

A Digital Health Literacy Framework for Nursing Practice

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Abstract: *Digital transformation in healthcare has reshaped immunization services, yet the mechanisms through which digitally enabled information environments improve nursing practice remain insufficiently integrated. This paper proposes a Digital Health Literacy Framework for Nursing Practice in which Digital Health Immunization Technology Capabilities—monitoring capability, integration capability, and decision-support capability—improve Nursing Practice Effectiveness through Decision-Making Quality, while Nursing Innovation Climate strengthens the extent to which these capabilities translate into better decisions. Grounded in a socio-technical perspective, the framework treats digital health literacy in practice as the ability of nurses to access, interpret, integrate, and act on digital information within immunization workflows rather than as an isolated technical skill. The paper reviews relevant theoretical foundations, develops hypotheses for the proposed direct relationships, identifies the moderating role of innovation climate, and highlights gaps in prior literature. Existing studies have examined digital systems, workflow issues, or adoption barriers separately, but they have rarely integrated concrete technology capabilities, organizational climate, decision-making quality, and nursing outcomes within one coherent model. The proposed framework explains how monitoring functions, interoperability, and decision-support tools can improve nursing practice when they are embedded in an innovation-supportive environment that enables sound, timely, and data-driven clinical decisions. The paper concludes with implications for nursing leaders, policymakers, and researchers seeking to strengthen digitally enabled immunization services.*

Keywords: Digital health literacy; immunization technology capabilities; nursing innovation climate; decision-making quality; nursing practice effectiveness.

1. Introduction

Immunization remains one of the most effective public health interventions for preventing infectious diseases, yet many health systems continue to face persistent challenges related to incomplete records, missed vaccinations, fragmented data systems, and unequal access to care (Karol & Thakare, 2024). In response, digital immunization technologies such as electronic immunization registries, mobile reminder systems, digital dashboards, and clinical decision-support tools have become increasingly integrated into national and local vaccination programs (Sheel et al., 2025). These technologies are no longer viewed as merely administrative tools; rather, they increasingly shape documentation

practices, patient communication, and clinical decision-making in immunization services (De Martinis & Ginaldi, 2024). More broadly, digital technologies are reshaping how nurses plan, deliver, and evaluate care, placing them at the center of contemporary immunization systems (Bimerew, 2024). Integrating digital health solutions into immunization strategies can also improve coverage monitoring, strengthen data quality, and support continuity of care (Sanya, 2025).

Within this rapidly evolving digital environment, nurses are often the primary users of immunization technologies at the point of care, making their engagement essential to successful implementation (Gaughan et al., 2022). Electronic immunization registries, in particular, have the potential to improve data quality, reduce duplication, and strengthen continuity of care (Sheel et al., 2025). However, these benefits are more likely to emerge when digital systems are embedded in frontline workflows rather than used as parallel or purely administrative platforms (Engalichev, 2023). This suggests that the value of digital immunization technology depends not only on technical design but also on how nurses use, interpret, and integrate these tools in everyday practice (Bimerew, 2024). Despite substantial investment in digital immunization technologies, much of the existing literature has emphasized implementation, infrastructure, and system design more than nursing practice as an outcome of digital transformation (Cano et al., 2023). As a result, the literature still provides limited insight into how these technologies reshape nurses' roles, workflows, and decision processes in immunization settings (De Martinis & Ginaldi, 2024). Understanding digital health in nursing therefore requires attention to the interaction among technology, users, and organizational context (Bimerew, 2024). From this perspective, digital transformation in immunization represents not only a technical shift but also a change in professional nursing practice and clinical routines (De Martinis & Ginaldi, 2024).

At the same time, the value of digital tools depends not simply on their availability, but on whether they support higher-quality nursing decisions under favorable organizational conditions (Alenazi et al., 2024). Evidence further indicates that nurses' digital readiness and competence are shaped by workplace factors rather than by technology exposure alone (Erfani et al., 2025). Taken together, this literature reveals a clear gap: although digital immunization technologies are advancing rapidly, there is still no widely accepted framework that explains how specific technology capabilities—monitoring, integration, and decision-support—improve nursing practice effectiveness through decision-making quality while accounting for nursing innovation climate. To address this gap, this paper proposes a Digital Health Literacy Framework for Nursing Practice. Rather than treating digital health literacy as a purely individual attribute, the framework conceptualizes it as nurses' practical capacity to access, integrate, interpret, and apply digital immunization information through technology capabilities that support better decisions and more effective care.

2. Theoretical Foundations

2.1 Socio-Technical Change in Digital Health

Digital transformation in healthcare is widely conceptualized through a socio-technical perspective, which views technology, people, and organizational structures as interdependent rather than separate components. From this standpoint, digital health systems do not simply automate existing processes but actively reshape professional roles, communication patterns, and clinical decision-making routines. In immunization services, socio-technical change involves the interaction between electronic registries, clinical protocols, nursing workflows, and institutional policies, emphasizing that successful digital implementation depends on alignment between technical design and human work practices rather than technology alone (Wynn et al., 2023). Within this framework, digital

immunization systems generate both opportunities and challenges for nursing practice. On one hand, these systems can improve data visibility, coordination, and accountability across levels of care; on the other hand, they may introduce new complexities related to workload, role negotiation, and system usability. A socio-technical perspective therefore highlights the importance of considering organizational culture, training, workflow fit, and professional identity alongside technical functionality when implementing digital health innovations in immunization programs (Livesay et al., 2023).

