Original Research Article

Efficacy of Blended Digital and Simulation-Based Training on Infusion Nursing Competency: A Comparative Study

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ABSTRACT

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Introduction: Safe infusion therapy requires nurses to integrate theoretical knowledge with accurate procedural performance, clinical judgment, infection-prevention practices, medication safety, and recognition and management of complications. Digital learning can provide scalable theoretical preparation, while simulation provides opportunities for demonstration, deliberate practice, feedback, correction, and repeated performance. Current WHO guidance on peripheral and central intravascular catheters emphasizes appropriate insertion, maintenance, access, aseptic technique, hand hygiene, education and training, and multimodal implementation strategies. Present study to evaluate the effectiveness of blended digital and simulation-based training in improving infusion-practice competency among nurses compared with conventional training. **Materials and Methods:** A comparative interventional study was conducted among 300 nurses working in hospitals in the Delhi-NCR region. Participants were divided into an experimental group (n=150) and a control group (n=150). The experimental intervention comprised approximately 30 hours of theoretical learning through the Vidyanta App followed by three days of hands-on simulation-based training. Infusion-practice competency was assessed before and after training using a structured 12-domain assessment with a maximum score of 110. **Results:** The study reported mean competency scores of 62.4 ± 8.7 to 86.8 ± 6.1 in the experimental group and 61.9 ± 9.1 to 70.3 ± 8.4 in the control group. Competency achievement was reported to increase from 32.0% to 91.3% in the experimental group and from 30.7% to 62.7% in the control group. **Conclusion:** Nurses receiving blended digital and simulation-based training demonstrated greater improvement in assessed infusion-practice competency than those receiving conventional training. The findings are limited to assessed competency and do not establish long-term retention, bedside performance, or patient outcomes.

Keywords:
Infusion nursing, Blended learning, Simulation-based education, Nursing competency, Intravenous therapy, Vascular access.

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Introduction

Infusion therapy is an essential component of clinical care across acute and general healthcare settings. Peripheral intravenous catheters, central venous access devices, infusion pumps, intravenous medications and other infusion therapies require nurses to integrate technical skills, clinical judgment, infection-prevention practices, medication safety, device assessment and communication.

Intravascular catheter care requires consistent adherence to evidence-informed practices. The World Health Organization guidelines on peripheral and central intravascular catheters emphasize appropriate insertion, maintenance, access, aseptic technique, hand hygiene, healthcare-worker education and training, and multimodal implementation strategies. [1,2]

These requirements highlight an educational challenge: theoretical knowledge alone does not demonstrate that a nurse can

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consistently perform infusion-related procedures safely and effectively. Simulation-based education provides opportunities for demonstration, deliberate practice, feedback, error correction and repeated performance. Recent evidence supports simulation as an approach for developing nursing knowledge, clinical skills and competence, although heterogeneity in interventions, and assessment methods remains. [3-5]

Blended learning can complement simulation by allowing foundational theoretical learning to occur through flexible digital formats before face-to-face skills practice. A 2025 systematic review of 54 studies found multidimensional educational benefits of blended learning in nursing education while identifying continuing gaps in the quality and standardization of evidence. [6] An umbrella review published in 2025 similarly noted beneficial effects but highlighted limitations in methodological quality and standardized outcome evaluation. [7]

Infusion-specific evidence also demonstrates the use of technology-enhanced and blended approaches. Keleekai et al. reported improved knowledge, confidence and peripheral intravenous catheter insertion skills among nurses following a simulation-based blended learning programme.[8] Wu et al. evaluated patient simulators combined with Internet-based and scenario-simulation teaching for intravenous infusion nursing and reported improvements across several educational and practical outcomes.[9] A systematic review of virtual-reality intravenous injection training identified variation in outcome measures and limited evaluation beyond immediate learning outcomes.[10] Recent studies have also examined 3D virtual reality for peripheral intravenous catheterization and mixed-reality training for intravenous infusion pump assembly, primarily among nursing students. [11,12]

Despite this growing evidence, existing studies have frequently focused on nursing students, individual infusion-related procedures, or specific technologies such as virtual or mixed reality. Evidence remains comparatively limited regarding a structured digital learning programme combined with hands-on simulation for comprehensive, multi-domain infusion-practice competency among practicing nurses, particularly when compared with conventional training. The present study addresses this gap by evaluating a structured digital-plus-simulation programme among nurses working in hospitals in the Delhi-NCR region.

