A Digital Health Immunization Technology Framework for Nursing Practice

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Abstract: *Digital transformation in healthcare has significantly reshaped immunization services, yet the mechanisms through which digital technologies influence nursing practice remain insufficiently theorized and empirically integrated. This paper proposes a Digital Health Immunization Technology Framework for Nursing Practice that explains how digital immunization technologies affect nursing outcomes through both direct and indirect pathways. Grounded in a socio-technical perspective, the study conceptualizes Digital Health Immunization Technology as the independent variable, Nursing Practice as the dependent variable, and Digital Competence and Technology Adoption as parallel mediators. The framework synthesizes insights from digital health, nursing informatics, and technology adoption research to clarify how technological environments shape professional capabilities and behavioral engagement in immunization settings. The paper first reviews theoretical foundations related to socio-technical change, digital leadership, digital competence, and contemporary nursing practice in digital immunization. It then develops a series of hypotheses linking digital technology to competence, adoption, and practice, including two mediation pathways. A gap analysis highlights limitations in existing literature, particularly the fragmented treatment of technology, competence, and adoption as separate constructs. The proposed conceptual model integrates these elements into a coherent structure that explains how digital immunization systems can enhance documentation quality, decision-making, workflow efficiency, and continuity of care. The paper concludes by outlining practical implications for nursing leaders, policymakers, and educators, emphasizing the need for user-centered system design, continuous digital competence development, and supportive organizational environments to maximize the benefits of digital immunization technologies for nursing practice and public health outcomes.*

Keywords: Digital health; Immunization technology; Digital competence; Technology adoption; Nursing practice.

1. Introduction

Immunization remains one of the most effective public health interventions for preventing infectious diseases, yet many health systems continue to experience persistent challenges related to incomplete records, missed vaccinations, fragmented data systems, and inequities in access to care. In response

to these challenges, digital health 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. These technologies are no longer viewed as auxiliary administrative tools but as central components of contemporary nursing practice that shape documentation, patient communication, and clinical decision-making in immunization services. Digital technologies are progressively redefining how nurses plan, deliver, and evaluate care, positioning them at the core of modern immunization systems rather than at their periphery (Abdashimov & Abdiraufova, 2026). Pavia et al. (2024) further illustrate that integrating digital health solutions with immunization strategies can enhance coverage monitoring, data accuracy, and continuity of care in the post–COVID-19 era.

Within this rapidly evolving digital landscape, nurses are typically the primary users of immunization technologies at the point of care, making their engagement with these systems essential for successful implementation. Electronic immunization registries, in particular, have demonstrated potential to improve data quality, reduce duplication, and strengthen continuity of care, especially in low- and middle-income settings. However, empirical evidence indicates that these benefits materialize only when digital registries are meaningfully embedded in frontline nursing workflows rather than used as parallel or purely administrative systems. This finding suggests that the impact of digital immunization technology depends not only on technical design but also on how nurses interact with, interpret, and integrate these tools into everyday clinical practice (Secor et al., 2022). Despite substantial investment in digital immunization technologies, much of the existing research has prioritized system performance, interoperability, and managerial outcomes rather than positioning nursing practice as the central outcome of digital transformation. Many studies assess whether digital systems function effectively from an information-technology perspective but provide limited insight into how these systems transform nurses' roles, workflows, and decision processes. Recent scholarship argues that understanding digital health in nursing requires a socio-technical perspective that considers the interaction between technology, users, and organizational contexts. From this viewpoint, digital transformation in immunization represents not only a technological shift but also a transformation of professional nursing practice and clinical routines (Wynn et al., 2023).

At the same time, technology adoption among nurses remains uneven and influenced by multiple factors, including usability, workload, organizational support, and technostress. Baek et al. (2025) demonstrate that technostress and nursing informatics competence jointly shape nursing work performance, indicating that the mere availability of digital tools does not automatically lead to improved practice. Dermody et al. (2025) further reveal that variations in nurses' readiness for digital health technologies significantly affect how effectively these systems are used in clinical settings. Coffetti et al. (2023) identify individual and team-level factors that influence nurses' adoption of digital technologies, emphasizing that adoption should be understood as a dynamic process rather than a one-time decision. Taken together, this body of literature reveals a critical gap: although digital health immunization technologies are advancing rapidly, there is no widely accepted, nursing-centered conceptual framework that clearly explains how these technologies translate into improved nursing practice. In particular, prior research has not sufficiently integrated nurses' digital competence and technology adoption as parallel mediating pathways linking digital immunization technology to nursing outcomes. To address this gap, this paper proposes a Digital Health Immunization Technology Framework for Nursing Practice, in which Digital Health Immunization Technology (independent variable) influences Nursing Practice (dependent variable) both directly and indirectly through Digital Competence and Technology Adoption. This framework seeks to provide a theoretically grounded and practically relevant model to guide future research, inform

nursing education, and support organizational and policy decision-making in digitally enabled immunization services (Dermody et al., 2025).

