GLAND SURGERY

EVALUATING THE KNOWLEDGE AND ATTITUDES OF NURSES TOWARD PICC CARE BEFORE AND AFTER SPECIALIZED TRAINING IN DAMMAM HEALTH NETWORK (DHN) IN THE KSA

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Abstract

Peripherally Inserted Central Catheters (PICC) are essential for administering long-term intravenous therapies, but their effective management depends heavily on nurses' knowledge, attitudes, and practices. Insufficient training in PICC care can lead to complications such as infections, thrombosis, and occlusions, underscoring the need for targeted educational programs. This study evaluated the impact of a specialized training program on nurses' knowledge and

attitudes toward PICC care, aiming to enhance competencies, improve patient outcomes, and reduce complications. Using a quasi-experimental pre- and post-test design, 180 registered nurses from Dammam Health Network participated in a six-session, two-week training program combining theoretical and practical components of PICC care. Pre- and post-test assessments revealed significant improvements in knowledge and attitudes ($p < 0.05$), with notable gains in understanding aseptic techniques (63.3% to 87.2%, p=0.001), flushing protocols, and infection prevention. Participants also expressed greater readiness for ongoing education, demonstrating the program's success in fostering continuous learning. The findings highlight the critical role of specialized training in enhancing nurses' clinical competency, improving patient care, and minimizing PICC-related complications, emphasizing the importance of regular, tailored educational interventions.

1 Introduction

The care of Peripherally Inserted Central Catheters (PICC) is essential for maintaining safe and effective vascular access in patients needing prolonged intravenous therapy. Proficiency in PICC care is critical for nurses, encompassing both technical abilities and a comprehensive awareness of maintenance protocols, infection prevention, and patient safety (Oliveira et al., 2023). Effective PICC management necessitates compliance with established protocols, encompassing aseptic practices, appropriate flushing and locking methods, and prompt recognition of issues such as blockage, infection, or thrombosis. Nurses must have the expertise to instruct patients on PICC management and post-discharge care, guaranteeing the continuity and safety of treatment (Jiang et al., 2022). By augmenting nurses' proficiency and assurance in administering PICC lines, healthcare organizations can markedly enhance patient outcomes and mitigate the hazards linked to vascular access (Hu et al., 2023; Fu et al., 2024).

For patients who need continuous intravenous access, PICC are crucial in today's healthcare system, especially in paediatrics, intensive care units, and oncology. In order to avoid complications like infections, thrombosis, and catheter occlusions, nurses are essential in making sure that these devices are properly maintained, cared for, and managed (Sharp et al., 2024; Bedwell et al., 2024). However, studies reveal notable differences in nurses' attitudes and understanding regarding PICC care, particularly with regard to maintaining them and preventing complications (Xu et al., 2020). Inadequate training and a lack of standardised education programs can result in subpar treatment, raising the risk of serious side effects such central line-associated bloodstream infections (CLABSI) (Muschitiello et al., 2024).

A study by de Souza et al. (2024) looked at how a specialized software called PiccPed® can help nurses learn more about PICC care and avoid negative outcomes in paediatric healthcare settings. According to the study, nurses who utilized the app showed a better comprehension of appropriate PICC maintenance procedures. These results imply that focused interventions, including digital tools, can successfully enhance patient safety and clinical procedures. Additionally, it has been demonstrated that training programs that integrate theoretical knowledge with real-world

ISSN:2227-684XE-ISSN:2227-8575

experiences improve nurses' competency, particularly in high-risk healthcare settings (Da Silva et al., 2022).

Nurses need to be well-versed in catheter management procedures since patients in intensive care units and oncology wards are more likely to experience PICC-related problems (Ramadan, 2024). The usefulness of practical training in enhancing nurses' proficiency in PICC maintenance was investigated by Da Silva et al. (2022). According to the study, nurses who participated in specialized training sessions showed enhanced practical abilities and a greater comprehension of infection control procedures than their colleagues who received standard instruction (Peng et al., 2022). Further highlighting the need of specialized training for nurses in paediatric and neonatal settings, Saltah and Abusaad (2022) observed improvements in neonatal outcomes with the establishment of a structured PICC care education program.

To guarantee the best possible outcomes for patients, regular and thorough training in PICC care is essential. Despite a high degree of awareness regarding infection prevention, many nurses lacked the practical expertise required to carry out these practices effectively, according to Muschitiello et al.'s (2024) investigation into nurses' attitudes and practices surrounding infection control and PICC maintenance. The necessity of ongoing professional development is highlighted by this disparity in practical skills. Furthermore, a study by Hu et al. (2023) demonstrated the value of institutional investment in educational resources by identifying hands-on experience, training program availability, and institutional support as critical factors in enhancing nurses' competency in handling PICCs.

Specialized instructional programs have been shown to be useful in increasing nurses' confidence and understanding of PICC care. A knowledge-based questionnaire on PICC management was created and verified by Piredda et al. (2024), who also emphasized the benefits of evidence-based training for raising nurses' self-efficacy in PICC-related tasks. The knowledge and confidence of nurses who took part in these evidence-based training significantly increased. The management of central venous devices, which is closely related to PICC care, was also found to be improved by nurses in intensive care units (ICUs) who received targeted instruction on CLABSI prevention (Chen and Feliciano, 2024).

There are still gaps in the availability and accessibility of specialized training programs in certain healthcare settings, despite the mounting evidence of its efficacy. According to a study by Xu et al. (2020), nurses in China's primary and rural healthcare facilities were less likely to participate in advanced training programs, which had an impact on their capacity to efficiently administer PICCs. This result is consistent with study by Muschitiello et al. (2024), which hypothesized that insufficient access to training materials may result in practice variances and raise the possibility of PICC management difficulties.

To sum up, PICC management and upkeep are crucial components of nursing practice, and specialized training programs are important to guarantee that nurses have the abilities and know-

ISSN:2227-684XE-ISSN:2227-8575

how to deliver safe, efficient care. Research indicates that focused educational initiatives can greatly enhance nurses' PICC care-related knowledge, attitudes, and behaviours, lowering problems and improving patient safety. Sustained expenditure on education is essential for raising the standard of treatment generally and guaranteeing the best possible results for patients, especially in high-risk healthcare settings (Da Silva et al., 2022; Saltah & Abusaad, 2022).

The purpose of this study is to assess how nurses' attitudes and knowledge regarding the care of PICC are affected by specialized training programs. It aims to evaluate how these initiatives affect patient safety and lessen PICC care-related problems. It also seeks to investigate how well various teaching strategies might enhance clinical procedures.

2 Materials and Methods

2.1 Study Area Selection

The study was conducted within the Dammam Health Network (DHN) and focused on evaluating the impact of specialized training on nurses' knowledge and attitudes toward Peripherally Inserted Central Catheter (PICC) care. The training program was innovated and delivered by the Nursing Professional Development Department (NPDD) within DHN, targeting inpatient staff nurses in medical and surgical units where PICC lines were frequently used.

2.2 Sample Collection

A purposive sampling method was used to recruit 180 inpatient registered nurses (RNs) directly involved in PICC care. The inclusion criteria required participants to have been employed in the DHN for at least six months and to be actively engaged in patient care involving PICC lines. Nurses on extended leave during the study period were excluded. Based on similar interventions in prior studies (Xu et al., 2020; de Souza et al., 2024), a sample size of 169 was determined to provide adequate statistical power. Demographic data, including age, years of experience, and education level, were collected alongside pre- and post-intervention knowledge and attitude assessments.

2.3 Isolation and Identification of Knowledge and Attitudes

Participants completed pre- and post-intervention questionnaires designed to measure knowledge and attitudes toward PICC care. The knowledge questionnaire consisted of 19 multiple-choice and true/false questions addressing topics such as insertion, maintenance, and complication management. Attitudes were assessed using a validated scale that included two components: attitudes toward PICC care and maintenance (7 questions) and perceptions of care quality (10 questions). The questionnaires were pilot-tested to ensure clarity and reliability before full implementation (Field, 2013). Data were collected in face-to-face sessions to ensure participants understood the questions and responded accurately.