For this study, infusion-practice competency is defined as the nurse's demonstrated ability to perform the knowledge, procedural, safety, complication-recognition, and communication activities required for safe intravenous infusion practice according to the study assessment. It encompasses 12 domains: hand hygiene and infection prevention; aseptic technique; patient identification and preparation; IV equipment preparation; peripheral IV catheter management; infusion administration; infusion-pump operation; vascular-access assessment; medication safety; identification of complications; management of infiltration/extravasation; and documentation and communication.

Objectives

Primary objective

To evaluate the effectiveness of a structured blended digital learning and hands-on simulation programme in improving overall infusion-practice competency among nurses compared with conventional training.

Secondary objectives

1. To compare pre-training and post-training overall infusion-practice competency scores within and between the blended-training and conventional-training groups.
2. To compare the magnitude of improvement in overall infusion-practice competency between the two groups.
3. To compare the proportion of nurses achieving the study-defined competency threshold following training between the two groups.
4. To compare post-training performance across the 12 domains of infusion-practice competency between the two groups.
5. To estimate the effect size of the intervention on overall post-training competency and change in competency scores.

Research Hypothesis

Null hypothesis: There is no statistically significant difference in change in assessed infusion-practice competency between nurses receiving blended digital and simulation-based training and nurses receiving conventional training.

Alternative hypothesis: Nurses receiving blended digital and simulation-based training demonstrate greater improvement in assessed infusion-practice competency than nurses receiving conventional training.

Materials and Methods

Study design

A comparative interventional study was designed to compare a blended digital and simulation-based training programme with conventional training. The available study record does not document the allocation mechanism; therefore, the study is described as a comparative interventional study without assigning a randomized design.

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Study setting

The study was conducted among nurses working in selected hospitals in the Delhi-NCR region. The hands-on component was conducted in hospital-based training environments supported by the Vidyanta Medical Simulation Center. The number and type of participating hospitals are not specified in the source manuscript.

Participants and allocation

A total of 300 nurses were included, with 150 participants in the experimental group and 150 in the control group. The available study record did not report the recruitment procedure, inclusion and exclusion criteria, or allocation process.

Intervention

The experimental group received a structured blended learning programme consisting of two sequential components.

Digital learning

Participants completed approximately 30 hours of theoretical learning through the Vidyanta App. The curriculum covered principles of infusion therapy; vascular access; peripheral IV catheter care; central venous access; hand hygiene; aseptic technique; infection prevention; medication safety; infusion equipment; infusion pumps; line assessment; catheter maintenance; infiltration; extravasation; occlusion and complications; documentation; patient safety; and patient education.

Hands-on simulation

After the digital component, participants attended three days of hands-on simulation-based training. The practical programme included demonstration, guided practice, deliberate practice, scenario-based learning, clinical decision-making, error identification, faculty feedback, repeat performance, and competency assessment.

Control group

The control group consisted of 150 nurses who received conventional/standard training through their respective institutions. The available study record did not report the exact content, duration, faculty, or delivery mode of the control intervention.

Competency assessment

Infusion-practice competency was assessed using a structured assessment comprising 12 domains with a maximum score of 110 points.

Assessment domain	Maximum score
Hand hygiene and infection prevention	10
Aseptic technique	10
Patient identification and preparation	5
IV equipment preparation	10
Peripheral IV catheter management	10
Infusion administration	10
Infusion pump operation	10
Vascular access assessment	10
Medication safety	10
Identification of complications	10
Management of infiltration/extravasation	10
Documentation and communication	5
Total	110

The study record states that the overall score was converted to a 100-point standardized score. It also lists ≥80% as competent, 60–79% as partially competent, and <60% as not competent; however, this was labelled a 'Competency Classification'. The reported competency classification used ≥80% as competent, 60–79% as partially competent, and <60% as not competent.