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 Digital Leadership in Healthcare

Digital leadership in healthcare refers to the capacity of organizational leaders to guide, support, and sustain digital transformation through strategic vision, resource allocation, and workforce development. Effective digital leaders create an enabling environment that promotes continuous learning, collaboration, and innovation, ensuring that nurses are not only trained to use digital tools but also empowered to shape how these tools are integrated into clinical practice. In immunization settings, leadership commitment is particularly important for aligning digital systems with clinical priorities, workflow realities, and quality improvement objectives (Dermody et al., 2025). Leadership also plays a crucial role in shaping nurses' attitudes toward digital health technologies by reducing resistance, addressing technostress, and ensuring access to technical and educational support. Evidence indicates that when leaders actively champion digital initiatives and invest in professional development, nurses are more likely to engage positively with new systems and integrate them into routine practice. This underscores that digital leadership is a key contextual enabler of successful digital immunization implementation and sustained technology use in nursing (Coffetti et al., 2023).

2.3 Digital Competence in Nursing

Digital competence in nursing encompasses the knowledge, skills, and confidence required to effectively use digital health technologies in clinical practice. This includes technical proficiency, data literacy, critical interpretation of digital information, and the ability to integrate technology into patient-centered care. In immunization services, digitally competent nurses are better positioned to manage electronic records, interpret vaccination data, and make informed clinical decisions, thereby enhancing both efficiency and safety in care delivery (D'Agostino et al., 2026). Research increasingly

conceptualizes digital competence not as a peripheral skill but as a central mechanism linking digital systems to improved healthcare outcomes. Higher levels of digital competence enable nurses to navigate complex information systems, adapt to technological change, and minimize errors in documentation and clinical decision-making. Consequently, digital competence is now regarded as a foundational capability for contemporary nursing practice, particularly in digitally intensive areas such as immunization programs and public health services (Heponiemi et al., 2024).

2.4 Nursing Practice in Digital Immunization

Nursing practice in digital immunization is characterized by the integration of clinical expertise with digital tools that support vaccination delivery, documentation, monitoring, and follow-up. Electronic immunization registries, decision-support systems, and mobile tracking applications increasingly shape how nurses identify eligible patients, track missed doses, and coordinate care across settings. These technologies have the potential to improve accuracy, timeliness, and continuity of immunization services when effectively embedded in nursing workflows (Secor et al., 2022). However, the impact of digital systems on nursing practice is not uniformly positive and depends on system design, usability, and alignment with clinical processes. Evidence suggests that digital tools can both enhance and complicate clinical decision-making, sometimes introducing cognitive burden or workflow disruptions when poorly implemented. This highlights the need for careful integration of digital technologies into nursing practice to ensure that they support rather than hinder high-quality, patient-centered immunization care (Hants et al., 2023).

3. Hypotheses Development

3.1 Digital Health Immunization Technology and Digital Competence

The rapid diffusion of digital health immunization technologies has fundamentally altered the knowledge and skill requirements of contemporary nursing practice. Electronic immunization registries, digital dashboards, mobile reminder systems, and clinical decision-support tools increasingly mediate how nurses access patient information, document care, and make clinical judgments. As these technologies become embedded in routine workflows, nurses are continuously exposed to digital environments that require ongoing learning, adaptation, and cognitive engagement. This repeated interaction with digital systems is expected to strengthen nurses' digital competence by enhancing their technical proficiency, data interpretation skills, and confidence in using technology for clinical purposes. Abdashimov and Abdiraufova (2026) argue that the growing centrality of digital tools in nursing care directly contributes to the development of nurses' digital capabilities through experiential learning and professional engagement with technology. Digital immunization technologies also create structured opportunities for competence development by standardizing documentation processes, providing real-time feedback, and offering embedded decision-support features. These functionalities not only facilitate task completion but also promote reflective learning, as nurses interpret digital outputs, verify data accuracy, and refine their clinical reasoning.

D'Agostino et al. (2026) highlight that exposure to well-designed digital systems is closely associated with improvements in nurses' digital competence, particularly in areas related to information management and clinical informatics. Similarly, Li et al. (2025) demonstrate that nurses who regularly interact with digital platforms exhibit higher levels of digital literacy and confidence

compared to those with limited exposure. Beyond technical skills, digital immunization systems also shape nurses' cognitive and professional competencies by requiring critical evaluation of digital information, ethical data handling, and collaborative problem-solving. De Martinis and Ginaldi (2024) emphasize that digital tools not only enhance technical proficiency but also cultivate broader professional capabilities that are essential for high-quality care delivery in modern healthcare environments. In immunization contexts, this includes the ability to interpret vaccination trends, identify at-risk populations, and make evidence-informed decisions based on real-time data. However, the extent to which digital technologies enhance competence depends on system usability, training availability, and organizational support. Dermody et al. (2025) reveal that nurses' readiness for digital health technologies significantly influences how effectively they develop and apply digital skills in practice. When digital systems are aligned with clinical workflows and supported by adequate training, they serve as catalysts for competence development rather than sources of frustration or technostress.

H1: Digital Health Immunization Technology has a significant positive effect on Digital Competence.

