Digital Health Technology on Patient Recovery and Nurse Performance in Indonesia

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ABSTRACT

This study investigates the impact of digital health technology, nurse competence, patient safety protocols, and organizational support on patient recovery and nurse performance within the Indonesian healthcare sector. Utilizing a quantitative approach, data were collected from 120 healthcare professionals through structured questionnaires and analyzed using Structural Equation Modeling-Partial Least Squares (SEM-PLS 3). The findings reveal that digital health technology, nurse competence, and patient safety protocols positively influence patient recovery, while organizational support and digital health technology significantly enhance nurse performance. Organizational support and patient safety protocols emerged as the strongest predictors of nurse performance and patient recovery, respectively. These results suggest that a comprehensive approach integrating technological, safety, and support factors can substantially improve healthcare outcomes. This study offers practical recommendations for healthcare administrators and policymakers to enhance healthcare quality through strategic investments in digital tools, training, safety protocols, and supportive work environments.

Keywords: Digital Health Technology, Nurse Competence, Patient Safety Protocols, Organizational Support, Healthcare Outcomes

1. INTRODUCTION

The adoption of digital health technologies in Indonesia is crucial for addressing the country's healthcare challenges, such as limited resources and varying levels of access. Digital transformation can significantly enhance patient outcomes and support healthcare workers, including nurses, in delivering efficient care. Digital health technologies can streamline healthcare delivery by integrating e-government services, which have proven to drive transformative changes in healthcare systems [1]. Digitalization offers opportunities to elevate healthcare quality by increasing service accessibility and providing training for medical personnel [2]. However, digital healthcare transformation in Indonesia faces hurdles, such as varying levels of readiness among healthcare facilities and stakeholder skepticism [3]. Organizational and technological challenges, including the lack of digital culture and concerns around data privacy, are significant barriers to digital transformation in the healthcare supply chain [4]. To mitigate these challenges, fostering a supportive digital culture and offering incentives for top managers to prioritize digital initiatives is essential (Şeker & Aydın, 2024). Addressing governance issues and systematically integrating digital technologies can help reduce risks and improve service quality [5].

Nurses are an integral part of healthcare, with a significant impact on patient safety, comfort, and recovery through their clinical skills and decision-making abilities, yet their effectiveness does not only depend on individual competencies; organizational support plays an important role in empowering nurses and improving their performance by providing resources, training and a supportive work environment, which collectively contribute to improved patient outcomes. Nurses' clinical and decision-making skills are crucial to patient safety and quality of care, while education

plays an important role in equipping them with the necessary competencies to handle critical situations, such as in the ICU or in cases of thrombosis and stroke [6]. The Nursing Outcomes Classification (NOC) framework emphasizes the importance of education in developing patient safety competencies [6]. In addition, nurses often experience mixed emotions, from contentment to stress and burnout due to the demands of the job, so emotional support and a positive work environment are important to help them manage these challenges [7]. Organizational standards and support, including human and material resources, are essential to ensure quality of care, serve as a measure of quality practice, and support professional development [8]. Employers have a responsibility to create an environment that enables nurses to meet these standards, improving safety and quality of care [8]. The evolving role of nurses now includes greater autonomy and authority in decision-making, allowing them to develop personalized care plans and collaborate with interdisciplinary teams, while the integration of technologies such as electronic health records and telehealth platforms facilitates evidence-based care and optimizes patient outcomes [9].

The implementation of patient safety protocols in Indonesian healthcare is vital for reducing adverse events and standardizing care, fostering a safer environment that minimizes medical errors and accelerates patient recovery. Effectiveness depends on healthcare staff attitudes, organizational culture, and regulatory frameworks. In Banjarmasin, Indonesia, a study showed a weak positive correlation between nurses' attitudes and patient safety culture, with age and workload as key risk factors; targeted interventions can address these issues to strengthen safety culture [10]. At RSUD Kota Mataram, 97.50% of respondents rated patient safety goal implementation as very good, indicating strong commitment and the need for continuous leadership support [11]. Additionally, a study using GLM-RM confirmed patient safety culture's effectiveness in preventing adverse events, highlighting its critical role in inpatient care [12]. Hospital bylaws and regulatory frameworks are also essential for maintaining safety protocol compliance, requiring stakeholder collaboration and adaptive evaluation to address challenges such as workload impacts [13].

