Research Article

Practice Variation In Evidence-Based Infusion Therapy And Peripheral Intravenous Cannulation Among Nurses In A Tertiary Care Teaching Hospital: An Exploratory Cross-Sectional Study

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ABSTRACT

Background: Peripheral intravenous catheters (PIVCs) are among the most frequently used vascular access devices in hospitalized patients and are essential for administering intravenous fluids, medications, blood products, and vasoactive agents. Despite the availability of international evidence-based recommendations, variation in infusion therapy and vascular access practices persists across healthcare settings. In India, the absence of a nationally standardized vascular access framework may contribute to inconsistencies in medication administration, catheter maintenance, flushing practices, and the management of difficult intravenous access.
Objectives: To evaluate variation in evidence-informed infusion therapy and peripheral intravenous catheter practices among nurses and to examine professional and workplace factors associated with adherence to selected evidence-based infusion practices.
Methods: An exploratory cross-sectional questionnaire-based study was conducted among 186 registered nurses working in inpatient wards, intensive care units (ICUs), operating theatres (OTs), and emergency medical services (EMS) at a tertiary care teaching hospital in South India between August and November 2024. A structured 24-item questionnaire assessed vascular access assessment, medication administration safety, catheter maintenance, flushing practices, patient education, and professional confidence and stress perception. An exploratory Evidence-Based Infusion Practice Adherence Indicator (EBIPAI; range 0–10) was developed to summarize adherence to selected evidence-informed infusion practices. Descriptive statistics, chi-square tests, and multivariable logistic regression were used for analysis.
Results: The mean EBIPAI score was 7.05 ± 1.31. Most participants (58.6%) demonstrated moderate adherence, while 39.2% demonstrated good adherence to evidence-informed infusion practices. Considerable variation was observed in the safety of medication administration and in catheter maintenance practices. Only 47.8% correctly identified recommended Piperacillin–Tazobactam dilution practices, 55.9% recognized complications associated with prolonged peripheral administration of dextrose-containing solutions, and 19.4% reported using recommended flush volumes. Although 90.3% reported flushing after medication administration, substantial variability was observed in flushing frequency and volume. Clinical experience of more than 5 years was independently associated with good adherence to evidence-informed infusion practices (adjusted odds ratio [AOR], 2.06; 95% confidence interval [CI], 1.11–3.82; p = 0.023).
Conclusion: Substantial variation exists in infusion therapy and peripheral intravenous catheter practices among nurses, particularly in medication administration safety, flushing behaviours, and catheter maintenance. The findings highlight important evidence–practice gaps and support the need for standardized institutional protocols, competency-based education, audit-feedback mechanisms, and development of a national vascular access framework to improve infusion safety and practice consistency.

Keywords: Peripheral intravenous catheter; infusion therapy; vascular access; practice variation; medication safety; nursing practice; patient safety.

INTRODUCTION

Peripheral intravenous catheters (PIVCs) are the most commonly used vascular access devices in healthcare and are indispensable for the administration of intravenous fluids, medications, blood products, and vasoactive agents. Approximately 70–90% of hospitalized patients require peripheral intravenous access during their hospital stay, making infusion therapy one of the most frequently performed clinical procedures worldwide.[1–3]

Despite their widespread use, PIVCs are associated with a high incidence of complications, including infiltration, occlusion, thrombophlebitis, extravasation, accidental dislodgement, and catheter-related infections. These complications may result in treatment delays, repeated cannulation, increased healthcare costs, prolonged hospitalization, and adverse patient outcomes.[2–6]

Safe infusion therapy extends beyond successful catheter insertion and requires evidence-informed practices throughout the catheter lifecycle. These include appropriate vascular assessment, vascular access device selection, medication preparation and dilution, flushing and maintenance, catheter securement, patency assessment, timely management of difficult intravenous access (DIVA), early recognition of complications, and patient education.[5–11] To support these practices, several organizations, including the Infusion Nurses Society (INS), the Centers for Disease Control and Prevention (CDC), the Association for Vascular Access (AVA), and the Vessel Health and Preservation (VHP) framework, have published comprehensive recommendations for vascular access management and infusion therapy.[6–10] Recent reviews have further reinforced the importance of adopting standardized vascular access practices to preserve vessel health, reduce catheter failure, minimize complications, and improve patient outcomes.[11]

