

Original Article

Digital Health Competence and Patient-Centered Care among Hospital Nurses: The Mediating Role of Patient-Centered Nurse-Patient

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Abstract

Objective: This study examined the relationships among digital health competence, patient-centered nurse-patient communication, and patient-centered care, with particular attention to the mediating role of patient-centered communication.

Methodology: We conducted a quantitative cross-sectional study among nurses working across diverse clinical departments in five major private hospitals in Multan, Pakistan. We collected data from 280 nurses using a structured self-report questionnaire. We examined the hypothesized relationships using partial least squares structural equation modeling (PLS-SEM) in SmartPLS 4.

Results: Digital health competence positively influenced patient-centered nurse-patient communication ($\beta = 0.603$, $p < .001$) and patient-centered care ($\beta = 0.298$, $p < .001$). Patient-centered nurse-patient communication also positively influenced patient-centered care ($\beta = 0.584$, $p < .001$). The indirect effect of digital health competence on patient-centered care through patient-centered communication was significant ($\beta = 0.352$, $p < .001$; 95% CI [0.289, 0.423]), supporting complementary mediation.

Conclusion: Digital health competence contributes to patient-centered care both directly and through patient-centered nurse-patient communication. Strengthening digital and interpersonal competencies together may support more effective patient-centered nursing practice in digitally transforming hospital environments.

Introduction

Primary care is a cornerstone of effective healthcare delivery, with nurses playing a central role in health promotion, disease prevention, chronic disease management, care coordination, and continuous patient support. The growing adoption of electronic health records, telehealth, mobile health applications, clinical decision-support systems, and remote monitoring has transformed how hospital-based care is delivered. Consequently, nurses are increasingly required to combine clinical expertise with digital and interpersonal competencies. The World Health Organization emphasizes that digital transformation in healthcare should support person-centered care while strengthening health professionals' capacity to use digital technologies effectively (WHO, 2024). One capability needed in this evolving environment is digital health competence, which refers to the knowledge, skills, confidence, and proficiency of healthcare practitioners in using digital technologies in their clinical work. Digital health competence encompasses information system literacy, digital information evaluation, digital communication, remote care provision, and consideration of ethics and privacy issues (Jarva et al., 2023). Previous studies have also shown the importance of digital competencies for healthcare professionals in information management, using electronic health records, and incorporating digital technologies into everyday practice (Jimenez et al., 2020). Moreover, current evidence shows that digital competencies have become essential to modern nursing practice as more healthcare services are delivered digitally (Longhini et al., 2024). In this way, nurses possessing high levels of digital health competence are more likely to use technologies in a manner helpful, rather than detrimental, to patient care. However, technological proficiency is not enough on its own to achieve patient-centered results. Communication centered around patients' needs serves as an example of how nurses can apply their professional and technological skills through effective interaction with patients. Patient-centered communication includes exchanging clear information, seeing the patient as an individual, respecting the patient's preferences, and establishing therapeutic relationships. (Joo et al., 2024) A 12-item scale of patient-centered communication among nurses was created and tested, with items involving information sharing, patient-as-person, and therapeutic alliance. These aspects indicate that communication is not limited to exchanging medical information but also requires establishing respectful, trustful relationships. In hospital care facilitated by digital technology, nurses' technological proficiency helps achieve these objectives. Communication is especially relevant in patient-centered care. Patient-centered care involves nurses recognizing patients' values and preferences, involving patients in decision-making, offering comfort, and advocating on their behalf. The work by Hwang (2015) developed a construct for patient-centered care competency of nurses that involved these four dimensions and showed good reliability and validity of this scale. Additional studies have confirmed the usefulness of this model for nurses' competencies in various healthcare settings. Patient-centered care thus relies not only on the competence of nurses in terms of clinical practice, but also on their capacity to comprehend, communicate, and take into account the situation of each particular patient (Abugre & Bhengu, 2025). The relationships among these constructs suggest a logical pathway. Digital health competence may enable nurses to use digital technologies effectively, patient-centered communication may translate these capabilities into meaningful nurse-patient interactions, and these interactions may subsequently facilitate patient-centered care. Recent evidence provides preliminary support for the relationship between digital health competence and patient-centered nursing practice (Van Sebille et al., 2025). For example, (El-Sayed et al., 2025) found evidence linking digital health competence with patient-centered care among oncology nurses. Similarly, research

on digitally enabled nursing services emphasizes that nurses require both technological and communication competencies to deliver patient-focused care effectively (Schmidt et al., 2024). Nevertheless, much of the existing literature has examined digital competence, communication, and patient-centered care as separate areas rather than explaining the mechanism through which digital competence may contribute to patient-centered care (Pakkonen et al., 2023). This creates a significant research gap, especially in nursing in hospital settings, where communication, health education, prevention services, chronic disease management, and care coordination are key nursing activities. Although several studies have found the importance of digital health competence (Jarva et al., 2023; Longhini et al., 2024), patient-centered communication (Joo et al., 2024), and patient-centered care (Hwang, 2015), there is little known about the extent to which patient-centered nurse-patient communication mediates the effect of digital health competence on patient-centered care. Closing this research gap may contribute towards the understanding of how the digital competences can translate to a relational and patient-centered nursing practice. Based on the above gaps, this study postulates a mediation model where digital health competence will be the independent variable, patient-centered nurse-patient communication will be the mediator, while patient-centered care will be the dependent variable. In other words, this study seeks to determine whether nurses with high levels of digital health competence have higher levels of patient-centered communication and whether the former promotes patient-centered care. Also, the study tries to determine whether patient-centered nurse-patient communication mediates the relationship between digital health competence and patient-centered care. The proposed model is particularly relevant to the ongoing digital transformation of healthcare and may inform nursing education, digital-health training, workforce development, and patient-centered hospital-based care.