2.4 Intervention and Data Collection

The intervention consisted of a specialized training program developed by NPDD and delivered over two weeks. The program was repeated six times in 2024 to cover most inpatient nurses in medical and surgical units. It comprised both theoretical and practical components, including:

1. Overview of PICC lines: indications, contraindications, and insertion techniques.
2. Maintenance and troubleshooting: preventing complications such as infections, thrombosis, and occlusion.
3. Best practices for patient safety, including hygiene protocols and adverse event monitoring.
4. Legal and ethical aspects of PICC care: documentation and patient consent.

The practical sessions included hands-on training with simulated models, supervised by experienced instructors. Demographic data and knowledge/attitude metrics were collected before the intervention (pre-test) and immediately after completion (post-test) using validated tools.

2.5 Antibiogram Study of Intervention Effectiveness

Data analysis employed descriptive and inferential statistical methods to evaluate changes in nurses' knowledge and attitudes. Paired t-tests were used to assess pre- and post-test differences, with effect sizes calculated to determine the magnitude of change (Field, 2013). Multivariate analysis was applied as needed to account for confounding factors such as age, years of experience, and educational background. Post-intervention improvements included a significant increase in knowledge of aseptic techniques (from 63.3% to 87.2%, p=0.001) and enhanced attitudes toward PICC care and maintenance.

2.6 Ethical Considerations

The study was approved by the DHN Institutional Review Board (IRB No. NUR-41, dated 08/07/2024). All participants provided informed consent and were assured of confidentiality, with data de-identified and stored securely. Participation was voluntary, and participants could withdraw at any time without repercussions. These measures ensured adherence to ethical research standards, protecting participant rights and data integrity.

Results

Part 1. Demographic data

The demographic data of the study participants indicates a significant majority of female nurses (97.2%) relative to male nurses (2.8%). The predominant age group of participants is 31 to 35 years (57.2%), with the majority possessing 11 to 15 years of nursing experience (48.3%). All participants possess the professional designation of "Staff Nurse," with no representation in senior management positions such as Nurse Manager or Supervisor Nurse. Regarding education, the majority of nurses possess a Diploma of Nursing (66.7%), but a lesser proportion hold a Bachelor's degree (30%) or further degrees. The study focuses on inpatient staff nurses from both medical

ISSN:2227-684XE-ISSN:2227-8575

and surgical departments at Dammam Health Network (DHN), with participants categorized into specific units, which are *medical* (C1, C2, D1, D2) and *surgical* (A1, A2, B1, B2) staff nurses. The distribution of nurses across these departments shows that the medical units (C1 and C2) have the highest representation, with 47 nurses (26.1%) in C1 and 43 nurses (23.9%) in C2, D1 with 17 nurses (9.4%), and D2 with 19 nurse (10.1%). Surgical departments have a relatively even distribution, with A1 having 16 nurses (8.9%), A2 with 12 nurses (6.7%), B1 with 12 nurses (6.7%), and B2 with 14 nurses (7.8%). The data indicates a higher concentration of medical nurses compared to surgical nurses, which may reflect the workload and staffing requirements of different units within the hospital. This distribution should be considered when analyzing the results, as the varying representation from each unit could influence the findings and their generalizability to different nursing specialties. By this mean, 57.8% of individuals underwent training on PICC care and maintenance, whereas 42.2% did not, highlighting a possible opportunity for additional training and instruction. The research underscores the necessity for managerial diversity and ongoing professional development for nurses.

Table 1. Demographic characters of the study participants:

		Frequency (n)	Percentage (%)
Gender	Female	175	97.2
	Male	5	2.8
Age	25 to 30	15	8.3
	31 to 35	103	57.2
	36 to 40	53	29.4
	41 to 45	9	5.0
Years of nursing experience	1 to 5	24	13.3
	6 to 10	59	32.8
	11 to 15	87	48.3
	16 and above	10	5.6
Professional titles	Staff Nurse	180	100
	Nurse Manager	0	0
	Supervisor Nurse	0	0
	Nurse Director	0	0
	Other…	0	0

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Education levels	Diploma of Nursing	120	66.7
	Bachelors Science of Nursing	54	30.0
	Postgraduate Diploma from (SCHS)	2	1.1
	Master in Nursing	4	2.2
Work settings/ Department	A1	16	8.9
	A2	12	6.7
	B1	12	6.7
	B2	14	7.8
	C1	47	26.1
	C2	43	23.9
	D1	17	9.4
	D2	19	10.1
Whether PICC care and maintenance training was obtained before?	Yes	104	57.8
	No	76	42.2

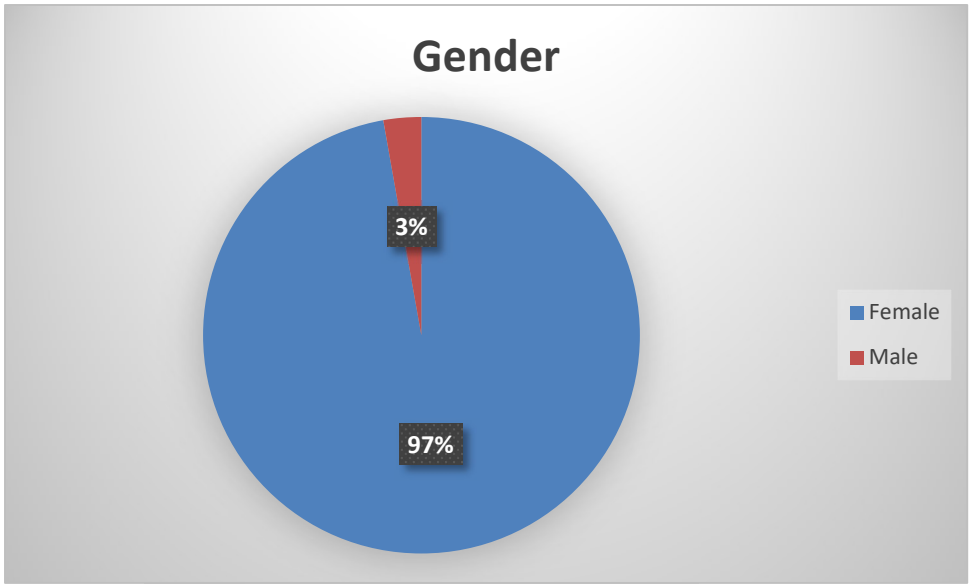

Figure 1. Gender distribution of study participants.

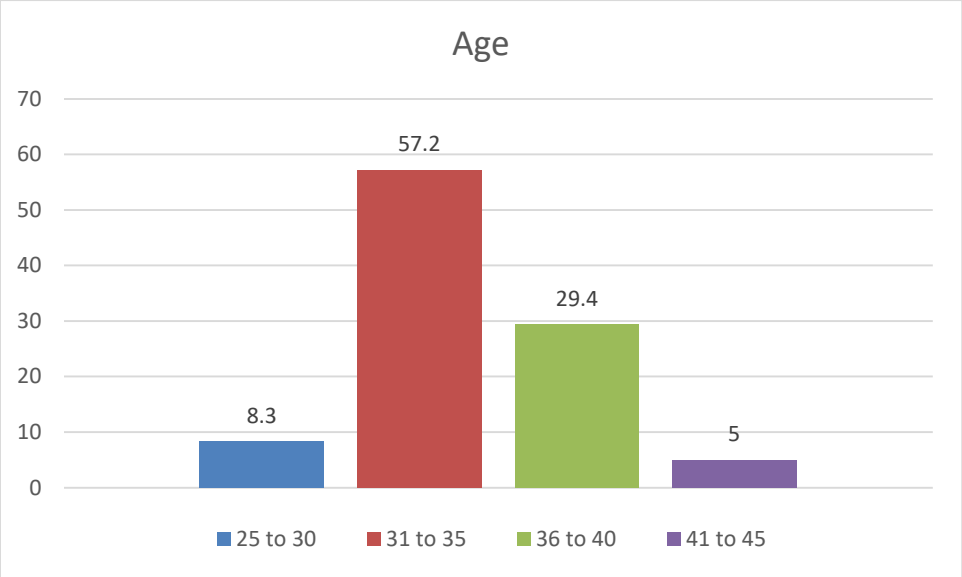

Figure 2. Age distribution of study participants.