Despite the availability of international guidelines, adherence to recommended infusion therapy practices remains inconsistent across healthcare settings. Previous studies have reported considerable variation in medication dilution, flushing techniques, catheter maintenance, vascular access device selection, and complication prevention, contributing to catheter occlusion, thrombophlebitis, premature device failure, and avoidable patient harm.[11–13] Emerging evidence also suggests that environmental factors, including climate-related changes affecting temperature and humidity, may influence cannulation success, vascular access device performance, and infusion safety, further emphasizing the need for standardized vascular access practices.[14]

These challenges are particularly relevant in India, where no nationally endorsed vascular access framework or standardized guideline for peripheral intravenous catheter management currently exists.[15] Although internationally accepted recommendations are available, their implementation varies considerably among healthcare institutions because of differences in organizational policies, resource availability, workforce training, and local clinical practices. Consequently, infusion therapy practices are often influenced by institutional protocols and individual clinical experience rather than a unified national standard. Recent literature has highlighted the need for a coordinated national strategy that incorporates evidence-based vascular access practices, competency-based education, difficult intravenous access management, vascular access teams, infusion safety, and continuous quality improvement across Indian healthcare settings.[15,16]

Nurses play a pivotal role in infusion therapy, as they are primarily responsible for peripheral intravenous catheter insertion, medication administration, catheter maintenance, complication surveillance, and patient education. Therefore, understanding current nursing practices is essential for identifying evidence-to-practice gaps and informing targeted quality improvement initiatives. Although previous studies have evaluated nurses' knowledge and practices regarding peripheral intravenous catheter care [17,18], evidence describing variation in infusion therapy and PIVC practices among nurses in Indian tertiary care hospitals remains limited. Therefore, this exploratory cross-sectional study was undertaken to evaluate variation in infusion therapy and peripheral intravenous catheter practices among nurses and to examine professional and workplace factors associated with adherence to recommended vascular access practices.

METHODS

Study Design and Reporting

An exploratory cross-sectional survey was conducted between August and November 2024 to evaluate variation in evidence-informed infusion therapy and peripheral intravenous catheter (PIVC) practices among nurses working in a tertiary care teaching hospital. The study was designed to assess current infusion therapy practices and explore professional and workplace factors associated with adherence to selected evidence-based infusion practices.

Study Setting

The study was conducted at a tertiary care teaching hospital in Puducherry. The institution provides comprehensive healthcare services, including inpatient, outpatient, emergency, perioperative, and critical care services, to adult and pediatric populations.

The hospital has an established anaesthesiologist-led vascular access team that provides support for difficult intravenous access, ultrasound-guided vascular access, and advanced vascular access procedures. However, routine peripheral intravenous cannulation, infusion therapy administration, catheter maintenance, and

monitoring remain primarily the responsibility of bedside nurses working in wards, intensive care units (ICUs), operating theatres (OTs), and emergency medical services (EMS).

Study Population and Sampling

The study population comprised registered staff nurses involved in peripheral intravenous cannulation and infusion therapy practices across clinical departments. A census sampling approach was adopted, and all eligible nurses available during the study period were invited to participate.

Inclusion criteria were that participants be registered nurses involved in direct patient care and routine infusion therapy practices. Nurses in administrative positions without direct clinical responsibilities and incomplete questionnaire responses were excluded. A total of 198 eligible nurses were approached; 186 completed the questionnaire, yielding a response rate of 93.9%.

Questionnaire Development

A structured questionnaire was developed following an extensive review of contemporary literature and evidence-based vascular access recommendations, including the Infusion Nurses Society (INS) Infusion Therapy Standards of Practice, Centers for Disease Control and Prevention (CDC) guidelines for prevention of intravascular catheter-related infections, Vessel Health and Preservation (VHP) principles, and published literature related to infusion safety, difficult intravenous access, medication administration, catheter maintenance, and vascular access complications.[6,7,17]

Questionnaire development followed a systematic process involving identification of relevant domains, item generation, expert review, pilot testing, and refinement. Survey domains were selected based on areas commonly associated with infusion-related complications, patient safety, and vascular access quality indicators. Questionnaire design was informed by established principles of survey development and validation described in healthcare research literature.