3.2 Digital Health Immunization Technology and Technology Adoption

Technology adoption in nursing is influenced by a combination of system characteristics, perceived usefulness, workflow compatibility, and organizational context. In the case of digital immunization technologies, adoption is more likely when systems demonstrably support core nursing responsibilities such as patient tracking, vaccination scheduling, documentation, and follow-up care. Secor et al. (2022) show that electronic immunization registries are more readily adopted by nurses when they clearly enhance frontline tasks rather than serving solely administrative or managerial purposes. This suggests that the functional value of digital systems plays a central role in shaping adoption behavior. Perceived usability is another critical determinant of technology adoption. Digital immunization tools that are intuitive, reliable, and seamlessly integrated into existing workflows reduce cognitive burden and increase nurses' willingness to engage with them. Livesay et al. (2023) document that poorly designed systems can generate resistance, frustration, and workarounds, whereas user-friendly platforms promote sustained engagement and routine use. In immunization settings, where timely data entry and accurate record-keeping are essential, usability becomes particularly salient for adoption decisions.

Organizational support further mediates the relationship between technology characteristics and adoption. Coffetti et al. (2023) identify leadership commitment, training opportunities, and team collaboration as key enablers of nurses' adoption of digital health technologies. When healthcare organizations invest in infrastructure, provide ongoing technical assistance, and foster a culture of innovation, nurses are more likely to perceive digital systems as beneficial and incorporate them into daily practice. Dermody et al. (2025) similarly emphasize that institutional readiness and supportive environments significantly shape nurses' willingness to adopt digital health tools. From a socio-technical perspective, adoption is not merely an individual decision but a dynamic process influenced by interactions among technology, users, and organizational structures. Wynn et al. (2023) argue that successful adoption requires alignment between digital systems and nursing workflows, professional identities, and institutional priorities. In immunization programs, this alignment ensures that digital tools are perceived as enhancers rather than disruptors of care delivery. Empirical evidence also suggests that perceived performance benefits drive adoption. Baek et al. (2025) demonstrate that when nurses believe digital systems improve efficiency, reduce errors, and facilitate decision-making, they are more likely to adopt and consistently use these technologies. In vaccination contexts, where accuracy and timeliness are critical, such perceived benefits are particularly influential.

H2: Digital Health Immunization Technology has a significant positive effect on Technology Adoption.

3.3 Digital Competence and Nursing Practice

Digital competence has emerged as a foundational capability for modern nursing practice, particularly in digitally intensive areas such as immunization services. Nurses who possess strong digital skills are better equipped to navigate complex information systems, accurately interpret electronic health data, and integrate digital tools into clinical decision-making. D'Agostino et al. (2026) highlight that higher levels of digital competence are associated with more effective use of digital health technologies and improved clinical performance among nurses. This suggests a direct link between digital competence and the quality of nursing practice. In immunization settings, digitally competent nurses are more proficient in managing electronic registries, identifying missed doses, and ensuring accurate documentation. This reduces the likelihood of errors, enhances continuity of care, and supports timely vaccination delivery. Secor et al. (2022) demonstrate that nurses with stronger digital capabilities are more likely to use electronic immunization systems effectively, leading to better data quality and improved patient outcomes. Digital competence therefore functions as a critical enabler of high-quality nursing practice in vaccination programs.

Beyond technical proficiency, digital competence also enhances nurses' clinical reasoning and decision-making abilities. Hants et al. (2023) show that nurses who are adept at interpreting digital information can more effectively integrate clinical judgment with system-generated insights, resulting in safer and more informed care decisions. In immunization contexts, this includes the ability to assess vaccination risks, prioritize high-risk populations, and tailor patient education based on digital data. Digital competence further influences professional confidence and autonomy. Dermody et al. (2025) reveal that nurses with higher digital readiness feel more empowered to engage with technology, advocate for patient needs, and contribute to quality improvement initiatives. This increased confidence translates into more proactive and efficient nursing practice. However, the impact of digital competence on practice is moderated by system design and organizational support. Baek et al. (2025) demonstrate that even highly competent nurses may experience technostress if systems are poorly designed or inadequately supported. This underscores that digital competence must be complemented by user-friendly technologies and supportive environments to fully enhance practice outcomes.

H3: Digital Competence has a significant positive effect on Nursing Practice.

3.4 Technology Adoption and Nursing Practice

The extent to which nurses adopt and actively use digital immunization technologies directly shapes their clinical practice. When nurses consistently engage with electronic registries, reminder systems, and decision-support tools, they can more effectively track patient immunization status, identify gaps in coverage, and coordinate care across settings. Secor et al. (2022) demonstrate that routine use of electronic immunization registries is associated with improved data accuracy and continuity of care, suggesting that adoption has tangible benefits for nursing practice. Technology adoption also streamlines workflow processes by reducing manual documentation, minimizing duplication of effort, and enabling real-time access to patient information. Pavia et al. (2024) show that digital immunization solutions enhance monitoring and service delivery, thereby supporting more efficient and coordinated nursing practice. When nurses adopt these tools as integral components of their daily

work, they can allocate more time to patient education and clinical decision-making rather than administrative tasks.