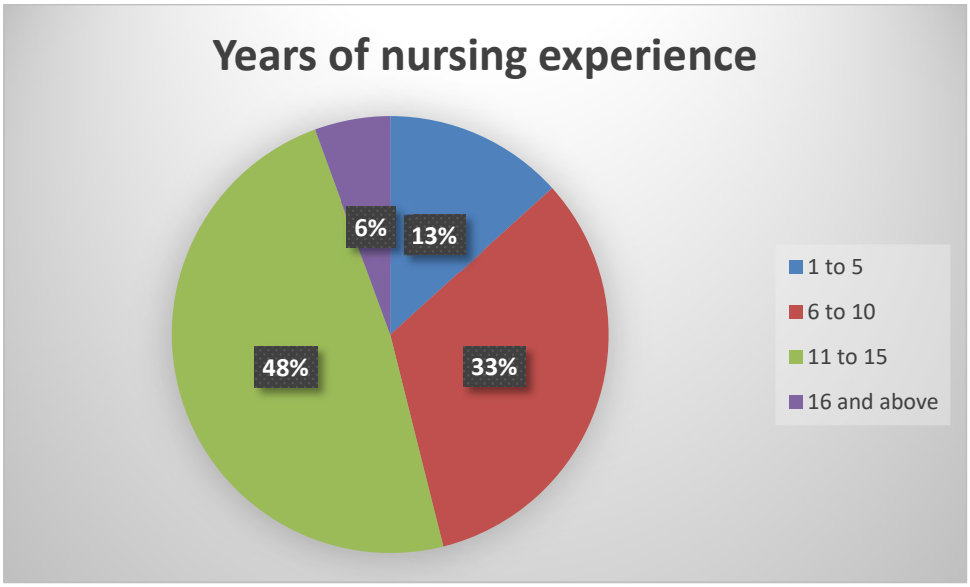

Figure 3. Years of nursing experience of study participants.

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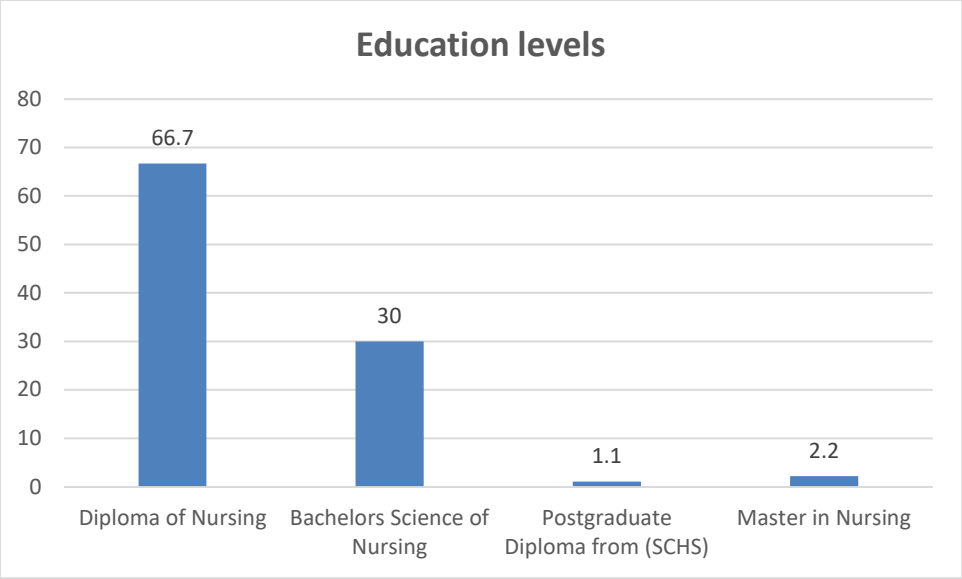

Figure 4. Education levels of study participants.

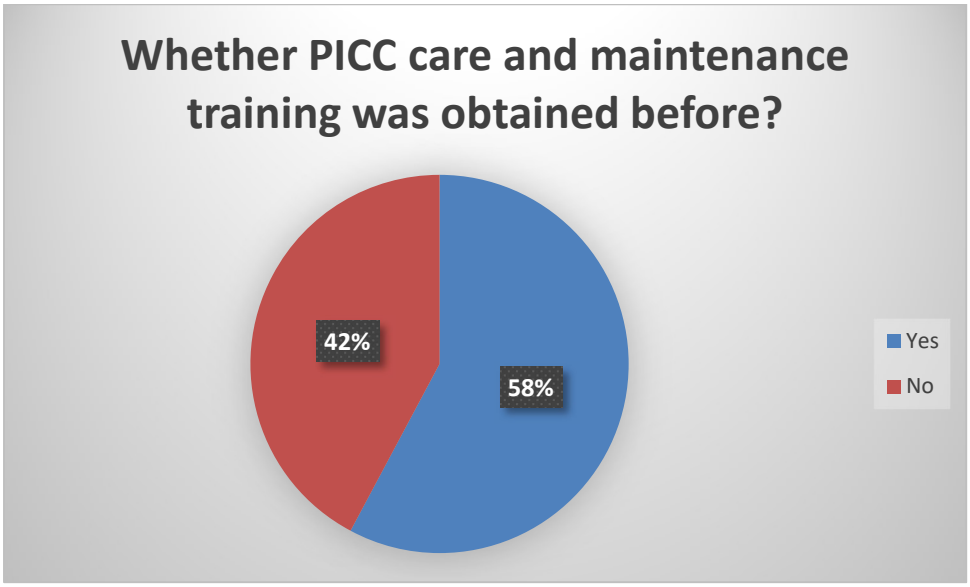

Figure 5. PICC care and maintenance training among study participants.

Part 2. Attitudes about PICC care and maintenance

The comparison of pre-test and post-test data indicates significant enhancements in participants' views toward PICC care and maintenance. In the initial statement concerning the importance of regular catheter care throughout the treatment phase and intermission, the proportion of individuals who "strongly agree" remained relatively constant (45.6% pre-test vs. 46.1% post-test), whereas the percentage of those who "agree" rose from 46.7% to 52.2%. A reduction in neutrality and disagreement was observed post-test, signifying a heightened consensus following training ($p=0.003$).

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The correlation between indwelling time and appropriate PICC care revealed a significant increase in the percentage of participants who "strongly agree," rising from 25.0% pre-test to 41.1% post-test. Conversely, those who "disagree" or remained "neutral" decreased markedly, indicating an enhanced comprehension of this concept among participants (p=0.021).

The significance of standardized processes for PICC care, experienced a minor decrease in "strongly agree" responses (45.0% pre-test to 43.9% post-test), while the proportion of participants who "agree" rose from 46.1% to 50%, indicating a more pronounced acknowledgment of the necessity for a standardized approach (p=0.007).

The most notable alteration was noted in perceptions of aseptic techniques to avert PICC-associated infections. The proportion of people who "strongly agree" decreased from 65.0% to 46.1%, although those who "agree" increased from 28.3% to 48.9%. This alteration indicates a more equitable perspective, with a reduced number of participants adopting extreme stances, while overall consensus persists robustly (p=0.001).

Concerning flushing and locking techniques to avert occlusion, there was a slight decline in the proportion of participants who "strongly agree" (50.6% to 45.0%), accompanied by an increase in those who "agree" from 44.4% to 53.3%. This suggests that while strong conviction diminished marginally, overall consensus on its significance increased (p=0.004).

The item regarding frequent PICC training in clinical settings experienced a minor decline in "strongly agree" responses (43.3% to 39.4%), accompanied by a notable increase in "agree" responses (41.7% to 50.0%), indicating a widespread consensus on the necessity for regular training (p=0.04).