Despite the recognized importance of these factors, there remains a need for empirical research in Indonesia that comprehensively examines how digital health technology, nurse competence, patient safety protocols, and organizational support interact to influence both patient recovery and nurse performance. Previous studies have highlighted these variables individually, yet few studies have integrated them within a single analytical framework, particularly in the Indonesian healthcare context. This study aims to address this gap by quantitatively analyzing the relationships among digital health technology, nurse competence, patient safety protocols, and organizational support, and their combined impact on patient recovery and nurse performance.

2. LITERATURE REVIEW

2.1 Digital Health Technology

Digital health technology, including tools like electronic health records (EHRs), telemedicine, and mobile health applications, plays a vital role in enhancing healthcare delivery, particularly in resource-limited settings like developing countries. These technologies streamline healthcare processes, improve patient monitoring, and enhance communication among providers. In Indonesia, digital health adoption is advancing, with initiatives like Indonesia Health Services (IHS) expanding digital infrastructure. Benefits include enhanced diagnostics through digital twin technology, which offers

personalized therapy using real-time data [14], and improved access through telemedicine and mobile health, aiding remote populations, especially during pandemics [15]. Additionally, digital health integration has led to standardized care and higher patient satisfaction [2]. However, challenges persist in data security, interoperability (Kumar et al., 2024), and training for medical personnel to leverage these technologies (Viegas, 2024), with resource constraints further hindering widespread adoption in developing regions (Paul, 2024). Opportunities for improvement include government-led digital health initiatives to address these challenges [16] and advancements in AI and machine learning, which promise to further enhance healthcare delivery [14].

2.2 Nurse Competence

Nurse competence is a multifaceted construct essential to patient care quality and safety, encompassing clinical skills, decision-making abilities, and interpersonal communication, all critical for achieving effective patient outcomes. The research underscores the significance of experience, education, and continuous professional development in enhancing nursing competence. In Indonesia, efforts to align nursing education with international standards continue, though challenges persist, especially in rural areas where highly skilled nurses are scarce. Education and training, including theoretical knowledge and clinical practice, lay the foundation for clinical judgment and decision-making [17], [18], while experience across diverse clinical settings further strengthens competence, improving patient safety and care quality [17], [19]. Supportive work environments that promote autonomy also play a critical role, in fostering high-quality nursing skills [17], [18]. Moreover, critical thinking and communication are essential for clinical decision-making and patient interactions, directly impacting safety and satisfaction [19], [20]. Enhanced competencies contribute to patient safety through reduced errors and adherence to international standards [19], while competent practice boosts patient satisfaction through personalized care and effective health education [21].

2.3 Patient Safety Protocols

Patient safety is a critical component of healthcare quality, focused on preventing adverse events and ensuring safe care delivery, with the World Health Organization (WHO) underscoring the importance of standardized safety protocols globally to reduce hospital-related complications and promote recovery. In Indonesia, while some hospitals have adopted these protocols, adherence varies, especially in under-resourced facilities; improved compliance could significantly lower preventable adverse events and boost recovery rates. Patient safety protocols, such as infection control, medication administration, and patient identification, are designed to minimize risks and improve outcomes [22], [23]. However, challenges persist in Indonesia, where adherence is inconsistent due to factors like inadequate staffing, limited training, and poor team communication, exacerbated by high patient-to-staff ratios [11], [23]. Strategies for improvement include standardized protocols, advanced training, health information technologies like EHRs and CPOE systems to streamline processes, and fostering a non-punitive environment that encourages error reporting and continuous learning [23].

2.4 Organizational Support

Organizational support in healthcare is essential for enhancing nurse performance, retention, and job satisfaction by providing resources, training, and a positive working environment. Research shows that perceived organizational support significantly influences nurses' psychological well-being, commitment, and intention to stay, which are critical for workforce stability (Duong et al., 2024). In Indonesia, efforts to strengthen organizational support, such as resource provision, supportive culture, and career development, correlate with higher nurse satisfaction and reduced turnover, ultimately improving healthcare quality [24]. Organizational support positively impacts job performance, mediated by stress control and optimism, and educational programs focused on support further boost work performance [25], [26]. Additionally, perceived support is tied to workplace well-being, impacting productivity, turnover, and customer loyalty, as a supportive environment fosters stress management, optimism, and strength-based development [26].

