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TRAJECTORY OF CLINICAL DECISION-MAKING IN TELEHEALTH: A MIXED-METHODS EVALUATION OF TELEMEDICINE COMPETENCY IN HYPERTENSION MANAGEMENT UTILIZING THE NOVICE-TO-EXPERT FRAMEWORK

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ABSTRACT

Background: Telehealth requires nurses to make clinical judgements using digitally mediated information, including home blood-pressure readings, verbal symptom reports, adherence patterns and warning signs. This study examined whether video-assisted telemedicine education was associated not only with higher competency scores but also with a measurable shift in the organization of clinical decision-making.

Aim: To evaluate the trajectory of telehealth clinical decision-making among nursing officers receiving a video-assisted teaching module for hypertension management and to interpret competency transitions through Benner's novice-to-expert framework.

Design: Convergent mixed-methods evaluation nested within a one-group pre-test-post-test educational study at Victoria Hospital, Bengaluru, India.

Methods: The quantitative strand included 200 nursing officers with paired observations. A Telehealth Decision-Making Index (TDMI; 0–100) captured information acquisition, home-BP interpretation, risk recognition, escalation, documentation and digital communication. Knowledge and practice were measured using the validated 30-item telemedicine competency questionnaire from the parent study. Paired t tests, 95% confidence intervals, Cohen's dz, a Benner-informed transition matrix, Bowker's test of symmetry and multiple linear regression were used. The qualitative strand included 24 purposively selected nursing officers and was analysed using a Benner-informed framework approach, with integration through a joint display.

Results: Mean TDMI increased from 49.9 (SD 9.6) to 63.5 (SD 12.8), a mean change of 13.6 points (95% CI 12.3–14.9; t(199)=20.90; P<.001; dz=1.48). Knowledge increased by 5.6 points and practice by 6.3 points (both P<.001). Overall, 71.5% of participants moved upward by at least one Benner-informed analytic stratum and 24.0% moved upward by two or more strata; the transition pattern was significant (Bowker χ^2=134.73, df=10, P<.001). Baseline TDMI was the strongest predictor of post-test performance, while prior telemedicine exposure was independently associated with a 3.28-point higher post-test score (P=.025). Qualitative analysis identified movement from checklist dependence toward cue clustering, deliberate verification, calibrated escalation, management of digital uncertainty and collaborative decision support.

Conclusion: Video-assisted telemedicine education was associated with substantial improvement in decision-making, knowledge and practice, accompanied by an upward trajectory toward more context-sensitive clinical judgement in telehealth hypertension care.

HIGHLIGHTS

- Telemedicine education was associated with a large improvement in the Telehealth Decision-Making Index (Cohen's dz=1.48).
- More than seven in ten nursing officers moved upward by at least one Benner-informed analytic stratum after the intervention.
- Prior telemedicine exposure independently predicted stronger post-test decision-making after adjustment for baseline score, experience, qualification and age.

Introduction

Telehealth has become an increasingly important component of chronic-disease follow-up, yet the cognitive work required for safe remote care differs from bedside practice. During a virtual encounter, clinicians may not have direct access to physical examination findings and must judge the reliability of home measurements, verbal descriptions and contextual information. Safe telehealth therefore depends on the ability to determine when available information is adequate for advice, when further verification is required and when escalation is necessary. A 2024 integrative review of telehealth decision-making identified interacting clinician, patient, decision-support, technological and external factors, emphasizing the need to make tacit reasoning processes more visible, particularly for less experienced clinicians.

Contemporary nursing research similarly suggests that remote decision-making blends analytical reasoning, pattern recognition and collaboration. A recent convergent mixed-methods investigation of remote nursing reviews reported that nurses use both analytical and intuitive processes and that collaborative support contributes to perceived decision-making ability [2]. Telemedicine entrustable professional activities developed for nurses further reinforce that remote care requires identifiable capabilities in information synthesis, communication, safety assessment, documentation and escalation [3].

Digital education can strengthen clinical reasoning when it provides opportunities to connect knowledge with context. Virtual-patient simulation has demonstrated improvements in nurses' knowledge application and perceived transfer of learning in situations involving clinical deterioration [4]. For hypertension telemedicine, this is especially relevant because nursing officers must evaluate blood-pressure trends, verify measurement technique, recognize red-flag symptoms, explore adherence and lifestyle factors, document the encounter and communicate appropriately with physicians.