Ultimately, the readiness to engage actively in PICC care training enhanced, with "strongly agree" comments escalating from 35.0% to 40.0%, and "agree" responses climbing from 51.1% to 53.9%. The proportion of neutral and dissenting individuals diminished, signifying an increased degree of involvement and desire for future training following the post-test (p=0.003). The post-test results demonstrate statistically significant enhancements in the majority of categories, reflecting the training program's efficacy in improving participants' knowledge and attitudes regarding PICC care and maintenance.

Table 2. Comparison of Pre-test and Post-test results on attitudes about PICC care and maintenance

		Pre-test results		Post-test results		P value
		Frequency (n)	Percentage (%)	Frequency (n)	Percentage (%)	
	Strongly agree	82	45.6	83	46.1	0.003

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1. Patients with PICC need regular catheter care and maintenance during both the treatment period and the treatment intermission.	Agree	84	46.7	94	52.2	
	Neutral	5	2.8	0	0	
	Disagree	7	3.9	2	1.1	
	Strongly disagree	2	1.1	0	0	
2. There is a correlation between indwelling time and the correct PICC care and maintenance.	Strongly agree	45	25.0	74	41.1	0.021
	Agree	103	57.2	99	55.0	
	Neutral	23	12.8	6	3.3	
	Disagree	9	5.0	0	0	
	Strongly disagree	0	0	0	0	
3. PICC care and maintenance need to be performed according to a standardized process.	Strongly agree	81	45.0	79	43.9	0.007
	Agree	83	46.1	90	50.0	
	Neutral	11	6.1	8	4.4	
	Disagree	5	2.8	2	1.1	
	Strongly disagree	0	0	0	0	
4. Strict aseptic procedures in the process of PICC care and maintenance are essential to prevent PICC-related infections.	Strongly agree	117	65.0	83	46.1	0.001
	Agree	51	28.3	88	48.9	
	Neutral	9	5.0	6	3.3	
	Disagree	3	1.7	2	1.1	
	Strongly disagree	0	0	0	0	
5. Using the correct flushing and locking techniques is essential to prevent PICC occlusion.	Strongly agree	91	50.6	81	45.0	0.004
	Agree	80	44.4	96	53.3	
	Neutral	6	3.3	2	1.1	
	Disagree	3	1.7	0	0	
	Strongly disagree	0	0	0	0	

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6. PICC care and maintenance training should be conducted regularly in clinical settings.	Strongly agree	78	43.3	71	39.4	0.04
	Agree	75	41.7	90	50.0	
	Neutral	16	8.9	10	5.6	
	Disagree	7	3.9	4	2.2	
	Strongly disagree	4	2.2	4	2.2	
7. I am willing to take an active part in PICC care and maintenance training.	Strongly agree	63	35.0	72	40.0	0.003
	Agree	92	51.1	97	53.9	
	Neutral	21	11.7	8	4.4	
	Disagree	4	2.2	2	1.1	
	Strongly disagree	0	0	0	0	

Significant value ≤0.05

Part 3: Quality of care and maintenance

The comparison of pre-test and post-test findings reveals substantial enhancements in nurses' knowledge and practices for PICC and CVC care. The pre- and post-test results highlight a positive shift in clinical decision-making among respondents, particularly in an increased selection of placing the patient in the left lateral Trendelenburg position (from 13.3% to 20%) suggests growing awareness of positioning to prevent complications such as air embolism. Meanwhile, less critical actions like instructing the patient to take a deep breath and administering a sedative saw minimal or no increase, reflecting better prioritization skills. Nonetheless, the majority now preferred acquiring an arterial blood gas test, increasing from 71.7% to 79.4%, indicating a heightened inclination for this procedure.

In instances of resistance during PICC removal, a greater proportion of nurses accurately chose to cease the process and inform the practitioner, with a significant rise from 71.7% to 89.4% (p=0.003). In inquiries on appropriate CVC care, there was a significant enhancement in the correct identification of the need to replace the dressing when it is damp, loose, or soiled, with 80.6% selecting this option post-test, compared to 40% pre-test (p=0.04).

The pre- and post-test results indicate a concerning shift away from the correct instruction for patients during PICC removal, which is to “Take a deep breath and hold it.” Initially, 20% of respondents correctly selected this option, but this increased to 36.1% in the post-test, to reduce the risk of air embolism.

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A significant alteration occurred in the identification of the CVC insertion site with the highest infection risk, as the percentage of selections for the femoral vein plummeted from 65.6% to 6.7%, while the preference for the subclavian vein surged from 25.0% to 87.2% (p=0.01). This demonstrates enhanced knowledge of infection hazards.

The results for the teaching question on post-PICC removal dressing indicate a positive trend, with an increase from 46.1% to 65% in respondents choosing “Put a dry sterile gauze over the site and tape it on three sides.” This is generally recognized as an appropriate practice to secure the access site. However, the increase in the response “Place an air-occlusive dressing immediately on the site,” from 2.2% to 35.6%, suggests a growing but incorrect focus on air occlusion, which could be due to misconceptions about post-removal care requirements. These results indicate the need for clarification on best practices in dressing choice, reinforcing that a dry, sterile gauze taped on three sides remains the optimal choice to protect the access site after PICC removal.

The results for the question on the frequency of changing a semipermeable transparent chlorhexidine-impregnated gel dressing reveal a marked improvement in understanding. In the post-test, 95% of respondents correctly identified the dressing should be changed "At least every 7 days," a significant increase from 43.9% in the pre-test. This shift indicates a better grasp of recommended dressing change intervals, which are crucial for infection control and maintaining the site’s sterility. These findings reflect an effective learning outcome, promoting adherence to best practices in patient care.

The results for understanding the correct placement of a PICC line tip demonstrate a significant improvement. In the post-test, 83.9% of respondents correctly identified the "Superior vena cava" as the appropriate location, an increase from 53.9% in the pre-test. However, some confusion persists, as seen in the increased selection of incorrect answers such as the "Right atrium" (11.1%) and "Cephalic vein" (13.3%) in the post-test. This suggests that, while a majority of participants now understand the correct placement, additional clarification may be beneficial to reinforce that the PICC line tip should be in the superior vena cava. Improved knowledge of correct catheter positioning is essential for safe and effective patient care, reducing the risk of complications associated with improper line placement.

The results for the question on appropriate action when a nurse notices redness, swelling, and drainage at a PICC access site reveal a marked improvement in prioritizing proper clinical response. In the post-test, 82.8% of respondents correctly chose to "Notify the practitioner," up from 58.9% in the pre-test, indicating a stronger understanding of the importance of immediate communication with a healthcare provider to address potential infection or complications. Although there was a slight increase in selections for options such as discontinuing the PICC line and flushing with sodium chloride, the substantial rise in the correct response reflects enhanced recognition of escalation protocols. This shift suggests effective learning and prioritization of practitioner notification to ensure timely intervention, essential for patient safety and infection control.

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The results indicate a notable enhancement in nurses' understanding and decision-making about PICC and CVC care following training, with statistically significant alterations observed across several scenarios.