2.2 Nursing Innovation Climate

Nursing innovation climate also reflects the shared values and everyday norms that influence how nurses respond to technological change in practice. It is expressed not only through formal policies, but also through leadership behavior, openness to feedback, and the extent to which nurses feel safe to test new approaches and suggest improvements. In digitally enabled immunization settings, this climate matters because nurses often need to adapt digital tools to real clinical workflows, documentation demands, and patient needs. When the environment supports learning and collaboration, nurses are more likely to use digital systems actively and meaningfully rather than in a routine or defensive way. This is important because digital technologies do not improve nursing practice automatically. Even well-designed systems may have limited value if the organizational environment discourages initiative or treats digital adoption as a compliance task. Dermody et al. (2025) show that nurses' readiness for digital health is shaped by implementation conditions. Nursing innovation climate therefore serves as a key contextual factor that influences whether digital capabilities are converted into sound judgment and better care.

2.3 Decision-Making Quality in Nursing

Decision-making quality in nursing refers to the extent to which nurses make judgments that are accurate, timely, evidence-based, and appropriate to the clinical situation. In immunization services, this involves assessing vaccination status correctly, identifying missed or overdue doses, reconciling incomplete records, and responding to patient needs using current and reliable information. Because nurses often work in fast-paced settings where decisions affect continuity of care, the quality of those decisions has direct implications for documentation accuracy, follow-up actions, and service coordination. Hants et al. (2023) show that digital health systems increasingly influence how nurses interpret information, prioritize tasks, and carry out clinical processes. This concept is especially important in digitally enabled immunization environments, where nurses rely on data visibility and system functionality to support judgment. When digital information is accessible, relevant, and well integrated into workflow, nurses are better positioned to make sound decisions about scheduling, record management, patient education, and follow-up care. Decision-making quality therefore serves as a strong explanatory mechanism between digital system capabilities and nursing practice outcomes, because it captures how better information is translated into more effective clinical action.

2.4 Nursing Practice Effectiveness in Digital Immunization

Nursing practice effectiveness in digital immunization refers to the extent to which nursing care is delivered accurately, efficiently, and consistently while maintaining continuity across patient encounters. In practice, this is reflected in complete documentation, timely follow-up, coordinated

service delivery, and the reliable use of digital information to guide clinical action. In immunization settings, nurses are central to record management, patient communication, and care coordination, which makes the effectiveness of their work a critical indicator of whether digital systems are improving service delivery in meaningful ways. Secor et al. (2022) suggest that electronic immunization registries can support these functions when they are integrated into routine practice. At the same time, improved outcomes do not result simply from the presence of digital tools. Reminder systems, registries, and decision-support features add value only when they reduce fragmentation and strengthen frontline workflow rather than creating extra administrative burden. Nursing practice effectiveness is therefore an appropriate outcome variable because it captures whether digital immunization technologies produce real improvements in care quality, coordination, and service reliability.

3. Hypotheses Development

3.1 Monitoring Capability and Decision-Making Quality

Monitoring capability refers to the extent to which digital immunization systems enable nurses to observe vaccination status, track missed doses, identify service gaps, and monitor service performance in real time. Reliable monitoring functions reduce informational uncertainty by making relevant patient and service data visible at the point of care. Evidence on electronic immunization systems indicates that monitoring-oriented functionality can improve data visibility and strengthen frontline oversight in immunization services (Sheel et al., 2025). When nurses have access to timely monitoring information, they are better positioned to prioritize follow-up, reconcile records, and determine appropriate actions for individual patients and target populations. Monitoring capability is therefore expected to improve decision-making quality by supporting judgments that are more timely, evidence-informed, and responsive to gaps in immunization delivery (Engalichev, 2023).

H1: Monitoring Capability has a significant positive effect on Decision-Making Quality.

3.2 Integration Capability and Decision-Making Quality

Integration capability refers to the extent to which digital immunization systems connect data, workflows, and communication across units, platforms, and points of care. In fragmented service environments, weak integration forces nurses to work with incomplete records and disconnected processes, thereby undermining sound clinical judgment. Research on digital health systems indicates that alignment across systems and workflows is essential to effective digital practice in nursing (De Martinis & Ginaldi, 2024). Stronger integration capability should improve decision-making quality because it enables nurses to access more complete information, coordinate more effectively across providers, and reduce duplicative or conflicting actions. When digital systems support interoperability and workflow continuity, nursing decisions are more likely to be accurate, consistent, and feasible within routine immunization practice (Karol & Thakare, 2024).

H2: Integration Capability has a significant positive effect on Decision-Making Quality.

3.3 Decision-Support Capability and Decision-Making Quality

Decision-support capability refers to the extent to which digital systems provide prompts, reminders, risk indicators, and evidence-based guidance that assist nurses during care delivery. In immunization settings, these functions can help identify due or overdue vaccinations, detect inconsistencies, and guide responses to patient-specific circumstances (Acebes et al., 2025). Decision-support capability is expected to improve decision-making quality because it can reduce cognitive burden and support more systematic clinical reasoning (Alenazi et al., 2024). Digital technologies increasingly shape how nurses interpret information and apply clinical judgment in practice (Gaughan et al., 2022). Accordingly, decision-support tools are expected to improve the clarity, consistency, and overall quality of nursing decisions in immunization services (Engalichev, 2023).

H3: Decision-Support Capability has a significant positive effect on Decision-Making Quality.

3.4 Decision-Making Quality and Nursing Practice Effectiveness

Decision-making quality is expected to influence nursing practice effectiveness because everyday nursing outcomes depend on the quality of judgments that guide documentation, patient follow-up, coordination, and care prioritization. When nurses make accurate and timely decisions, practice is more likely to be efficient, consistent, and clinically appropriate. Research on nurses' use of technology in practice indicates that stronger decision processes support safer and more coherent care delivery (Gaughan et al., 2022). In immunization services, higher-quality decisions should lead to fewer documentation errors, better continuity of care, more reliable scheduling and follow-up, and greater responsiveness to patient needs (Engalichev, 2023). Decision processes also remain central to nursing performance in technology-rich work environments (Alenazi et al., 2024). Decision-making quality is therefore expected to be a direct antecedent of nursing practice effectiveness.

