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Socio-Technical Determinants of Electronic Medical Record Implementation Among Nurses: A Mixed-Methods Study in a Regional Indonesian Hospital

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ABSTRACT

Electronic Medical Records (EMR) aim to improve healthcare quality, but successful implementation relies on infrastructure, training, interoperability, and data privacy. This sequential explanatory mixed-methods study examines these factors' impact on hospital service quality at a regional Indonesian hospital. Quantitative data from 227 nurses, analyzed via multiple linear regression, were contextualized through qualitative stakeholder interviews. The results show all four factors significantly improve EMR service quality (R = 0.793), with infrastructure being the most dominant. However, qualitative findings highlight ongoing challenges: uneven infrastructure, limited continuous training, and inconsistent integration and security practices. Ultimately, maximizing EMR benefits requires a sustainable socio-technical approach integrating technological readiness, human capacity, and robust data governance.

Penerapan Rekam Medis Elektronik (EMR) bertujuan meningkatkan kualitas layanan kesehatan, namun keberhasilannya bergantung pada kesiapan infrastruktur, pelatihan, interoperabilitas, dan privasi data. Penelitian metode campuran (sequential explanatory) ini mengkaji pengaruh keempat faktor tersebut di sebuah RS daerah di Indonesia. Data kuantitatif dari 227 perawat yang dianalisis dengan regresi linier berganda, dikontekstualisasikan lebih dalam melalui wawancara kualitatif dengan pemangku kepentingan. Hasil penelitian menunjukkan keempat faktor tersebut berpengaruh positif dan signifikan terhadap kualitas layanan (R = 0,793), dengan infrastruktur sebagai faktor paling dominan. Namun, temuan kualitatif juga mengungkap tantangan berupa infrastruktur yang tidak merata, minimnya pelatihan lanjutan, serta inkonsistensi integrasi dan keamanan data. Kesimpulannya, optimalisasi EMR menuntut pendekatan sosio-teknis yang berkelanjutan dengan memadukan kesiapan teknologi, kapasitas SDM, dan tata kelola data yang tangguh.

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Introduction

Digital transformation has become a strategic agenda in efforts to improve the quality of healthcare services in various countries. The digitization of health information systems enables hospitals to improve the efficiency, effectiveness, and security of services, one of which is through the implementation of Electronic Medical Records (EMR) (Amin et al., 2021). Electronic medical records replace manual records with a digital system that is more accurate, easily accessible, and supports clinical coordination between healthcare professionals, especially nurses as the main users of the system (Ayaad et al., 2019). In the context of hospital organizations, the implementation of EMR is also in line with the concept of Enterprise Resource Planning (ERP), which enables cross-unit integration, reduction of data redundancy, and increased transparency and accountability of services (Fiaz et al., 2018; Halimuzzaman et al., 2024). In the era of Healthcare 4.0, digital technology is no longer positioned merely as an administrative tool, but rather as an instrument of service transformation that directly impacts patient care quality and safety (Al-Assaf et al., 2024).

Despite its great potential, the implementation of Electronic Medical Records in Indonesia still faces various challenges. The readiness of information technology infrastructure, human resource competencies, and uneven regulatory support are the main obstacles in the hospital digitization process (Ati et al., 2024). Infrastructure is a fundamental prerequisite because the success of EMRs is highly dependent on the availability of hardware, software, and stable network connectivity. Disparities in internet network quality between healthcare facilities have been shown to have a significant impact on the performance and sustainability of electronic medical record usage (Aisyah et al., 2025). In addition, hospital information system management also requires effective organizational governance, strong leadership, and a work culture that is adaptive to technological changes (Wijayakusuma & Rinawati, 2025).

In addition to infrastructure, training and human resource readiness, particularly nursing staff, play a crucial role in the successful implementation of Electronic Medical Records. Hospital policies, management commitment, and the level of understanding and skills of health workers have a direct impact on the acceptance and utilization of digital systems (Sugiarto et al., 2024). However, resistance to change, limited digital competence, and suboptimal perceptions of benefits are still commonly found among healthcare workers (Harahap et al., 2022). This situation has the potential to hinder the optimization of Electronic Medical Records, even though various studies show that this system is capable of improving patient safety, reducing medical errors, speeding up service processes, and improving the accuracy of nursing documentation (Firdaus, 2019).

