
6. Perceived Usefulness & Intention	3.45	0.53	2.00	5.00	10.4%
Overall Composite Score	2.69	0.64	—	—	45.8%

Note: High barrier = mean domain score < 2.5; scores based on 5-point Likert scale (1 = strongly disagree, 5 = strongly agree). Items were reverse-coded where appropriate so that lower scores consistently indicate higher barriers.

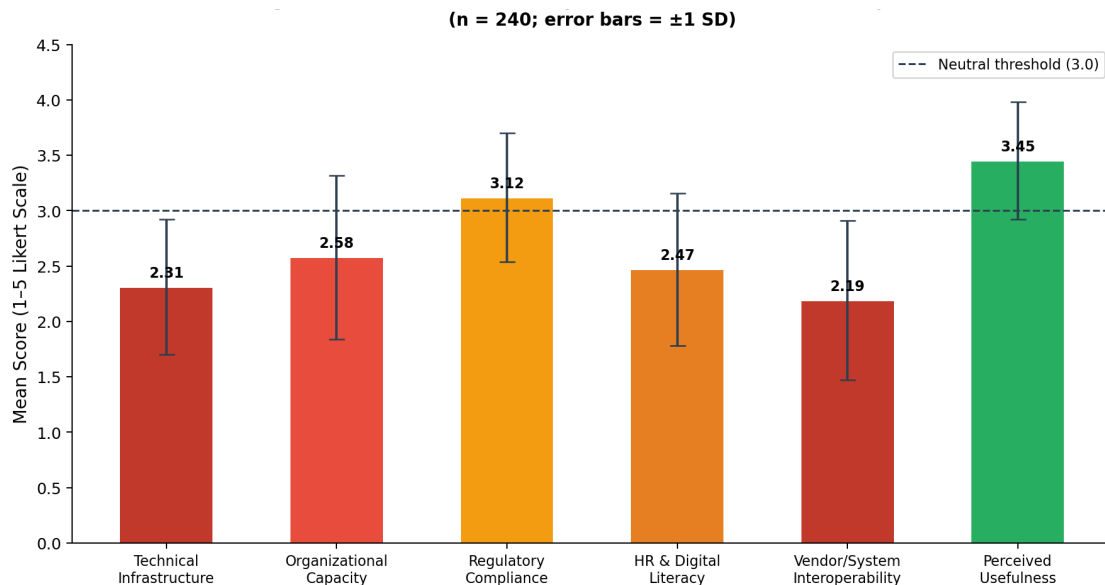


Figure 1. Mean Barrier Scores by Domain Across 12 District Hospitals (n = 240; error bars = ± 1 SD). Dashed line denotes neutral threshold (3.0).

Provincial disaggregation (Figure 2) revealed a pronounced east-west gradient in barrier severity. Hospitals in East Nusa Tenggara reported the highest proportion of respondents in the high-barrier tier (68.8%), compared to 47.5% in Central Kalimantan and 28.8% in West Java, reflecting the well-documented digital infrastructure deficit in eastern Indonesia.