The source manuscript does not identify the instrument's source/development process or provide validity, reliability, assessor-training, or assessor-blinding information.

Assessment timing and setting

The study included pre-training and post-training competency assessments. The exact interval between training and post-test, and whether the final assessment occurred in a simulation/laboratory environment or clinical practice, were not reported.

Statistical analysis

The manuscript reports group means, standard deviations, proportions, p-values, and Cohen's d values. It does not identify the statistical tests used for each comparison, statistical software/version, or 95% confidence intervals. The statistical methods available in the study record are described below the exact tests used for baseline comparisons, within-group pre/post comparisons, between-group comparison of change, categorical competency comparisons, and effect-size estimation.

Ethical considerations

The study was done in simulated environment therefore ethical approval was not obtained.

Results

Baseline characteristics

The study included 300 nurses, with 150 in the experimental group and 150 in the control group. The available study record reports 300 paticipants distributed equally between the two groups; detailed participant-flow numbers were not reported. Baseline characteristics are reported descriptively in Table 1.

Table 1: Baseline characteristics

Characteristic	Experimental (n=150)	Control (n=150)
Mean age, years ± SD	29.8 ± 5.4	30.1 ± 5.7
Female, n (%)	132 (88.0)	129 (86.0)
Male, n (%)	18 (12.0)	21 (14.0)
B.Sc. Nursing, n (%)	91 (60.7)	88 (58.7)
GNM, n (%)	59 (39.3)	62 (41.3)
Clinical experience, years ± SD	5.6 ± 3.9	5.8 ± 4.1
Previous infusion training, n (%)	72 (48.0)	70 (46.7)
ICU experience, n (%)	63 (42.0)	65 (43.3)
Previous simulation exposure, n (%)	19 (12.7)	17 (11.3)

Competency assessment

There was no statistically significant difference between the experimental and control groups at baseline (pre-test mean ± SD: 62.4±8.762.4±8.7 vs. 61.9±9.161.9±9.1, respectively; (*p=.627*), confirming that both groups were well-matched prior to the intervention. Following the training period, the experimental group demonstrated a statistically significant improvement compared to the control group (post-test mean ± SD: 86.8±6.1vs. 70.3±8.4 respectively; (*p<.001*). The experimental group achieved a substantially higher absolute change of 24.4 points compared to 8.48.points in the control group. (Table 2)

Table 2: Pre- and post-training competency assessment

Group	Pre-test mean ± SD	Post-test mean ± SD	Absolute change
Experimental (n=150)	62.4 ± 8.7	86.8 ± 6.1	24.4
Control (n=150)	61.9 ± 9.1	70.3 ± 8.4	8.4
p value;	.627	<.001	

Competency achievement

Baseline competency levels were comparable between groups (48 vs.46; *p=.790*). Post-training, a significantly higher frequency of participants in the experimental group achieved competency compared to the control group (137 vs. 94; (p<.001), demonstrating a substantially larger increase in competent individuals (Table 3)

Table 3: Competency achievement

Group	Pre-training competent	Post-training competent	Percentage-point change
Experimental (n=150)	48 (32.0%)	137 (91.3%)	59.3
Control (n=150)	46 (30.7%)	94 (62.7%)	32.0
p value;	.79	<.001	

Domain-wise post-training performance

Domain values are presented descriptively; no inferential comparison of individual domains is reported. (Table 4)

Table 4: Domain-wise post-training performance

Domain	Experimental mean %	Control mean %
Hand hygiene and infection prevention	93.2	78.4
Aseptic technique	91.8	75.1
Patient identification/preparation	94.1	82.3
Equipment preparation	89.7	72.8
Peripheral IV management	87.9	69.4
Infusion administration	90.5	73.6
Infusion pump operation	86.8	67.9
Vascular access assessment	88.4	68.7
Medication safety	89.1	71.2
Complication recognition	85.6	64.5
Infiltration/extravasation management	83.7	61.8
Documentation and communication	91.4	77.3

Discussion

The study examined whether combining digital theoretical learning with structured simulation-based practice was associated with greater improvement in assessed infusion-practice competency than conventional training. The intervention intentionally combined complementary educational components rather than relying on a single modality.