Another equally important challenge is the aspect of interoperability and data privacy. The integration of health data through national platforms such as SATUSEHAT requires hospital information systems to be ready in terms of technology and governance (Pratiwi et al., 2025). However, limitations in interoperability between information systems still hinder the effective use of health information technology (Lazuardi et al., 2021). On the other hand, the implementation of Electronic Medical Records also has legal and ethical implications related to patient data protection. The enactment of the Personal Data Protection Law requires hospitals to guarantee the security and confidentiality of medical data through a reliable security system and compliance with applicable regulations (Budiyanti et al., 2023; Rahman et al., 2025). However, the implementation of these regulations still faces challenges, particularly in terms of institutional readiness and consistency in law enforcement (Prasetyo et al., 2025).

Various empirical studies in Indonesia show that the successful implementation of Electronic Medical Records is influenced by the interaction between technological, organizational, and human factors. Infrastructure limitations, unstructured training, uneven human resource readiness, and weak system integration remain dominant obstacles in various hospitals (Faida et al., 2023; Jiwani, 2024; Suryani & Apriyani, 2025). The synthesis of these findings was reinforced through a systematic literature review conducted by Ariyanto et al. (2025), which divides the difficulties in putting EMR into practice into a number of primary categories, such as infrastructure and resources, user acceptability and adoption, organizational culture and change management, interoperability and data security, training and support, and governance and legislation. The relationships between these dimensions and their implications for patient safety and hospital service quality are illustrated theoretically in **Figure 1.**

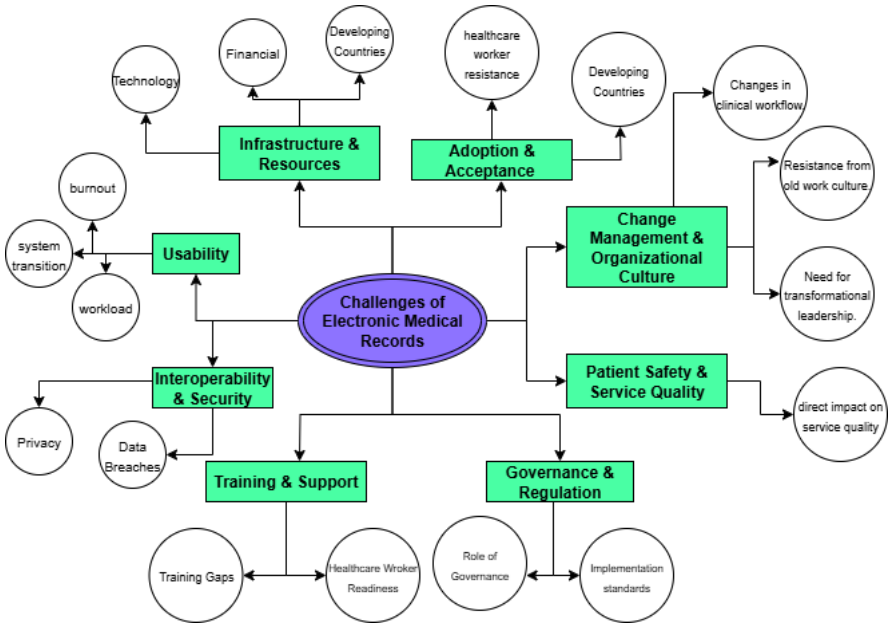

Figure 1. Synthesis of challenges in implementing Electronic Medical Records based on findings from a systematic literature review
Source: (Ariyanto et al., 2025)

However, most prior research has focused on large hospitals or referral hospitals, and it often only examines a subset of the factors related to the adoption of electronic medical records. Particularly with regard to rural hospitals, there are still relatively few studies that integrate infrastructure, training, interoperability, and privacy into a comprehensive analytical framework. Additionally, the association between these factors and service quality is often studied directly without explaining how the use of electronic medical records acts as a link between improved nurse service quality and digital readiness.

Regional and resource-constrained hospitals represent a particularly important context for examining EMR implementation because they frequently operate with limited financial resources, heterogeneous technological infrastructure, fewer specialized information technology personnel, and more gradual organizational change processes than large tertiary hospitals. These conditions create unique socio-technical challenges that may influence EMR implementation differently from those reported in well-resourced healthcare institutions. Despite these distinctive characteristics, empirical evidence focusing specifically on regional hospitals remains limited, leaving an important gap in understanding how digital transformation can be effectively achieved in decentralized healthcare settings.