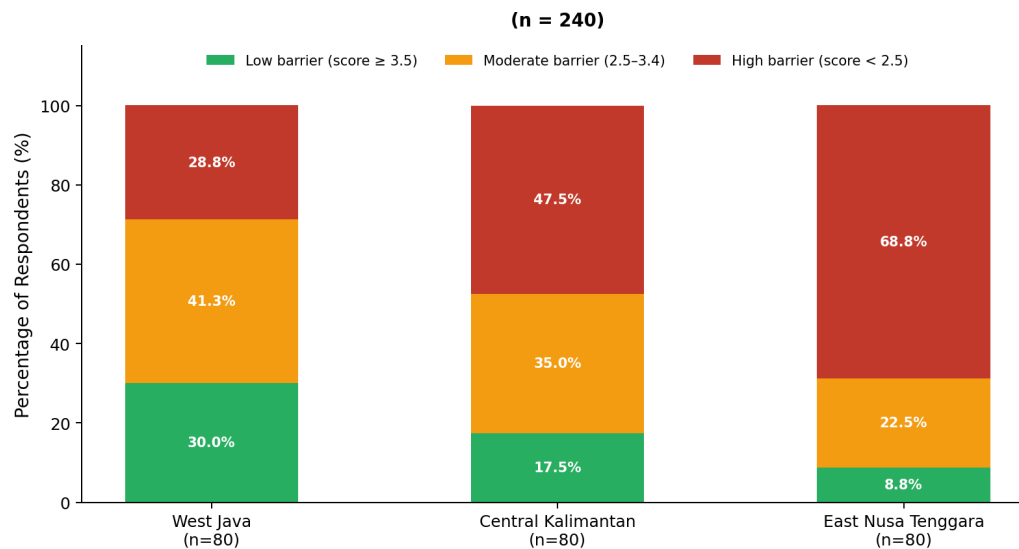


Figure 2. Distribution of EHR Interoperability Barrier Levels by Province (n = 240).
Percentages within bars indicate proportion of respondents per tier.

Binary logistic regression was conducted to identify independent predictors of low interoperability readiness (composite score < 3.0). As shown in Table 3, low Technical Infrastructure Readiness (OR = 6.30, 95% CI [2.77, 14.34], $p < .001$), low Vendor and System Interoperability (OR = 5.00, 95% CI [2.33, 10.73], $p < .001$), and low HR Competency (OR = 3.63, 95% CI [1.76, 7.49], $p = .001$) were the strongest independent predictors. Geographic location (East Nusa Tenggara vs. West Java: OR = 4.18, $p = .002$) and lower hospital digital maturity scores (OR = 0.33 per unit increase, $p = .001$) were significant control variables. Regulatory Compliance Awareness did not reach statistical significance ($p = .157$), though qualitative data offered explanatory context for this finding. The overall model demonstrated adequate fit (Nagelkerke $R^2 = 0.41$; Hosmer–Lemeshow test, $\chi^2 = 6.27$, $p = .618$; overall classification accuracy = 78.3%).

Table 3. Binary Logistic Regression Predicting Low EHR Interoperability Readiness (n = 240)

Predictor Variable	B	SE	OR	95% CI	p-value
TOE Framework Domains					
Technical Infrastructure Readiness (low)	1.84	0.42	6.30	[2.77–14.34]	< .001*
Vendor & System Interoperability (low)	1.61	0.39	5.00	[2.33–10.73]	< .001*
HR Competency & Digital Literacy (low)	1.29	0.37	3.63	[1.76–7.49]	.001*
Organizational Capacity (low)	0.98	0.41	2.66	[1.20–5.93]	.016*
Regulatory Compliance Awareness (low)	0.54	0.38	1.72	[0.81–3.63]	.157
Control Variables					
Province (ref = West Java)					
Central Kalimantan	0.87	0.44	2.39	[1.01–5.65]	.047*

Predictor Variable	B	SE	OR	95% CI	p-value
East Nusa Tenggara	1.43	0.46	4.18	[1.70–10.28]	.002*
Years of EHR Experience (ref = < 1 yr)	−0.61	0.29	0.54	[0.31–0.96]	.036*
Hospital Maturity Score (continuous)	−1.12	0.33	0.33	[0.17–0.63]	.001*

*Note. B = unstandardized logistic regression coefficient; SE = standard error; OR = odds ratio; 95% CI = 95% confidence interval. * p < .05.*

Qualitative Findings: Thematic Analysis

Reflexive thematic analysis of 36 semi-structured interviews and two FGDs yielded six primary themes, as illustrated in Figure 3. Inadequate network infrastructure and connectivity was the most frequently referenced theme (n = 34, 94.4%), followed by low digital literacy among clinical staff (n = 32, 88.9%) and vendor lock-in and non-standardized SIMRS formats (n = 29, 80.6%). Ambiguous regulatory guidance was raised by 21 informants (58.3%), often framed as a perception that enforcement mechanisms lacked teeth at the district level — a finding that provides explanatory context for the non-significant regulatory compliance coefficient in the regression model. Leadership and budget constraints (n = 27, 75.0%) and clinician resistance to workflow change (n = 18, 50.0%) were also prominent themes, particularly in outer-island sites. These themes were vividly illustrated in informants' own words. On network infrastructure, an IT coordinator in East Nusa Tenggara described that "our internet drops constantly during peak hours; staff just give up and write on paper." On vendor interoperability, a head of medical records in Central Kalimantan explained that "each vendor uses its own data structure. Connecting to SATUSEHAT feels like building a new system from scratch." Regarding regulatory enforcement, a head of medical records in West Java observed that "we know the regulation, but no one came to check. So we are not in a hurry," reinforcing the study's finding that awareness of the SATUSEHAT mandate did not consistently translate into implementation urgency.