H4: Decision-Making Quality has a significant positive effect on Nursing Practice Effectiveness.

3.5 Moderating Role of Nursing Innovation Climate in the Relationship between Monitoring Capability and Decision-Making Quality

Monitoring information creates value only when the organizational environment encourages nurses to use data proactively, question routine practices, and respond to emerging signals. In weak innovation climates, monitoring data may be available but underused because staff are discouraged from experimentation and improvement-oriented action. Team and organizational conditions strongly influence how nurses engage with digital tools in practice (Coffetti et al., 2023). A stronger nursing innovation climate should therefore strengthen the positive effect of monitoring capability on decision-making quality. When the clinical environment supports learning, feedback, and adaptation, nurses are more likely to translate monitoring data into timely and higher-quality decisions (Erfani et al., 2025).

H5: Nursing Innovation Climate significantly strengthens the positive relationship between Monitoring Capability and Decision-Making Quality.

3.6 Moderating Role of Nursing Innovation Climate in the Relationship between Integration Capability and Decision-Making Quality

The decision benefits of integration capability are also contingent on organizational climate. Even highly connected systems can fail to improve decisions if the work environment does not support collaboration, shared problem-solving, and the practical use of integrated information across professional boundaries. Digital nursing research shows that workflow coordination and system value depend partly on the surrounding practice context (Livesay et al., 2023). Accordingly, nursing innovation climate should strengthen the positive effect of integration capability on decision-making quality. In settings where experimentation and coordinated improvement are encouraged, integrated data are more likely to be interpreted collectively and converted into better nursing decisions.

H6: Nursing Innovation Climate significantly strengthens the positive relationship between Integration Capability and Decision-Making Quality.

3.7 Moderating Role of Nursing Innovation Climate in the Relationship between Decision-Support Capability and Decision-Making Quality

Decision-support tools are most effective when nurses feel able to engage with alerts, recommendations, and digital prompts critically and constructively. In unsupportive climates, such tools may be ignored, bypassed, or treated as bureaucratic interruptions rather than as resources for judgment. Organizational support and readiness therefore influence whether decision-support features improve nursing decisions in practice (Dermody et al., 2025). For this reason, nursing innovation climate is expected to strengthen the positive effect of decision-support capability on decision-making quality. A more innovative climate should increase nurses' willingness to use decision-support features reflectively and integrate their outputs into clinical reasoning.

H7: Nursing Innovation Climate significantly strengthens the positive relationship between Decision-Support Capability and Decision-Making Quality.

4. Gap in the Literature

4.1 Gaps in Digital Health Immunization Technology Capabilities

Existing research on digital immunization systems has focused primarily on system development, service tracking, and implementation functions, while giving less attention to how distinct digital capabilities shape nurses' decisions in practice (Docuyanan et al., 2023). As a result, monitoring, integration, and decision-support functions are often treated as broad technical features rather than analytically distinct capabilities with different implications for clinical judgment and practice effectiveness. This leaves an important gap in explaining which digital capabilities matter most for frontline nursing work in immunization services.

4.2 Gaps in Decision-Making Quality

Although decision-making is central to nursing practice, the literature has more often emphasized digital competence and capability assessment than decision-making quality as the mechanism through which technology influences practice outcomes (Golz et al., 2023). Much of the existing evidence

therefore focuses on skill, readiness, or system use, while giving insufficient attention to how digitally enabled information is translated into better nursing judgment. Consequently, the pathway linking digital capability to nursing practice effectiveness remains theoretically underdeveloped.

4.3 Gaps in Nursing Innovation Climate

Prior research has also tended to emphasize digital literacy, preparedness, and adoption factors more than nursing innovation climate as a contextual condition shaping the value of digital capabilities (Li et al., 2025). This is an important omission because the same digital functions may produce different decision outcomes depending on whether the work environment supports experimentation, collaboration, and data-informed improvement. The moderating role of nursing innovation climate therefore remains insufficiently theorized in digital immunization research.

4.4 Integrated Gaps in the Model

Overall, the literature remains fragmented, with some studies focusing on digital service systems, others on competence development, and others on technology use in practice settings (Harsono et al., 2026). Few studies integrate these strands into a single framework explaining how monitoring capability, integration capability, and decision-support capability influence nursing practice effectiveness through decision-making quality, and how nursing innovation climate shapes these relationships. This integrated gap justifies the proposed conceptual framework.

5. Conceptual Framework Development

5.1 Digital Health Immunization Technology Capabilities and Decision-Making Quality

Within the proposed framework, Digital Health Immunization Technology Capabilities are represented by three complementary dimensions: monitoring capability, integration capability, and decision-support capability. Monitoring capability improves visibility over patient status and service gaps; integration capability connects data and workflows across points of care; and decision-support capability embeds prompts and guidance into routine tasks. Together, these capabilities determine the informational quality of the environment within which nurses make clinical and operational decisions. When these capabilities are strong, nurses can access more complete information, interpret it more efficiently, and act on it with greater confidence. The framework therefore positions monitoring, integration, and decision-support capability as direct antecedents of decision-making quality. In practical terms, the model proposes that digitally enabled nursing practice becomes more effective when technology capabilities strengthen the quality of the judgments nurses make during immunization delivery.

5.2 Nursing Innovation Climate as a Moderator

Nursing innovation climate is conceptualized as the contextual condition that determines how effectively digital capabilities are converted into better decisions. A supportive climate encourages experimentation, reflective use of data, interprofessional coordination, and local problem-solving; an

unsupportive climate constrains these same processes even when digital tools are available. For this reason, the framework treats nursing innovation climate as a moderator of the relationships between monitoring capability, integration capability, and decision-support capability on the one hand and decision-making quality on the other.