The final questionnaire consisted of 24 items distributed across six domains:

1. Demographic and professional characteristics
2. Vascular access assessment and escalation behaviour
3. Medication administration safety
4. Catheter maintenance and flushing practices
5. Patient education practices
6. Professional confidence and stress perception

Questionnaire Validation and Pilot Testing

Face and content validity were established through expert review involving faculty members from anaesthesiology and nursing with expertise in vascular access, infusion therapy, and clinical education. Experts assessed the questionnaire for clarity, relevance, comprehensiveness, and alignment with contemporary evidence-based infusion therapy recommendations. Revisions were made based on expert feedback to improve wording, response options, and contextual applicability.

Pilot testing was subsequently conducted among ten nurses who were not included in the final study sample. Pilot testing evaluated comprehensibility, feasibility, question interpretation, and completion time. Minor modifications were incorporated before final administration. Face and content validation were considered appropriate for this exploratory institutional assessment instrument. Formal construct validity, criterion validity, and psychometric reliability testing were not undertaken because the questionnaire was intended to assess current practice variation rather than function as a standardized competency measurement tool.

Data Collection

Data were collected using a self-administered electronic questionnaire distributed through Google Forms. Participation was voluntary. Before participation, nurses received information regarding study objectives, confidentiality, anonymity, and voluntary participation. Electronic informed consent was obtained from all participants before completing the questionnaire. No personally identifiable information was collected. Responses were anonymized and stored securely for analysis.

Evidence-Based Infusion Practice Adherence Indicator (EBIPAI)

To summarize adherence to selected evidence-informed infusion therapy practices, an exploratory Evidence-Based Infusion Practice Adherence Indicator (EBIPAI) was developed. The indicator was based on ten practice-related variables derived from international infusion therapy recommendations and vascular access standards.[6,7,17]

The indicator included:

i. Recognition of difficult intravenous access
ii. Appropriate Piperacillin–Tazobactam dilution
iii. Appropriate vasopressor administration route

iv. Recognition of dextrose-related infusion risks
v. Identification of medications unsuitable for prolonged peripheral administration
vi. Appropriate patency assessment practices
vii. Flushing after medication administration
viii. Appropriate flush volume selection
ix. Appropriate flushing frequency
x. Appropriate escalation following failed cannulation attempts

Each evidence-informed response was assigned a score of 1, and each non-adherent response a score of 0, resulting in a total score ranging from 0 to 10.

For descriptive interpretation, participants were categorized as:

• Poor adherence (0–4)
• Moderate adherence (5–7)
• Good adherence (8–10)

The EBIPAI was developed solely as an exploratory adherence indicator for institutional assessment and should not be interpreted as a validated psychometric or competency assessment instrument.

Ethical Considerations

As this study was exploratory in nature and did not involve the collection of identifiable personal data or any intervention involving human participants, formal approval from the Institutional Ethics Committee was not sought. The study was conducted in accordance with the principles of the Declaration of Helsinki. Participation was voluntary, informed consent was obtained from all participants, and confidentiality and anonymity were maintained throughout the study.

Statistical Analysis

Data were analysed using IBM SPSS Statistics version 26.0. Continuous variables were summarized using means and standard deviations, while categorical variables were presented as frequencies and percentages.

Associations between participant characteristics and EBIPAI adherence categories were assessed using Chi-square tests. Variables considered clinically relevant a priori, including educational qualification, clinical experience, workplace area, training modality, confidence level, and stress level, were entered into multivariable logistic regression analysis to identify factors associated with good adherence to evidence-informed infusion practices.

For regression analysis, participants with good adherence (EBIPAI score 8–10) were coded as 1, and those with poor or moderate adherence (EBIPAI score 0–7) as 0. Adjusted odds ratios (AORs) with 95% confidence intervals (CIs) were reported.

Model calibration was assessed using the Hosmer–Lemeshow goodness-of-fit test, and explanatory power was evaluated using Nagelkerke R^2 statistics. Incomplete questionnaires were excluded prior to analysis; therefore, no imputation procedures for missing data were required. A two-sided p-value of <0.05 was considered statistically significant.

RESULTS

Participant Characteristics

A total of 186 registered nurses participated in the study, resulting in a response rate of 93.9%. Most participants were female (91.9%), and the largest age group was 25–30 years (36.0%), followed by 30–40 years (35.0%). The majority held a Bachelor of Science in Nursing qualification (83.3%). Regarding professional experience, 35.5% reported 5–10 years of clinical experience, while 14.5% reported more than 10 years.