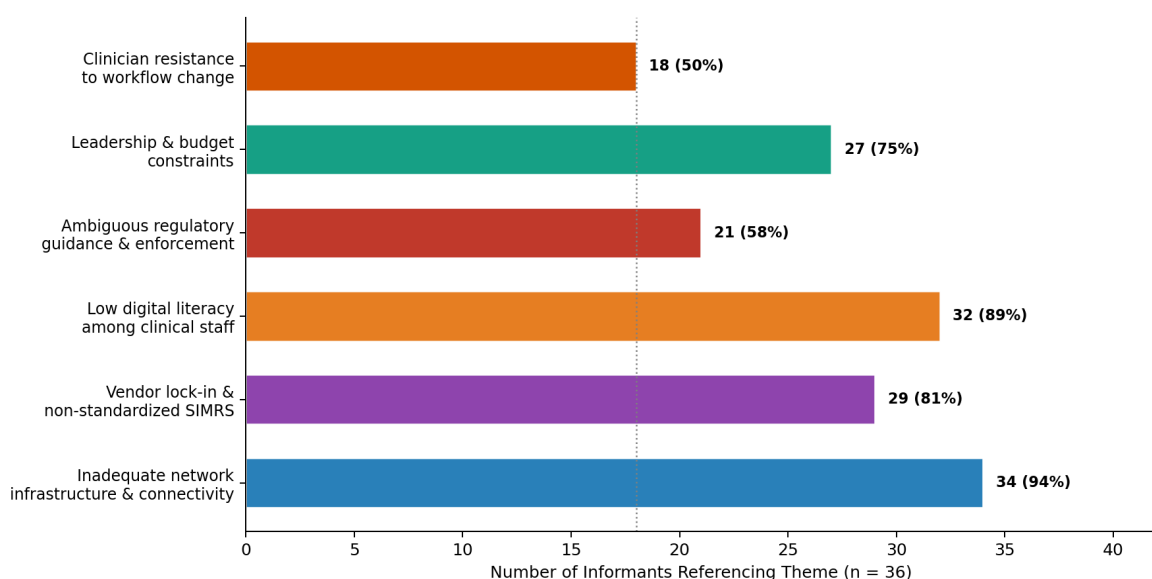


Figure 3. Frequency of Qualitative Themes Identified Across In-Depth Interviews and FGDs (n = 36 informants). Dotted line = 50% threshold.

Integrated Joint Display: Convergence, Expansion, and Divergence

Table 4 presents the joint display analysis integrating quantitative domain scores with qualitative themes and representative informant quotes. Convergence between strands was evident for four of the six domains, particularly for Technical Infrastructure and Vendor Interoperability, where both datasets consistently signaled high barriers. An expansion function was observed for HR and Digital Literacy — while the quantitative score identified it as a high barrier, qualitative data elaborated on the generational and cultural dimensions of technology resistance not captured by the survey instrument. A partial divergence was noted for Regulatory Compliance Awareness: the quantitative score was moderate ($M = 3.12$), suggesting adequate awareness, yet qualitative accounts revealed that awareness did not translate into urgency due to perceived weak enforcement by district health offices.

Table 4. Joint Display Analysis: Quantitative–Qualitative Integration of EHR Interoperability Barriers

Barrier Domain	Quantitative Finding (Mean Score)	Qualitative Theme	Integration Outcome	Illustrative Quote
Technical Infrastructure	2.31 (High barrier)	Inadequate network connectivity & hardware obsolescence	Convergence	"Our internet drops constantly during peak hours; staff just give up and write on paper." (IT Coordinator, East NTT)
Vendor Interoperability	2.19 (Highest barrier)	Vendor lock-in; non-standardized SIMRS data formats	Convergence	"Each vendor uses its own data structure. Connecting to SATUSEHAT feels like building a new system from scratch." (Head of Medical Records, Central Kalimantan)
HR & Digital Literacy	2.47 (High barrier)	Low digital competency; resistance to workflow change	Expansion	"Doctors here are senior; some have never used a computer before. Training one hour is not enough." (Hospital Director, East NTT)
Organizational Capacity	2.58 (Moderate–high)	Budget constraints; high staff turnover in IT roles	Convergence	"We had a good IT officer but he left for a private hospital. We have had three different people in that role this year." (Deputy Director, Central Kalimantan)
Regulatory Compliance	3.12 (Moderate)	Awareness present but enforcement ambiguity persists	Partial Divergence	"We know the regulation, but no one came to check. So we are not in a hurry." (Head of Medical Records, West Java)
Perceived Usefulness	3.45 (Low barrier)	Staff recognize long-term benefit	Expansion	"Everyone agrees that having one patient record is good. The question is