5.3 Decision-Making Quality and Nursing Practice Effectiveness

Decision-making quality is the central explanatory mechanism linking digital capabilities to nursing outcomes. Higher-quality decisions should improve the accuracy of documentation, the timeliness of follow-up, the coordination of care, and the consistency of immunization delivery. In this framework, decision-making quality therefore mediates the practical value of digital capabilities by translating better information and better support into more effective nursing practice. Nursing Practice Effectiveness is positioned as the outcome variable because it captures whether digital capability ultimately improves frontline care. The framework assumes that nursing practice becomes more effective when nurses use monitoring information, integrated data, and decision-support tools to make higher-quality judgments that improve workflow execution and patient care.

5.4 Proposed Conceptual Framework

The proposed framework explains nursing practice effectiveness through a capability-to-decision pathway shaped by organizational climate. Monitoring capability, integration capability, and decision-support capability represent the core dimensions of Digital Health Immunization Technology Capabilities. These three capabilities are expected to improve Decision-Making Quality by making information more visible, more connected, and more actionable within immunization workflows. At the same time, Nursing Innovation Climate is expected to strengthen each of these relationships by creating conditions in which nurses are encouraged to use digital resources proactively, collaboratively, and reflectively. Decision-Making Quality then functions as the mechanism through which digitally enabled information and support are translated into Nursing Practice Effectiveness. In this sense, the framework gives concrete operational form to digital health literacy in nursing practice by focusing on how nurses access, integrate, interpret, and apply digital information in care delivery. Figure 1 synthesizes this model and provides a theoretically grounded basis for subsequent empirical testing.

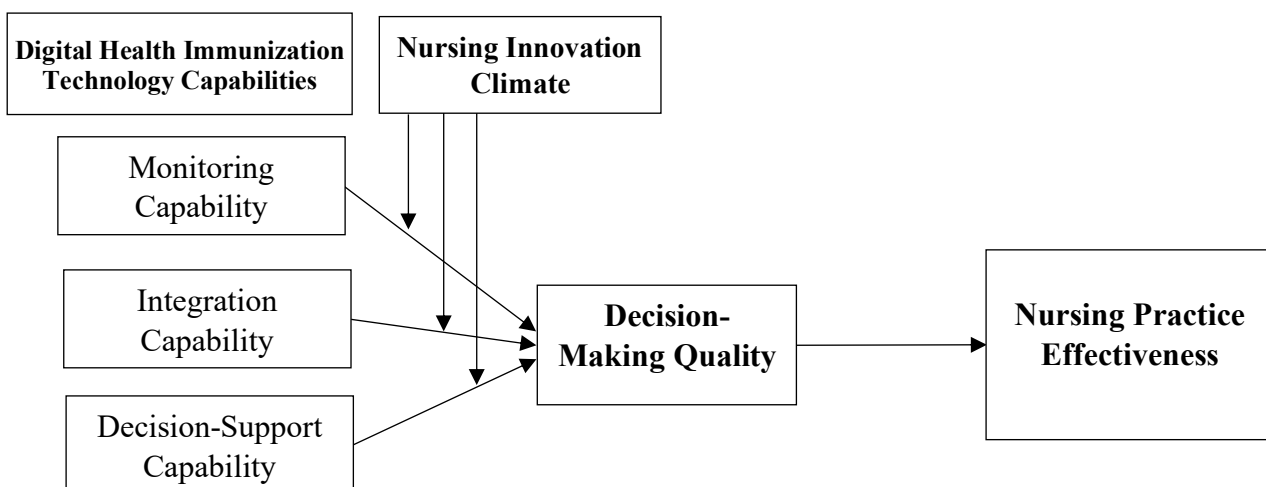


Figure 1: Conceptual Framework

6. Extending the Digital Health Literacy Argument

6.1 Digital Health Literacy as a Socio-Technical Practice Capability

The framework is therefore stronger when digital health literacy is interpreted as a socio-technical practice capability rather than as an isolated individual attribute. Contemporary nursing research increasingly shows that digital work is shaped by the interaction of technologies, professional routines, communication patterns, and organizational arrangements. In this perspective, nurses do not simply use technologies; they work through them, with consequences for coordination, judgment, accountability, and care continuity (Rud, 2023). Reframing the argument in this way also clarifies what the paper means by digital health literacy in nursing practice. Within immunization services, literacy is not limited to the ability to read information on a screen. It includes the practical capacity to locate relevant records, reconcile inconsistent data, judge their adequacy, and act on them in real time during care delivery. Electronic immunization registries are valuable precisely because they provide actionable patient-level and aggregate information that can support these activities when they are embedded in frontline workflows (Secor et al., 2022).

6.2 Why Decision-Making Quality Functions as the Central Mechanism

This mediating logic also helps explain why the same technology can generate very different practice outcomes across settings. Where nurses possess stronger informatics competence and share digital knowledge effectively, work performance tends to improve; where digital overload and technostress dominate, gains may be muted or reversed. The framework therefore benefits from treating decision-making quality as the immediate mechanism through which capability becomes practice value rather than assuming that system use automatically improves care (Baek et al., 2025). Decision-making quality is also the most defensible mediating mechanism in the model because nursing practice effectiveness is not improved by digital capability in the abstract; it improves when better information leads to better judgments. In immunization settings, nurses must continuously decide whether records are complete, whether a dose is overdue, whether a patient requires follow-up, and how to respond when digital records conflict. Digital systems matter to the extent that they improve the quality, speed, and consistency of those decisions (Hants et al., 2023).