Research Gap

Prior research has shown the significance of digital health literacy, patient-centered communication, and patient-centered care as distinct domains of nursing practice (Jarva et al., 2023; Jimenez et al., 2020; Joo et al., 2024). However, scant literature has been available that has explored the role of patient-centered nurse-patient communication in explaining the linkage between digital health literacy of nurses and patient-centered care within the hospital setting.

Problem Statement

As digital technology integrates into the health sector, nurses are expected to be competent in its use while also establishing meaningful relationships with patients. The limitation, in this case, is that being digitally competent does not necessarily mean that patient-centered care will be attained. The challenge lies in understanding how digital competence translates to patient-centered care through communication with patients.

Research Objectives

- To examine the effect of digital health competence on patient-centered nurse-patient communication.
- To examine the effect of patient-centered nurse-patient communication on patient-centered care.
- To examine the effect of digital health competence on patient-centered care.
- To test the mediating role of patient-centered nurse-patient communication.

Research Questions

- Does digital health competence influence patient-centered nurse-patient communication?

- Does patient-centered nurse–patient communication influence patient-centered care?
- Does digital health competence influence patient-centered care?
- Does patient-centered nurse–patient communication mediate the relationship between digital health competence and patient-centered care?

Underpinning Theory: Social Cognitive Theory

Social cognitive theory (Bandura, 1989) asserts that people's abilities determine their behavior, while their behavior determines outcomes within a particular environment. In the current study, digital health competency is considered the ability of the nurse, patient-centered communication is the professional behavior, and patient-centered care is the outcome of this behavior.

Table 1 Underpinning Theory

Theory element	Study construct	Logic
Capability	Digital Health Competence	Ability to use digital health technologies effectively
Behaviour	Patient-Centered Communication	Communication used to understand, involve, and support patients
Outcome	Patient-Centered Care	Respecting preferences, involving patients, providing comfort, and advocacy

Research Framework

Figure 1. Research Framework

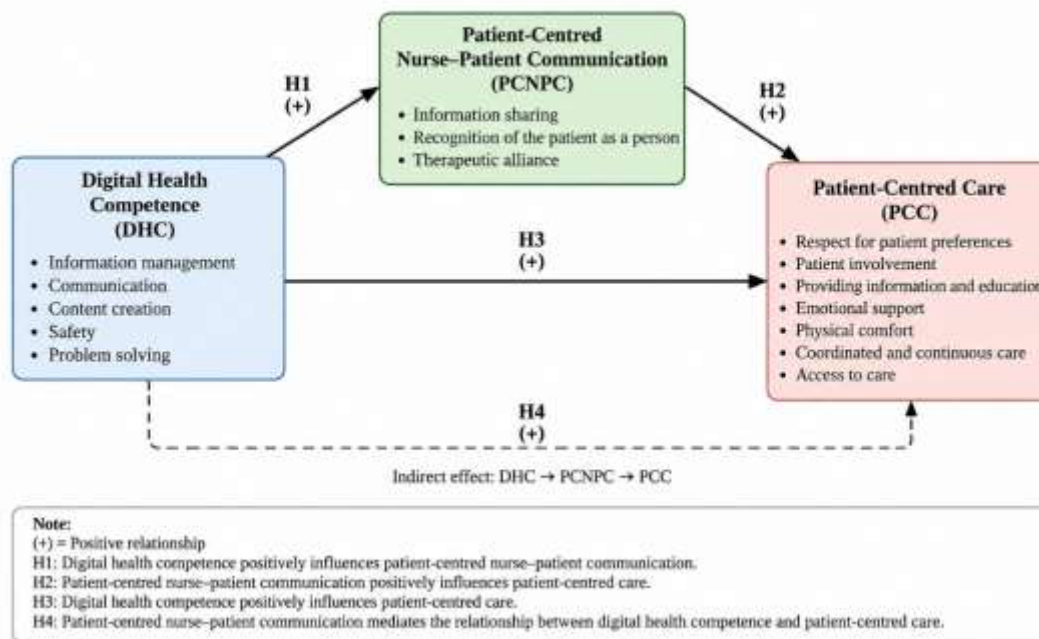


Figure 1 Research Framework

Literature Review and Hypothesis Development: Digital Health Competence and Patient-Centered Nurse–Patient Communication

Digital health literacy has gained significance as a capability among healthcare professionals owing to the integration of digital technology within the field of medicine. Digital technologies in hospitals can various competency domains are necessary for efficient digital practice in hospitals. The authors note that the mere presence of technology is not enough; healthcare professionals need a competent workforce. This ability is critical for nursing professionals, since nurses act as intermediaries between digital systems and patients. Digital health competence goes beyond basic digital skills to include the ability to apply digital information, communicate through digital tools, evaluate digital

support electronic documentation, patient information access, teleconsultations, remote monitoring, health education, and communication across healthcare facilities. Nevertheless, the usefulness of such technologies depends significantly on the competency of healthcare professionals in their use. According to Jimenez et al. 2020), in a review on digital health competencies in healthcare professionals, solutions, and address ethical issues. Jarva et al. 2023) created the DigiHealthCom tool designed specifically to measure the digital health competence of healthcare professionals. The tool was validated among 817 healthcare professionals and covers five dimensions: digital solutions competence, information and communication technology competence, evaluation and application of digital solutions competence, remote counseling competence, and ethical competence.