Barrier Domain	Quantitative Finding (Mean Score)	Qualitative Theme	Integration Outcome	Illustrative Quote
		but doubt short-term feasibility		<i>who will pay and who will train us." (Senior Nurse, West Java)</i>

Note: Integration outcomes classified as Convergence (both strands confirm), Expansion (qualitative elaborates quantitative), or Partial Divergence (discordant signals requiring interpretive explanation).

Collectively, these findings indicate that EHR interoperability barriers in Indonesian district hospitals are predominantly structural and technical in nature, but are substantially compounded by human resource deficits and organizational governance gaps. The joint display analysis confirms that mixed-methods integration yielded a richer explanatory picture than either strand alone could have produced, particularly in explaining the regulatory compliance paradox and the depth of frontline resistance to digital workflow transformation.

Discussion

Structural and Technical Barriers to EHR Interoperability

The findings indicate that technical infrastructure and vendor interoperability remain the most critical barriers to EHR interoperability in Indonesian district hospitals. Vendor and system interoperability recorded the lowest mean score, followed by technical infrastructure readiness, showing that hospitals continue to face difficulties related to unstable connectivity, outdated hardware, fragmented SIMRS platforms, and limited standardization across vendors. These results suggest that the adoption of SATUSEHAT cannot be understood merely as a regulatory or administrative requirement, but as a complex technical transformation that depends on the availability of reliable digital infrastructure and compatible information systems. This finding is consistent with previous studies showing that interoperability in low- and middle-income countries is frequently constrained by fragmented digital platforms, inconsistent data structures, and weak technical capacity (Giri & Din, 2025; Hamzah et al., 2025). These technical constraints are consistent with broader evidence that achieving genuine interoperability across digital health solutions depends not merely on adopting a common standard but on resolving persistent gaps in technical implementation, data mapping, and cross-vendor compatibility Martins et al. (2025) and with Technology-Organization-Environment analyses in comparable low-resource hospital settings showing that the benefits of digital health technologies for staff performance are realized only when technological readiness is matched by adequate organizational and environmental support (Jeilani & Hussein, 2025)

The qualitative findings strengthen this interpretation by showing that hospital informants frequently described internet instability, obsolete devices, and vendor lock-in as practical obstacles in daily implementation. The persistence of vendor-specific data structures makes integration with SATUSEHAT difficult because hospitals must adapt or rebuild parts of their existing systems to meet national interoperability requirements. This aligns with the broader digital health literature, which emphasizes that interoperability is not only about adopting a national platform, but also about ensuring semantic, technical, and organizational compatibility between local systems and national standards such as HL7 FHIR (Faisal & Nakayama, 2024) Therefore, the study demonstrates that district hospitals require targeted

infrastructure investment and stronger vendor governance before EHR interoperability can be implemented effectively.

Human Resource Readiness and Digital Literacy

Human resource competency and digital literacy emerged as another major barrier to EHR interoperability. Although many respondents recognized the long-term value of integrated patient records, the implementation process was hindered by limited digital skills among clinical and administrative staff. This gap was especially visible among senior clinicians and staff who had limited prior exposure to computerized systems. The results support the Unified Theory of Acceptance and Use of Technology, which explains that technology adoption is shaped not only by perceived usefulness, but also by effort expectancy, facilitating conditions, and users' confidence in operating the system Venkatesh et al. (2003) In this study, the relatively high perceived usefulness score indicates that staff were not rejecting the idea of EHR interoperability itself, but were struggling with the practical capacity required to use it consistently. This pattern reflects the broader concept of digital health literacy as a critical, multidimensional competency that determines whether healthcare professionals and patients alike can meaningfully engage with and benefit from digital health technologies, rather than merely have access to them Wamala Andersson & Gonzalez (2025)