2.5 Impact on Patient Recovery

The interplay of digital health technology, nurse competence, patient safety protocols, and organizational support collectively impacts patient recovery and nurse performance, with theories on healthcare quality and performance management indicating that these elements are interconnected in driving optimal healthcare outcomes (Donabedian, 1988). For instance, digital technology enables effective monitoring and care coordination, which, when paired with skilled nursing and strong safety protocols, can significantly reduce recovery times and enhance patient satisfaction (Aiken et al., 2011). Additionally, organizational support that fosters a positive work environment enhances nurse performance and facilitates the effective implementation of safety and technology-driven protocols. The healthcare sector in Indonesia could benefit from an integrated approach, as the literature suggests that addressing these variables in isolation yields limited improvements in outcomes. This study, therefore, seeks to build on this integrative framework by quantitatively examining the relationships among digital health technology, nurse competence, patient safety protocols, and organizational support in influencing patient recovery and nurse performance within Indonesian healthcare. Although research exists on these elements independently, few studies explore their combined effects, especially within Indonesia's unique healthcare context, characterized by challenges such as unequal healthcare access, regional disparities in nursing skills, and limited organizational resources. This study aims to fill this gap by analyzing the synergistic effects of these variables to offer evidence-based recommendations for policymakers and healthcare administrators in Indonesia.

3. METHODS

3.1 Approach

This study adopted a cross-sectional quantitative design to examine the relationships between digital health technology, nurse competence, patient safety protocols, and organizational support as independent variables, and patient recovery and nurse performance as dependent variables. This approach enabled a systematic evaluation of these variables at a single point in time, capturing their current states and interactions within Indonesian healthcare facilities. The study

sample comprised 120 healthcare professionals, including nurses, administrators, and support staff from various hospitals and clinics across Indonesia. The sample size was determined based on statistical requirements for SEM-PLS analysis, which generally requires at least 100 respondents to ensure model reliability and validity [27]. A purposive sampling technique was used, targeting healthcare facilities that had implemented digital health technologies and adhered to standardized patient safety protocols. This method ensured that participants had relevant experience and knowledge concerning the variables, thereby enhancing response reliability.

Data were collected through a structured questionnaire designed to measure each variable in the study, administered to healthcare professionals either in person or online, depending on accessibility and participant availability. The survey instrument included questions adapted from existing, validated scales to ensure both reliability and relevance to the Indonesian healthcare context. To encourage participation, respondents were informed about the study's purpose, assured anonymity, and notified that their responses would be used solely for academic purposes. Data collection spanned four weeks, with 150 questionnaires distributed and 120 complete responses received, resulting in an 80% response rate.

3.2 Data Analysis Technique

Data were analyzed using SEM-PLS 3, chosen for its suitability in complex models with moderate sample sizes and its flexibility with non-normally distributed data [28]. Initial data cleaning and descriptive statistics confirmed alignment with the target population. Reliability and validity testing followed, with Cronbach's alpha, composite reliability, and AVE values meeting the required standards [29]. The structural model was then analyzed to assess hypothesized relationships, examining path coefficients, R-squared values, and p-values. Hypotheses on the effects of digital health technology, nurse competence, patient safety protocols, and organizational support on patient recovery and nurse performance were tested with a 0.05 significance threshold.

4. RESULTS AND DISCUSSION

4.1 Demographic

The demographic profile of the 120 healthcare professionals in this study includes gender, age, educational level, years of experience, and job role, providing insights into their background characteristics. Among respondents, 58.3% were female and 41.7% male, a distribution that aligns with the nursing profession in Indonesia. Age-wise, the largest group (37.5%) was 30–39 years, indicating a relatively young workforce. Educationally, most respondents held a Bachelor's degree (54.2%), typical for nursing and healthcare roles in Indonesia. In terms of experience, the majority had 5–10 years (33.3%), contributing valuable insight into healthcare practices. Job roles were predominantly nurses (66.7%), with the remainder being administrators, support staff, and other healthcare professionals, underscoring the study's focus on nurse competence and patient care performance.

The descriptive statistics provide an overview of the mean and standard deviation values for each variable assessed in this study. The variables include digital health technology, nurse competence, patient safety protocols, organizational support, patient recovery, and nurse performance.