Reflecting these challenges, several hospitals in Karanganyar Regency continue to operate hybrid medical record systems, indicating that the transition toward fully electronic records remains incomplete. In Karanganyar Regency, several hospitals still operate hybrid medical record systems, referring to the concurrent use of paper-based and electronic medical records during the transition toward full EMR implementation (Septina et al., 2025). A study at X Karanganyar General Hospital also indicates that the readiness for the implementation of Electronic Medical Records needs to be reviewed comprehensively in terms of infrastructure, human resources, and management (Meylani et al., 2024). This indicates that the digital transformation process has not yet been fully completed.

Based on these limitations, this study intends to examine the influence of infrastructure, training, interoperability, and privacy on the quality of medical services through the implementation of Electronic Medical Records at X Karanganyar General Hospital. In contrast to earlier research, this study incorporates these three key elements into a single analytical model by using the use of electronic medical records as an

explanatory mechanism that connects increases in nursing service quality with digital readiness. Therefore, it is anticipated that this study will offer a more thorough empirical contribution to the literature on the digitization of health services and serve as a foundation for strategic recommendations for hospital management and policy makers in order to maximize the use of EMRs in regional hospitals.

Research Methodology

This study employs an explanatory sequential mixed-methods design to examine the influence of infrastructure and resources, training, interoperability, and privacy on the quality of hospital services through the implementation of Electronic Medical Records (EMR) (Christodoulou, 2025). In this design, quantitative data are collected and analyzed first, followed by qualitative exploration to explain and contextualize the statistical findings (Creswell, 2017; Toyon, 2021).

In compliance with Indonesian Minister of Health Regulation No. 24 of 2022 about Medical Records, the study was carried out at X Karanganyar General Hospital, a local government hospital in Karanganyar Regency, Central Java Province. Furthermore, X Karanganyar General Hospital in Central Java Province is a regional hospital that is implementing EMR as part of its digital transformation. Since nurses are the main users of the EMR system in clinical services, the quantitative study's subjects were practicing nurses who had been using it for at least three months (Hossain et al., 2025).

The IT staff, the head of nursing, and the head of medical records made up the qualitative subjects. These individuals were specifically chosen for their strategic positions in the EMR deployment (Swarjana, 2022). While practicing nurses were selected for the quantitative phase to capture frontline user perceptions of EMR implementation, structural stakeholders including IT personnel, the head of nursing, and the head of medical records were purposively selected for the qualitative phase. This non-nested sampling strategy was intentionally applied to explore organizational, infrastructural, and governance-related barriers that could not be comprehensively identified through bedside clinician perspectives alone.

The study population consisted of 498 nurses working at X Karanganyar General Hospital. The minimum required sample size was calculated using the Slovin formula with a 5% margin of error, resulting in a target sample of 222 respondents. Proportional random sampling was applied to ensure representation from each service unit (Hossan et al., 2023). During data collection, 227 valid responses were successfully obtained and included in the final quantitative analysis.

Table 1

Research Population and Sample

Installation/Service Unit	Population	Minimum Target Sample
Inpatient Care Unit	271	121
Outpatient Care Unit	33	15
Emergency Care Unit	39	17
Radiology Unit	15	7
Laboratory Unit	28	12
Pharmacists and Pharmacy Unit	56	25
Medical Records Unit	41	18
IBS Nurses	15	7
Total	**498**	**222**

Source: Researcher 2026

The values presented in **Table 1,** represent the minimum proportional sample allocation derived from the Slovin calculation. The final analyzed dataset consisted of 227 valid respondents after oversampling and data

screening procedures. The study used primary and secondary data. Primary data were obtained through structured questionnaires and semi-structured interviews, while secondary data were obtained through policy documentation studies, internal hospital reports, and regulations related to EMR (Andini et al., 2023; Kusumastuti et al., 2021).

A validated international instrument was adapted to the context of nursing practice in regional hospitals to create a structured questionnaire that served as the research tool. Based on the EMR evaluation model, indicators of system quality, information quality, and information technology support service quality were used to measure the infrastructure and resources variable (X1) (Tilahun & Fritz, 2015). The Technology Acceptance Model (TAM), namely the categories of Perceived Ease of Use and Perceived Usefulness, was used to quantify training variables (X2) (Ketikidis et al., 2012). Privacy and interoperability factors (X3) are measured using standard indicators of technical interoperability, system integration, and data security and protection that have been adapted and modified (Torab-Miandoab et al., 2023). Measurement of Electronic Medical Record service quality variables (Y) using SERVQUAL model-based instruments (Fatima et al., 2019; Ye et al., 2024). This has been adjusted for use with digital health services. With a 5-point Likert scale (1 being strongly disagree and 5 being strongly agree), each question is organized as a closed statement.