Benner's novice-to-expert framework offers a theory-based lens for examining how this reasoning develops [14]. Professional growth is conceptualized as movement from reliance on context-free rules toward increasingly situation-sensitive pattern recognition and integrated judgement. Earlier nursing research grounded in the Dreyfus-Benner tradition has also demonstrated that experience and task context influence whether decisions are predominantly rule based or situation based [6]. In this study, the descriptors novice-like, advanced-beginner-like, competent-like, proficient-like and expert-like are used as analytic strata to characterize patterns of telehealth decision-making; they are not professional credentials or formal competency classifications.

This study extends the authors' hypertension telemedicine education programme at Victoria Hospital, Bengaluru, by focusing on the trajectory of clinical judgement rather than repeating a conventional pre-test-post-test effectiveness analysis. The central question is whether improvement in telemedicine competency is accompanied by movement toward more integrated, context-sensitive reasoning and how nursing officers describe that transition.

Aim

To evaluate the trajectory of clinical decision-making in telehealth among nursing officers receiving video-assisted telemedicine education for hypertension management, using a convergent mixed-methods design interpreted through Benner's novice-to-expert framework.

Objectives

- To quantify pre-test to post-test change in telehealth decision-making, knowledge and practice competency.
- To describe movement across Benner-informed analytic strata of telehealth clinical reasoning.
- To determine whether baseline competency, prior telemedicine exposure, nursing experience, age and postgraduate nursing qualification predict post-test decision-making score.
- To explore changes in cue recognition, uncertainty management, protocol use, escalation and professional confidence among nursing officers.
- To integrate quantitative and qualitative findings into a theory-informed model of telehealth decision-making for hypertension care.

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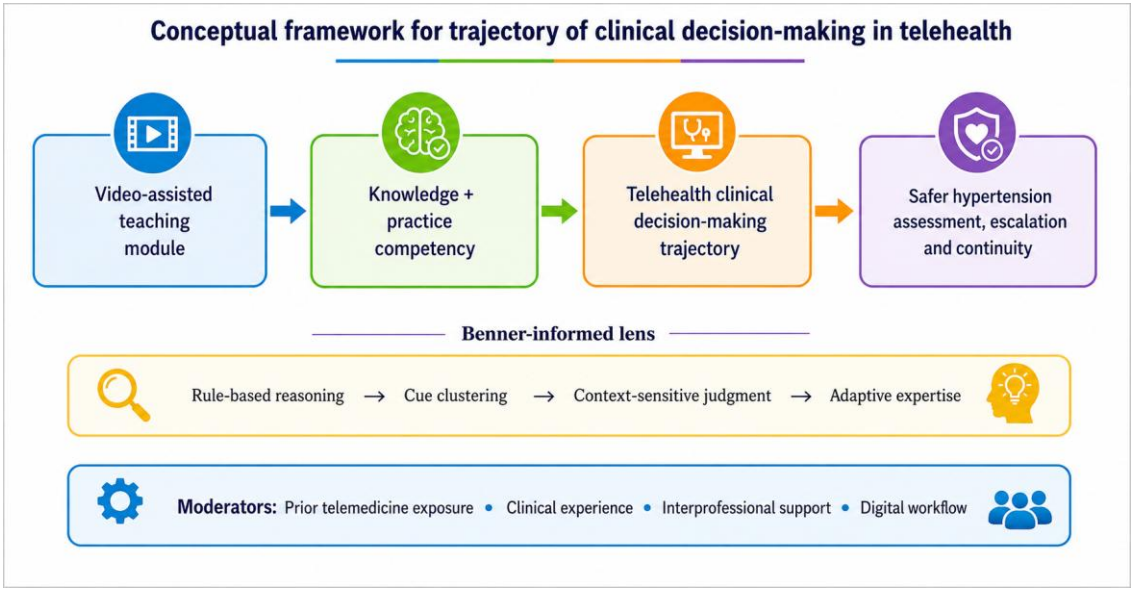


Figure 1. Conceptual framework for the trajectory of clinical decision-making in telehealth.