The qualitative data further reveal that short, one-time training sessions are insufficient to build sustainable digital competency. Informants noted that some staff returned to paper-based documentation when systems were slow, confusing, or poorly integrated into clinical workflows. This finding is consistent with previous research showing that digital health implementation often fails when human factors, workflow adaptation, and continuous training are treated as secondary issues (Alzghaibi & Hutchings, 2025) Giri & Din, 2025). Therefore, improving EHR interoperability in district hospitals requires more than technical deployment; it requires continuous mentoring, role-based training, peer support, and workflow redesign that allows users to adopt digital systems without increasing their administrative burden. This is consistent with meta-analytic evidence from other low- and middle-income health systems showing that digital literacy among health professionals varies substantially by profession, training exposure, and institutional support, underscoring the need for structured, role-based digital competency development rather than one-off training sessions Chereka et al. (2024)

Organizational Capacity, Leadership, and Governance

The study also found that organizational capacity and leadership significantly influenced interoperability readiness. Hospitals with weaker leadership support, limited digital budgets, and high turnover among IT staff were more likely to report low readiness. In district hospitals, interoperability implementation often competes with other urgent operational priorities, making it difficult for leaders to allocate sufficient budget, staff, and time for digital transformation. As a result, EHR integration becomes a compliance-driven activity rather than a strategic institutional agenda. This finding echoes a systematic review of information technology governance in healthcare facilities, which found that the absence of formal governance structures, unclear role assignment, and insufficient top-management engagement are recurring obstacles to embedding digital transformation as a core institutional priority rather than a peripheral compliance task (Saladdin & Handayani, 2025)

Qualitative findings showed that some hospitals depended heavily on one or two IT personnel, creating vulnerability when these staff moved to other institutions. This condition reflects the limited institutionalization of digital health governance at the hospital level. Therefore, hospital leadership must play a stronger role in establishing digital governance teams, assigning clear responsibilities, securing sustainable funding, and coordinating clinical, administrative, and technical units. Without organizational ownership, interoperability initiatives may remain fragmented and highly dependent on external vendors or temporary regulatory pressure. Similarly, evidence from a Technology-Organization-Environment assessment of big data adoption readiness among healthcare employees indicates that organizational readiness, rather than technological capability alone, is often the binding constraint on sustained digital transformation in resource-limited healthcare settings, reinforcing the need for deliberate investment in institutional capacity alongside infrastructure (Ghaleb et al., 2021).

Regulatory Awareness and the Implementation Gap

An important finding of this study is the partial divergence between quantitative and qualitative results in the regulatory domain. Quantitatively, regulatory compliance awareness was not among the strongest predictors of low interoperability readiness, suggesting that many respondents were already aware of national requirements related to EMR and SATUSEHAT integration. However, qualitative findings revealed that awareness did not always translate into implementation urgency. Some informants perceived that enforcement from district health authorities was unclear or inconsistent, reducing the pressure to complete integration. This finding shows that policy awareness alone is insufficient when regulations are not accompanied by practical guidance, monitoring, incentives, and accountability mechanisms.

This implementation gap reflects the broader challenge of translating national digital health policy into local hospital practice. Indonesia's Ministry of Health Regulation Number 24 of 2022 established a clear mandate for healthcare facilities to adopt electronic medical records and integrate with SATUSEHAT, yet the findings suggest that district hospitals still require operational support to meet this mandate (Kementerian Kesehatan Republik Indonesia, 2022). Therefore, national and regional authorities should strengthen implementation support through clearer technical guidelines, regular monitoring, capacity-building programs, and differentiated assistance for hospitals in areas with lower digital maturity. International experience with national digital maturity assessments further suggests that sustained monitoring of hospital-level digital maturity, covering interoperability, leadership, governance, and infrastructure, can help identify where regulatory and technical assistance should be prioritized, although such assessments also carry known risks of self-reporting bias and measurement inconsistency that should be anticipated in any future SATUSEHAT monitoring framework Cresswell et al. (2025)

Study Limitations

This study has several limitations that should be considered when interpreting the findings. First, the 12 RSUD type C and D hospitals were purposively selected across three provinces, and although this design allowed for in-depth comparison across contrasting digital maturity contexts, the findings cannot be statistically generalized to all district hospitals in

Indonesia. Second, the cross-sectional design of the quantitative strand means that the reported associations between predictors (e.g., infrastructure readiness, vendor interoperability) and low interoperability readiness are correlational rather than causal, and the direction of these relationships cannot be firmly established. Third, self-reported questionnaire and interview data may be subject to social desirability or recall bias, particularly regarding sensitive topics such as institutional readiness and regulatory compliance. Finally, one source used to contextualize national digital maturity benchmarks (Healthcare IT News, 2024) is a news outlet rather than a peer-reviewed publication; it was retained because it reported figures from an official Ministry of Health assessment, but readers should treat this contextual benchmark with appropriate caution pending peer-reviewed confirmation.