The digital component provided a structured theoretical foundation, while the simulation component focused face-to-face time on demonstration, guided practice, deliberate practice, feedback, correction, repetition, and assessment. This sequence is consistent with evidence supporting simulation as a strategy for developing clinical competence among nurses. [3]

The control group also improved in the source manuscript. This indicates that conventional education may contribute to competency development; the relevant comparison is therefore the additional improvement associated with the blended programme.

Because digital learning, simulation, deliberate practice, faculty feedback, repeated performance, and competency assessment were delivered as an integrated programme, the study cannot isolate the contribution of any individual component.

WHO guidance for peripheral and central intravascular catheters emphasizes appropriate insertion, maintenance,

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access, aseptic technique, hand hygiene, education and training, and implementation strategies. [1,2] A competency-focused educational approach may therefore provide an educational mechanism for translating knowledge into observable performance. However, assessed competency should not be equated with direct evidence of patient outcomes.

Recent systematic reviews support simulation-based learning for nursing clinical practice skills and competence, while also identifying heterogeneity in interventions, populations, assessment methods, and implementation.[3-6] The present study focuses specifically on infusion-practice competency within a blended digital-plus-simulation format.

Implications for Nursing Education

- Digital learning can provide a structured theoretical foundation before face-to-face skills practice.
- Simulation can provide opportunities for demonstration, deliberate practice, feedback, correction, and repeated performance.
- Competency assessment can make observable performance measurable rather than relying solely on attendance or knowledge testing.
- Blended programmes may support standardized theoretical content across multiple clinical sites while retaining practical simulation components.
- Competency results can help identify domains requiring additional practice.

Limitations

- Selected Delhi-NCR hospitals may limit generalizability.
- The allocation procedure is not documented; if non-randomized, selection bias may influence findings.
- Participants may have differed in previous infusion experience and training.
- Exact control-group content and duration are not documented.
- The competency instrument's validity and reliability are not documented.
- The outcome is assessed competency rather than direct patient outcomes.
- Immediate post-training assessment, if confirmed, would not establish long-term retention.
- Institutional differences may influence outcomes.
- Assessor blinding is not documented.
- The integrated intervention prevents attribution to a single component.

Future Research

- Evaluate competency retention at 3, 6, and 12 months.
- Examine translation of assessed competency into clinical performance.
- Evaluate infusion-related clinical outcomes where appropriate.
- Compare different simulation intensities and blended-learning configurations.
- Evaluate cost-effectiveness across hospital settings.
- Use validated competency instruments with transparent psychometric evidence.
- Use randomized or stronger quasi-experimental designs where feasible.

Conclusion

The study evaluated a blended educational approach combining approximately 30 hours of digital theoretical learning with three days of structured hands-on simulation-based training for infusion nursing. The study reported greater improvement in assessed competency in the experimental group than in the conventional-training group; The conclusion is limited to the reported assessed competency findings. The conclusion is limited to assessed infusion-practice competency and does not infer long-term retention, bedside performance, or patient outcomes.

Declarations

- **Funding:** The available study record did not report external funding.
- **Conflict of interest:** The available study record did not report any competing interests.
- **Acknowledgements:** No acknowledgements were reported in the available study record.
- **Data availability:** A data-availability statement was not reported in the available study record.
- **AI-assisted writing disclosure:** This manuscript was language-edited with AI assistance; the authors remain responsible for the scientific content, interpretation and final manuscript.

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