Table 1. Descriptive Statistics

Variable	Mean	Standard Deviation
Digital Health Technology	4.12	0.67
Nurse Competence	4.25	0.61
Patient Safety Protocols	4.30	0.59
Organizational Support	4.05	0.72
Patient Recovery	4.20	0.65

Nurse Performance	4.18	0.63

Source: Results of Data Analysis (2024)

The analysis of variables shows that respondents generally perceive digital health technology positively, with a mean score of 4.12 (SD = 0.67), reflecting agreement on its effectiveness in healthcare settings and low variability, indicating consistent views. Nurse competence is rated highly, with a mean of 4.25 (SD = 0.61), suggesting strong perceptions of clinical skills and decision-making abilities, again with minimal variation. Patient safety protocols received the highest mean score of 4.30 (SD = 0.59), underscoring their critical role in care, with consistent agreement among respondents. Organizational support, with a mean of 4.05 (SD = 0.72), is generally perceived positively, though with slightly more variability, possibly due to differences in support across facilities. Patient recovery outcomes have a mean score of 4.20 (SD = 0.65), aligning with a focus on quality care facilitated by technology, competence, and protocols. Finally, nurse performance is rated at 4.18 (SD = 0.63), reflecting strong agreement on effective nurse performance, with low variability across respondents.

4.2 Measurement

The measurement model assessment ensures the robustness of constructs by evaluating reliability, convergent validity, and discriminant validity. Each construct—digital health technology, nurse competence, patient safety protocols, organizational support, patient recovery, and nurse performance—was rigorously assessed for internal consistency and validity using Cronbach's alpha, composite reliability (CR), average variance extracted (AVE), factor loadings, and discriminant validity. Reliability was confirmed through Cronbach's alpha and CR values exceeding 0.7, indicating strong internal consistency. Convergent validity, supported by AVE values above 0.5, confirms that each construct explains over half of the variance of its items. Digital health technology achieved a Cronbach's Alpha of 0.857, CR of 0.899, and AVE of 0.622, with factor loadings from 0.713 to 0.832. Nurse competence demonstrated high reliability (Alpha = 0.884, CR = 0.917, AVE = 0.673) with loadings from 0.742 to 0.863. Patient safety protocols displayed a Cronbach's Alpha of 0.877, CR of 0.903, and AVE of 0.668, with loadings from 0.727 to 0.848, while organizational support met standards with an Alpha of 0.832, CR of 0.886, AVE of 0.612, and loadings from 0.693 to 0.822. Patient recovery and nurse performance achieved reliable measures, with Alphas of 0.865 and 0.848, CRs of 0.904 and 0.892, AVEs of 0.654 and 0.636, and loadings from 0.735 to 0.856 and 0.712 to 0.831, respectively. All constructs surpassed the 0.70-factor loading threshold, indicating strong loading onto respective constructs and confirming robust construct validity.

Discriminant validity was further assessed using the Heterotrait-Monotrait Ratio (HTMT) criterion, which examines the extent to which constructs are distinct from one another. HTMT values below 0.90 are typically considered acceptable for establishing discriminant validity (Henseler et al., 2015). The HTMT values between each pair of constructs in this study are presented below.

Table 2. Discriminant

Constructs	DHT	NC	PSP	OS	PR	NP
Digital Health Technology						
Nurse Competence	0.625					
Patient Safety Protocols	0.583	0.573				
Organizational Support	0.657	0.688	0.612			
Patient Recovery	0.602	0.636	0.625	0.666		
Nurse Performance	0.636	0.664	0.649	0.694	0.673	

Source: Results of data analysis (2024)

All HTMT values between constructs are below the threshold of 0.90, indicating that each construct is empirically distinct from the others. This confirms discriminant validity among digital

health technology, nurse competence, patient safety protocols, organizational support, patient recovery, and nurse performance.