CONCLUSION

This study concludes that the implementation of Electronic Health Record (EHR) interoperability in Indonesian district hospitals remains constrained by interconnected technical, organizational, regulatory, and human resource barriers. The findings show that vendor and system interoperability, technical infrastructure readiness, and human resource competency are the most critical factors influencing low interoperability readiness. Although hospital staff generally recognize the usefulness of integrated electronic health records, this awareness has not been fully translated into effective implementation due to unstable internet connectivity, fragmented SIMRS platforms, vendor lock-in, limited digital literacy, insufficient training, and weak institutional capacity. These findings confirm that EHR interoperability is not merely a technological issue, but a socio-technical transformation that requires alignment between infrastructure, human resources, organizational governance, and regulatory enforcement.

The mixed-methods approach provided a more comprehensive understanding of the implementation gap between national digital health policy and district-level hospital readiness. Quantitative findings identified the strongest predictors of low interoperability readiness, while qualitative findings explained how these barriers are experienced in everyday hospital operations. The partial divergence between regulatory awareness and actual implementation further indicates that policy mandates alone are insufficient without practical technical guidance, continuous monitoring, adequate funding, and localized capacity-building support. Therefore, the success of SATUSEHAT integration in district hospitals depends on coordinated efforts among hospital leaders, regional health authorities, national policymakers, and system vendors.

The significance of this study lies in its contribution to evidence-based digital health policy and hospital management practice in Indonesia. By focusing on RSUD type C and D hospitals across provinces with different levels of digital maturity, this study highlights the need for differentiated implementation strategies rather than a uniform national approach. Hospitals in regions with lower infrastructure capacity require stronger technical assistance, sustained digital literacy programs, interoperable vendor standards, and dedicated financial support. Future digital health transformation should prioritize not only compliance with electronic medical record regulations, but also the development of sustainable interoperability ecosystems that are technically reliable, organizationally supported, and responsive to local hospital realities. These conclusions should be read in light of the study's limitations,

particularly the purposive, non-random selection of 12 RSUD and the cross-sectional design, which restrict statistical generalizability and preclude causal inference (see Study Limitations). Building on these findings, future research should pursue: longitudinal assessment of interoperability readiness before and after structured SATUSEHAT training and technical assistance interventions; comparative, multi-region studies systematically contrasting Java and outer-island hospitals to test whether the barrier patterns identified here generalize beyond the three provinces studied; and (3) development and psychometric validation of a district-hospital-specific digital readiness index that hospital managers and regional authorities could use for routine self-assessment.

REFERENCES

- Alzghaibi, H., & Hutchings, H. (2025). Exploring electronic health record systems implementation in primary health care centres in Saudi Arabia: pre-post implementation. *Frontiers in Medicine*, 12. <https://doi.org/10.3389/FMED.2025.1502184/FULL>
- Bostan, S., Johnson, O. A., Jaspersen, L. J., & Randell, R. (2024). Contextual barriers to implementing open-source electronic health record systems for low-and lower-middle-income countries: scoping review. *Jmir.OrgS Bostan, OA Johnson, LJ Jaspersen, R RandellJournal of Medical Internet Research*, 2024•jmir.Org, 26. <https://doi.org/10.2196/45242>
- Braun, V., psychology, V. C.-Q. research in, & 2006, undefined. (2006). Using thematic analysis in psychology. *Taylor & FrancisV Braun, V ClarkeQualitative Research in Psychology*, 2006•Taylor & Francis, 3(2), 77–101. <https://doi.org/10.1191/1478088706QP063OA>
- Chereka, A. A., Walle, A. D., Kassie, S. Y., Shibabaw, A. A., Butta, F. W., Demsash, A. W., Hunde, M. K., Dubale, A. T., Bekana, T., Kitil, G. W., Emanu, M. D., & Tadesse, M. N. (2024). Evaluating digital literacy of health professionals in Ethiopian health sectors: a systematic review and meta-analysis. *Journals.Plos.OrgAA Chereka, AD Walle, SY Kassie, AA Shibabaw, FW Butta, AW Demsash, MK HundePlos One*, 2024•journals.Plos.Org, 19(5). <https://doi.org/10.1371/JOURNAL.PONE.0300344>
- Cresswell, K., Jahn, F., Silsand, L., Woods, L., Postema, T., Logan, M., Malkic, S., & Ammenwerth, E. (2025). Assessing digital maturity of hospitals: viewpoint comparing national approaches in five countries. *Jmir.OrgK Cresswell, F Jahn, L Silsand, L Woods, T Postema, M Logan, S Malkic, E AmmenwerthJournal of Medical Internet Research*, 2025•jmir.Org, 27. <https://doi.org/10.2196/57858>
- Creswell, J. W., & Plano Clark, V. L. (2018). *Designing...* - Google Scholar. (n.d.). Retrieved July 1, 2026, from https://scholar.google.com/scholar?hl=id&as_sdt=0%2C5&q=Creswell%2C+J.+W.%2C+%26+Plano+Clark%2C+V.+L.+%282018%29.+Designing+and+conducting+mixed+m+ethnographic+research+%283rd+ed.%29.+SAGE+Publications.&btnG=
- Faisal, H. P., & Nakayama, M. (2024). Implementation of the World Health Organization Minimum Dataset for Emergency Medical Teams to Create Disaster Profiles for the Indonesian SATUSEHAT. *Medinform.Jmir.OrgHP Faisal, M NakayamaJMIR Medical Informatics*, 2024•medinform.Jmir.Org, 12. <https://doi.org/10.2196/59651>