Table 3. Comparison of pre-test and post-test results on nursing actions and knowledge related to PICC and CVC care

		Pre-test results		Post-test results		P value
		Frequency (n)	Percentage (%)	Frequency (n)	Percentage (%)	
1. After removing a PICC, the patient becomes hypotensive, light-headed, confused, tachycardic, anxious, and short of breath. What should the nurse do next?	Instruct the patient to take a deep breath and hold it.	4	2.2	2	1.1	0.01
	Obtain an arterial blood gas measurement.	129	71.7	143	79.4	
	Administer a sedative to the patient.	10	5.6	10	5.6	
	Place the patient in the left lateral trendelenburg position.	24	13.3	36	20	
2.While discontinuing a PICC, the nurse meets resistance, and the catheter appears stuck. What should be the nurse's next action?	Ask another more experienced nurse to try to remove the catheter.	22	12.2	4	2.2	0.003
	Stop the procedure and notify the practitioner.	129	71.7	161	89.4	
	Switch hands and try to	5	2.8	6	3.3	

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	remove the catheter again.					
	Have the patient take several deep breaths and cough.	24	13.3	8	4.4	
3. Which nurse action is included in proper CVC care?	Cleansing the access site with antiseptic solution every shift.	64	35.6	145	80.6	0.04
	Replacing the dressing when it is damp, loose, or soiled.	18	10	72	40	
	Changing the dressing no more frequently than every 96 hours.	26	14.4	8	4.4	
	Applying antimicrobial ointment to the access site.	18	10.0	8	4.4	
4.Before removing a PICC, the nurse should give what instructions to the patient?	"Exhale quickly when the catheter is being removed."	6	3.3	4	2.2	0.01
	"Breathe normally during the removal process."	35	19.4	129	71.7	
	"Take a deep breath and	74	41.1	10	5.6	

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	exhale slowly."					
	"Take a deep breath and hold it."	36	20.0	65	36.1	
5. While inserting a CVC, the practitioner observes the return of bright red blood under high pressure into the syringe during venipuncture of the vein. This observation indicates which complication?	Hemothorax.	34	18.9	12	6.7	0.004
	Air embolism.	93	51.7	139	77.2	
	Arterial puncture or laceration.	37	20.6	12	6.7	
	Catheter malposition.	16	8.9	16	8.9	
6. Which CVC insertion site has an increased risk of infection and should be used when the other sites are NOT available?	Femoral vein.	118	65.6	12	6.7	0.01
	Right internal jugular vein.	12	6.7	6	3.3	
	Left internal jugular vein.	5	2.8	4	2.2	
	Subclavian vein.	45	25.0	157	87.2	
7. A nurse is teaching a student nurse about the type of dressing to place on the access site after removing a PICC. Which	"Put a dry sterile gauze over the site and tape it on three sides."	83	46.1	117	65.0	0.02
	"Place an air-occlusive dressing	4	2.2	64	35.6	

ISSN:2227-684XE-ISSN:2227-8575

statement would indicate the student nurse understood the information?	immediately on the site."					
	"Use an alginate dressing and change it every day."	21	11.7	40	22.2	
	"Put some antibiotic cream over the site and cover it with a gauze dressing."	12	6.7	18	10.0	
8. How often should a semipermeable transparent chlorhexidine-impregnated gel dressing be routinely changed?	At least every 3 days.	4	2.2	87	48.3	0.04
	At least every 5 days.	2	1.1	8	4.4	
	At least every 7 days.	79	43.9	171	95.0	
	At least every 10 days.	2	1.1	6	3.3	
9. Where is the tip of the PICC line located?	Superior vena cava.	97	53.9	151	83.9	0.003
	Right atrium.	11	6.1	20	11.1	
	Basilic vein.	11	6.1	20	11.1	
	Cephalic vein.	6	3.3	24	13.3	
10. When changing a PICC dressing, the nurse notices redness, swelling, and drainage at the access site. What should be	Discontinue the PICC and start a peripheral IV line.	8	4.4	33	18.3	0.006
	Flush each catheter lumen with 0.9% sodium	12	6.7	18	10.0	

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the nurse's next action?	chloride solution followed by an antibiotic flush solution.					
	Swab the site with antiseptic solution, apply povidone-iodine ointment, and apply a gauze dressing.	10	5.6	23	12.8	
	Notify the practitioner.	106	58.9	149	82.8	

Significant value ≤0.05

Part 4: General Knowledge about PICC care and maintenance

There was a significant enhancement in the identification of appropriate PICC maintenance content. Prior to the intervention, merely 59.4% of participants accurately recognized the necessity of flushing the catheter with saline and heparin according to procedure, whereas post-test findings indicated an increase in this knowledge to 79.4% (P = 0.001). A notable decrease in misconceptions occurred, namely about the practice of changing the dressing every 48 hours irrespective of its state, which fell from 34.4% to 16.7%.

There was a significant enhancement in recognizing chlorhexidine as the recommended disinfectant. Pre-test data indicated that 65% of participants responded correctly, which rose to 93.9% in the post-test (P = 0.02). This transition signifies an improved comprehension of optimal infection control techniques.

Concerning the technique of film ripping during dressing replacement, there was a change in the comprehension of the erroneous procedure. Initially, merely 12.2% identified ripping towards the insertion site as erroneous; however, following the test, this percentage increased to 62.8% (P = 0.0073). This alteration indicates enhanced awareness of preserving sterility at the insertion site.

The post-test results indicated that a greater proportion of participants (72.8%) accurately recognized the necessity of replacing dressings and connectors every 7 days, in contrast to 46.7% in the pre-test (P = 0.001). This enhancement indicates improved compliance with clinical recommendations.

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In response to the incorrect method of sterilizing the spiral part when replacing the infusion connector is rinsing with sterile water. This method received a 20.6% selection rate, indicating that some may still misunderstand sterilization practices. While sterile water can rinse surfaces, it lacks the disinfectant properties of alcohol, chlorhexidine, or povidone-iodine and does not effectively kill microbes. Alcohol swabs are most commonly preferred (75%) as they are effective against a wide range of pathogens, with chlorhexidine and povidone-iodine as other acceptable options for reducing infection risk.

For the flushing fluid after the infusion of blood products and fat emulsions, the correct answer is Normal saline, 20 mL. This selection is preferred for both blood and fat emulsions, as it effectively clears residues without the risks associated with heparinized saline or sterile water. The sufficient volume of 20 mL ensures thorough flushing, especially important for fat emulsions, reducing the likelihood of line occlusions and supporting patient safety.

Following blood product infusions, there was a significant enhancement in comprehension about the flushing fluid, with the utilization of sterile water increasing from 7.2% in the pre-test to 67.2% in the post-test ($P = 0.006$). This signifies that participants possess an enhanced comprehension of the fluids and volumes required for flushing PICCs.

The management of a fully dislodged PICC, understanding significantly enhanced. Initially, only 46.1% of participants acknowledged that attempting to reinsert the catheter is erroneous; however, post-test results reveal a reduction to 10% ($P = 0.001$), signifying an improved comprehension of suitable emergency protocols.

In the management of PICC blockage, the correct intervention for PICC (Peripherally Inserted Central Catheter) occlusion is removing the PICC line immediately when other methods to resolve the blockage are ineffective or if there's a severe blockage that cannot be cleared safely. This response received the highest selection rate (52.2%), reflecting clinical preference for immediate removal to prevent complications such as infection or vein damage if other methods fail. While flushing or using thrombolytic agents are initial approaches, immediate removal is essential when these interventions are unsuccessful or contraindicated, prioritizing patient safety.

Upon inquiry on the favored diagnostic modality for PICC-related thrombosis, there was a notable increase in participants selecting ultrasound as the preferred technique, escalating from 59.4% pre-test to 86.1% post-test ($P = 0.02$). This signifies an enhanced comprehension of diagnostic methodologies.

The proportion of participants acknowledging the significance of aseptic practices during dressing changes rose from 63.3% in the pre-test to 87.2% in the post-test ($P = 0.001$), indicating enhanced awareness of infection control.

In relation to PICC breakage in vitro, the incorrect intervention for PICC breakage in vitro is flushing the catheter with saline. This action is inappropriate as it could force any remaining

contents through the break, potentially leading to leakage or further damage. Both flushing and cutting the catheter below the break each received a selection rate of 34.1%, indicating some confusion, but flushing presents a greater immediate risk in the event of breakage. Proper interventions include clamping above the break to control any leakage and notifying a practitioner immediately to address the issue safely.

The first intervention for PICC breakage in vivo is notifying the practitioner immediately. This option received the highest selection rate (67.2%), emphasizing the importance of professional assessment and intervention to prevent complications like infection or air embolism. While actions like applying pressure or clamping may be necessary to control leakage, immediate notification allows for timely and appropriate management, ensuring the correct protocol is followed for patient safety. Removing the catheter or applying other measures without professional guidance could introduce further risks.