In particular, the connection between this competence and communication is especially vital. Technologies allow opening up new communication channels for nurses in order to exchange information and communicate with the patient in another way. Nurses competent in digital technologies are expected to better find necessary information, share it efficiently, interact with patients through digital technologies, and adapt communication to the technological environment (Hopstaken et al., 2021). On the other hand, lack of digital competence may result in inefficient use of the technologies and creation of barriers in communication instead of patient interaction. (Longhini et al., 2024) in their systematic review of digital health competencies of healthcare professionals, also pointed out that digital competence becomes more and more important for healthcare transformation and that individual and contextual factors affect development of such competences. Communication that is patient-centered offers one of the critical behavioral channels that make digital competence relevant in nursing practice (Abugre & Bhengu, 2024). The Patient-Centered Communication Scale was developed by Joo et al. (2024) as a tool to measure the effectiveness of communication among nurses. The scale measures three major dimensions, including information sharing, patient-as-a-person, and therapeutic alliance, thus showing that effective communication is not just about conveying clinical information. It also involves understanding the patient as an individual and building a therapeutic relationship.

On this basis, digital health competence can contribute to patient-centered communication because nurses with digital competence can more easily incorporate digital communication tools into patient care (Papachristou et al., 2023). This means that digital competence can help nurses gather information, share information, conduct remote interactions, and maintain continuity of communication with digital technology.

Accordingly, the literature suggests that digital health competence represents an important professional capability that can strengthen nurses' ability to engage in effective patient-Centered communication. However, empirical research directly testing this relationship among hospital-based nurses remains limited. Therefore:

H1: Digital health competence positively influences patient-centered nurse–patient communication.

Patient-Centered Nurse–Patient Communication and Patient-Centered Care

Patient-Centered care puts at its heart the values, preferences, needs, engagement, respect, and unique situation of patients. In terms of nursing practice, patient-centered care involves communication since there is a need for the nurse to communicate with the patient to learn from their perspective, provide explanations regarding health issues, address any concerns, involve them in decision-making, and offer emotional and practical assistance (Abugre & Bhengu, 2025). Thus, one can consider patient-centered communication to be an effective behavioral approach that helps implement patient-centered care.

The connection between the two approaches becomes obvious when looking at the definition of patient-centered communication. According to Joo et al. (2024), a nurse-specific Patient-Centered Communication Scale includes three dimensions: information sharing, patient-as-person, and therapeutic alliance. The information sharing dimension relates to providing understandable, relevant health information, while patient-as-person focuses on recognizing patients' individuality and preferences (Van Sebillie et al., 2025). The last dimension, therapeutic alliance, is related to the establishment of trustful relations with the patient. The significance of communication may also be explained in the framework

of the patient-centered care competency approach. Hwang (2015) developed a 17-item Patient-Centered Care Competency Scale for nurses, including four dimensions: respecting patients' perspectives, encouraging patients' participation in the care process, caring for patients' comfort, and advocating for patients. The measure showed high reliability and validity among 594 nurses, with a total Cronbach's alpha of .92. Importantly, the correlation between patient-centered care performance and the patient-centered care competency scale was statistically significant, indicating that patient-centered care is embedded in nursing practice, not just an idea. The similarity in concepts serves as a strong reason to expect the existence of the relationship. Respecting patient perspectives is impossible without listening to patients; encouraging participation is impossible without discussing options with them; and advocacy is impossible without knowing their preferences. Communication becomes an essential procedure through which nurses realize that patients are people (Nazeha et al., 2020).

Further empirical evidence has also reinforced the significance of communication in patient-Centered nursing. In the validation study of Hwang's Patient-Centered Care Competency Scale in Finland, it was noted that the concept of patient-Centered care competence involves the possession of knowledge, skills, and attitudes regarding the recognition of the patients' point of view, promoting their participation, provision of comfort, and advocating for them (Hwang, 2015). Good communication is linked to the concept of patient-Centered care competence because it helps nurses to know what the patients' needs and preferences are and involve them in the care process (Erfani et al., 2025). The importance of the relationship might be particularly significant in the case of hospital nursing care. In primary care, nurses usually educate, counsel, monitor, and manage patients with chronic diseases, and all of these activities involve constant interaction with patients (Scott et al., 2023). Such activities differ from clinical encounters in the sense that they involve trust and an understanding of the unique situation of each patient.

Thus, patient-centered communication should not be regarded merely as a desirable interpersonal skill. It represents a mechanism through which nurses understand patients and translate this understanding into patient-Centered care practices (Tumuhimbise et al., 2025). Accordingly:

H2: Patient-Centered nurse–patient communication positively influences patient-centered care.