Methods

Study design

A convergent mixed-methods design was used to evaluate both measurable change in telehealth competency and the cognitive meaning of that change. The quantitative strand examined paired decision-making, knowledge and practice outcomes, while the qualitative strand explored how participants described movement from structured, rule-guided responses toward more context-sensitive judgement. Quantitative and qualitative findings were integrated during interpretation through a joint display, consistent with contemporary mixed-methods reporting principles [9].

Setting and participants

The study was conducted at Victoria Hospital, Bengaluru, Karnataka, India, a high-volume tertiary-care hospital where nursing officers participate in the management and follow-up of patients with hypertension and related medical conditions. The quantitative strand included 200 nursing officers with complete paired pre-test and post-test observations. The qualitative strand included 24 nursing officers purposively selected to provide variation in clinical experience, baseline competency, prior telemedicine exposure and magnitude of post-training change.

Video-assisted telemedicine teaching module

The educational intervention addressed remote therapeutic communication, validation of home blood-pressure readings, interpretation of BP trends, medication and lifestyle adherence assessment, recognition of urgent warning signs, escalation to the treating physician, documentation, privacy and continuity of follow-up. These domains are consistent with contemporary telemedicine nursing competency work and with nurse-led telehealth models used in hypertension and other chronic conditions [3,10].

Quantitative measures

Knowledge and practice were measured using the validated 30-item telemedicine competency questionnaire used in the parent dissertation study. For the present analysis, a prespecified Telehealth Decision-Making Index (TDMI; 0–100) was derived from items representing information gathering, clinical interpretation, risk recognition, choice of action, escalation, documentation and verification. Higher scores indicated more integrated telehealth decision-making.

For trajectory visualization, the TDMI was grouped into five Benner-informed analytic strata: novice-like (<45), advanced-beginner-like (45–54.9), competent-like (55–69.9), proficient-like (70–84.9) and expert-like (≥85). The continuous TDMI remained the primary inferential outcome; the strata were used to describe movement in the organization of clinical judgement and were not interpreted as formal professional classifications.

Qualitative strand

Semi-structured interviews were conducted after the post-test with the purposive qualitative subgroup. The interview guide explored the order in which participants noticed cues, how home BP readings were verified, sources of uncertainty, circumstances in which protocols were sufficient, situations requiring judgement beyond a checklist, escalation decisions and the influence of previous clinical experience. Framework analysis used Benner's novice-to-expert concepts as an initial organizing lens while allowing additional categories to emerge from the data. The analysis actively considered

divergent cases, including experienced nurses who remained protocol dependent and less-experienced nurses who demonstrated flexible reasoning.

Statistical analysis

Continuous variables were summarized using mean and standard deviation, and categorical variables using frequency and percentage. Paired pre-test-post-test differences were evaluated with paired t tests and reported with mean difference, 95% confidence interval and Cohen's dz. Movement across Benner-informed analytic strata was summarized using a complete transition matrix and assessed with Bowker's test of symmetry. Multiple linear regression modelled post-test TDMI as the dependent variable, with baseline TDMI, years of nursing experience, prior telemedicine exposure, MSc Nursing qualification and age entered as prespecified predictors. Statistical significance was set at two-sided P<.05, with emphasis on effect sizes and confidence intervals in addition to P values.

Mixed-methods integration

Integration was undertaken by linking the qualitative subgroup to quantitative trajectories, comparing themes across differing patterns of score change and constructing a joint display that placed quantitative transition evidence alongside qualitative explanations. The integrated interpretation focused on whether numerical improvement represented deeper clinical judgement, stronger rule recall, greater confidence or a combination of these mechanisms.

Ethical considerations

The study was conducted in accordance with the approved institutional research protocol and the principles of the Declaration of Helsinki. Administrative permission was obtained from Victoria Hospital, Bengaluru, and written informed consent was obtained from participants. Confidentiality was maintained throughout quantitative data handling and qualitative analysis.