For the incorrect intervention for phlebitis is flushing the catheter vigorously. This response received an 80.6% selection rate, highlighting a strong consensus that vigorous flushing can worsen inflammation and increase discomfort or risk of further vein irritation. Appropriate interventions include applying warm compresses, administering anti-inflammatory medication, and elevating the affected limb, all of which help reduce inflammation and relieve symptoms without exacerbating the condition.

For the correct intervention for contact dermatitis is applying a steroid cream to the affected area. This option was chosen by 79.4% of respondents, indicating its effectiveness in reducing inflammation and itching associated with dermatitis. Other options, like using alcohol-based cleansers, continuing the same dressing, or ignoring symptoms, are inappropriate as they may irritate the skin further or delay healing. Applying a steroid cream provides targeted relief, promoting faster recovery.

Concerning health education for discharged patients, there was a significant enhancement in instructing patients on dressing changes, with the correct response rising from 16.1% to 78.3% ($P = 0.001$), indicating a heightened emphasis on patient education following discharge.

The incorrect operation when removing the PICC is applying pressure to the site after removal. This received the highest selection rate (76.7%), indicating a clear understanding that applying pressure immediately after PICC removal can increase the risk of complications such as air embolism, as it may prevent proper closure of the insertion site. Instead, standard practice includes ensuring the site is allowed to seal properly without immediate pressure, often in combination with instructing the patient to lie flat and perform the Valsalva maneuver to reduce the risk of air entering the bloodstream.

Ultimately, for emergency measures for problems after PICC removal, there was an improved comprehension that the application of a tourniquet above the insertion site is unsuitable, with

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awareness rising from 42.8% to 67.2% (P = 0.001). This demonstrates heightened awareness of vital care in emergencies.

The post-test findings reveal a substantial enhancement in participants' comprehension of PICC care and the proper management of associated problems, underscoring the efficacy of the educational intervention.

Table 4. **Pre-test and Post-test results on general knowledge about PICC care and maintenance**

		Pre-test results		Post-test results		P value
		Frequency (n)	Percentage (%)	Frequency (n)	Percentage (%)	
1. Which of the following is the content of PICC maintenance?	Changing the dressing every 48 hours regardless of its condition.	62	34.4	30	16.7	0.001
	Flushing the catheter with saline and heparin as per protocol.	107	59.4	143	79.4	
	Removing the PICC line and reinserting it every week.	2	1.1	0	0	
	Administering antibiotics through the PICC line with the same glove of patient cleaning.	9	5.0	6	3.3	
2. Which of the following is the preferred disinfectant	Hydrogen peroxide over a 1-inch radius around the site.	22	12.2	8	4.4	0.02

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and correct disinfection range for skin disinfection when replacing the dressing?	Chlorhexidine over a 2-inch radius around the site.	117	65.0	169	93.9	
	Alcohol swab over a 1-inch radius around the site.	11	6.1	0	0	
	Iodine solution over a 2-inch radius around the site.	30	16.7	2	1.1	
3. Which of the following is the INCORRECT method of tearing the film when replacing it?	Tearing it toward the insertion site.	22	12.2	113	62.8	0.0073
	Tearing it away from the insertion site.	32	17.8	66	36.7	
	Tearing it horizontally from one corner.	81	45.0	0	0	
	Tearing it vertically from the middle.	45	25.0	0	0	
4. Which of the following is the **wrong** time to replace the transparent dressing and infusion connector?	When the dressing is damp.	58	32.2	44	24.4	0.001
	Every 7 days.	84	46.7	131	72.8	
	When the connector is visibly soiled.	20	11.1	4	2.2	
	Every 24 hours.	18	10.0	0	0	
5. Which of the following is	Using an alcohol swab.	90	50.0	135	75.0	0.05

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the INCORRECT method of sterilizing the spiral part when replacing the infusion connector?	Using a chlorhexidine swab.	25	13.9	32	17.8	
	Using a povidone-iodine swab.	6	3.3	28	15.6	
	Rinsing with sterile water.	6	3.3	37	20.6	
6. What type of flushing fluid should be used after the infusion of blood products and fat emulsions? And what is the minimum volume?	Normal saline, 10 mL.	57	31.7	2	1.1	0.006
	Heparinized saline, 5 mL.	90	50.0	56	31.1	
	Sterile water, 5 mL.	0	0	20	11.1	
	Normal saline, 20 mL.	13	7.2	121	67.2	
7. Which of the following is the correct type and volume of sealing fluid when maintaining PICCs?	Sterile water, 5 mL.	36	20.0	0	0	0.04
	Heparinized saline, 10 mL.	88	48.9	4	2.2	
	Normal saline, 10 mL.	0	0	62	34.4	
	Heparinized saline, 3 mL.	56	31.1	113	62.8	
8. What kind of techniques should be used for tube flushing and locking when	Continuous flow technique.	35	19.4	12	6.7	0.008
	Push-pause technique.	91	50.6	149	82.8	
	Rapid flush technique.	26	14.4	4	2.2	

maintaining PICCs?	Slow drip technique.	28	15.6	14	7.8	
9. Which of the following is the INCORRECT intervention if PICC is accidentally completely dislodged?	Applying direct pressure to the insertion site.	42	23.3	18	10.0	0.038
	Notifying the practitioner immediately.	28	15.6	8	4.4	
	Attempting to reinsert the catheter.	83	46.1	18	10.0	
	Covering the site with a sterile dressing.	27	15.0	135	75.0	
10. Which of the following is the correct intervention for PICC occlusion?	Flushing with normal saline forcefully.	38	21.1	45	25.0	0.009
	Attempting to aspirate the occlusion.	24	13.3	32	17.8	
	Using a thrombolytic agent as prescribed.	63	35.0	8	4.4	
	Removing the PICC line immediately.	55	30.6	94	52.2	
11. Which of the following is the preferred auxiliary examination for PICC-	MRI.	6	3.3	2	1.1	0.02
	CT scan.	26	14.4	4	2.2	
	Ultrasound.	107	59.4	155	86.1	
	X-ray.	41	22.8	18	10.0	

related thrombosis?						
12. Which of the following is the correct preventive measure for PICC-related infections?	Changing the dressing every 48 hours.	45	25.0	8	4.4	0.002
	Administering prophylactic antibiotics.	11	6.1	12	6.7	
	Using aseptic technique during dressing changes.	114	63.3	157	87.2	
	Avoiding the use of the catheter for blood draws.	10	5.6	2	1.1	
13. Which of the following is the **INCORRECT** intervention for PICC breakage in vitro?	Clamping the catheter above the break.	29	16.1	18	10.0	0.005
	Flushing the catheter with saline.	37	20.55	61.5	34.1	
	Cutting the catheter below the break.	37	20.55	61.5	34.1	
	Notifying the practitioner immediately.	77	42.8	123	68.3	
14. Which of the following is the first intervention for PICC	Applying pressure to the break site.	56	31.1	22	12.2	0.04
	Removing the catheter.	56	31.1	16	8.9	

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breakage in vivo?	Clamping the catheter above the break.	20	11.1	28	15.6	
	Notifying the practitioner immediately.	62	34.4	121	67.2	
15. Which of the following is the **INCORRECT** intervention for phlebitis?	Applying warm compresses to the affected area.	34	18.9	20	11.1	0.01
	Administering anti-inflammatory medication.	29	16.1	10	5.6	
	Flushing the catheter vigorously.	87	48.3	145	80.6	
	Elevating the affected limb.	30	16.7	4	2.2	
16. Which of the following is the correct intervention for contact dermatitis?	Applying a steroid cream to the affected area.	107	59.4	143	79.4	0.04
	Using alcohol-based cleansers.	30	16.7	14	7.8	
	Continuing to use the same type of dressing.	33	18.3	18	10.0	
	Ignoring the symptoms as they will resolve on their own.	10	5.6	4	2.2	
17. Which of the following is	Informing patients about	33	18.3	12	6.7	0.037