6.3 Nursing Innovation Climate as a Boundary Condition

Positioning nursing innovation climate as a boundary condition therefore strengthens the explanatory logic of the framework. It prevents the model from overstating the direct power of technology and instead recognises that digital capabilities are activated through organizational context. This point is consistent with recent evidence that nurses' readiness for digital health technologies is influenced by the surrounding implementation environment and not simply by individual willingness or exposure to systems (Dermody et al., 2025). The moderator in the model is equally important because the same technology can produce very different outcomes across nursing units. When team norms reward data use, support reflective practice, and allow local adaptation, nurses are more likely to act on alerts, reconcile digital records, and coordinate care across settings. By contrast, in low-support environments, even technically capable systems are often reduced to compliance tools. Prior evidence on nurses' adoption of information and communication technology underscores the importance of

collaboration, leadership, and team conditions in shaping whether digital tools become meaningful in practice.

7. Operationalization and Empirical Validation

7.1 Construct Definitions and Measurement Logic

Operationalizing the framework requires researchers to distinguish digital capability from mere technology presence. The existence of an electronic registry or reminder system does not, by itself, indicate that nurses can use it effectively for monitoring, integration, or decision support. Measurement should therefore focus on experienced capability at the point of care and on decision consequences rather than on hardware or software availability alone. This distinction aligns with recent work showing that digital nursing competence must be assessed with conceptually valid instruments rather than with crude adoption proxies (D'Agostino et al., 2026).

Table 1: Proposed Construct Definitions and Illustrative Indicators

Construct	Working definition	Illustrative indicators for empirical testing
Monitoring Capability	The extent to which digital immunization systems enable nurses to track patient status, missed doses, service gaps, and service performance in real time.	Visibility of vaccination status; timeliness of alerts; exception tracking; ability to monitor individual and cohort trends.
Integration Capability	The extent to which data, workflows, and communication are connected across systems, units, and points of care.	Interoperability; record reconciliation; continuity of data across encounters; coordination between providers or sites.
Decision-Support Capability	The extent to which digital tools provide prompts, reminders, risk flags, and evidence-based guidance during care delivery.	Due or overdue prompts; protocol reminders; patient-specific recommendations; support for consistent documentation and follow-up.
Nursing Innovation Climate	The degree to which the work environment encourages experimentation, learning, collaboration, and local adaptation in digital practice.	Leadership support; psychological safety; knowledge sharing; openness to workflow redesign; improvement-oriented norms.
Decision-Making Quality	The extent to which nursing decisions are timely, accurate, evidence-informed, and appropriate to patient and service needs.	Decision timeliness; appropriateness; completeness of information used; confidence in judgments; consistency of action.
Nursing Practice Effectiveness	The extent to which nursing work is delivered accurately, efficiently, consistently, and with continuity of care.	Documentation quality; follow-up reliability; workflow coordination; continuity of care; responsiveness to patient needs.

7.2 Research Design for Testing the Framework

The proposed model is well suited to empirical testing in hospital vaccination units, primary care clinics, and public health immunization programs where nurses use electronic registries, decision-support prompts, and digital communication tools as part of routine care. A cross-sectional multi-site survey could provide an initial theory test, but a stronger design would combine survey data with service-performance records so that nursing practice effectiveness is not inferred solely from perception. The unit of analysis should remain the nurse because the framework explains how individual practice is shaped by digital capabilities within organizational context. For hypothesis testing, structural equation modelling offers the most defensible analytical pathway because it enables simultaneous estimation of direct effects, the mediating effect of decision-making quality, and the moderating effect of nursing innovation climate. Moderated-mediation testing would allow researchers to assess whether the indirect effects of monitoring, integration, and decision-support capability on nursing practice effectiveness become stronger under more innovative workplace conditions. This design would move the framework from conceptual logic to a fully testable explanatory model.

7.3 Model Estimation, Validity, and Common Method Safeguards

Because the framework includes closely related organizational and decision constructs, empirical testing should proceed with careful attention to construct validity. Item development should begin with clear conceptual boundaries, followed by expert review, pilot testing, and confirmatory factor analysis to verify convergent and discriminant validity. This step is particularly important in digital nursing research because instruments labelled as digital competence, digital health capability, or informatics readiness often overlap conceptually even when they are intended to capture different dimensions of practice (D'Agostino et al., 2026). To reduce common method bias, future studies should avoid relying on a single self-report instrument collected at one point in time. A stronger design would separate measurement sources by assigning nursing innovation climate to unit-level responses, capturing decision-making quality and technology capabilities from frontline nurses, and assessing nursing practice effectiveness with supervisor ratings or routine performance indicators such as documentation completeness, follow-up timeliness, or missed-opportunity rates. A time-lagged design would further strengthen causal interpretation by measuring capabilities and climate before practice outcomes are evaluated.

7.4 Boundary Conditions and Scope of the Framework

The framework is most applicable to settings in which nurses play a central role in immunization documentation, follow-up, and clinical coordination. It is less likely to explain practice variation in environments where digital tasks are highly centralized, where nurses have limited discretion, or where registry use is detached from routine care delivery. Defining the scope of the model matters because conceptual overreach would weaken both empirical testing and practical interpretation. The model should also be interpreted alongside broader questions of digital equity and infrastructure readiness. Digital capability can improve care only when nurses have stable system access, usable interfaces, and sufficiently reliable data to support judgment. Recent evidence suggests that digital competence partly mediates access and utilization patterns within healthcare, which reinforces the importance of capability development and equitable system conditions rather than assuming that digital expansion alone will improve outcomes (Heponiemi et al., 2024).