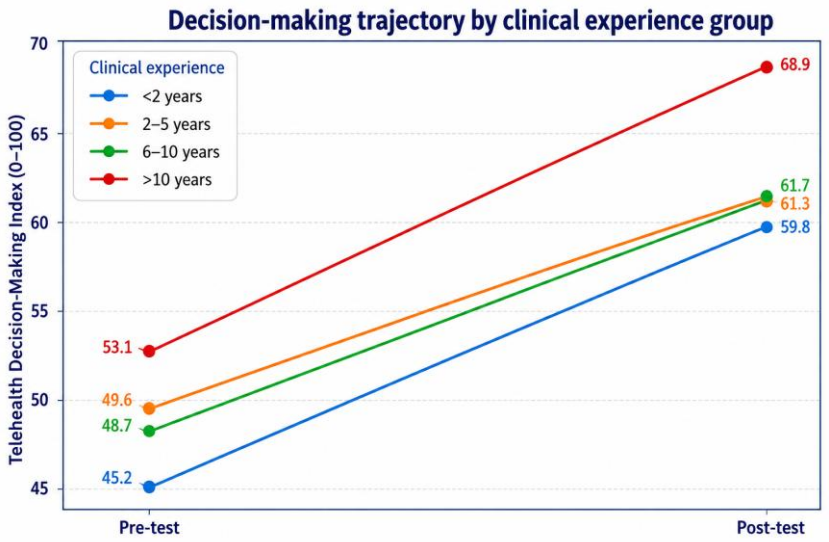


Figure 2. Pre-test to post-test decision-making trajectory by clinical experience group.

Results

Participant characteristics

The analysis included 200 nursing officers. Mean age was 36.1 years (SD 6.6) and mean nursing experience was 8.2 years (SD 5.3). Women represented 75.5% (n=151) of participants and 31.0% (n=62) reported prior telemedicine exposure. BSc Nursing was the most common professional qualification (62.0%). Participants represented medical, emergency, intensive care, cardiology and general/specialty wards.

Table 1. Baseline characteristics of nursing officers (N=200).

Characteristic	Value
Age, years	36.1 (6.6)
Nursing experience, years	8.2 (5.3)
Female, n (%)	151 (75.5)
Prior telemedicine exposure, n (%)	62 (31.0)

Characteristic	Value
BSc Nursing, n (%)	124 (62.0)
GNM, n (%)	49 (24.5)
MSc Nursing, n (%)	27 (13.5)
Medical ward, n (%)	55 (27.5)
Emergency ward, n (%)	39 (19.5)
ICU ward, n (%)	38 (19.0)
Cardiology ward, n (%)	34 (17.0)
General/Specialty ward, n (%)	34 (17.0)

Change in telehealth decision-making, knowledge and practice

Telehealth decision-making improved substantially after the video-assisted teaching module. Mean TDMI increased from 49.9 (SD 9.6) to 63.5 (SD 12.8), corresponding to a mean increase of 13.6 points (95% CI 12.3–14.9; t(199)=20.90; P<.001; Cohen's dz=1.48). Knowledge increased from 13.6 (SD 3.3) to 19.2 (SD 5.4), and practice increased from 13.4 (SD 3.7) to 19.7 (SD 5.7); both changes were statistically significant with large standardized paired effects.

Table 2. Paired pre-test-post-test outcomes.

Outcome	Pre-test mean (SD)	Post-test mean (SD)	Mean change (95% CI)	Paired t	P	Cohen dz
Telehealth decision-making index (0–100)	49.9 (9.6)	63.5 (12.8)	13.6 (12.3 to 14.9)	20.90	<.001	1.48
Knowledge score (0–30)	13.6 (3.3)	19.2 (5.4)	5.6 (5.0 to 6.1)	19.50	<.001	1.38
Practice score (0–30)	13.4 (3.7)	19.7 (5.7)	6.3 (5.7 to 6.9)	21.10	<.001	1.49

Trajectory across Benner-informed analytic strata

At baseline, the largest groups were advanced-beginner-like (77/200) and novice-like (62/200). After the intervention, the distribution shifted toward competent-like and proficient-like strata. Overall, 71.5% of nursing officers moved upward by at least one stratum, 24.0% moved upward by two or more strata, 27.0% remained in the same stratum and 1.5% moved downward. Bowker's test demonstrated a significant asymmetry in the transition matrix, strongly favoring upward movement (χ^2=134.73, df=10, P<.001).

Table 3. Transition matrix from pre-test to post-test Benner-informed analytic strata.