Digital Health Competence and Patient-Centered Care

The rise in healthcare digitalization raises a critical question about nurses' capacity to use digital technologies to support patient-centered care (Scott et al., 2023). High digital competence may support patient-centered nursing care by enabling nurses to access information easily, facilitate continuity of care, communicate digitally, deliver remote care, and incorporate patient information into decision-making (Nazeha et al., 2020). Hence, digital competence may endow nurses with means of delivering personalized care. The literature has recognized the significance of digital competence in hospital care. (Jimenez et al., 2020) noted digital health competence as a fundamental requirement for healthcare professionals to utilize the advantages of digital technologies fully. In their study, they identified 17 dimensions of competency and highlighted the need for training and organizational support to develop digitally competent nursing staff. Recently, Jarva et al. (2023) showed that digital health competence can be conceptualized and measured as multidimensional competence, including digital solutions, ICT competence, remote counseling, assessment of digital technology, and

ethical competence. The possible link between digital competence and patient-centered care may be based on resources that are available through digital technology. If nurses are capable of utilizing the electronic health record system and other digital systems properly, they will be able to have better access to information regarding the patients and thus will be in a position to understand their specific needs (Schmidt et al., 2024). Digital communication and telehealth technologies will also allow contact with patients who have geographical, mobility, and accessibility issues. In a similar way, remote monitoring and digital health applications will facilitate the continuous management of patients who have chronic diseases (Nazeha et al., 2020). In this way, digital competence can help nurses provide continuous, informed, accessible, and responsive care. There is recent empirical evidence that supports this proposition. The results of (El-Sayed et al., 2025) on oncology nursing suggest that digital health competence has significantly enhanced the effect of clinical governance climate on patient-centered care competency. These findings show that digital health competence is related to patient-centered nursing outcomes and not only to technical/administrative outcomes. Although oncology nursing is different from hospital care, this result is significant since it shows that there is empirical evidence for linking digital health competence with patient-centered nursing practice (Van Seville et al., 2025). On the other hand, digital competence should not automatically lead to patient-centered care. Merely the availability of technologies does not mean individualization (Papachristou et al., 2023). Digital technologies can become barriers for nurses if they focus too much on documentation, screens, or other technological processes while neglecting interpersonal communication (Hopstaken et al., 2021). Consequently, the impact of digital competence might also be determined by the way nurses employ technological sources in their communication with patients. This conclusion corresponds to a number of studies stressing that the digital transformation in healthcare should involve both technological competencies and clinical and interpersonal competencies in the work of healthcare professionals. According to Lnghini et al. (2024), digital health competencies have become a significant element of modern healthcare practice, and they highlight the impact of professional and organizational factors on these competencies. Accordingly, it seems reasonable to suggest that digital health competencies can contribute to patient-centered care. However, direct evidence concerning this relationship remains relatively limited in hospital-based nursing. Therefore, the present study proposes:

H3: Digital health competence positively influences patient-centered care.

Mediating Role of Patient-Centered Nurse–Patient Communication
Even though digital health competence might contribute to patient-centered care directly, the literature above implies that its effect can be mediated by the behavior of nurses. This aspect is particularly important because digital health technologies are not ends per se but rather means of patient-centered healthcare (Abugre & Bhengu, 2024). Their contribution to patient-centered healthcare is dependent on how well nurses use them in their practice and interpersonal interactions with patients. Patient-Centered communication can be seen as the intermediary variable that mediates between digital health competence and patient-centered care (Abugre & Bhengu, 2025). This theory will be useful in describing this process as well. It argues that individual competencies and behavior, in turn, result in outcomes within the environmental context (Bandura, 1998). In the context of the present study, digital health competence will be considered as an individual

professional competency, patient-centered communication as a result of this capability, and patient-centered care as a practice outcome. Evidence supports the importance of digital competencies for modern-day healthcare practitioners. (Jarva et al., 2023) defined digital health competence as the ability to apply digital tools and tele-counseling, evaluate digital technology, and practice ethically. These competencies can give nurses the resources required to utilize digital technologies not only for administrative purposes but also for communication and interaction with patients (Erfani et al., 2025). Communication forms the second part of the causal pathway. Joo et al. (2024) stated that nurse-patient communication based on patient-centered care includes information exchange, recognizing the patient as an individual, and a therapeutic alliance. These components present a reasonable pathway through which digital competence could affect patient-centered care. Digitally competent nurses can better access and understand patient information, communicate through digital technologies, provide clear information, and adapt communication to patients' needs (Abugre & Bhengu, 2024). Such behaviors will allow the nurse to understand patient preferences and participate in care provision, provide personalized care, and advocate for patients (Abugre & Bhengu, 2025). The last stage of the pathway is patient-centered care. According to Hwang (2015), patient-centered care includes four competencies: respect for patient perspectives, engagement, comfort provision, and advocacy. In order to provide such competencies, one should first ensure the presence of good communication skills because a nurse should know patient perspectives and preferences first (Pakkonen et al., 2023). Recent empirical studies also confirm the plausibility of the entire proposed relationship. In particular, El-Sayed et al. (2025) found digital health competencies important for patient-centered nursing practice, while Schmidt et al. (2024) stressed the importance of combining technical and interpersonal competencies for nurses working in patient-centered telehealth settings. There is thus evidence that digital health competencies are somehow associated with patient-centered care, but the relationship between them is poorly studied. This study seeks to fill this gap by assuming that digitally competent nurses may not be able to provide patient-centered care directly, but can use their digital competencies for more effective patient-centered communication, which in turn allows them to provide more patient-centered care. Accordingly:

H4: Patient-Centered nurse–patient communication mediates the relationship between digital health competence and patient-centered care.