The instruments have undergone content validity testing through expert judgment and reliability testing using Cronbach's Alpha and have been declared valid and reliable for use in this study. The qualitative instruments consist of semi-structured interview guides and documentation study checklists compiled based on the research variable indicators. The qualitative instruments consist of semi-structured interview guides and documentation study checklists compiled based on the research variable indicators.

In accordance with the explanatory sequential mixed-methods design, the qualitative interview guide was developed after the preliminary quantitative analysis had been completed. The initial regression results from the survey of 227 nurses were reviewed to identify findings that required further explanation. Specifically, the strong influence of infrastructure, together with the significant effects of training and interoperability–privacy, informed the development of the semi-structured interview questions. Consequently, interviews with the Head of Nursing, IT personnel, and Medical Record Officer focused on exploring the organizational and operational factors underlying these statistical findings, including network reliability, device availability, continuity of EMR training, data synchronization processes, and privacy practices. This approach ensured that the qualitative phase served to explain and contextualize the quantitative results, consistent with the explanatory sequential mixed-methods design.

Table 2.

Summary of Variables and Number of Items

Variable	Number of Items
Infrastructure and Resources	15
Training	6
Interoperability and Privacy	7
Quality of Electronic Medical Record Services	16
TOTAL	44

Source: (Ketikidis et al., 2012; Tilahun & Fritz, 2015; Torab-Miandoab et al., 2023), with modification

The validity of the instrument was determined through expert judgment and analyzed using the Content Validity Ratio (CVR) and Content Validity Index (CVI) (Almanasreh et al., 2019; Mohamad et al., 2015). All items obtained a CVI value of 1.00, indicating validity. Reliability testing was conducted using Cronbach's Alpha, with all variables showing a value > 0.90, indicating very high reliability (Hidayat, 2021).

Table 3.

Reliability Test Results

Variable	Cronbach's Alpha
Infrastructure and Resources	0,939
Training	0,915
Interoperability and Privacy	0,902
Quality of Electronic Medical Record Services	0,962

Source: Researcher 2026

Based on **Table 3**, the EMR service quality variable questionnaire instrument can be considered highly reliable, as indicated by a value of $0.90 \leq 0.962 \leq 1.00$ with a high reliability coefficient. Thus, it can be said that the entire questionnaire is valid and reliable with an acceptable category.

According to the sequential explanatory mixed methods design, the data analysis in this study was done in a sequential manner. Quantitative questionnaire data were analyzed in the first stage. Descriptive analysis was used to examine the data using SPSS software version 26 (Gunawan, 2018). In addition to using multiple linear regression analysis to examine the impact of infrastructure, training, and interoperability–privacy on service quality, this approach was utilized to characterize respondent characteristics and answer distributions. Additionally, the function of Electronic Medical Record (EMR) deployment in the link between independent factors and service quality was evaluated using mediation analysis at a significance level of $\alpha = 0.05$. The second stage is the examination of qualitative data gathered from semi-structured interviews and documentation studies. Qualitative data are studied using theme analysis, which comprises data reduction, data presentation, and conclusion drawing and verification (Lochmiller, 2021; Miles et al., 2014). In order to obtain a thorough understanding of the factors that affect the quality of hospital services through the implementation of Electronic Medical Records, both approaches are integrated at the interpretation stage. Qualitative analysis results are used to explain and deepen quantitative findings.

The study has received formal authorization from X Karanganyar General Hospital and ethical approval from the Ethics Committee of the Faculty of Medicine at Universitas Muhammadiyah Surakarta. Confidentiality was ensured and informed consent was provided to each respondent.

Results

A total of 227 Electronic Medical Record (EMR) users at X Karanganyar General Hospital were included in the final analysis. Given that nursing personnel are the primary users of the EMR system, the majority of responders (82.8%) were female. Respondents were split fairly evenly among productive age groups based on age, with the biggest proportion in the 23–33 age group (35.7%), followed by the 44–56 age group (33.5%) and the 34–43 age group (30.8%). The majority of responders (83.3%) had a diploma (D3) in education and worked as nurses, demonstrating sufficient fundamental technical proficiency with the EMR system. Respondents came from a variety of service units, with inpatient care accounting for the majority of work units (40.5%), followed by outpatient care (17.6%), emergency rooms (8.4%), and other support units. The representation of hospital service units is displayed in this distribution. The intensity of the respondents' exposure to the system under research was confirmed by the fact that 49.8% of respondents had worked for one to ten years, 37.4% had used EMR for more than two years, and 80.2% used EMR daily. The overall characteristics of the respondents are provided in **Table 4**.