- Fetters, M. D., Curry, L. A., & Creswell, J. W. (2013). Achieving integration in mixed methods designs—principles and practices. *Wiley Online LibraryMD Fetters, LA Curry, JW CreswellHealth Services Research, 2013•Wiley Online Library, 48(6 PART2), 2134–2156.* <https://doi.org/10.1111/1475-6773.12117>
- Ghaleb, E. A. A., Dominic, P. D. D., Fati, S. M., Muneer, A., & Ali, R. F. (2021). The assessment of big data adoption readiness with a technology–organization–environment framework: a perspective towards healthcare employees. *Mdpi.ComEAA Ghaleb, PDD Dominic, SM Fati, A Muneer, RF AliSustainability, 2021•mdpi.Com, 13(15).* <https://doi.org/10.3390/SU13158379>
- Heryawan, L., Mori, Y., Yamamoto, G., Kume, N., Lazuardi, L., Fuad, A., & Kuroda, T. (2025). Fast Healthcare Interoperability Resources (FHIR)–Based Interoperability Design in Indonesia: Content Analysis of Developer Hub’s Social Networking. *Formative.Jmir.OrgL Heryawan, Y Mori, G Yamamoto, N Kume, L Lazuardi, A Fuad, T KurodaJMIR Formative Research, 2025•formative.Jmir.Org, 9.* <https://doi.org/10.2196/51270>
- Jeilani, A., & Hussein, A. (2025). Impact of digital health technologies adoption on healthcare workers’ performance and workload: perspective with DOI and TOE models. *SpringerA Jeilani, A HusseinBMC Health Services Research, 2025•Springer, 25(1), 271.* <https://doi.org/10.1186/S12913-025-12414-4>
- Kassie, S. Y., Shibabaw, A. A., Chereka, A. A., Dubale, A. T., Demsash, A. W., Damtie, Y., Ngusie, H. S., & Walle, A. D. (2025). The impact of confidentiality and privacy concerns on behavioral intention to adopt electronic personal health records among chronic patients in southwest Ethiopia in 2023: an application of the UTAUT2 model. *Frontiers in Digital Health, 7.* <https://doi.org/10.3389/FDGTH.2025.1475460/FULL>
- Kyratsis, Y., Scarbrough, H., Begley, A., & Denis, J. L. (2022). Editorial: Digital health adoption: Looking beyond the role of technology. *Frontiers in Digital Health, 4,* 989003. <https://doi.org/10.3389/FDGTH.2022.989003/FULL>
- Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic...* - Google Scholar. (n.d.). Retrieved July 1, 2026, from https://scholar.google.com/scholar?hl=id&as_sdt=0%2C5&q=Lincoln%2C+Y.+S.%2C+%26+Guba%2C+E.+G.+%281985%29.+Naturalistic+inquiry.+SAGE+Publications.&btnG=
- Martins, D., Lewerenz, S., Carmo, A., & Martins, H. (2025). Interoperability of telemonitoring data in digital health solutions: a scoping review. *Frontiers in Digital Health, 7.* <https://doi.org/10.3389/FDGTH.2025.1502260/FULL>
- Organization, W. H. (2025). *Global strategy on digital health 2020-2027.* [https://books.google.com/books?hl=id&lr=&id=_DWcEQAAQBAJ&oi=fnd&pg=PA2&dq=World+Health+Organization.+\(2021\).+Global+strategy+on+digital+health+2020%E2%80%932025.+World+Health+Organization.+https://www.who.int/publications/i/item/9789240020924&ots=rVtEiDs-LW&sig=FofDFWX6ADH36hFLwE23wncVpU](https://books.google.com/books?hl=id&lr=&id=_DWcEQAAQBAJ&oi=fnd&pg=PA2&dq=World+Health+Organization.+(2021).+Global+strategy+on+digital+health+2020%E2%80%932025.+World+Health+Organization.+https://www.who.int/publications/i/item/9789240020924&ots=rVtEiDs-LW&sig=FofDFWX6ADH36hFLwE23wncVpU)
- Pallant, J. (2020). SPSS survival manual: A step by step guide to data analysis using IBM SPSS. *SPSS: SURVIVAL MANUAL: A STEP BY STEP GUIDE TO DATA ANALYSIS USING IBM SPSS: 7th EDITION,* 1–361. <https://doi.org/10.4324/9781003117452>