Research Methodology

Research Design

For this research study, a cross-sectional, quantitative research methodology was adopted for examining the relationship between digital health competence, patient-centered nurse-patient communication, and patient-centered care among nurses practicing in private hospitals in Multan, Pakistan. A quantitative approach was deemed suitable because the study empirically tested the relationships among three latent variables, along with their mediating effects on one another (Polit & Beck, 2010). The theoretical model comprised three variables: digital health competence as the independent variable, patient-centered nurse-patient communication as the mediating variable, and patient-centered care as the dependent variable.

Population and Study Setting

The target population was the nurses working in five major private

hospitals situated in the city of Multan, Pakistan. The choice of these particular hospitals was made due to the reason that they are regarded as important providers of healthcare services in the private sector in the city of Multan and are associated with a large number of professional nurses taking part in providing patient care services. The total population of nurses working in the selected hospitals was estimated at 500. The rationale behind focusing on the nurses is based on their regular and consistent involvement with patients and increasing demands for the use of digital technologies in the modern healthcare system for different purposes.

Sample Size Determination

Table 2 Sample and Study Parameters

Parameter	Description
Study population	Nurses working in five major private hospitals.
Study location	Multan, Pakistan
Approximate population	500 nurses
Minimum calculated sample	218 nurses
Final sample	280 nurses
Sampling technique	Non-probability purposive sampling
Research design	Quantitative, cross-sectional
Data collection instrument	Structured self-administered questionnaire
Data analysis	SmartPLS 4 / PLS-SEM

Sampling Technique

Purposive sampling, a form of non-probability sampling, was used to select the sample for the research (Campbell et al., 2020). Purposive sampling was considered Most appropriate because the research required recruiting Individuals with specific professional qualities. This is because the study did not involve healthcare workers in general but only nurses working in the selected hospitals who had experience dealing with patients and technology in healthcare. The researchers recruited nurses who met these criteria in the selected hospitals. The intention was to include nurses with varying degrees of professional experience and educational background.

Inclusion and Exclusion Criteria

The criteria for the participants' selection in this research were being registered/licensed nurses, who were actively working in one of the five chosen private hospitals in Multan, were engaged in any form of direct or indirect care provision for patients, and had at least six months of professional practice as a nurse in their current position. Volunteers had to be willing to participate in the research and provide informed consent. The participant group also included students and interns; nurses in administrative positions who did not perform any duties related to patient care; and nurses with less than six months of experience in their current position.

Since the study had a finite population of around 500 nurses, the sample size necessary for the study was first calculated using a finite population correction method. Using the finite population size, the necessary minimum sample size was 8 nurses. However, the researcher increased the minimum sample size from 218 to 280 nurses to increase statistical power, parameter precision, and stability, and to provide a better platform for PLS-SEM analysis. In other words, the study used 280 responses in the final analysis. Therefore, while the minimum sample size required was 218 using the finite population correction calculation, the study sample size was increased to 280 as a margin (Ahmed, 2024).

Research Instrument and Measurement Scales

Data collection was carried out through a structured questionnaire that included demographic/professional questions and measurement items for the three constructs of the study. The items used to measure the constructs were drawn from previously validated scales to ensure conceptual and psychometric equivalence with existing literature. We evaluated nurses' digital health competence using items adapted from the DigiHealthCom scale (Jarva et al., 2023), which assesses the digital health competence of healthcare professionals. The scale evaluates nurses' capability and confidence in using digital technologies; accessing and assessing digital information; communicating through digital technologies; providing support for digital and remote care; and handling ethical and technological issues. Patient-centered nurse-patient communication was evaluated using items adopted from the Patient-Centered Communication Scale developed by Joo et al. (2024). This scale was developed for nurses and addresses key dimensions of patient-centered communication: information sharing, the patient as a person, and therapeutic alliance. The concept of patient-centered care was evaluated using questions derived from the Patient-Centered Care Competence Scale developed by Hwang (2015). This tool evaluates key aspects of patient-centered nursing practice, such as respecting patients' perspectives, encouraging patient involvement, and providing comfort and advocacy for their interests. In the current research, the scales were adjusted to fit the context of nurses working in a private hospital. All

measurement questions were evaluated on a five-point Likert scale, from

1 = strongly disagree to 5 = strongly agree.