Table 4.

Respondent Characteristics

Characteristic	Category	Count	Percentage (%)
Gender	Male	39	17,2
	Female	188	82,8
Age	23–33	81	35,7
	34–43	70	30,8
	44–56	76	33,5
Education	D3 Nursing	112	49,3
	Nursing Profession	77	34,0
	Others	38	16,7
Work Unit	Inpatient Care	92	40,5
	Outpatient Care	40	17,6
	Emergency Room	19	8,4
	Other units	76	33,5
Length of Service	1–10 year	113	49,8
	>10 year	114	50,2
Duration of EMR Use	≤2 year	142	62,6
	>2 year	85	37,4

Source: research respondents' processed results, 2026

Table 5's findings of the classical assumption test demonstrate that the regression model satisfies every need for analysis. The residuals are normally distributed, according to the Kolmogorov-Smirnov normality test result of Asymp. Sig. = 0.947 (>0.05). There are no indications of multicollinearity, according to the multicollinearity test, since all independent variables have tolerance values > 0.10 and VIF < 10. Additionally, the Glejser method heteroscedasticity test reveals that there is no heteroscedasticity because every variable's significance value is greater than 0.05. The findings of the simultaneous test (F test) indicate that the quality of Electronic Medical Records services is significantly impacted by infrastructure, training, and interoperability-privacy taken jointly ($F = 125.393$; $p < 0.001$). An R value of 0.793 suggests a strong link between the independent factors and the quality of Electronic Medical Records services. The R^2 value of 0.628 implies that 62.8% of the variation in Electronic Medical Record service quality can be described by these three variables, while the remainder is impacted by other factors outside the model. The quality of Electronic Medical Record services is significantly impacted by all independent variables, according to the t-test results. The highest significant influence is found in infrastructure ($\beta = 0.629$; $t = 15.365$; $p < 0.001$), followed by interoperability–privacy ($\beta = 0.278$; $t = 6.797$; $p < 0.001$) and training ($\beta = 0.345$; $t = 8.425$; $p < 0.001$). These results show that enhancing the quality of services based on electronic medical records requires infrastructural readiness.

Table 5.

Results of Multiple Linear Regression Test on EMR Service Quality

Independent Variable	β	t	Sig.
Infrastructure and Resources (X1)	0,629	15,365	<0,001
Training (X2)	0,345	8,425	<0,001
Interoperability and Privacy (X3)	0,278	6,797	<0,001
R	0,793		
R^2	0,628		
Uji F (Sig.)			**<0,001**

Source: research respondents' processed results, 2026

The quantitative findings are supported by the outcomes of field observations and interviews. Although X Karanganyar General Hospital's technology infrastructure is thought to be widely accessible, there are still issues with inconsistent device specifications, network outages during peak hours, and a small backup power supply (UPS). The efficient operation of services based on electronic medical records is directly impacted by these factors. According to sources, systematic follow-up training for Electronic Medical Records is typically limited to the initial stages of installation. User adaption to the system is usually done autonomously or through informal help, such as talks through internal communication groups. The Electronic Medical Record system is linked to the SATUSEHAT platform and employs both national and international interoperability standards. However, the data interchange process is not yet entirely automated and still suffers data consistency challenges. Although the system has access tracking and authentication features, there are still cases of shared account usage, which may present data security problems.

Table 6.

Summary of Qualitative Findings Supporting EMR Implementation

Aspects	Key findings
Infrastructure and Resources (X1)	Devices and networks are available, but not evenly distributed; network disruptions occur during peak service hours. "During peak service hours, the network occasionally becomes unstable, which delays patient documentation and slows down service processes." (Participant 2, IT Staff)
Training (X2)	EMR training was conducted at the early stages of implementation, but was not continuous or structured. "Most EMR training was conducted only during the early implementation period. After that, staff mainly learned independently or through peer support." (Participant 4, Head of Nursing)
Interoperability (X3)	The system has been connected to SATUSEHAT, but data exchange is not yet fully automated. "Although the system is already connected to SATUSEHAT, several data synchronization processes still require manual verification." (Participant 1, Medical Record Officer)
Privacy (X3)	Security mechanisms are available, but shared accounts are still being used. "Shared account usage still occurs in several units, especially during busy shifts, even though individual access accounts are available." (Participant 3, IT Personnel)