Participants represented a broad range of clinical settings, including inpatient wards (43.5%), intensive care units (27.4%), operating theatres (27.4%), and emergency medical services (1.6%). Hands-on training was the most frequently reported form of vascular access education (70.4%), whereas only 20.4% reported exposure to simulation-based training (Table 1).

Table 1. Demographic and professional characteristics of participants (N = 186)

Variable	Category	n (%)
Age group	21–25 years	26 (14.0)
	25–30 years	67 (36.0)
	30–40 years	65 (35.0)
	>40 years	28 (15.0)
Gender	Female	171 (91.9)

	Male	14 (7.5)
	Transgender	1 (0.5)
Qualification	B.Sc. Nursing	155 (83.3)
	DGNM	21 (11.3)
	Post B.Sc. Nursing	10 (5.4)
Clinical experience	<1 year	25 (13.4)
	1–3 years	36 (19.4)
	3–5 years	32 (17.2)
	5–10 years	66 (35.5)
	>10 years	27 (14.5)
Work area	Inpatient ward	81 (43.5)
	ICU	51 (27.4)
	OT	51 (27.4)
	Casualty/EMS	3 (1.6)
Training Modality	Hands-on training	131 (70.4)
	Simulation-based training	38 (20.4)
	Lectures	12 (6.5)
	Online courses	5 (2.7)

Domain 1: Vascular Access Assessment and Escalation Behaviour

Most participants (85.5%) correctly identified obesity, poor venous visibility, and difficult veins as indicators of difficult intravenous access. However, substantial variation was observed in escalation practices following failed cannulation attempts.

Following an unsuccessful cannulation attempt, 36.0% of nurses reported changing the cannulation site, 27.4% attempted one or two additional cannulations before escalation, 20.4% preferred a smaller-gauge cannula, and only 16.1% reported immediate referral to the vascular access team.

Variation was also observed regarding when assistance was sought. While 41.4% reported seeking help after one failed attempt, 30.1% escalated only after two or three failed attempts, and 28.5% sought assistance only in selected difficult cases (Table 2).

Table 2. Vascular Access Assessment, Escalation Behaviour, Medication Administration Safety, and Patient Education Practices (N = 186)

Variable	Response	n (%)
Recognition of Difficult IV Access	Small/deep veins, obesity, poor visibility	159 (85.5)
	Previous failed attempts	11 (5.9)
	Difficulty reported by colleague	9 (4.8)
	No anticipated difficulty	7 (3.8)
Response Following Failed Cannulation	Change insertion site	67 (36.0)
	Retry 1–2 additional attempts	51 (27.4)
	Use smaller-gauge cannula	38 (20.4)
	Contact vascular access team	30 (16.1)
When Assistance is Sought	After one failed attempt	77 (41.4)
	After 2–3 failed attempts	56 (30.1)
	Only in difficult cases	53 (28.5)
Piperacillin–Tazobactam Dilution	Correct	89 (47.8)
	Incorrect	97 (52.2)
Vasopressor Administration Route	Correct	128 (68.8)
	Incorrect	58 (31.2)
Recognition of Dextrose-related Risk	Correct	104 (55.9)
	Incorrect	82 (44.1)
Identification of Unsuitable Drugs for Peripheral Administration	Correct	117 (62.9)
	Incorrect	69 (37.1)

Provides Patient Education	Yes	158 (84.9)
	No	28 (15.1)

Domain 2: Medication Administration Safety

Marked variation was observed in medication administration practices.

Only 47.8% of participants correctly identified recommended Piperacillin–Tazobactam dilution practices, while 52.2% reported incorrect responses. Similarly, only 55.9% correctly identified complications associated with prolonged peripheral administration of dextrose-containing solutions.

Appropriate vasopressor administration routes were correctly identified by 68.8% of participants. Additionally, only 62.9% correctly identified medications unsuitable for prolonged peripheral intravenous administration (Table 2).

These findings demonstrate important variation in medication preparation and infusion safety practices despite the availability of international evidence-based recommendations.

Domain 3: Catheter Maintenance and Flushing Practices

Considerable variation was observed in catheter maintenance behaviours and flushing practices.

Approximately half of the participants (50.5%) reported assessing catheter patency once per shift, whereas 41.9% reported assessing patency before and after medication administration. A small proportion reported hourly assessment (6.5%) or assessment every 24 hours (1.1%).