Table 3 Measurement Scale Summary

Variable	Role in Model	Source / Adapted Scale	Items Used
Digital Health Competence (DHC)	Independent Variable	(Jarva et al., 2023) DigiHealthCom	12
Patient-Centered Nurse–Patient Communication (PCC)	Mediator	(Joo et al., 2024) , Patient-Centered Communication Scale for Nurses	12
Patient-Centered Care (PCCare)	Dependent Variable	(Hwang, 2015) Patient-Centered Care Competency Scale	12
Total measurement items	—	—	36

The adaptation of measurement instruments was carried out in order to ensure consistency with the study environment without compromising the conceptual definition of the variables. Before the actual survey was conducted, the questionnaire was subjected to review for clarity and consistency with the environment, and the necessary changes were made in item wording.

Data Collection Procedure

Questionnaire data were collected from nurses working in the five selected private hospitals in Multan. After obtaining all required permissions and maintaining ethical standards, the researchers contacted nurses and asked them to participate in the study. They were informed of the study objectives and told that participation was voluntary and that their responses would be kept confidential.

They completed the questionnaire independently, without an interviewer present, so that they could answer the questions based on their experiences and perceptions. They were not asked for their personal details. After screening for incomplete responses, the analysis included 280 valid questionnaires.

Data Analysis

The collected data were analyzed using IBM SPSS and SmartPLS 4. The former was utilized to screen data and conduct descriptive analysis, including demographic characteristics, missing data, and potential data quality problems. The latter was utilized to estimate the proposed PLS-SEM model (Becker et al., 2023).

The analysis was conducted in two main phases: measurement model assessment and structural model assessment.

First, the measurement model was assessed to test the reliability and validity of the constructs. Indicator reliability was assessed using outer loadings, while internal consistency reliability was assessed using

Table 4. Outer Loadings

Construct	Item	Outer Loading	VIF
DHC	DHC1	0.824	2.854
	DHC10	0.834	2.907
	DHC11	0.820	2.659
	DHC12	0.849	3.228
	DHC2	0.807	2.537
	DHC3	0.845	3.078
	DHC4	0.826	2.767

Cronbach's alpha, rho_A, and composite reliability. Convergent validity was assessed using Average Variance Extracted (AVE). Discriminant validity was tested mainly using the Heterotrait-Monotrait ratio (HTMT) (J. F. Hair et al., 2013).

Second, the structural model was assessed using the test for collinearity, R², effect size (f²), predictive relevance, and the significance of the hypothesized relationships. The proposed direct relationships between the constructs of digital health competence, patient-Centered communication, and patient-Centered care were tested via bootstrapping in SmartPLS 4 (J. Hair et al., 2018).

We used a 5,000-sample bootstrapping technique to calculate standard errors, t-values, p-values, and confidence intervals for path coefficients (Sarstedt et al., 2022). The mediation hypothesis was assessed using the significance and confidence interval of the specific indirect effect of digital health competence on patient-centered care through patient-centered nurse–patient communication.

Ethical Considerations

This research followed all ethical standards for research with human subjects. Participation was voluntary, and participants were informed of the research objective before completing the questionnaire. The confidentiality of the information provided by the respondents was assured. Moreover, the study did not require any personal information from respondents. They were also told that non-participation in the research would not have any repercussions.

Results

The results below are extracted from the SmartPLS algorithm and bootstrapping tests on the proposed model, which include Digital Health Competence (DHC), Patient-Centered Nurse–Patient Communication (PCNPC), and Patient-Centered Care (PCC).

Digital Health Competence and Patient-Centered Care among.

	DHC5	0.812	2.581
	DHC6	0.853	3.277
	DHC7	0.835	3.014
	DHC8	0.824	2.701
	DHC9	0.844	3.143
PCC	PCC1	0.746	2.055
	PCC10	0.780	2.261
	PCC11	0.780	2.204
	PCC12	0.751	2.015
	PCC2	0.732	1.912
	PCC3	0.772	2.144
	PCC4	0.752	2.031
	PCC5	0.826	2.607
	PCC6	0.747	2.052
	PCC7	0.720	1.949
	PCC8	0.795	2.438
	PCC9	0.775	2.262
PCNPC	PCNPC1	0.820	2.648
	PCNPC10	0.799	2.375
	PCNPC11	0.788	2.294
	PCNPC12	0.792	2.351
	PCNPC2	0.827	2.667
	PCNPC3	0.811	2.533
	PCNPC4	0.819	2.643
	PCNPC5	0.832	2.859
	PCNPC6	0.802	2.459
	PCNPC7	0.796	2.399
	PCNPC8	0.811	2.537
	PCNPC9	0.795	2.326

Outer loadings assess how strongly each indicator represents its respective reflective construct. A loading of 0.708 or above is generally considered satisfactory. All indicators exceeded this threshold, with loadings ranging from 0.720 to 0.854, supporting adequate indicator

reliability. The VIF values for all indicators are below the conservative threshold of 3.3, thereby indicating that no issues of multicollinearity exist among indicators (Matthews et al., 2018).