However, mere availability of digital systems is insufficient; meaningful adoption requires consistent and intentional use. Baek et al. (2025) emphasize that actual engagement with digital tools, rather than passive acceptance, is what ultimately improves nursing work performance. In immunization settings, this means that nurses must actively rely on digital platforms for scheduling, documentation, and patient follow-up to realize practice improvements. Adoption also influences collaboration and communication within healthcare teams. Livesay et al. (2023) document that when nurses adopt shared digital platforms, they are better able to coordinate care, exchange information, and align practices across departments. This enhances collective efficiency and reduces the risk of fragmented care. Nevertheless, the relationship between adoption and practice is contingent on system usability and organizational support. Coffetti et al. (2023) note that nurses are more likely to sustain technology use when systems are user-friendly and supported by leadership. Without these conditions, adoption may be superficial or inconsistent, limiting its impact on practice.
H4: Technology Adoption has a significant positive effect on Nursing Practice.

3.5 Direct Effect: Digital Health Immunization Technology and Nursing Practice

Beyond its indirect effects through digital competence and technology adoption, Digital Health Immunization Technology may exert a direct influence on Nursing Practice by structurally transforming clinical workflows, standardizing documentation, and enabling real-time data access. Well-integrated digital systems can automate routine tasks, reduce administrative burden, and enhance coordination among healthcare providers, thereby improving overall nursing efficiency and care quality. Pavia et al. (2024) demonstrate that digital immunization solutions can directly enhance monitoring, continuity of care, and service delivery, indicating a direct relationship between technology and practice outcomes. Digital systems also create new possibilities for evidence-based practice by providing nurses with timely access to patient histories, vaccination records, and population-level data. Secor et al. (2022) show that electronic registries enable nurses to make more informed clinical decisions by offering comprehensive and up-to-date information. This direct access to data can improve clinical judgment and reduce reliance on incomplete or fragmented records.

Moreover, digital technologies can standardize care processes through embedded protocols and decision-support algorithms. Hants et al. (2023) note that when designed effectively, these tools can guide nurses toward best practices, thereby enhancing consistency and safety in immunization delivery. Even in the absence of changes in individual competence or adoption levels, such system-level features can directly shape practice behaviors. However, the direct effect of technology on practice is not uniformly positive. Livesay et al. (2023) caution that poorly designed systems may introduce workflow disruptions, cognitive overload, or documentation burdens that negatively affect nursing performance. This suggests that the direct impact of digital technology depends on design quality and implementation context. Despite these nuances, the overall body of evidence supports the existence of a direct relationship between Digital Health Immunization Technology and Nursing Practice. When systems are well designed and aligned with clinical needs, they can directly enhance efficiency, accuracy, and coordination in immunization services.
H5: Digital Health Immunization Technology has a significant positive effect on Nursing Practice.

3.6 The Mediating Role of Digital Competence between Digital Health Immunization Technology and Nursing Practice

Digital competence is expected to mediate the relationship between Digital Health Immunization Technology and Nursing Practice because technology alone does not automatically produce better clinical outcomes; rather, its benefits depend on nurses' ability to use it effectively. As digital systems become more sophisticated, they require higher levels of technical and cognitive skills for optimal utilization. Abdashimov and Abdiraufova (2026) suggest that increased exposure to digital tools fosters competence development, which in turn enhances care delivery. Empirical research supports the mediating role of digital competence in technology-driven practice change. Heponiemi et al. (2024) demonstrate that digital competence mediates the relationship between digital health-related factors and healthcare utilization outcomes, indicating that competence serves as a key pathway through which digital innovations influence practice. This suggests that improvements in nursing practice attributable to digital immunization systems are likely to occur through enhanced digital skills.

In immunization contexts, digitally competent nurses are better able to interpret electronic data, manage registries, and integrate digital insights into clinical decision-making. Secor et al. (2022) show that nurses with stronger digital capabilities derive greater benefits from electronic registries, resulting in more accurate documentation and improved continuity of care. This implies that digital competence translates technological potential into tangible practice improvements. Additionally, digital competence reduces technostress and enhances confidence, enabling nurses to engage more fully with digital systems. Baek et al. (2025) highlight that nurses with higher informatics competence experience less technostress and perform more effectively in technology-rich environments. This further supports the mediating role of competence in linking technology to practice outcomes.
H6: Digital Competence mediates the relationship between Digital Health Immunization Technology and Nursing Practice.

3.7 The Mediating Role of Technology Adoption between Digital Health Immunization Technology and Nursing Practice

Technology Adoption is also expected to mediate the relationship between Digital Health Immunization Technology and Nursing Practice because the benefits of digital systems depend on their consistent and meaningful use. Even when digital immunization technologies are technically advanced, their impact on nursing practice remains limited if nurses do not actively adopt them in their daily workflows. Dermody et al. (2025) emphasize that nurses' readiness and willingness to adopt digital health technologies significantly shape how effectively these systems influence clinical practice. When nurses adopt digital tools as integral components of their work, they are more likely to use them for patient tracking, documentation, and decision-making. Secor et al. (2022) demonstrate that routine adoption of electronic immunization registries leads to improved data quality and continuity of care, suggesting that adoption translates technological capabilities into practice improvements.