Although most nurses (90.3%) reported flushing after medication administration, variability existed regarding flushing frequency and flush volume selection. Most participants (70.4%) reported flushing before and after medication administration.

Only 19.4% reported using the recommended flush volume of 5–10 mL, whereas 66.7% reported using smaller flush volumes of 2–5 mL. A small proportion reported using 1 mL (4.3%) or volumes greater than 20 mL (2.2%), while 7.5% reported not performing flushing practices routinely (Table 3).

Table 3. Cannulation Performance, Catheter Maintenance, and Flushing Practices (N = 186)

Variable	Response	n (%)
Successful Cannulation Attempts	Single attempt	60 (32.3)
	1–2 attempts	79 (42.5)
	>2 attempts	47 (25.3)
Preferred Source of Help After Failed Cannulation	Senior nursing staff	92 (49.5)
	Vascular access team	58 (31.2)
	Consultant physician	28 (15.1)
	Colleague	8 (4.3)
Patency Assessment Frequency	Once per shift	94 (50.5)
	Before and after medication administration	78 (41.9)
	Every hour	12 (6.5)
	Every 24 hours	2 (1.1)
Flushes After Medication Administration	Yes	168 (90.3)
	No	18 (9.7)
Flushing Frequency	Before and after medication administration	131 (70.4)
	Every 8 hours	44 (23.7)
	Every 4 hours	11 (5.9)
Flush Volume Used	1 mL	8 (4.3)
	2–5 mL	124 (66.7)
	5–10 mL	36 (19.4)
	>20 mL	4 (2.2)
	No flushing	14 (7.5)

Domain 4: Patient Education Practices

Most participants (84.9%) reported routinely providing patient education regarding intravenous cannulation, infusion therapy, and monitoring for complications. However, 15.1% reported that patient education was not routinely performed as part of infusion therapy care (Table 2).

Domain 5: Professional Confidence

Participants generally reported favourable confidence levels regarding intravenous cannulation and infusion-related procedures.

The mean confidence score was 7.32 ± 2.67. More than half of participants (58.1%) demonstrated high confidence, while 22.6% reported moderate confidence and 16.1% reported low confidence (Table 4).

Domain 6: Professional Stress Perception

The mean stress score was 4.29 ± 2.25.

More than half of participants (51.6%) reported low stress levels during intravenous cannulation and infusion-related procedures. Moderate stress levels were reported by 36.0%, while only 10.8% reported high stress levels (Table 4).

Evidence-Based Infusion Practice Adherence Indicator (EBIPAI)

The mean Evidence-Based Infusion Practice Adherence Indicator (EBIPAI) score was 7.05 ± 1.31.

Most participants demonstrated moderate adherence to selected evidence-informed infusion practices (58.6%), whereas 39.2% demonstrated good adherence. Only four participants (2.2%) were categorized as having poor adherence.

The mean knowledge score was 3.13 ± 1.28 (Table 4).

Table 4. Knowledge, Professional Confidence, Stress Perception, and Evidence-Based Infusion Practice Adherence Indicator (EBIPAI)

Variable	Category	n (%)	Mean ± SD
Knowledge Score	Low (0–1)	14 (7.5)	
	Moderate (2–4)	144 (77.4)	
	High (5–6)	28 (15.1)	**3.13 ± 1.28**
Professional Confidence	Low	30 (16.1)	
	Moderate	42 (22.6)	
	High	108 (58.1)	**7.32 ± 2.67**
Stress Perception	Low	96 (51.6)	
	Moderate	67 (36.0)	
	High	20 (10.8)	**4.29 ± 2.25**
EBIPAI	Poor Adherence (0–4)	4 (2.2)	
	Moderate Adherence (5–7)	109 (58.6)	
	Good Adherence (8–10)	73 (39.2)	**7.05 ± 1.31**

Factors Associated with Evidence-Informed Infusion Practice Adherence

The distribution of EBIPAI adherence categories according to participant characteristics is presented in Table 5. Nurses with greater clinical experience demonstrated higher proportions of good adherence. Good adherence was observed in 20.0% of nurses with less than 1 year of experience, compared with 55.6% of nurses with more than 10 years of experience.

Differences were also observed across workplace settings. Nurses working in intensive care units demonstrated the highest proportion of good adherence (58.8%), followed by inpatient wards (35.8%) and operating theatres (25.5%).