Measurement Model

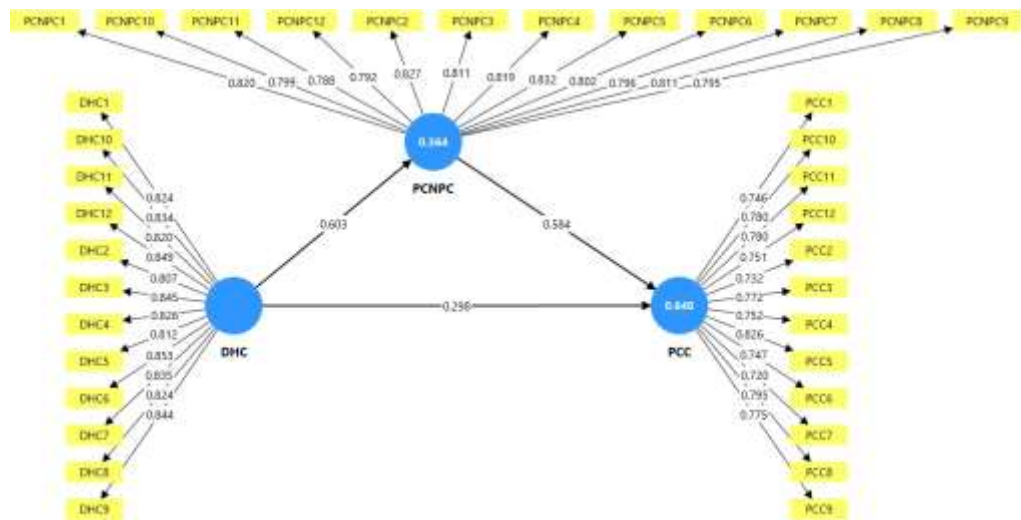


Figure 2 Measurement Model

Table 5 Reliability and Convergent Validity

Construct	Cronbach's α	rho_A	rho_C	AVE
DHC	0.959	0.960	0.964	0.691
PCC	0.935	0.936	0.944	0.585
PCNPC	0.952	0.952	0.958	0.653

Reliability is deemed satisfactory whenever the coefficient values are more than 0.70, while convergent validity becomes satisfactory if the AVE value exceeds 0.50. The alpha coefficient, rho_A, and composite reliability coefficient were above 0.70 for all constructs, while the AVE value was between 0.585 and 0.691 (J. F. Hair et al., 2019) .

Table 6 Coefficient of Determination

Endogenous Construct	R ²	Adjusted R ²
PCC	0.640	0.637
PCNPC	0.364	0.362

The coefficient of determination (R²) is the proportion of the variance in the endogenous variable accounted for by the independent variables. The value of R² was 0.640 for Patient-Centered Care, meaning that 64.0% of the variance in the variable was accounted for by Digital Health Competence and Patient-Centered NNurse-Patient Communication. For PCNPC, R² was 0.364, indicating that Digital Health Competence accounted for 36.4% of the variance (Matthews et al., 2018).

Table 7 Heterotrait–Monotrait Ratio (HTMT)

Construct Pair	HTMT
PCC ↔ DHC	0.684
PCNPC ↔ DHC	0.628
PCNPC ↔ PCC	0.808

HTMT values below 0.90 are often used as an indicator of good discriminant validity. In this case, the values ranged from 0.628 to 0.808 and remained below 0.90, meaning the three constructs could be distinguished (J. Hair et al., 2017).

Table 8. Fornell–Larcker Criterion

Construct	DHC	PCC	PCNPC
DHC	0.831		
PCC	0.651	0.765	
PCNPC	0.603	0.764	0.808

According to the Fornell-Larcker rule, the square root of the AVE in the diagonals must be greater than the correlations of the construct with other constructs. The diagonal entries were 0.831 for DHC, 0.765 for PCC, and 0.808 for PCNPC, all of which were higher than their respective inter-construct correlations (Sarstedt et al., 2020).

Table 9. Inner Variance Inflation Factor (VIF)

Structural Path	VIF
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DHC → PCC	1.572
DHC → PCNPC	1.000
PCNPC → PCC	1.572

VIF values below 5.00 are generally considered acceptable for assessing collinearity, with lower values indicating less concern. The inner VIF values ranged from 1.000 to 1.572, well below the 5.00 threshold, indicating no problematic multicollinearity among the predictor constructs (J. F. Hair et al., 2013).

Table 10 Structural Model and Hypothesis Testing

Hyp.	Relationship	β	SD	t	p	95% CI	Decision
H1	DHC → PCNPC	0.603	0.037	16.301	< .001	[0.524, 0.670]	Accepted
H2	PCNPC → PCC	0.584	0.038	15.517	< .001	[0.507, 0.657]	Accepted
H3	DHC → PCC	0.298	0.046	6.548	< .001	[0.205, 0.385]	Accepted
H4	DHC → PCNPC → PCC	0.352	0.034	10.331	< .001	[0.289, 0.423]	Accepted

Path coefficients, standard deviations. We used t-statistics, p-values, and 95% bootstrap confidence intervals to establish structural relations. We concluded statistical significance when $p < .05$ and the confidence interval included no zero value. All four relationships under consideration were positive and statistically significant. In consequence, hypotheses H1, H2, H3, and H4 were confirmed. The p-values for all hypotheses provided by SmartPLS were 0.000, which should be indicated as $p < .001$ in the manuscript (J. F. Hair et al., 2013).