Technology adoption also facilitates workflow integration and interprofessional collaboration. Livesay et al. (2023) show that when nurses adopt shared digital platforms, communication and coordination across care teams improve, leading to more efficient and cohesive practice. This indicates that adoption not only affects individual performance but also enhances collective care delivery. However, adoption is influenced by system usability and organizational support. Coffetti et

al. (2023) highlight that nurses are more likely to sustain technology use when systems are user-friendly and supported by leadership. In the absence of such conditions, adoption may be inconsistent, limiting its mediating effect. Empirical evidence from Baek et al. (2025) further suggests that actual use of digital systems, rather than mere acceptance, is what ultimately improves nursing performance. This reinforces the importance of treating Technology Adoption as a mediating variable rather than a simple outcome.

H7: Technology Adoption mediates the relationship between Digital Health Immunization Technology and Nursing Practice.

4. Gap in the Literature

4.1 Gaps in Digital Health Immunization Technology

Existing research on digital health immunization technologies has largely concentrated on technical performance, system interoperability, and data management capabilities rather than on how these technologies reshape frontline nursing practice. Many studies evaluate whether digital systems improve coverage monitoring, data accuracy, or administrative efficiency but pay limited attention to how specific technological features influence nurses' daily clinical work, decision-making processes, and patient interactions. As a result, there remains an incomplete understanding of how digital immunization technologies translate into meaningful changes in nursing practice rather than merely improving back-end data systems (Abdashimov & Abdiraufova, 2026). Although digital immunization solutions have demonstrated potential to strengthen monitoring and continuity of care, prior research has often treated technology as a standalone solution rather than as part of a broader clinical and organizational ecosystem. This narrow focus overlooks the ways in which system design, usability, and workflow alignment determine whether digital tools actually enhance or disrupt nursing practice. Consequently, there is a persistent gap in explaining how specific digital immunization technologies contribute to improved nursing performance, patient safety, and care quality at the point of service (Pavia et al., 2024). Furthermore, while electronic immunization registries have been widely implemented in many settings, studies have primarily emphasized their role in improving data quality rather than examining how they shape nursing roles, professional judgment, and clinical workflows. Evidence suggests that registries are most effective when embedded in nursing practice, yet few studies systematically analyze the conditions under which digital systems meaningfully support nurses rather than burden them with additional documentation tasks (Secor et al., 2022).

4.2 Gaps in Digital Competence

Although digital competence is increasingly recognized as essential for contemporary nursing, much of the literature treats it as a general professional skill rather than as a central mechanism linking digital immunization technology to nursing practice outcomes. Many studies measure digital competence descriptively or as a training outcome but do not conceptualize it as a mediating variable that explains how technology leads to better clinical performance, documentation quality, or patient safety in immunization settings. This represents a theoretical gap in understanding the causal role of digital competence in digital health contexts (D'Agostino et al., 2026). Empirical research has demonstrated that digital competence influences healthcare access and utilization, yet its specific role in shaping nursing practice in immunization programs remains underexplored. Most existing studies examine digital competence in broad healthcare contexts rather than focusing on vaccination services,

leaving unclear how competence affects tasks such as vaccine tracking, missed-dose identification, and data-driven decision-making in nursing practice (Heponiemi et al., 2024). Additionally, while some studies acknowledge that nurses' readiness for digital health affects technology use, few explicitly analyze how variations in digital competence lead to differential practice outcomes in immunization care. There is limited evidence on how digital competence interacts with system design, workflow integration, and organizational support to shape nursing performance, indicating a need for more theoretically integrated models that position digital competence as a key explanatory variable (Dermody et al., 2025).

4.3 Gaps in Technology Adoption

Research on technology adoption in nursing has often emphasized attitudes, intentions, or acceptance rather than actual, routine use of digital systems in clinical workflows. Many studies measure willingness to adopt technology but do not examine whether nurses consistently integrate digital immunization tools into their daily practice, leaving a gap in understanding the real behavioral impact of adoption on nursing outcomes (Coffetti et al., 2023). Moreover, much of the adoption literature focuses on physicians, managers, or mixed healthcare professionals, with comparatively less attention to nurses working specifically in immunization services. As a result, there is limited evidence on how technology adoption among nurses in vaccination programs influences documentation accuracy, decision-making, and patient follow-up, particularly in resource-constrained settings (Baek et al., 2025). Existing studies also tend to overlook the socio-technical nature of adoption, treating it as an individual choice rather than a process shaped by system design, team dynamics, and organizational context. Few studies analyze how workflow fit, usability, and institutional support interact to shape sustained technology adoption among nurses in digital immunization systems, creating a gap in understanding the conditions that enable or hinder meaningful adoption (Livesay et al., 2023).