Chi-square analysis demonstrated a statistically significant association between workplace area and EBIPAI adherence category ($\chi^2 = 28.354$, $p < 0.001$). No statistically significant associations were observed for educational qualification, training modality, confidence level, or stress level (Table 5).

Table 5. Evidence-Based Infusion Practice Adherence Categories According to Nurse-Related Characteristics

Variable	Category	Poor n (%)	Moderate n (%)	Good n (%)	χ^2	p-value
Qualification	B.Sc. Nursing	3 (1.9)	89 (57.4)	63 (40.6)	6.733	0.151
	DGNM	0 (0.0)	16 (76.2)	5 (23.8)		

	Post B.Sc. Nursing	1 (10.0)	4 (40.0)	5 (50.0)		
Clinical Experience	<1 year	1 (4.0)	19 (76.0)	5 (20.0)	8.790	0.360
	1–3 years	1 (2.8)	23 (63.9)	12 (33.3)		
	3–5 years	1 (3.1)	19 (59.4)	12 (37.5)		
	5–10 years	1 (1.5)	36 (54.5)	29 (43.9)		
	>10 years	0 (0.0)	12 (44.4)	15 (55.6)		
Work Area	Ward	2 (2.5)	50 (61.7)	29 (35.8)	28.354	<0.001*
	ICU	1 (2.0)	20 (39.2)	30 (58.8)		
	OT	0 (0.0)	38 (74.5)	13 (25.5)		
	EMS	1 (33.3)	1 (33.3)	1 (33.3)		
Training Type	Hands-on	4 (3.1)	75 (57.3)	52 (39.7)	2.452	0.653
	Simulation-based	0 (0.0)	20 (52.6)	18 (47.4)		
	Lectures	0 (0.0)	10 (83.3)	2 (16.7)		
	Online Courses	0 (0.0)	4 (80.0)	1 (20.0)		

Factors Associated with Good Infusion Practice Adherence

Multivariable logistic regression analysis was performed to explore factors associated with good adherence to evidence-informed infusion practices.

After adjustment for potential confounders, clinical experience greater than 5 years remained independently associated with good adherence (adjusted odds ratio [AOR], 2.06; 95% confidence interval [CI], 1.11–3.82; p = 0.023).

Although ICU or OT posting (AOR 1.39, 95% CI 0.76–2.55), simulation-based training exposure (AOR 1.29, 95% CI 0.62–2.68), and higher confidence levels (AOR 0.88, 95% CI 0.47–1.66) demonstrated positive associations with adherence, these relationships did not reach statistical significance.

Stress level was not significantly associated with adherence to evidence-informed infusion practices (AOR 1.04, 95% CI 0.39–2.73; p = 0.944).

The final model demonstrated acceptable calibration (Hosmer–Lemeshow goodness-of-fit p = 0.705). However, explanatory power remained modest (Nagelkerke R^2 = 0.048), suggesting that additional unmeasured factors may contribute to variation in infusion therapy practices (Table 6).

Table 6. Multivariable Logistic Regression Analysis of Factors Associated with Good Evidence-Informed Infusion Practice Adherence

Predictor	Adjusted OR (AOR)	95% CI	p-value
Clinical experience >5 years	2.06	1.11–3.82	0.023*
ICU/OT posting	1.39	0.76–2.55	0.291
Simulation-based training exposure	1.29	0.62–2.68	0.504
High confidence level	0.88	0.47–1.66	0.704
High stress level	1.04	0.39–2.73	0.944
Model Performance			
Statistic	**Value**		
Hosmer–Lemeshow goodness-of-fit (p)	0.705		
Nagelkerke R^2	0.048		

***Statistically significant at p<0.05.**

DISCUSSION

This exploratory cross-sectional study evaluated variation in infusion therapy and peripheral intravenous catheter (PIVC) practices among nurses working in a tertiary care teaching hospital. Although most participants demonstrated moderate adherence to recommended infusion therapy practices, substantial variation was identified across several domains, including medication administration safety, drug dilution, flushing practices, catheter maintenance, patency assessment, and management of difficult intravenous access (DIVA). Clinical experience of more than five years was independently associated with better adherence to recommended practices, suggesting that professional experience may influence infusion therapy competence.