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NOT true related to health education for discharged patients with PICC?	signs of infection.					
	Instructing patients on how to flush the catheter.	28	15.6	16	8.9	
	Advising patients that they do need to change dressing in bathing time in running water.	90	50.0	10	5.6	
	Teaching patients how to change the dressing if needed.	29	16.1	141	78.3	
18. Which of the following is the wrong operation when removing the PICC?	Having the patient perform the valsalva maneuver.	39	21.7	20	11.1	0.002
	Gently pulling the catheter out.	19	10.6	10	5.6	
	Applying the medication through the catheter before removal.	11	6.1	28	15.6	
	Applying pressure to the site after removal.	94	52.2	138	76.7	
19. If the patient suddenly develops signs	Placing the patient in the left lateral	33	18.3	20	11.1	0.05

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and symptoms such as dyspnea, chest pain, hypotension, dysphoria, and sweating in the process of PICC removal, which of the following is the INCORRECT intervention?	trendelenburg position.					
	Administering 100% oxygen.	70	38.9	38	21.1	
	Applying a tourniquet above the insertion site.	77	42.8	121	67.2	
	Notifying the practitioner immediately.	0	0	0	0	

Significant value ≤0.05

Results summary:

1. **Demographic insights**: Most participants were female nurses, aged between 31 and 35, with a significant portion having 11 to 15 years of experience. The majority held a diploma in nursing.
2. **PICC care attitudes**: The training led to noticeable improvements in participants' attitudes towards PICC care and maintenance, with more agreement on the importance of proper care, particularly in relation to indwelling time and aseptic techniques to prevent infections.
3. **Enhancements in practices**: After the training, nurses showed substantial improvements in their knowledge and handling of PICC and CVC care, particularly in responding to occlusions and applying aseptic techniques.
4. **General knowledge improvements**: There was a marked increase in understanding correct PICC maintenance practices, such as the appropriate flushing techniques and the proper use of disinfectants.
5. **Improved management of complications**: Nurses demonstrated better awareness of managing PICC-related complications, recognizing infection risks, dealing with occlusions, and following emergency protocols after PICC removal.
6. **Patient education**: The training highlighted the importance of educating patients on PICC care after discharge, with an increased emphasis on teaching about dressing changes and recognizing signs of infection.
7. **Training effectiveness**: The training was highly effective in enhancing both the knowledge and practical skills of nurses in PICC care, leading to significant improvements in most areas of evaluation.

ISSN:2227-684XE-ISSN:2227-8575

4 Discussion

The results of this study indicate significant improvements in nurses' knowledge, attitudes, and readiness for specialized training in PICC care. These findings align with existing literature that highlights the importance of targeted educational interventions in enhancing clinical competencies. Xu et al. (2020) and de Souza et al. (2024) both observed that nurses who underwent training on PICC care demonstrated a marked improvement in their knowledge and skills, leading to better patient outcomes and enhanced confidence in handling PICC lines. Our study further corroborates these results, showing that post-training nurses exhibited greater enthusiasm for future training (Xu et al., 2020; de Souza et al., 2024).

The demographic data of the study participants indicate a clear predominance of female nurses (97.2%), with a notable concentration in the age group of 31-35 years (57.2%). This finding aligns with previous studies that demonstrate a predominance of female nurses in the healthcare workforce (Xu et al., 2020). The relatively young age profile of the participants suggests a workforce that is potentially more adaptable to training and educational interventions. Studies by de Souza et al. (2024) and Muschitiello et al. (2024) have also noted that younger nurses tend to demonstrate higher enthusiasm for training programs, particularly in areas such as PICC care, which require up-to-date knowledge and practices.

Furthermore, the study participants predominantly possess a nursing diploma (66.7%), with a smaller proportion holding a Bachelor's degree (30%). This aligns with findings from Xu et al. (2020), who observed that nurses with lower levels of formal education may have less foundational knowledge in specialized areas such as vascular access management. This points to a need for continuous professional development to bridge the knowledge gap among nurses with varying educational backgrounds. As pointed out by Saltah and Abusaad (2022), providing targeted educational programs can be a crucial strategy to enhance the clinical skills and knowledge of nurses across different educational levels.

The demographic data in this study, particularly the preponderance of female nurses and the high proportion of participants with 11 to 15 years of experience, reflect the current workforce makeup in many healthcare settings. This finding mirrors the research of da Silva et al. (2022) and Salgueiro-Oliveira et al. (2021), who both reported a similar demographic profile in their studies on nursing training and attitudes toward PICC care. The fact that a significant portion of the nurses in our study had prior training on PICC care suggests a baseline knowledge level that may contribute to the observed improvements post-training (Salgueiro-Oliveira et al., 2021; da Silva et al., 2022). These results underscore the importance of fostering a culture of continuous professional development, especially in the critical areas of venous access management.

The participants' work environments, primarily in medical units like C1 and C2, D1 and D2, suggest a setting where PICC care is likely to be critical, yet may lack specialized training for all staff members as compared with all inpatient areas. Studies by Chen and Feliciano (2024) and da

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Silva et al. (2022) emphasize the importance of tailored training for nurses working in high-demand clinical areas where PICC lines are frequently used. The lack of managerial diversity, as indicated by the absence of higher management roles in this study, could also suggest limitations in career progression for nursing staff, which could impact their motivation to engage in advanced training programs. Addressing these structural issues may further enhance training outcomes and overall job satisfaction (Muschitiello et al., 2024).

In terms of attitudes, the observed shift in responses regarding PICC maintenance techniques reflects a nuanced change in nurses' perspectives. Specifically, the decrease in "strongly agree" responses regarding flushing and locking techniques suggests a more cautious approach, but overall agreement still increased, suggesting growing awareness of the importance of these techniques. Similar findings were reported by Xu et al. (2020) in their study, which indicated that while nurses' attitudes toward catheter care improved post-training, the degree of conviction regarding specific practices varied. Muschitiello et al. (2024) also highlighted the critical role of regular training in shaping positive attitudes, emphasizing that a consistent educational framework is essential for sustaining these improvements over time (Muschitiello et al., 2024; Xu et al., 2020).

Moreover, the study's focus on nurses' readiness to engage in future training complements findings from Piredda et al. (2024) and de Souza et al. (2024), who observed that improved knowledge led to increased self-efficacy and readiness for further learning. Our results further reinforce the notion that increasing nurses' involvement in training programs directly contributes to a more proactive and informed approach to patient care. This is in line with Piredda et al. (2024), who noted that when nurses feel adequately prepared, they are more likely to take a proactive role in preventing complications associated with PICC lines, such as infection and thrombosis.

The decrease in the proportion of nurses who "strongly agree" with the necessity of regular training could be interpreted as a sign of increased awareness of the complexities of PICC care. Similar shifts in response patterns were noted by Muschitiello et al. (2024), who suggested that as nurses' understanding of PICC care deepens, they become more attuned to the nuanced requirements of maintaining central venous access devices. This aligns with findings from Hu et al. (2023), who reported that training programs not only improved knowledge but also fostered a more reflective attitude toward clinical practices, leading to enhanced patient care outcomes (Hu et al., 2023; Muschitiello et al., 2024).

In terms of knowledge gains, our study demonstrated a notable increase in both the "strongly agree" and "agree" responses regarding engagement with future PICC training. This mirrors the work of Saltah and Abusaad (2022), who found that targeted educational programs significantly enhanced nurses' attitudes toward professional development, particularly in specialized care areas such as PICC management. Their study highlighted that the structured training not only improved knowledge but also facilitated a positive shift in nurses' readiness to incorporate new skills into their daily practice (Saltah & Abusaad, 2022; Sowan et al., 2018). The increase in readiness post-

ISSN:2227-684XE-ISSN:2227-8575

training in our study supports this by showing a tangible improvement in nurses' willingness to engage in continuous learning.