4.4 Integrated Gaps in the Model

The literature reveals a fragmented understanding of how digital immunization technologies influence nursing practice. While some studies focus on system performance, others examine digital competence, and still others analyze technology adoption, there is no widely accepted integrated framework that connects these elements in a coherent model. As a result, existing research fails to fully explain how Digital Health Immunization Technology affects Nursing Practice through specific mediating mechanisms rather than assuming a direct technological effect (Wynn et al., 2023). More specifically, prior studies rarely examine Digital Competence and Technology Adoption simultaneously as parallel pathways linking digital immunization technology to nursing practice outcomes. This creates a conceptual gap in understanding whether improvements in nursing practice are primarily driven by enhanced skills, increased system use, or a combination of both. Without an integrated model, it remains unclear how these mechanisms interact to produce better clinical performance in immunization services (Dermody et al., 2025). These integrated gaps justify the need for a comprehensive conceptual framework in which Digital Health Immunization Technology Influences Nursing Practice both directly and indirectly through Digital Competence and Technology Adoption. Such a model is necessary to move beyond fragmented findings and provide a theoretically grounded explanation of how digital immunization systems transform nursing practice in meaningful and measurable ways.

5. Conceptual Framework Development

5.1 Digital Technology and Digital Competence

Digital Health Immunization Technology is conceptualized in this framework as a central driver of nurses' digital competence rather than merely a set of technical tools. As electronic immunization registries, digital dashboards, mobile reminder systems, and clinical decision-support platforms become embedded in everyday nursing workflows, nurses are increasingly required to engage with digital environments as part of routine care delivery. Through repeated exposure, hands-on use, and problem-solving in real clinical situations, nurses gradually develop stronger technical skills, data literacy, and confidence in using digital systems. Abdashimov and Abdiraufova (2026) emphasize that the growing centrality of digital technologies in nursing care inherently cultivates digital capabilities by transforming how nurses think, work, and interact with patient information. Beyond simple exposure, digital immunization systems actively shape competence development through structured features such as standardized documentation templates, real-time data visualization, and embedded decision-support tools. These features encourage nurses to interpret digital information critically, verify data accuracy, and integrate system outputs into clinical reasoning.

D'Agostino et al. (2026) demonstrate that interaction with well-designed digital health systems is strongly associated with higher levels of nursing informatics competence, particularly in information management and clinical data interpretation. The relationship between digital technology and competence is also influenced by system usability and workflow alignment. When digital immunization tools are intuitive, clinically relevant, and seamlessly integrated into practice, they facilitate meaningful learning rather than creating frustration or cognitive overload. Dermody et al. (2025) show that nurses' readiness for digital health is closely linked to how well technologies fit their work processes, reinforcing the idea that technology actively shapes competence rather than merely requiring it. Within this framework, Digital Health Immunization Technology is therefore positioned as a key antecedent of Digital Competence, establishing a foundational pathway from technology to professional capability.

5.2 Digital Technology and Technology Adoption

Within the proposed framework, Technology Adoption is conceptualized as the sustained, routine use of digital immunization systems in everyday nursing practice rather than a one-time decision to accept technology. Adoption is shaped primarily by nurses' perceptions of system usefulness, usability, and clinical relevance. When digital immunization tools clearly support core nursing responsibilities such as patient tracking, documentation, and follow-up care, nurses are more likely to incorporate them into their daily workflows. Secor et al. (2022) illustrate that electronic immunization registries are most effectively adopted when they are perceived as directly beneficial to frontline nursing tasks rather than as purely administrative reporting tools. System design and workflow compatibility play a critical role in shaping adoption behavior. Livesay et al. (2023) document that poorly designed digital systems often lead to resistance, workarounds, or inconsistent use, whereas user-centered platforms promote sustained engagement and deeper integration into clinical routines. This suggests that adoption is not simply an individual preference but a socio-technical process influenced by how well technology aligns with nursing practice. Organizational context further strengthens or weakens adoption. Coffetti et al. (2023) highlight that leadership support, access to training, and collaborative team environments significantly increase nurses' willingness to adopt digital health tools. Dermody et al. (2025) similarly emphasize that institutional readiness and supportive cultures are essential for

meaningful technology uptake. Accordingly, the pathway Digital Health Immunization Technology → Technology Adoption in this framework reflects the interaction between system characteristics, user perceptions, and organizational conditions rather than technology alone.

5.3 Digital Competence & Adoption and Nursing Practice

The framework positions Digital Competence and Technology Adoption as parallel mechanisms through which Digital Health Immunization Technology influences Nursing Practice. This dual pathway acknowledges that improved practice depends both on what nurses are capable of doing with technology (competence) and how consistently they actually use it in their work (adoption). Digital competence enhances nursing practice by enabling accurate interpretation of electronic data, reducing documentation errors, and supporting evidence-based decision-making. D'Agostino et al. (2026) show that higher digital competence is associated with more effective clinical performance in technology-rich environments. Heponiemi et al. (2024) further demonstrate that digital competence mediates the relationship between digital health-related factors and healthcare outcomes, suggesting that competence is a key channel through which digital systems improve practice.