One of the most important findings was the variability in medication administration and drug dilution practices. Less than half of the participants correctly identified the recommended dilution of piperacillin–tazobactam, while many were unable to recognize medications unsuitable for prolonged peripheral administration or the risks associated with prolonged infusion of dextrose-containing solutions. These findings are clinically important because inappropriate medication preparation and administration can increase the risk of chemical phlebitis, infiltration, extravasation, vascular irritation, and premature catheter failure. The Infusion Nurses Society (INS) Standards of Practice emphasize that medication preparation, dilution, compatibility assessment, infusion rate, and vascular access device selection should be individualized according to drug characteristics and patient factors to minimize infusion-related complications and improve patient safety.[6] Similarly, the Michigan Appropriateness Guide for Intravenous Catheters (MAGIC) recommends selecting the most appropriate vascular access device based on the prescribed therapy, expected duration of treatment, and characteristics of the infusate to reduce catheter-related complications.[5]

Considerable variation was also observed in flushing practices and catheter maintenance. Although most participants reported flushing the catheter after medication administration, only a minority used the recommended flush volume. Flushing is a fundamental component of catheter maintenance because it preserves catheter patency, prevents medication residue and incompatibility, and reduces the risk of catheter occlusion.[6] Keogh et al. demonstrated considerable variation in flushing frequency and techniques among healthcare professionals and reported an association between suboptimal flushing practices and peripheral intravenous catheter failure.[12] Likewise, the recent integrative review by Corley et al. identified inconsistent flushing, inadequate catheter maintenance, and failure to follow standardized protocols as important contributors to PIVC complications and avoidable catheter failure.[13] The present findings therefore support the need for standardized flushing protocols, competency assessment, and regular reinforcement of best practices.

Variation was also evident in the recognition and management of difficult intravenous access. Although most participants correctly identified common risk factors for DIVA, there was considerable variation regarding the appropriate timing for escalation following unsuccessful cannulation attempts. Early identification of patients with DIVA and prompt escalation to experienced clinicians or ultrasound-guided vascular access are key recommendations of the Vessel Health and Preservation (VHP) framework and have been associated with improved first-attempt success, reduced vessel trauma, fewer insertion attempts, and better patient experience.[9,10] Delayed escalation following repeated failed attempts may compromise vessel preservation, delay treatment, and increase patient discomfort. These findings highlight the importance of implementing structured DIVA assessment tools and clearly defined escalation pathways within routine nursing practice.

An important observation was that practice variation persisted despite the presence of an established anaesthesiologist-led vascular access team. Specialist vascular access teams have consistently been associated with improved insertion success, fewer complications, and better vascular access outcomes.[8] However, the present findings suggest that specialist services alone are insufficient to ensure uniform adherence to recommended infusion therapy practices among frontline nurses. Sustainable improvement requires integration of vascular access teams with ongoing staff education, competency-based training, clinical mentorship, and routine audit of infusion practices. Similar conclusions were drawn in a recent narrative review, which emphasized that successful vascular access programs depend on multidisciplinary collaboration, standardized institutional policies, and continuous professional development in addition to specialist expertise.[11]

The findings should also be considered within the broader context of vascular access practice in India. Although international standards provide comprehensive guidance for infusion therapy, India currently lacks a nationally endorsed vascular access framework or standardized guideline for peripheral intravenous catheter management.[15] Consequently, practice varies across institutions depending on local policies, available resources, and workforce training. A recent review of vascular access practice in India highlighted deficiencies in standardized infusion protocols, competency assessment, DIVA pathways, and quality monitoring, and called for the development of a coordinated national vascular access strategy.[11] The variation observed in the present study likely reflects not only individual differences in knowledge and experience but also broader organizational and system-level factors influencing implementation of best practices.