7.5 Directions for Future Research

A further research priority is to examine whether unintended consequences dilute the benefits predicted by the model. Alert fatigue, documentation burden, and technostress may weaken the positive effect of decision-support or monitoring functions when digital systems are poorly configured or when staff are overloaded. Testing these countervailing mechanisms would make the framework more realistic and would help identify the threshold at which digital support shifts from enabling judgment to disrupting it (Jang and Yang, 2025). Longitudinal designs would also allow researchers to examine whether the model evolves as digital systems mature. It is plausible that monitoring capability exerts stronger effects during early implementation, while integration and decision-support capability become more influential once data quality stabilizes and nurses begin to rely on digital tools for more complex judgment tasks. Future studies may therefore test non-linear or stage-dependent relationships rather than assuming that all pathways remain constant over time.

Future research should extend the framework beyond a single-setting explanation and test whether its relationships hold across different immunization delivery models, levels of digital maturity, and healthcare systems. Comparative studies between hospitals, primary care clinics, and community immunization programs would help determine whether monitoring, integration, and decision-support capability have similar salience across contexts or whether particular capabilities become dominant under different service arrangements. Such work would improve the external validity of the framework and clarify where adaptation is necessary.

7.6 Theoretical Contribution to Digital Health Literacy Research

An additional strength of the framework is that it helps reposition digital health literacy within nursing scholarship. Instead of treating literacy as a generic individual competency detached from practice realities, the model links literacy to the organizationally embedded use of monitoring, integration, and decision-support capabilities. This move has theoretical value because it connects literacy to work design, clinical judgment, and measurable practice outcomes rather than limiting it to attitudes, confidence, or isolated digital skill. The framework also creates a bridge between digital health literacy research and broader socio-technical theories of healthcare change. By showing how capabilities, climate, decisions, and outcomes interact, it offers a more practice-sensitive interpretation of digital transformation in nursing. That contribution is useful because many current discussions of digital capability still separate technology adoption from the day-to-day quality of nursing work, leaving a gap between conceptual language and practice improvement.

7.7 Measurement Development Priorities

A further methodological priority is the development of context-sensitive instruments that capture digital capability in immunization nursing rather than generic technology acceptance alone. Existing digital competence tools are useful starting points, but they often assess broad confidence or self-reported skill without distinguishing monitoring, integration, and decision-support capability in frontline immunization work (Kumara et al., 2025). Future scale development should therefore adapt items to the actual informational tasks nurses perform in vaccination services and test those items rigorously for content and construct validity (D'Agostino et al., 2026). Measurement should also combine perceptual and objective indicators wherever possible. Self-report responses can reveal

whether nurses experience digital systems as usable and decision-enabling, but system-generated data can show whether those capabilities translate into action. Registry completeness, follow-up completion, duplicate-record resolution, missed-opportunity rates, and response time to overdue alerts would provide stronger evidence that the framework is capturing meaningful practice effects rather than attitudes alone (Mwamba et al., 2024). This logic is consistent with prior work showing that electronic immunization registries generate service-level information that can support quality improvement and operational decision-making (Secor et al., 2022).

Finally, future measurement models should recognize that not all constructs in the framework operate at the same level. Nursing innovation climate is partly shared within teams, whereas decision-making quality and perceived capability may vary at the individual level. Multi-level designs would therefore allow researchers to test cross-level effects more accurately and reduce the risk of treating collective organizational conditions as purely individual attributes. Such refinement would increase the explanatory precision of the framework and improve its value for intervention design in digitally enabled nursing practice (Abdashimov & Abdiraufova, 2026). Another measurement issue concerns cross-context comparability. Instruments that perform adequately in tertiary hospitals may not function equivalently in community clinics, public health outreach settings, or low-resource immunization programs, where immunization delivery conditions and digital infrastructure often differ substantially (Promise et al., 2025). Researchers should therefore test measurement invariance before drawing conclusions across institutions, service models, or countries. Without this step, observed differences in digital capability or decision-making quality may reflect instrument instability rather than genuine differences in nursing practice. Researchers should also distinguish formative from reflective measurement logic where conceptually appropriate. Some elements of digital capability may be better represented as formative composites because monitoring, integration, and decision-support functions jointly shape the informational environment rather than reflecting one interchangeable latent trait. This is especially relevant in immunization settings, where monitoring functions, decision-support tools, and broader digital integration often operate as complementary rather than substitutable system capabilities (Pavia et al., 2024). Careful specification at the measurement stage would strengthen model identification and reduce the risk of oversimplifying complex digital work into a single broad competence score.

8. Practical Implications

8.1 Implications for Nursing Leaders

The proposed framework has clear implications for nursing leaders responsible for digital transformation in immunization services. First, leaders should not evaluate digital systems only in terms of installation or compliance; they should assess whether monitoring, integration, and decision-support capabilities are genuinely improving the quality of nursing decisions. Second, leaders should cultivate an innovation-supportive climate in which nurses are encouraged to use digital data for problem-solving, continuous improvement, and workflow redesign. Without such a climate, even technically capable systems may produce weak practice outcomes. Third, leaders should use practice indicators such as documentation quality, follow-up reliability, and care coordination to evaluate whether better decisions are translating into more effective nursing practice.

8.2 Implications for Policymakers

For policymakers, the framework indicates that digital immunization initiatives should be designed as socio-technical interventions rather than as simple technology rollouts. Policy support should prioritize interoperable infrastructure, clinically relevant monitoring functions, and decision-support features that fit nursing workflows. At the same time, implementation policy should invest in organizational conditions that help nurses use these capabilities effectively, including training, leadership support, and improvement-oriented workplace cultures. A policy agenda that ignores nursing innovation climate risks overestimating what technology alone can achieve in frontline practice.