Source: In-depth interview, 2026

The qualitative findings provide a deeper explanation of why infrastructure emerged as the most influential determinant of EMR service quality in the quantitative analysis. Although the hospital had generally established the technological infrastructure required to support EMR implementation, participants consistently described operational challenges related to uneven device specifications, intermittent network instability, and limited backup power capacity. These conditions were particularly evident during peak service hours, when unstable network connectivity delayed access to patient records and prolonged electronic documentation. As a consequence, nurses occasionally postponed documentation until the system became responsive or temporarily relied on handwritten notes before transferring the information into the EMR. Such workflow interruptions increased documentation time, created additional administrative workload, and reduced the efficiency expected from digital documentation systems.

Qualitative findings also revealed that training effectiveness depended not only on the availability of initial instruction but also on the continuity of competency development. While formal EMR training was provided during the early implementation phase, participants explained that subsequent learning relied primarily on self-directed adaptation and informal peer support. Although this approach enabled gradual user familiarization with the system, the absence of structured refresher training and competency evaluation resulted in inconsistent utilization of EMR features across clinical units. These findings suggest that continuous capacity-building is essential to ensure standardized EMR use and maintain nurses' digital competencies over time.

Regarding interoperability and privacy, participants acknowledged that integration with the national SATUSEHAT platform represented an important milestone in the hospital's digital transformation. Nevertheless, several data synchronization processes still required manual verification, reducing the efficiency expected from interoperable health information systems. Participants also reported that shared account practices occasionally occurred during busy clinical shifts to maintain workflow continuity, despite the availability of individual user accounts. Although considered a practical solution in demanding situations, this practice potentially weakened accountability and increased information security risks. Collectively, these qualitative findings demonstrate that successful EMR implementation depends not only on technological availability but also on organizational practices, continuous user support, and strong governance mechanisms that sustain efficient and secure nursing workflows.

Overall, the study's findings demonstrate that the application of EMR at X Karanganyar General Hospital has improved the standard of hospital services, especially in terms of data correctness and work efficiency. However, infrastructure preparedness, ongoing training, and the improvement of interoperability and data privacy protection all have a significant impact on its achievement. An integrated and sustainable approach is necessary to enhance healthcare service performance electronic medical records, as confirmed by the integration of quantitative and qualitative findings.

Table 7. J

Point Display Integration of Quantitative and Qualitative Findings

Quantitative Findings	Qualitative Findings	Meta-Inference
Infrastructure showed the strongest effect on EMR service quality (β = 0.629; p < 0.001).	Participants reported unstable networks, uneven device specifications, and limited UPS support.	Reliable digital infrastructure is the primary structural prerequisite for effective EMR implementation and service quality improvement.
Training significantly influenced EMR service quality (β = 0.345; p < 0.001).	Training was mostly limited to the initial implementation stage without structured evaluation.	Continuous and structured training is necessary to sustain user competency and optimize EMR utilization.
Interoperability and privacy significantly affected service quality (β = 0.278; p < 0.001).	Data synchronization remained partially manual, and shared account practices were still identified.	Effective interoperability and strong privacy governance are essential to ensure secure and integrated EMR services.

Source: research respondents' processed results, 2026

Based on **Table 7**, the joint display demonstrates convergence between the quantitative and qualitative findings. Quantitative regression results identified infrastructure, training, and interoperability–privacy as significant determinants of EMR service quality, while qualitative findings provided contextual explanations regarding operational barriers, governance limitations, and implementation challenges. This integration strengthens the meta-inference that EMR implementation success is shaped by interconnected socio-technical dimensions rather than technological readiness alone.

Discussion

The simultaneous test results show that infrastructure, training, and interoperability-privacy together have a significant effect on the quality of Electronic Medical Records (EMR) services at X Karanganyar General Hospital. The correlation coefficient value (R = 0.793) indicates a strong relationship between the independent variables and the quality of EMR services, confirming that the implementation of EMR is a socio-technical system. These findings show that service quality is not only determined by the availability of technology, but also by the readiness of human resources and data governance and information security. The results of the documentation study reinforce these quantitative findings by showing that all three aspects are available and implemented in the hospital, although the level of readiness and maturity still varies. Thus, improving service quality through EMR requires an integrated and sustainable approach. The findings of this study are in line with studies Nofitriyani et al. (2025) as well as Ikawati & Haris (2024), which states that EMR optimization has a direct implication on improving patient service quality. The main contribution of this study lies in the empirical proof that strengthening hospital service quality through EMR cannot be done partially, but must be done through the simultaneous strengthening of technology, human resources, interoperability, and data security. This approach is especially important in government hospitals that are in the digital transition stage, such as X Karanganyar General Hospital.