Table 11 Specific Indirect Effect (Mediation)

Mediated Relationship	β	SD	t	p	95% CI	Decision
DHC → PCNPC → PCC	0.352	0.034	10.331	< .001	[0.289, 0.423]	Mediation supported

This particular indirect effect is statistically significant since the 95% bootstrap confidence interval (0.289, 0.423) did not include zero and $p < .001$. This means Patient-Centered Nurse–Patient Communication mediates the link between Digital Health Competence and Patient-Centered Care. Given that the direct effect is also significant ($\beta = 0.298$, $p < .001$), this is a case of complementary (partial) mediation (J. Hair et al., 2018).

Table 12 Total Effects

Relationship	Total Effect	SD	t	p
DHC → PCC	0.651	0.034	19.377	< .001
DHC → PCNPC	0.603	0.037	16.301	< .001
PCNPC → PCC	0.584	0.038	15.517	< .001

Total effects refer to the overall impact of a predictor on an endogenous variable along all its relevant direct and indirect paths. Total effects for the model of Digital Health Competence to Patient-Centered Care were 0.651 and statistically significant ($p < .001$). The total effects of DHC on PCNPC and PCNPC on PCC were also positive and significant (J. F. Hair et al., 2019).

Discussion

The findings supported all four proposed hypotheses and demonstrate that digital health competence is positively associated with patient-centered nursing practice. Digital health competence had a strong positive effect on patient-centered nurse–patient communication ($\beta = 0.603$, $p < .001$), suggesting that digitally competent nurses are better positioned to use digital technologies while maintaining effective and meaningful communication with patients.

Patient-Centered nurse–patient communication also had a strong positive effect on patient-centered care ($\beta = 0.584$, $p < .001$). This indicates that effective information sharing, recognition of patients as individuals, and therapeutic relationships are important for promoting patient involvement, respecting preferences, providing comfort, and advocating for patients.

Digital health competence also demonstrated a significant direct effect on patient-centered care ($\beta = 0.298$, $p < .001$). This suggests that nurses who are more competent in using digital technologies may be better able to access patient information, support clinical decision-making,

facilitate continuity, and provide individualized care.

The mediation analysis provided the study's central finding. Patient-Centered nurse–patient communication significantly mediated the relationship between digital health competence and patient-centered care ($\beta = 0.352$, $p < .001$; 95% CI [0.289, 0.423]). Because the direct effect remained significant, the findings indicate complementary/partial mediation. Thus, digital competence contributes to patient-centered care both directly and indirectly through patient-centered communication, supporting the capability–behavior–outcome logic of Social Cognitive Theory. Because the direct effect remained significant, the findings indicate complementary/partial mediation. Thus, digital competence contributes to patient-Centered care both directly and indirectly through patient-centered communication, supporting the capability–behavior–outcome logic of Social Cognitive Theory. **Limitations & Future Research Direction** There are some limitations in the study. First, the cross-sectional design makes it difficult to infer causality. Second, purposive sampling and the use of nurses from five private hospitals in Multan may limit the generalizability of the results to other healthcare facilities. Third, participants belonged to various

clinical departments, so their work environments and demands may vary. Finally, the study used self-reported measures, which may be subject to social desirability and common method bias. Future research should use longitudinal or experimental designs to investigate changes in digital health competence and patient-centered care over time. Comparative research can test whether the same relationships exist in the ICU, surgical, neonatal, medical, emergency, and outpatient departments. Further research can also consider organizational variables such as digital infrastructure, leadership, organizational support, and training programs. Using patient and supervisor ratings, observational measures, and objective indicators of digital technology use will strengthen the results.

Conclusion

These results have significant implications not only for nursing education but also for hospital administration. In particular, digital-health training must extend beyond purely technological expertise and include patient-centered communication, including information exchange, active listening, empathy, patient engagement, and building therapeutic relationships. Thus, hospitals need to offer nurses continuing professional development and technical support that enable them to use digital health technologies effectively in patient care. Regarding nursing practice, the results imply that digital health technologies should enhance, not replace, interpersonal communication. Hospital managers and healthcare policymakers might add digital health competencies, along with patient-centered communication competencies, to the nursing competency framework.

Informed Consent

We obtained written informed consent from all participants before enrollment in the study. Participants were informed about the study's purpose and procedures, and participation was voluntary.

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Conflict of Interest

The authors declare that they have no competing interests or conflicts of interest related to this study.

Authors' Contributions

Haseeb Shahid: Conceptualization, study design, supervision, data interpretation, critical revision of the manuscript for important intellectual content, final approval of the version to be published, and accountability for all aspects of the work.

Abida Tariq: Conceptualization, study design, data collection, data curation, statistical analysis, data interpretation, manuscript drafting, critical revision of the manuscript, final approval of the version to be published, and accountability for all aspects of the work.

Saba Manzoor: Data collection, data curation, literature review, interpretation of data, manuscript revision, final approval of the version to be published, and accountability for all aspects of the work.

Zobia Latif: Data collection, laboratory assessment, data curation, literature review, manuscript revision, final approval of the version to be published, and accountability for all aspects of the work.

Palwasha Maryam: Study supervision, interpretation of findings, critical review of the manuscript for important intellectual content, final approval of the version to be published, and accountability for all aspects of the work.

Alia Nazar Sial: Statistical analysis, data interpretation, manuscript drafting and revision, critical review of the manuscript for important intellectual content, final approval of the version to be published, and accountability for all aspects of the work.

All authors approved the final version of the manuscript and agreed to be accountable for all aspects of the work.

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