- Policy, B. A. J.-J. of S. and T., & 2024, undefined. (2024). Examining the adoption of telehealth during public health emergencies based on technology organization environment framework. *Emerald.ComB Anthony JnrJournal of Science and Technology Policy Management*, 2024•*emerald.Com*, 15(6), 1311–1338. <https://doi.org/10.1108/JSTPM-05-2022-0079>
- Polit, D., & Beck, C. (2008). *Nursing research: Generating and assessing evidence for nursing practice*.
[https://books.google.com/books?hl=id&lr=&id=Ej3wstotgkQC&oi=fnd&pg=PA1&dq=Polit,+D.+F.,+%26+Beck,+C.+T.+\(2021\).+Nursing+research:+Generating+and+assessing+evidence+for+nursing+practice+\(11th+ed.\).+Wolters+Kluwer.&ots=wiQxIScEEr&sig=pWibT9C7ZNgYo1ewsdgiKoffmdc](https://books.google.com/books?hl=id&lr=&id=Ej3wstotgkQC&oi=fnd&pg=PA1&dq=Polit,+D.+F.,+%26+Beck,+C.+T.+(2021).+Nursing+research:+Generating+and+assessing+evidence+for+nursing+practice+(11th+ed.).+Wolters+Kluwer.&ots=wiQxIScEEr&sig=pWibT9C7ZNgYo1ewsdgiKoffmdc)
- Saladdin, I. R., & Handayani, P. W. (2025). Information Technology Governance Implementation Challenges in Healthcare Facilities: A Systematic Literature Review. *Journals.Sagepub.ComIR Saladdin, PW HandayaniSage Open*, 2025•*journals.Sagepub.Com*, 15(4). <https://doi.org/10.1177/21582440251369322>
- Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User Acceptance of Information Technology: Toward A Unified View1. *Misq.Umn.EduV Venkatesh, MG Morris, GB Davis, FD DavisMIS Quarterly*, 2003•*misq.Umn.Edu*, 27(3), 425–478. <https://doi.org/10.2307/30036540>
- Wamala Andersson, S., & Gonzalez, M. P. (2025). Digital health literacy—a key factor in realizing the value of digital transformation in healthcare. *Frontiers in Digital Health*, 7, 1461342. <https://doi.org/10.3389/FDGT.2025.1461342/FULL>
- Yi, S., Yam, E. L. Y., Cheruvettolil, K., Linos, E., Gupta, A., Palaniappan, L., Rajeshuni, N., Vaska, K. G., Schulman, K., & Eggleston, K. N. (2024). Perspectives of digital health innovations in low-and middle-income health care systems from South and Southeast Asia. *Jmir.OrgS Yi, ELY Yam, K Cheruvettolil, E Linos, A Gupta, L Palaniappan, N Rajeshuni, KG VaskaJournal of Medical Internet Research*, 2024•*jmir.Org*, 26(1). <https://doi.org/10.2196/57612>