From a practical perspective, the finding of unstructured and one-time training highlights a critical gap in EMR implementation strategies. Hospital management should shift from ad-hoc training approaches to structured, continuous capacity-building programs. This includes the development of standardized training modules, periodic refresher sessions, and competency-based evaluations such as pre- and post-training assessments. In addition, integrating mentorship mechanisms, such as super-users or clinical champions within each unit, can support peer-to-peer learning and accelerate user adaptation. Regular monitoring and feedback systems are also essential to ensure that training outcomes translate into improved system utilization and service quality. Without a structured training framework, the potential benefits of EMR systems may not be fully realized despite adequate technological infrastructure (Feryansyah et al., 2025).

From an infrastructure perspective, partial test results show that infrastructure is the most dominant factor affecting the quality of electronic medical record (EMR) services. Positive regression coefficients and high t-values indicate that the availability and reliability of digital infrastructure play an important role in ensuring the smooth use of EMR. This finding is reinforced by the results of a documentation study showing that hospitals have used a Khanza-based EMR system tailored to operational needs, supported by fiber optic-based hardware and networks in key units. However, limitations were still found in the form of device specification gaps, uneven UPS usage, and the need for network and bandwidth optimization. These conditions indicate that even though the infrastructure is available, its reliability level still has the potential to affect system stability and service quality, which greatly influences the quality of EMR implementation (Bekele et al., 2024). Conceptually, digital infrastructure is the main foundation in health information systems because it determines system stability, data access speed, and cross-unit service integration (Yanti et al., 2023). Yadegari & Asosheh (2025), emphasizes that clinical information system architecture supported by adequate infrastructure can improve operational efficiency and service quality. These findings are also consistent with Bisrat et al. (2021), which states that infrastructure limitations are a major obstacle in the implementation of EMR and have a

negative impact on service quality. Thus, the results of this study reinforce the evidence that infrastructure readiness is a crucial structural prerequisite for improving the quality of EMR services.

In addition to infrastructure, training has also been shown to have a positive and significant impact on the quality of Electronic Medical Records services. These findings indicate that improving human resource competencies through training plays an important role in supporting the successful implementation of Electronic Medical Records. Documentation studies show that X Karanganyar General Hospital has plans and documentation for implementing Electronic Medical Record training, but its implementation is still limited to initial socialization and has not been supplemented with structured evaluations such as pre-tests, post-tests, or certification. This condition indicates that the effectiveness of training in improving user competency has not been measured systematically. The implementation of Electronic Medical Records requires a change in the work patterns of health workers from a manual system to a digital system, thus requiring technological literacy and an understanding of workflows based on information systems (Gatiti et al., 2021). Siagian et al. (2025), states that the quality of human resources has a significant effect on the performance of health services in hospitals that implement Electronic Medical Records. This finding is also in line with Zuhdi & Darmawan (2024), which identified the lack of training as one of the main challenges in implementing EMR. Thus, the results of this study confirm that continuous and structured training is a key factor in ensuring that EMR technology can be optimally utilized to improve service quality. Wulandari et al. (2025), also emphasized that human resource training serves as a strategic bridge between technology adoption and service quality improvement.

Furthermore, interoperability and privacy have also been shown to have a significant impact on the quality of EMR services. The results of the documentation study show that hospitals already have standard interoperability documentation such as HL7, FHIR, CDA, and DICOM, as well as integration with the national SATUSEHAT platform. However, data exchange has not been implemented consistently, and there are still limitations in regulatory compliance and system security audits. The practice of shared accounts that is still found also has the potential to cause data leaks and reduce user trust (Bekele et al., 2024; Madhavan et al., 2021). Interoperability enables fast and accurate exchange of clinical data, thereby supporting continuity of care and clinical decision-making (Huang et al., 2020). Rajagopal et al. (2024), shows that organizational interoperability in health information systems directly improves the effectiveness of hospital services. On the other hand, data privacy and security aspects are important determinants in building user trust in Electronic Medical Record systems. Enaizan et al. (2020), states that perceptions of security and privacy influence the acceptance and use of EMR through trust as a mediator. These findings are reinforced by Shrivastava et al. (2021) and Zhang & Saltman (2022), which confirms that data security and interoperability standards have a positive impact on the quality of digital services and patient safety.