Technology adoption influences nursing practice by determining the extent to which digital tools are embedded in daily workflows. When nurses routinely use electronic immunization registries and digital tracking systems, they can more effectively monitor patient status, identify missed vaccinations, and coordinate care across settings. Secor et al. (2022) show that consistent use of electronic registries improves data quality and continuity of care. Pavia et al. (2024) demonstrate that sustained engagement with digital immunization systems enhances monitoring, coordination, and service delivery. However, the impact of adoption on practice depends on system usability and organizational support. Baek et al. (2025) indicate that actual use of digital systems, rather than mere availability, drives improvements in nursing performance. Livesay et al. (2023) further highlight that shared digital platforms enhance interprofessional communication and coordination when widely adopted by nursing teams. Within this framework, Digital Competence → Nursing Practice and Technology Adoption → Nursing Practice operate as complementary pathways that together explain how digital technology shapes clinical outcomes.

5.4 Proposed Conceptual Framework

The framework proposes that Digital Health Immunization Technology enhances Digital Competence by shaping nurses' skills, confidence, and data literacy through sustained interaction with digital systems. Simultaneously, the same technology influences Technology Adoption by affecting nurses' perceptions of usefulness, usability, and workflow fit. In turn, higher Digital Competence leads to better Nursing Practice by improving clinical reasoning, documentation accuracy, and data-driven decision-making. At the same time, greater Technology Adoption strengthens Nursing Practice by embedding digital tools into routine workflows, thereby enhancing coordination, efficiency, and continuity of care. The model also retains a direct relationship between Digital Health Immunization Technology and Nursing Practice, recognizing that well-designed systems can streamline workflows, standardize processes, and provide real-time information that directly improves care delivery even beyond individual competence or adoption levels. Wynn et al. (2023) support this integrated socio-technical perspective by emphasizing that digital health outcomes depend on the interaction between technology and professional practice contexts. Dermody et al. (2025) further reinforce that both readiness (competence) and engagement (adoption) are necessary for digital systems to meaningfully

shape nursing care. Figure 1 synthesizes existing evidence into a coherent model that explains how Digital Health Immunization Technology Influences Nursing Practice both directly and indirectly through Digital Competence and Technology Adoption, providing a theoretically grounded basis for subsequent empirical testing.