4.3 Structural Model Assessment and Hypothesis Testing

The structural model assessment evaluates the hypothesized relationships between variables, using Structural Equation Modeling-Partial Least Squares (SEM-PLS 3) to calculate path coefficients, R-squared values, and p-values, thereby testing the study's hypotheses. The results illuminate the strength and significance of relationships among digital health technology, nurse competence, patient safety protocols, organizational support, patient recovery, and nurse performance. R-squared (R^2) values show the explained variance in dependent variables: patient recovery ($R^2 = 0.656$) and nurse performance ($R^2 = 0.727$), indicating that the model accounts for 65.6% of the variance in patient recovery and 72.7% in nurse performance. These values suggest strong explanatory power, confirming that digital health technology, nurse competence, patient safety protocols, and organizational support substantially impact patient recovery and nurse performance.

Table 3. Hypothesis

Hypothesis	Path Coefficient (β)	t-value	p-value	Result
H1: Digital Health Technology → Patient Recovery	0.314	4.026	0.000	Supported
H2: Nurse Competence → Patient Recovery	0.286	3.754	0.001	Supported
H3: Patient Safety Protocols → Patient Recovery	0.362	4.602	0.000	Supported
H4: Organizational Support → Nurse Performance	0.417	5.106	0.000	Supported
H5: Digital Health Technology → Nurse Performance	0.292	3.854	0.003	Supported
H6: Nurse Competence → Nurse Performance	0.341	4.256	0.000	Supported

Source: Results of Data Analysis (2024)

The study's hypotheses reveal significant positive effects of digital health technology, nurse competence, patient safety protocols, and organizational support on patient recovery and nurse performance. For H1, digital health technology positively impacts patient recovery with a path coefficient of 0.314 (t = 4.026, p 0.000), highlighting its role in enhancing monitoring and communication. H2 shows that nurse competence, with a path coefficient of 0.286 (t = 3.754, p 0.001), significantly improves patient recovery, as skilled nurses provide quality care. H3 underscores that patient safety protocols have the strongest impact on recovery (path coefficient = 0.362, t = 4.602, p 0.000), emphasizing the role of stringent safety measures. Organizational support strongly influences nurse performance, as shown in H4 (path coefficient = 0.417, t = 5.106, p 0.000), indicating that resources and support enhance nurse effectiveness. H5 confirms that digital health technology positively affects nurse performance (path coefficient = 0.292, t = 3.854, p 0.003), facilitating task completion. Lastly, H6 demonstrates a significant effect of nurse competence on performance (path coefficient = 0.341, t = 4.256, p 0.000), reinforcing the value of competent nurses in delivering high-quality care.

Discussion

The results of this study provide critical insights into the relationships between digital health technology, nurse competence, patient safety protocols, organizational support, and their effects on patient recovery and nurse performance within the Indonesian healthcare sector. The findings underscore the interconnected nature of these variables and their collective role in shaping healthcare quality and outcomes. This section discusses the implications of each finding about existing literature and highlights potential applications for healthcare practices in Indonesia. The study found that digital health technology positively and significantly impacts both patient recovery and nurse performance, supporting existing research on the role of digital tools in enhancing care

delivery and operational efficiency (Nguyen et al., 2019; Ross & Shekelle, 2014). Digital health technologies enable real-time monitoring, streamlined communication among providers, and quick access to patient information, all of which contribute to improved patient outcomes and aid nurses in managing their tasks effectively. For Indonesian healthcare settings, which vary greatly in resource availability and technology access, these findings suggest that investing in digital health infrastructure could have a transformative effect. To maximize this impact, healthcare administrators should also emphasize training programs to ensure healthcare professionals are equipped to use these technologies effectively, particularly in rural areas where access to advanced digital tools is limited, and training could help bridge digital competency gaps.

Nurse competence significantly influences patient recovery and nurse performance, as competent nurses, equipped with advanced clinical skills and decision-making abilities, play a critical role in delivering high-quality care and facilitating quicker patient recovery, consistent with prior studies [30], [31]. Competence also enhances nurse performance by enabling effective responses to critical situations and complex patient needs. This finding holds important implications for Indonesian healthcare, where disparities in nurse training across regions remain a challenge despite advancements in educational standards [32]. Addressing these disparities through standardized training and certification programs nationwide, alongside continuing education focused on clinical skills, critical thinking, and best practices, could elevate nurse competence levels, leading to improved patient outcomes and performance across Indonesia.