Overall, the results of this study confirm that the quality of Electronic Medical Record services at X Karanganyar General Hospital is determined by the interaction between infrastructure readiness, human resource competence, and data interoperability and privacy governance. These three aspects do not stand alone, but rather reinforce each other in forming an effective, secure, and service-quality-oriented Electronic Medical Record system. These findings have practical implications for hospital management to prioritize infrastructure strengthening, continuous training development, and improved interoperability and data security governance as key strategies in improving the quality of Electronic Medical Record-based hospital services.

Revisiting the theoretical synthesis presented in **Figure 1**, the findings of this study provide empirical support for the socio-technical framework derived from the previous systematic literature review. Among the dimensions identified in the framework, infrastructure and resources, training and support, and interoperability–privacy governance were all confirmed as significant determinants of EMR service quality in the context of a regional public hospital. Notably, infrastructure emerged as the strongest predictor, suggesting that technological readiness constitutes the foundational condition upon which other socio-technical dimensions operate. The qualitative findings further reinforce this framework by illustrating how unstable network connectivity, uneven device specifications, limited continuous training, and partially manual data synchronization collectively influence nurses' daily workflows and the effectiveness of EMR implementation. At the same time, this study extends the theoretical model by demonstrating that, within resource-constrained regional hospitals, infrastructure readiness plays a more dominant role than other dimensions, while

organizational culture, change management, and user acceptance remain important but were not directly examined in the present analysis. Therefore, the Karanganyar case not only validates the proposed socio-technical synthesis but also refines it by highlighting the relative importance of infrastructure in supporting sustainable EMR implementation in regional healthcare settings.

Study Limitations

When evaluating the findings, it is important to take into account the many limitations of this study. First, the results cannot be applied to other hospitals with varied organizational traits, degrees of digital maturity, and resource availability because the study was limited to X Karanganyar General Hospital. The research site's particular implementation setting, technology readiness, and management practices may all have an impact on the findings. Second, a questionnaire based on respondent impressions was used to gather quantitative data. The use of perceptual data still carries the risk of subjective bias, including social desirability bias and variations in respondents' interpretations of the questions, even though the study instrument has passed validity and reliability assessments. Third, the quality, completeness, and timeliness of the accessible documents greatly influenced the depth of research because qualitative data were acquired through documentation studies. A number of crucial elements, including system security audits, formal training assessments, and verification of regulatory compliance, were not completely recorded. Furthermore, organizational culture, management leadership, the workload of healthcare professionals, and the degree of individual user acceptance of technology are all variables that have not been examined in this study. Although they are not included in this research model, these variables may have an impact on the implementation of EMR services. Despite these drawbacks, the study's findings still offer a pertinent empirical picture of how infrastructure, training, interoperability, and privacy affect the implementation of EMR services; however, they must be interpreted proportionately to the study's context and scope.

Conclusion

This study demonstrates that infrastructure readiness, human resource training, interoperability, and data privacy significantly influence the implementation of Electronic Medical Records (EMR) and, consequently, the quality of hospital services. Among these factors, infrastructure emerges as the most dominant determinant, highlighting its role as a fundamental prerequisite for stable and effective EMR utilization. In addition, structured and continuous training is essential to ensure that nurses possess the competencies required to optimally use EMR systems in clinical practice. Interoperability and data privacy also play critical roles in supporting secure, integrated, and reliable health information exchange, which ultimately enhances service quality and patient safety. These findings underscore the importance of a comprehensive socio-technical approach in EMR implementation, integrating technological readiness, human resource capacity, and governance mechanisms. Practically, hospital management should prioritize sustainable infrastructure investment, institutionalized training programs, and strengthened data governance frameworks. For clinical nursing practice, this study highlights the need for continuous digital competency development and active engagement of nurses in EMR optimization processes to ensure accurate documentation, efficient workflows, and improved patient care outcomes. Future research should explore additional organizational and behavioral factors to further strengthen EMR implementation in diverse healthcare settings.

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Conflict of Interest

The author affirms that there are no financial or non-financial conflicts of interest that could affect the data analysis, research methodology, or composition of this paper.

Credit Author Statement

Conceptualization, technique, data collecting, formal analysis, research, original draft writing, visualization, review, and correspondence are all covered by **Hani Purwo Ariyanto**. **Yusuf Alam Romadhon**: Writing, review, editing, validation, conception, and supervision. **Aflit Nuryulia Praswat**i: Writing review and editing, validation, supervision, and technique review.

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