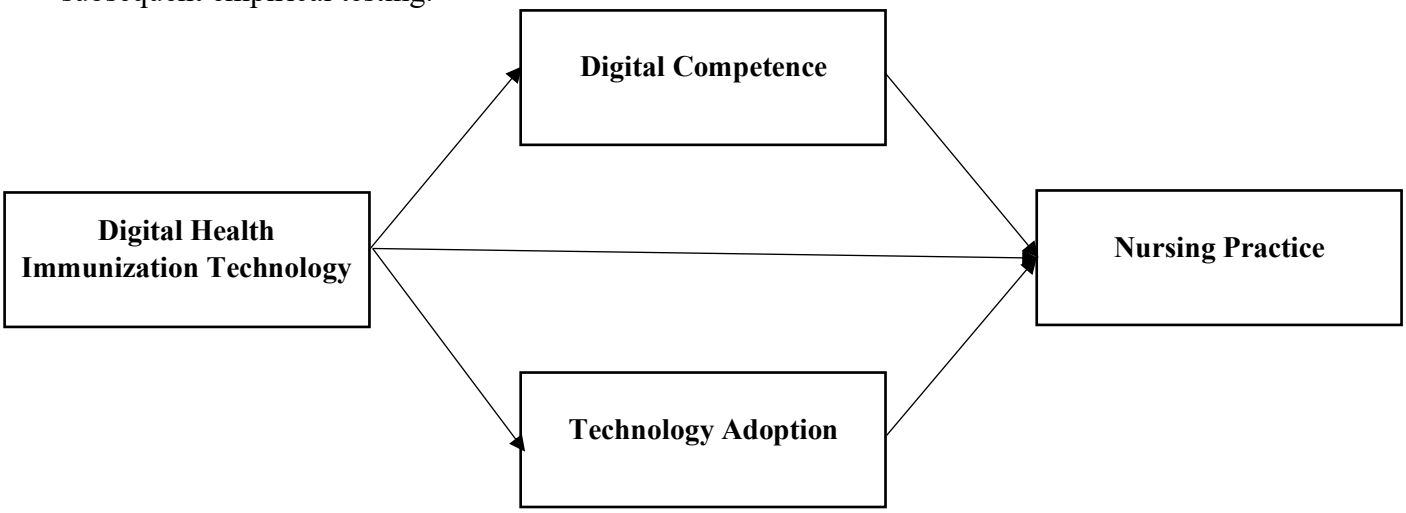

Figure 1: Conceptual Framework

6. Practical Implications

6.1 Implications for Nursing Leaders

The proposed framework has important implications for nursing leaders responsible for implementing and sustaining digital immunization technologies in clinical settings. Leaders should prioritize the alignment of digital systems with nursing workflows rather than treating technology as a purely technical or administrative initiative. This requires engaging nurses in system design, customization, and evaluation to ensure that digital tools meaningfully support clinical tasks such as vaccination tracking, documentation, and patient follow-up. Secor et al. (2022) demonstrate that electronic immunization registries are most effective when they are embedded in frontline nursing practice rather than imposed as external reporting systems, highlighting the importance of participatory leadership in digital transformation. Nursing leaders should also invest in structured digital competence development programs that go beyond basic technical training to include data literacy, clinical informatics, and decision-making with digital tools. Abdashimov and Abdiraufova (2026) emphasize that digital competence is shaped through sustained professional engagement with technology rather than one-off training sessions. Leaders should therefore create continuous learning environments that include mentoring, simulation-based training, and peer learning communities to build nurses' confidence and expertise in digital immunization systems. Furthermore, leaders must address technostress and promote a supportive digital culture that encourages experimentation, feedback, and iterative improvement. Baek et al. (2025) show that high technostress can undermine nursing performance even when digital systems are available, underscoring the need for psychological and organizational support. By fostering a climate of trust, providing adequate resources, and ensuring technical assistance, nursing leaders can enhance both technology adoption and digital competence, ultimately improving nursing practice in immunization services.

6.2 Implications for Policymakers

For policymakers, the framework highlights the necessity of viewing digital immunization initiatives as socio-technical interventions rather than purely technological solutions. National and regional health policies should integrate digital system deployment with workforce development strategies that explicitly address nurses' digital competence and readiness. Dermody et al. (2025) reveal that nurses' readiness for digital health significantly shapes the effectiveness of technology use, suggesting that policy frameworks must include targeted capacity-building measures alongside infrastructure investments. Policymakers should also prioritize the development and standardization of electronic immunization registries that are interoperable, user-centered, and aligned with clinical workflows. Pavia et al. (2024) demonstrate that well-integrated digital immunization solutions can enhance coverage monitoring and continuity of care, but these benefits depend on system quality and usability. Regulatory guidelines should therefore emphasize usability testing, clinician involvement in design, and continuous evaluation of system impact on nursing practice rather than focusing solely on data reporting requirements. In addition, health policies should support equitable access to digital resources, particularly in low- and middle-income settings where digital divides may hinder technology adoption. Secor et al. (2022) show that electronic registries can add significant value in resource-constrained contexts when properly implemented. Policymakers should ensure that digital immunization programs are accompanied by adequate funding for infrastructure, training, and ongoing technical support to prevent disparities in nursing practice and patient outcomes.

6.3 Implications for Researchers and Educators

For researchers, the framework provides a clear theoretical foundation for empirically testing the relationships among Digital Health Immunization Technology, Digital Competence, Technology Adoption, and Nursing Practice. Future studies should move beyond descriptive assessments of technology use and instead examine these constructs as part of an integrated mediation model using robust methods such as PLS-SEM or structural equation modeling. Wynn et al. (2023) emphasize the need for socio-technical research designs that capture the interaction between technology, users, and organizational contexts in digital health. Researchers should also develop and validate context-specific measurement instruments for digital competence and technology adoption in immunization settings. D'Agostino et al. (2026) highlight the importance of reliable tools for assessing nursing digital competence, suggesting that further refinement of such measures is necessary to support theory-driven research. Longitudinal studies are particularly needed to examine how digital competence and adoption evolve over time as nurses gain experience with digital immunization systems. For nursing educators, the framework underscores the need to embed digital health competencies into pre- and post-licensure curricula. Education programs should move beyond basic computer skills and include training in data interpretation, clinical decision-making with digital tools, and ethical use of health information. De Martinis and Ginaldi (2024) argue that digital skills are essential for modern nursing practice and should be integrated throughout professional education. By preparing nurses to engage confidently with digital immunization technologies, educators can strengthen both digital competence and technology adoption, ultimately enhancing nursing practice and patient care quality.

7. Conclusion

This paper has proposed a comprehensive Digital Health Immunization Technology Framework for Nursing Practice that integrates technology, professional capability, and behavioral engagement into a single coherent model. By positioning Digital Health Immunization Technology as the central independent variable and Nursing Practice as the primary outcome, the framework clarifies how digital transformation in immunization services can meaningfully influence frontline clinical work rather than remaining limited to technical or administrative improvements. The inclusion of Digital Competence and Technology Adoption as parallel mediators highlights that the impact of digital systems depends not only on their availability or technical sophistication but also on nurses' ability to use them effectively and their willingness to integrate them into routine practice. The framework advances understanding by demonstrating that improvements in nursing practice are likely to occur through both skill development and behavioral adoption pathways, while also recognizing that well-designed digital systems can exert a direct influence on workflows, documentation, and decision-making. This dual emphasis reflects a socio-technical perspective in which technology, human capability, and organizational context operate together to shape clinical outcomes. Rather than treating digital tools as standalone solutions, the model emphasizes the interconnected nature of technology, competence, and practice in modern immunization services. Overall, the proposed framework provides a theoretically grounded and practically relevant foundation for future empirical research, policy development, and professional education. It offers a clear structure for examining how digital immunization technologies can be designed, implemented, and supported in ways that genuinely enhance nursing practice and, ultimately, the quality and effectiveness of immunization care.

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