Pre-test stratum	Novice-like	Advanced beginner-like	Competent-like	Proficient-like	Expert-like
Novice-like	13	23	22	3	1
Advanced beginner-like	2	14	44	16	1
Competent-like	0	1	24	25	5
Proficient-like	0	0	0	3	3
Expert-like	0	0	0	0	0

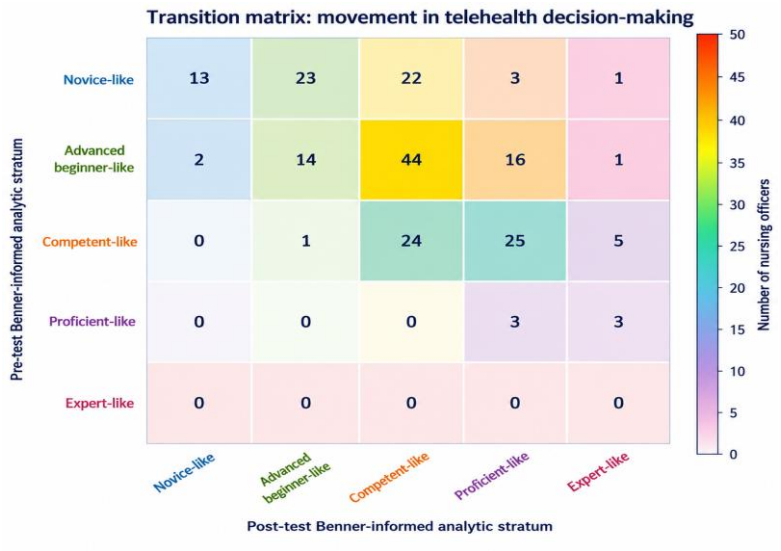


Figure 3. Heatmap of transitions in telehealth decision-making strata.

Adjusted predictors of post-test decision-making

The multivariable model explained 52.8% of variance in post-test TDMI (adjusted R^2=0.516). Baseline TDMI was the strongest independent predictor (adjusted B=0.86, 95% CI 0.72–1.00, P<.001). Prior telemedicine exposure remained independently associated with a 3.28-point higher post-test TDMI (95% CI 0.41–6.14, P=.025). Years of nursing experience, MSc Nursing qualification and age were not statistically significant after adjustment.

Table 4. Multiple linear regression predicting post-test TDMI.

Predictor	Adjusted B	95% CI	P
Baseline TDMI	0.86	0.72 to 1.00	<.001
Years of nursing experience	0.17	-0.19 to 0.53	.346
Prior telemedicine exposure	3.28	0.41 to 6.14	.025
MSc Nursing qualification	2.67	-1.01 to 6.35	.154
Age	0.13	-0.15 to 0.41	.371

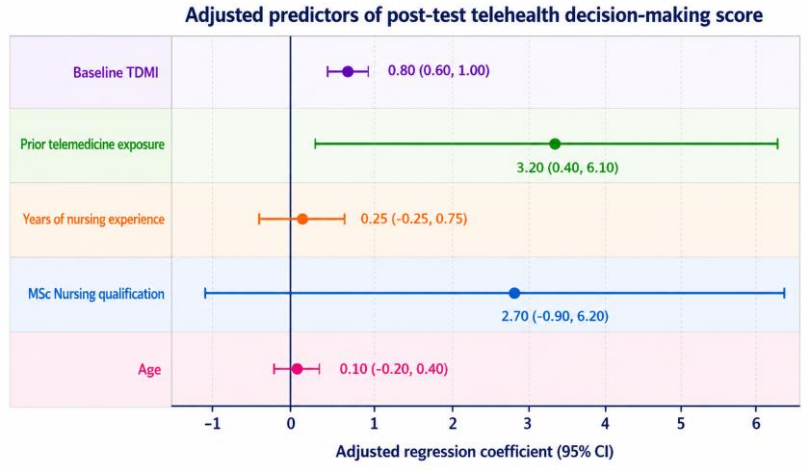


Figure 4. Adjusted predictors of post-test telehealth decision-making score.