The lack of representation of experienced nurses in higher managerial roles, as highlighted by our study, can be partly attributed to the repeated need for sessions over extended periods that was six sessions, which may signal a gap in leadership training and development. While nurses in clinical roles possess substantial hands-on experience, the ongoing necessity for multiple sessions to reinforce learning suggests that leadership structures within nursing education may not be adequately fostering or developing the leadership skills required for managerial roles. As Jones (2018) and Alfieri et al. (2017) noted, effective leadership in nursing education is essential for driving the adoption of evidence-based practices and ensuring the successful implementation of training. The fact that repeated sessions are needed indicates that leadership development programs might not be sufficiently equipping nurses with the skills to take on higher managerial responsibilities or effectively transfer their clinical knowledge into leadership roles. Therefore, strengthening leadership training and creating clear pathways for nurses to progress into managerial positions could address this gap and promote a more robust leadership structure in healthcare.

Furthermore, the study's focus on the effectiveness of training interventions in changing attitudes and behaviors aligns with the work of Chen and Feliciano (2024), who demonstrated that focused training on PICC care improved not only knowledge but also the practical application of skills. Similarly, Chen et al. (2018) found that regular training sessions led to improved adherence to best practices in PICC care, underscoring the value of continuous professional development in reducing complications like catheter-related infections and thrombosis. These findings reinforce the idea that training programs must be regular and tailored to meet the evolving needs of nursing staff (Chen & Feliciano, 2024; Chen et al., 2018).

One of the most striking results of the study is the observed shift in attitudes regarding PICC care practices, particularly in the area of flushing and locking techniques to prevent occlusion. The slight decrease in the proportion of participants who "strongly agree" with the importance of these techniques (from 50.6% to 45.0%) and the increase in those who "agree" (from 44.4% to 53.3%) suggests a subtle shift in the intensity of conviction about the significance of these practices. This shift, though modest, highlights an evolving understanding of the importance of consistent PICC care protocols. A study by Hu et al. (2023) supports this finding, indicating that while nurses' theoretical knowledge may be strong, translating that knowledge into consistent, high-quality clinical practice can sometimes be challenging. A similar shift was observed by Piredda et al. (2024), where nurses demonstrated greater general agreement on the necessity of certain practices but showed some variability in the level of confidence in executing them.

The statistically significant change ($p=0.004$) in attitudes towards these techniques after the training program emphasizes the potential impact of specialized education on reinforcing the importance of procedural knowledge. Several studies have shown that focused educational

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interventions, especially those incorporating hands-on training, can lead to significant improvements in clinical practices (Xu et al., 2020; da Silva et al., 2022). These findings support the growing consensus that regular, practical training on PICC care can enhance nurses' confidence in their skills, leading to more consistent application of best practices.

Another notable result is the increased agreement on the need for frequent PICC training in clinical settings. The shift from "strongly agree" (43.3% to 39.4%) to "agree" (41.7% to 50.0%) suggests that nurses recognize the necessity of ongoing education to maintain high standards of care. This is consistent with findings by Salgueiro-Oliveira et al. (2021) and Chen et al. (2018), who observed that regular, structured training programs are essential for keeping healthcare professionals updated on best practices and reducing the risk of complications associated with central venous access devices like PICCs. The increase in consensus regarding the importance of frequent training ($p=0.04$) highlights the need for more sustained educational efforts in healthcare settings, particularly in specialized areas such as PICC care.

The results also indicate an improvement in nurses' readiness to engage in future PICC care training, with "strongly agree" responses rising from 35.0% to 40.0%, and "agree" responses increasing from 51.1% to 53.9%. This positive shift suggests that the training program not only improved the nurses' immediate knowledge and attitudes but also fostered a greater willingness to continue learning. Previous research has shown that when nurses perceive training programs as effective and directly applicable to their practice, they are more likely to pursue further education in the future (de Souza et al., 2024; Xu et al., 2020). The reduction in neutral and dissenting responses ($p=0.003$) reflects a growing enthusiasm for professional development, a finding that is corroborated by studies such as those by Sowan et al. (2018) and de Souza et al. (2024), which highlighted how training interventions can enhance not only knowledge but also intrinsic motivation for continued professional growth.

This improvement in readiness for future training is an important indicator of the success of the specialized training program in instilling a long-term commitment to continuous education. According to a study by Chen et al. (2018), enhancing nurses' engagement in ongoing professional development is crucial for improving patient outcomes, especially in the context of complex procedures like PICC line insertion and maintenance. A well-structured training program not only boosts immediate knowledge but also cultivates a culture of lifelong learning, which is essential for maintaining high standards of care in any healthcare setting (Piredda et al., 2024; Xu et al., 2020).

The findings of this study suggest several important implications for clinical practice and nursing education. First, the results underline the importance of regular, specialized training programs in enhancing nurses' knowledge and attitudes toward PICC care. Such programs can significantly reduce the occurrence of complications such as occlusion and infection, improving patient safety and clinical outcomes. Studies by Hu et al. (2023) and Muschitiello et al. (2024) have similarly

emphasized the role of targeted training in improving procedural outcomes and reducing complications associated with vascular access devices.

Moreover, the study highlights the need for more comprehensive, evidence-based educational initiatives that address both the knowledge gaps and the attitudinal barriers identified in this research. Previous studies have shown that training programs should be multidimensional, integrating both theoretical knowledge and hands-on practice to maximize their effectiveness (Santiago, 2019; Xu et al., 2020). Additionally, as the demographic data indicate a significant proportion of nurses with lower levels of formal education, there is a pressing need to tailor training programs to accommodate varying educational backgrounds, ensuring that all nurses have the necessary skills to perform specialized tasks such as PICC care.

Future research should explore the long-term effects of specialized training on nurses' clinical practice, particularly in terms of patient outcomes related to PICC line maintenance and complication rates. Longitudinal studies, such as those by Saltah and Abusaad (2022) and Xu et al. (2020), would provide valuable insights into how sustained educational interventions impact nurses' performance over time.

This study provides strong evidence supporting the positive impact of specialized training on nurses' knowledge, attitudes, and readiness to engage in PICC care. The findings underscore the importance of continuous professional development and the need for tailored educational programs to enhance clinical competence and improve patient outcomes. As the healthcare field continues to evolve, fostering a culture of lifelong learning and ensuring that nurses have access to up-to-date training will be crucial for maintaining high standards of care in specialized areas such as PICC management.

5 Conclusion

This study conclusively demonstrates that specialized training markedly enhances nurses' knowledge and attitudes regarding PICC care. The nurses involved in the training exhibited an enhanced comprehension of essential elements of PICC maintenance, including appropriate flushing and locking practices, and conveyed increased enthusiasm for additional training opportunities. These enhancements indicate that continuous, focused education on PICC care is essential for maintaining high standards of nursing practice and safeguarding patient safety.

Despite the study indicating favorable outcomes, additional research is required to validate the durability of these enhancements. An expanded, more heterogeneous sample and extended follow-up might yield more thorough insights into the enduring impacts of such training. This study underscores the necessity for healthcare organizations to priorities ongoing professional development and customize training programs to address the specific requirements of their nursing personnel. By implementing this approach, healthcare organizations can boost clinical results, increase nurse satisfaction, and deliver superior patient care, especially in environments where PICC lines are often utilized.

Acknowledgement

"We extend our sincere gratitude to the Nursing Professional Development Department (NPDD) director, Mr. Robin Maarman, and the nurse educators for their unwavering commitment to this educational initiative. We also acknowledge the invaluable support of the medical-sugycal nursing director, nurse managers, and staff nurses in the medical and surgical inpatient units, whose meticulous efforts in coordinating staff schedules and ensuring availability for each session were instrumental in the success of this project. Special recognition is due to the medical units' dedicated advocacy nurses, whose collaboration with educators in monitoring and supporting inpatients with PICC lines exemplified their commitment to patient care. The outcomes of this study were made possible through their active engagement and dedication to the training process."

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ISSN:2227-684XE-ISSN:2227-8575