Among all variables studied, patient safety protocols had the strongest impact on patient recovery, underscoring the critical role of standardized safety measures in preventing adverse events and ensuring a safe healthcare environment. This positive effect aligns with literature linking patient safety to reduced medical errors and improved recovery rates [33], [34]. In Indonesia, however, enforcing safety protocols remains challenging, especially in under-resourced facilities [35]. These findings suggest that prioritizing patient safety training, particularly in high patient-to-staff ratio areas, could significantly enhance patient outcomes. Government support for enforcing safety standards and ensuring resources for consistent training would bolster safety compliance across Indonesian healthcare, promoting safer recovery environments for patients. Organizational support had the strongest positive impact on nurse performance, highlighting the crucial role of supportive structures, resources, and management in empowering nurses to perform effectively. Research consistently shows that when nurses feel supported by their organization through adequate staffing, training, and a positive work environment, their performance and job satisfaction improve significantly [36], [37]. In Indonesian healthcare, where resource limitations are common, these findings suggest the importance of investing in supportive work environments. Providing sufficient resources, professional growth opportunities, and strong managerial support can enhance nurse performance and reduce turnover rates, which is particularly valuable in high-stress settings where support systems help maintain a motivated and effective nursing workforce.

The study findings indicate that digital health technology, nurse competence, patient safety protocols, and organizational support function as interconnected elements within healthcare systems, as reflected in the high R^2 values for patient recovery (0.65) and nurse performance (0.72), which suggest these variables collectively drive significant improvements in healthcare outcomes. This aligns with the [38] theory of healthcare quality, advocating for a holistic management approach to achieve optimal outcomes. For Indonesian healthcare administrators and policymakers, a comprehensive strategy that concurrently addresses these four factors may enhance patient outcomes and nurse performance. By integrating digital health tools, standardizing nurse training, enforcing safety protocols, and ensuring strong organizational support, healthcare institutions in Indonesia can foster environments that promote quality care and positive patient outcomes.

Practical Implications and Recommendations
The results of this study offer several practical implications:

1. Indonesian healthcare institutions should prioritize investments in digital health technology, particularly in regions with limited healthcare access. These investments should be coupled with training to maximize the efficacy of digital tools.
2. Implementing nationwide training and certification programs for nurses could ensure consistent competency levels across healthcare facilities, thereby improving patient recovery and nurse performance.
3. Given the significant impact of safety protocols on patient recovery, healthcare facilities should enforce these protocols rigorously. Regular safety training and audits, along with government support, can enhance protocol adherence.
4. Healthcare administrators should focus on creating supportive work environments with adequate resources, career development opportunities, and strong managerial support to boost nurse performance and satisfaction.

Limitations and Directions for Future Research

While this study provides valuable insights, certain limitations should be considered. The cross-sectional design restricts the ability to make causal inferences, and reliance on self-reported data may introduce response biases. Future research could employ longitudinal designs to observe changes in patient recovery and nurse performance over time and incorporate qualitative approaches to gain deeper insights into the subjective experiences of healthcare professionals.

Additionally, expanding the sample size and diversity to include more healthcare facilities across different regions could provide a more comprehensive understanding of the factors influencing patient recovery and nurse performance in Indonesia. Further studies could also explore additional variables, such as the role of healthcare leadership and interprofessional collaboration, to develop a more nuanced understanding of healthcare quality in Indonesian contexts.

CONCLUSION

This study underscores the critical role of digital health technology, nurse competence, patient safety protocols, and organizational support in improving healthcare outcomes in Indonesia. The findings indicate that digital health technology enhances both patient recovery and nurse performance by streamlining communication and supporting efficient patient monitoring. Nurse competence is essential in promoting swift recovery and effective performance, highlighting the need for standardized and continuous training programs. Patient safety protocols emerged as the strongest predictor of patient recovery, emphasizing the importance of stringent safety measures to minimize adverse events. Organizational support significantly boosts nurse performance by providing the resources, training, and work environment necessary for high-quality care. For Indonesian healthcare administrators and policymakers, these insights offer a pathway toward comprehensive healthcare improvements. Investments in digital infrastructure, nurse training, safety enforcement, and organizational resources are recommended to create a healthcare system that fosters both patient and workforce well-being. Future research should consider longitudinal designs and a broader range of variables to build on these findings and explore additional factors influencing healthcare quality. Overall, this study provides valuable guidance for enhancing healthcare practices and outcomes in developing healthcare environments.

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