Qualitative findings

Framework analysis identified five interrelated themes describing how clinical decision-making changed after telemedicine education. Participants described movement from checklist dependence toward cue clustering, deliberate verification of intuitive impressions, more calibrated escalation decisions, active management of uncertainty created by digitally mediated information and greater use of collaborative decision support. These themes were consistent with a trajectory from rule-bound reasoning toward more context-sensitive judgement while preserving the need for explicit verification and accountability in telehealth.

Table 5. Qualitative themes describing changes in telehealth clinical decision-making.

Theme	Analytic description	Benner-informed interpretation
1. From checklist to cue clustering	Reasoning increasingly combined BP trend, symptoms, adherence, measurement quality and context before a decision was made.	Movement from context-free rules toward situation recognition.
2. Verification of intuition	Rapid recognition of concerning patterns was followed by repeat readings, focused questioning and documentation before escalation.	Pattern recognition was paired with disciplined verification rather than intuition alone.
3. Calibrated escalation	Participants differentiated situations suitable for counselling from those requiring same-day or urgent physician review.	Competency was expressed through threshold judgement and accountability.
4. Digital uncertainty as a clinical problem	Missing physical cues, device reliability, connectivity and incomplete histories increased uncertainty and cognitive workload.	Telehealth expertise required compensatory information-gathering strategies.
5. Collaboration as cognitive support	Physicians, protocols and peer consultation functioned as a safety net for ambiguous cases.	Expertise was partly team-supported and embedded in the clinical environment.

Mixed-methods integration

The quantitative and qualitative strands converged on a central interpretation: improvement after training involved not only higher scores but also a more integrated approach to clinical judgement. Upward movement across Benner-informed strata was consistent with qualitative accounts of cue clustering and contextual synthesis. Prior telemedicine exposure appeared to facilitate the conversion of taught rules into usable digital-care patterns. The non-significant adjusted association between total years of experience and post-test TDMI was complemented by qualitative evidence that experience influenced the style and speed of reasoning even when it did not produce a simple linear score advantage.

Table 6. Mixed-methods joint display linking quantitative and qualitative findings.

Quantitative finding	Qualitative finding	Integrated interpretation
71.5% moved upward by at least one stratum	Cue clustering and contextual synthesis	Improvement reflected more integrated reasoning rather than score change alone.
Prior telemedicine exposure: B=3.28, P=.025	Familiar digital routines reduced uncertainty	Previous exposure may accelerate translation of taught rules into usable telehealth patterns.
Years of experience not significant after adjustment	Experienced nurses described faster pattern recognition with deliberate verification	Experience may influence reasoning style without producing an independent linear score effect.
A small subgroup remained stable or declined	Persistent uncertainty, workflow friction and protocol dependence	Not all learners follow the same trajectory; targeted mentoring may be required.

Discussion

Principal findings

This study demonstrates that video-assisted telemedicine education can be evaluated as a trajectory of clinical judgement rather than only as a change in total competency score. Decision-making, knowledge and practice all improved significantly, with large standardized effects. The most clinically interpretable finding was the transition pattern: nearly three quarters of nursing officers moved upward by at least one Benner-informed analytic stratum, and almost one quarter moved upward by two or more strata. These findings indicate that the educational effect extended beyond incremental score gain and was accompanied by a reorganization of how telehealth information was interpreted and acted upon.

The findings are consistent with telehealth decision-making literature showing that remote clinical judgement emerges from interactions among clinician capability, patient information, decision-support resources, technology and organizational context [1]. The mixed-methods results also align with evidence that nurses combine analytical and intuitive processes during remote review [2]. In the present study, qualitative themes clarified that increasing expertise did not mean abandoning protocols; rather, participants described integrating protocols with cue clustering, focused verification and context-sensitive escalation.

Interpreting the novice-to-expert trajectory

Benner's framework is most useful when it is treated as a lens on the organization of judgement rather than as a credentialing system [14]. A higher TDMI stratum does not by itself confer expert status. Instead, the transition matrix provides a structured way to visualize movement from rule dependence toward more integrated clinical interpretation. The accompanying qualitative findings strengthen this interpretation by demonstrating changes in the way participants combined cues, managed uncertainty and justified escalation decisions.