Clinical experience exceeding five years was independently associated with better adherence to recommended infusion therapy practices. This finding is consistent with previous studies demonstrating that increasing clinical experience is associated with greater procedural confidence, improved decision-making, and enhanced competence in peripheral intravenous catheter management.[18,19] Nevertheless, experience alone cannot ensure consistent adherence to current recommendations because infusion therapy standards continue to evolve. Structured continuing education, competency-based assessment, simulation-supported training, and periodic updates based on contemporary guidelines remain essential to maintain high-quality practice across all levels of professional experience. Patient-reported experience measures should also be considered in vascular access.(20)
The relatively modest explanatory power of the regression model indicates that additional organizational and behavioural factors may contribute to practice variation. Staffing levels, workload, institutional culture, access to continuing professional education, availability of clinical protocols, leadership support, and exposure to vascular access specialists may all influence adherence to recommended practices. Future multicentre studies should examine these determinants to better understand barriers and facilitators to implementing evidence-informed infusion therapy.
The findings have several practical implications. Institutions should strengthen competency-based education focusing on medication administration safety, drug dilution, flushing practices, catheter maintenance, and DIVA management. Simulation-based vascular access training, regular audit and feedback, standardized infusion protocols, and closer collaboration between vascular access teams and bedside nurses may improve adherence to recommended practices and reduce unnecessary variation. At a national level, the findings further support the development of standardized vascular access guidelines for India to promote consistent practice, improve patient safety, and strengthen quality assurance across healthcare settings.(15)

Strengths

This study evaluated multiple dimensions of infusion therapy practice, including vascular access assessment, medication administration safety, catheter maintenance, flushing behaviours, patient education practices, professional confidence, and stress perception. The inclusion of nurses from diverse clinical environments and the high response rate enhanced the representativeness of findings within the study institution. Furthermore, the study examined practice variation rather than knowledge alone, providing insights into real-world infusion therapy behaviours that are directly relevant to vascular access quality and patient safety.

Limitations

Several limitations should be acknowledged. First, infusion therapy practices were assessed using self-reported responses rather than direct observation and may therefore be subject to recall and social desirability biases. Second, the study was conducted at a single tertiary care teaching hospital, limiting generalizability to other healthcare settings. Third, the questionnaire and Evidence-Based Infusion Practice Adherence Indicator (EBIPAI) were developed as exploratory institutional assessment tools and were not intended as validated psychometric instruments. Formal construct validity, criterion validity, and reliability testing were not performed. Fourth, the regression model demonstrated limited explanatory power, indicating that additional factors influencing infusion therapy practices were not captured. Finally, the cross-sectional design precludes causal inference.
Despite these limitations, the study provides important baseline data on variation in infusion therapy and PIVC practices among nurses and highlights several opportunities to strengthen vascular access quality, infusion safety, and the implementation of evidence-based practice.

CONCLUSION

This exploratory cross-sectional study identified considerable variation in infusion therapy and peripheral intravenous catheter (PIVC) practices among nurses in a tertiary care teaching hospital, highlighting important evidence–practice gaps in medication administration, drug dilution, catheter maintenance, flushing practices, and management of difficult intravenous access. Although greater clinical experience was associated with better adherence to recommended practices, variability persisted despite the presence of a vascular access team. These findings underscore the need for standardized protocols, competency-based education, simulation-supported training, and regular audits and feedback to improve infusion safety and consistency in practice. They also support the development of a nationally coordinated vascular access framework for India. Future multicentre studies incorporating direct observation and clinical outcome measures are warranted.

Declarations:

Funding:

This study received no funding.

Competing interests
The authors declare that they have no competing interests.
Ethical approval
As this study was exploratory in nature and did not involve the collection of identifiable personal data or any intervention involving human participants, formal approval from the Institutional Ethics Committee was not sought. The study was conducted in accordance with the principles of the Declaration of Helsinki. Participation was voluntary, informed consent was obtained from all participants, and confidentiality and anonymity were maintained throughout the study.
consent to participate:
Written informed consent was obtained from all participants prior to enrolment. Administrative permission was obtained from hospital authorities. Participation was voluntary, and confidentiality was maintained throughout the study.
Consent for publication:
Not applicable.
Availability of data and materials
The datasets collected during the current study are available from the corresponding author upon reasonable request. A preprint version of this manuscript is also available and has been posted with a digital object identifier. https://doi.org/10.21203/rs.3.rs-9690754/v1
Code availability:
No custom code or software was developed or used in this study. Statistical analysis was performed using IBM SPSS Statistics version 22.0.
Large language model (LLM):
No LLM tools were used in the conduct, analysis, or interpretation of this study.
Authors' contributions
AJ, HKVR, and CR conceived the study. AJ contributed to data acquisition. CR supervised. AJ, HKVR & CR performed statistical analysis. AJ & CR drafted the manuscript. All authors reviewed and approved the final manuscript.
Acknowledgements
The authors thank the study participants and the Nursing Department of Mahatma Gandhi Medical College Hospital and Research Institute.

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