8.3 Implications for Researchers and Educators

For researchers, the framework offers a parsimonious model for examining how specific digital capabilities affect nursing outcomes through decision-making quality under different organizational conditions. Future studies can test the proposed relationships using structural equation modeling, including moderated-mediation designs that estimate the indirect effects of monitoring, integration, and decision-support capability on nursing practice effectiveness through decision-making quality at different levels of nursing innovation climate. For educators, the framework underscores the need to prepare nurses not only to use digital tools, but also to interpret digital information critically, integrate data across care processes, and make high-quality decisions in technology-rich environments. For educators, the framework implies that digital preparation should move beyond software familiarization toward the cultivation of judgment-rich practice. Nursing curricula can embed scenario-based exercises in which students interpret incomplete immunization records, respond to overdue-dose alerts, reconcile conflicting information, and coordinate follow-up across care settings. Such training would align educational objectives with the actual decision processes that determine whether digital systems improve practice rather than merely increasing documentation activity.

For researchers, the framework also supports a stronger intervention agenda. Rather than testing only whether digital systems are accepted or adopted, future studies can evaluate whether leadership development, feedback loops, workflow redesign, and team-learning interventions strengthen the pathway from technology capability to decision-making quality. This would shift digital nursing research from descriptive implementation studies toward explanatory and improvement-oriented designs that can guide managerial action. A further implication concerns governance and accountability. Because digital immunization work relies on timely, accurate, and shareable information, researchers and educators should pay greater attention to data-quality stewardship, documentation standards, and responsible use of digital prompts in clinical reasoning. Preparing nurses to question data quality, identify system limitations, and use automated guidance critically will be essential if digital health literacy is to support safe and effective practice rather than routine compliance with flawed information.

9. Conclusion

This paper proposes a Digital Health Literacy Framework for Nursing Practice that explains how Digital Health Immunization Technology Capabilities influence Nursing Practice Effectiveness through Decision-Making Quality, while recognizing Nursing Innovation Climate as an important

contextual condition. The framework moves beyond broad discussions of digital transformation by identifying the specific capabilities that make digital systems meaningful in frontline nursing work: monitoring capability, integration capability, and decision-support capability. In doing so, it provides a more focused explanation of how digital environments support nursing practice in immunization services. The framework also clarifies that digital value is not created simply by the presence of technology. Rather, value emerges when digital systems help nurses access relevant information, interpret it accurately, coordinate care effectively, and make timely and appropriate clinical decisions. This position strengthens the argument that digital health literacy in nursing should be understood as a practical, workflow-embedded capability rather than as a narrow individual skill. In immunization settings, the ability to work effectively with digital information is closely tied to documentation quality, follow-up reliability, continuity of care, and the overall consistency of service delivery.

A further contribution of the paper is its emphasis on organizational context. By introducing Nursing Innovation Climate as a moderator, the framework acknowledges that the same technology may produce different outcomes depending on whether the work environment supports learning, collaboration, adaptation, and reflective data use. This helps explain why digital systems can succeed in some settings yet generate limited gains in others. The framework therefore presents digital transformation as a socio-technical process in which technological capabilities, decision processes, and workplace conditions interact to shape nursing outcomes. The proposed model offers a clear foundation for future empirical testing. It provides a structured basis for examining how distinct digital capabilities contribute to better decisions, how those decisions translate into improved nursing practice, and how organizational climate strengthens or weakens these relationships. This makes the framework useful not only for theory development, but also for guiding intervention design, leadership priorities, and measurement strategies in digitally enabled immunization services.

References

- Abdashimov, Z. B., & Abdiraufova, D. T. (2026). THE CONCEPT AND DEVELOPMENT OF DIGITAL TECHNOLOGIES IN NURSING CARE. *Eureka Journal of Health Sciences & Medical Innovation*, 2(1), 531-547.
- Acebes, J., Amiao, J. B., Calias, S., Fianza-Buya, M. A., & Ganado, L. (2025). Vaxi-eTrack: A Data-driven System for Infant Vaccination Management for Barangay Clinic Pico La Trinidad, Benguet. *Southeast Asian Journal of Science and Technology*, 10(1), 54-72.
- Alenazi, A. M., Al-Anzi, R. L., Alotaibi, H. L., Al-Rashidi, H. S. A., Al-Rashidi, A. S. A., Al-Anazi, A. F. D., ... & Al Khammash, M. M. A. (2024). Digital Fatigue And Clinical Decision-Making Among Nurses Using EHR Systems. *The Review of Diabetic Studies*, 211-222.
- Baek, G., Lee, Y. J., & Lee, E. (2025). The impact of technostress, nursing informatics competency and knowledge-sharing behaviour on nursing work performance among tertiary hospital nurses. *Journal of Advanced Nursing*, 81(8), 4734-4745.
- Bimerew, M. (2024). Barriers and enablers of nurses' adoption of digital health technology to facilitate healthcare delivery in Resource-Limited settings. In *Innovation in Applied Nursing Informatics* (pp. 64-68). IOS Press.
- Cano, I., Arismendi, E., & Borrat, X. (2023). Digital health frameworks. *Digital Respiratory Healthcare (ERS Monograph)*. Sheffield, European Respiratory Society, 27-37.