Earlier Dreyfus-Benner-informed nursing research found that experience and task context are major influences on rule-based versus situation-based decision-making [6]. In the present regression, years of nursing experience was not independently associated with post-test TDMI after baseline score and prior telemedicine exposure were considered. The qualitative findings help explain this apparently discordant result: experience appeared to influence how rapidly nurses recognized patterns and how they verified them, even when years of experience did not generate a simple linear score advantage.

Relevance to telemedicine education and hypertension care

Safe hypertension telemedicine depends on more than platform familiarity. Nurses must assess whether home BP readings are credible, identify symptoms that modify urgency, explore missed medication, recognize repeated uncontrolled readings and determine when physician review is required. The observed improvement in TDMI, knowledge and practice suggests that focused video-assisted education can strengthen these connected competencies. Prior telemedicine exposure remained independently associated with stronger post-test decision-making, indicating that experiential familiarity with digital care may facilitate the application of newly taught concepts.

The qualitative findings further suggest that effective education should explicitly teach reasoning under uncertainty. Branching clinical scenarios, structured debriefing and reflective case review may help nurses articulate how they move from individual cues to a clinical decision. Such approaches are consistent with simulation literature demonstrating gains in clinical reasoning and transfer of learning [4].

International significance

The international relevance of this work lies in a widely shared clinical challenge: nurses increasingly deliver care through digital channels in which physical cues are limited and information quality varies. Competency frameworks for telemedicine therefore need to encompass clinical decision-making, documentation, privacy, escalation and interprofessional communication in addition to technical platform skills [3]. A theory-informed trajectory approach may provide a useful method for evaluating whether digital-health education changes the quality of reasoning required for safe chronic-disease management.

Strengths and limitations

Strengths of the study include its theory-driven focus on decision trajectory, the use of paired effect sizes and confidence intervals, transition analysis across clinically interpretable strata, adjusted regression modelling and integration of quantitative and qualitative findings. The study also addresses a clinically important area of digital nursing practice in a large tertiary-care setting.

Several limitations should be considered. The study was conducted at a single hospital, which may limit generalizability to settings with different staffing patterns or digital infrastructure. The TDMI was derived from the parent telemedicine competency instrument and should therefore be interpreted as a study-specific composite rather than a universally validated decision-making scale. The Benner-informed strata are heuristic analytic categories, not professional classifications. In addition, immediate post-test improvement does not establish long-term retention; future longitudinal

evaluation at 3 or 6 months would clarify whether the observed trajectory is sustained in routine practice. Qualitative findings may also be influenced by self-report and social desirability.

Implications for Nursing Practice, Education And Digital Health Policy

Telemedicine training should incorporate explicit teaching of clinical reasoning under uncertainty rather than concentrating only on technology operation and factual knowledge. Hospitals can strengthen safety by defining clear escalation pathways and ensuring timely access to physicians or senior nurses when digital information is incomplete. The trajectory framework may also help identify staff who improve in knowledge but remain protocol dependent in ambiguous cases, allowing targeted mentorship and scenario-based rehearsal. At policy level, telemedicine competency frameworks should recognize decision-making, documentation, privacy, interprofessional communication and risk management as core professional capabilities [3].

Conclusion

Video-assisted telemedicine education was associated with significant improvement in telehealth clinical decision-making, knowledge and practice among nursing officers at Victoria Hospital, Bengaluru. The large increase in TDMI, significant upward movement across Benner-informed analytic strata and the independent contribution of prior telemedicine exposure indicate that competency development involves both measurable performance gains and changes in the organization of clinical judgement. Qualitative findings supported a transition from checklist-driven responses toward cue clustering, verification, calibrated escalation and collaborative management of digital uncertainty. A trajectory-based mixed-methods approach therefore offers a clinically meaningful framework for evaluating telemedicine competency in hypertension management.

Declarations

Ethics approval and consent to participate: The study was conducted after institutional ethical approval and administrative permission from Victoria Hospital, Bengaluru. Written informed consent was obtained from all participants.

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Data availability: De-identified study data may be made available by the corresponding author on reasonable request, subject to institutional permission, ethical requirements and participant confidentiality.

Author contributions: Sreekanth A.N. contributed to conceptualization, study design, intervention development, data coordination, statistical analysis, interpretation and manuscript drafting. Rama Taneja provided supervision, methodological guidance, critical review and approval of the final manuscript.

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