- Coffetti, E., Paans, W., Roodbol, P. F., & Zuidersma, J. (2023). Individual and team factors influencing the adoption of information and communication technology by nurses: a systematic review. *CIN: Computers, Informatics, Nursing*, 41(4), 205-214.
- D'Agostino, F., Erba, I., Ammenwerth, E., Robinzon, V., Segal, G., Harel, N., ... & Giannetta, N. (2026). Measurement Properties of Instruments Assessing Digital Competence in Nursing: A Systematic Review. *Applied Clinical Informatics*, 17(01), 001-018.
- De Martinis, M., & Ginaldi, L. (2024). Digital Skills to Improve Levels of Care and Renew Health Care Professions. *JMIR Medical Education*, 10(1), e58743.
- Dermody, G., Wadsworth, D., El Haddad, M., Prichard, R., Benson, A., Benson, T., & Craswell, A. (2025). Bridging the Digital Divide: A Multi-Method Evaluation of Nursing Readiness for Digital Health Technology. *Journal of Advanced Nursing*.
- Docuyanana, H. F. R., Solomon, C. P., Robles, M. J. S., & Castor, A. K. V. (2023). Patient-Specific Vaccine Tracking System. *Research in Clinical Pharmacy*, 1(1), 84-87.
- Engalichev, K. (2023). Assessing and Improving Pediatric Nurses' Documentation of Childhood Immunization Status Using the Electronic Health Record.
- Erfani, G., McCREADY, J., Gibson, B., Nichol, B., Unsworth, J., Jarva, E., ... & Tomietto, M. (2025). Factors influencing digital health competence among healthcare professionals: A cross-sectional study. *Applied Nursing Research*, 82, 151922.
- Gaughan, M. R., Kwon, M., Park, E., & Jungquist, C. (2022). Nurses' experience and perception of technology use in practice: a qualitative study using an extended technology acceptance model. *CIN: Computers, Informatics, Nursing*, 40(7), 478-486.
- Golz, C., Hahn, S., & Zwakhalen, S. M. (2023). Content validation of a questionnaire to measure digital competence of nurses in clinical practice. *CIN: Computers, Informatics, Nursing*, 41(12), 949-956.
- Hants, L., Bail, K., & Paterson, C. (2023). Clinical decision-making and the nursing process in digital health systems: an integrated systematic review. *Journal of clinical nursing*, 32(19-20), 7010-7035.
- Harsono, H., Mulyono, M., & Rinayati, R. (2026). Digital Transformation of Toddler Posyandu Services via an Android-Based Application. *Sinkron: jurnal dan penelitian teknik informatika*, 10(1), 37-48.
- Heponiemi, T., Kaihlanen, A. M., Virtanen, L., Kainiemi, E., Saukkonen, P., Koponen, P., ... & Elovainio, M. (2024). The mediating role of digital competence in the associations between the factors affecting healthcare utilization and access to care. *International journal of public health*, 68, 1606184.
- Jang, Y., & Yang, Y. (2025). Effects of e-health literacy on health-related quality of life in young adults with type 2 diabetes: Parallel mediation of diabetes self-efficacy and self-care behaviors. *Applied Nursing Research*, 82, 151917.
- Karol, S., & Thakare, M. M. (2024). Strengthening immunisation services in India through digital transformation from Co-WIN to U-WIN: A review. *Preventive Medicine: Research & Reviews*, 1(1), 25-28.
- Kumara, A. L. R. U., Burhan, N. A. S., Sabri, M. F., & Jaafar, W. M. W. (2025). Mediating Effect of Technology Adoption: Agricultural Extension Services Enhances Sustainability of Smallholder Tea Farmers in Sri Lanka. *e-BANGI*, 22(1), 72-85.
- Li, P., Tan, R., Yang, T., & Meng, L. (2025). Current status and associated factors of digital literacy among academic nurse educators: a cross-sectional study. *BMC Medical Education*, 25(1), 16.
- Livesay, K., Petersen, S., Walter, R., Zhao, L., Butler-Henderson, K., & Abdolkhani, R. (2023). Sociotechnical challenges of digital health in nursing practice during the COVID-19 pandemic: national study. *JMIR nursing*, 6, e46819.

- Mwamba, G. N., Nzaji, M. K., Numbi, O. L., Mapatano, M. A., & Lusamba Dikassa, P. S. (2024). A New Conceptual Framework for Enhancing Vaccine Efficacy in Malnourished Children. *Journal of Multidisciplinary Healthcare*, 6161-6175.
- Pavia, G., Branda, F., Ciccozzi, A., Romano, C., Locci, C., Azzena, I., ... & Scarpa, F. (2024). Integrating digital health solutions with immunization strategies: improving immunization coverage and monitoring in the Post-COVID-19 era. *Vaccines*, 12(8), 847.
- Promise, V. I., Alabere, I., Abdulraheem, I., & Raimi, M. O. (2025). The Effect of Mobile Phone and Home Visit on Childhood Vaccination Uptake in Rural Communities of Bayelsa State Nigeria. A Pragmatic Cluster Randomized Control Trial. *JMIR Preprints*. *JMIR Preprints*, 1(04), 2025.
- Rud, R. (2023). A Novel Educational Intervention for Home Visiting Public Health Nurses Based on the Technology Acceptance Model (TAM) to Improve Knowledge, Behavior, and Skills Interacting with Patients (Doctoral dissertation, Regis College).
- Sanya, M. A. (2025). A Qualitative Phenomenological Study of Modern Educational Technology Adoption in Nursing Education (Doctoral dissertation, National University).
- Secor, A. M., Mtenga, H., Richard, J., Bulula, N., Ferriss, E., Rathod, M., ... & Carnahan, E. (2022). Added value of electronic immunization registries in low-and middle-income countries: observational case study in Tanzania. *JMIR Public Health and Surveillance*, 8(1), e32455.
- Sheel, M., Patel, C., Saravanos, G., Lynch, M., Tinessia, A., Chanlivong, N., ... & Danovaro-Holliday, M. C. (2025). Strengthening Immunization Data: Protocol for the Evaluation of an Electronic Immunization Register. *JMIR Research Protocols*, 14(1), e65663.
- Wynn, M., Garwood-Cross, L., Vasilica, C., Griffiths, M., Heaslip, V., & Phillips, N. (2023). Digitizing nursing: A theoretical and holistic exploration to understand the adoption and use of digital technologies by nurses. *Journal of Advanced Nursing*, 79(10), 3737-3747.