Scientific Article Entitled: knowledge, Attitude, and Practice of Clinical Nurses Regarding Catheter-Related Thrombosis. A Cross-Sectional Study

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Abstract

The purpose of this cross-sectional study is to assess the knowledge, attitude, and practice of clinical nurses regarding catheter-related thrombosis, identify influencing factors, raise awareness among nursing managers and nurses, and provide a basis for developing training programs on catheter-related thrombosis.

Between January 1 and February 31, 2021, a total of 549 nurses from Saudi health sector were recruited using a two-stage random sampling method. A self-designed questionnaire with good reliability and validity was used to measure nurses' knowledge, attitudes, and practices related to catheter-related thrombosis. Data analysis was performed using χ^2 test, Welch t-test, and multiple linear regression analysis.

The results showed that clinical nurses had insufficient knowledge about catheter-related thrombosis (55.00%), while their attitudes were positive (88.49%) but their practices were inadequate (68.62%). Knowledge was significantly associated with job title, educational level, and training times (positive factors), while being specialized nurses in intravenous therapy and hospital level (negative factors) had an impact on knowledge. Attitude was

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influenced by training times, job title, and hospital level. Practice was only associated with training times.

In conclusion, although clinical nurses demonstrated a positive attitude toward catheter-related thrombosis, their knowledge level was inadequate and their practice was influenced by various factors. The study suggests that nursing managers should focus on strengthening training and skill assessment related to catheter-related thrombosis. Additionally, hospitals can implement relevant rules, regulations, and guidelines to reduce the incidence of catheter-related thrombosis.

Key words: *knowledge, practice, attitude, nurses, catheter-related thrombosis.*

Introduction

Catheter-related thrombosis (CRT) is a form of venous thromboembolism (VTE) that occurs as a result of venous catheters. It refers to the formation of blood clots in the vessel and vessel wall where the catheter is inserted, caused by puncture or mechanical injury to the vessel's inner lining or underlying patient conditions(Citla Sridhar et al., 2020; Liu et al., 2020).

With the advancement of intravenous infusion technology, procedures such as central venous catheterization, peripherally inserted central venous catheter (PICC), and infusion port (PORT) have become integral in modern medical practices. These techniques provide effective venous access for patients requiring emergency care, intensive care, and chemotherapy, alleviating issues associated with difficulties in peripheral venous puncture for medium to long-term infusion patients(Gorski, 2021).

However, the occurrence of catheter-related complications, particularly CRT, should not be overlooked. CRT incidents can lead to prolonged hospital stays, increased healthcare costs, and delayed treatment for patients(Bleker et al., 2016; Hou et al., 2019). When a thrombus detaches from the catheter, it can migrate to the pulmonary artery, resulting in pulmonary embolism and its associated complications.

Research indicates that the risk factors for CRT encompass various aspects, including patient characteristics, operator-related factors, and catheter-related factors. The average time of occurrence is around 10 days, with most cases being diagnosed within 100 days. The reported incidence of CRT in domestic and international literature ranges from 16% to 66%, which can be attributed to differences in study design, study population, catheter types and locations, duration of catheter retention, follow-up periods, and diagnostic methods(Baumann Kreuziger et al., 2017).

Therefore, it is crucial to enhance preventive measures and control strategies for CRT in order to reduce its risk and mitigate associated complications.

Clinical nurses, being the primary operators of central venous catheterization, have a significant impact on the occurrence of CRT. They play a crucial role in preventing and treating CRT and reducing its risk. Specialized nurses in intravenous therapy are responsible for performing central venous catheterization, while general ward nurses participate in catheter maintenance. If nurses fail to provide adequate care, it can contribute to the development of CRT. Research has shown that nurses' knowledge and skills in catheter maintenance are closely associated with the occurrence of CRT(Xu et al., 2020b, 2020a).

Despite the formulation of relevant practice guidelines by experts emphasizing the importance of preventing complications related to central venous catheterization, there is still a variation in the level of knowledge among clinical nurses regarding CRT(Murray et

al., 2013). Additionally, studies have found that central venous catheterization without professional nursing team involvement is more likely to lead to the formation of venous thrombosis(Zheng et al., 2020). Neglecting thrombosis or premature removal of the catheter by clinical staff can result in venous thrombosis detachment and vascular embolism, which can be life-threatening in severe cases. Therefore, the vital role of clinical nurses in the prevention and treatment of CRT should not be underestimated.

Utilizing the knowledge, attitude, and practice (KAP) management model has been found to be practical in enhancing the overall competency of nurses in managing venous thromboembolism(Sadideen et al., 2011). Therefore, the key to reducing the incidence of CRT lies in improving the knowledge mastery of clinical nurses regarding the prevention and treatment of CRT, correcting their attitudes towards CRT prevention and treatment, and reinforcing their proactive practices in CRT prevention and treatment.

Current research has primarily focused on investigating nurses' KAP in central venous catheterization, knowledge and practices related to catheter insertion and maintenance, and enhancing the experience and quality of PICC nursing(Almahmoud et al., 2020). Additionally, there have been studies focused on exploring nurses' KAP in preventing deep vein thrombosis and venous thromboembolism, particularly within specific departments such as oncology and geriatrics. However, there is still a need for clinical nurses to have a comprehensive understanding of CRT knowledge, attitudes, and behaviors. Understanding how clinical nurses perceive CRT and identifying factors that influence their KAP towards CRT is crucial, particularly in ensuring patient safety. Research has demonstrated the close relationship between nurses' and doctors' attitudes towards patient safety and actual patient safety outcomes(AL-Mugheed et al., 2022; Al-Mugheed & Bayraktar, 2020). Therefore, it is vital to assess the KAP of clinical nurses regarding CRT and develop corresponding measures to reduce the occurrence of CRT and enhance patient safety.

To address this knowledge gap, we conducted a cross-sectional study to evaluate the CRT knowledge, attitude, and practice among clinical nurses. Furthermore, we analyzed the factors influencing their KAP, aiming to enhance the awareness and attention of clinical nurses towards CRT. The findings of this study will provide a scientific foundation for developing CRT prevention and treatment training programs.

Methods

Study design

This cross-sectional research was conducted in Saudi Arabia from January 1 to February 31, 2021.

Study population

The participants in this study were registered nurses (RNs) employed in hospitals located in Saudi Arabia. The study included RNs who met the following inclusion criteria: (a) aged between 18 and 60 years, (b) provided informed consent and participated voluntarily, and (c) possessed more than one year of clinical work experience. Exclusion criteria encompassed: (a) RNs receiving medication for mental illness, (b) RNs on leave due to sickness, personal reasons, studying abroad, or other factors, and (c) RNs working in medical technology departments or other functional departments. Questionnaires with incomplete answers, consistent answer options, or excessively short completion times were rejected.

Sample size

The study used the Kendall estimation method to determine the appropriate sample size, which recommended a range of 275-550 participants based on the number of questionnaire

items (55 items). To account for potential non-response and invalid responses, the sample size was increased by 20% to a range of 330-660 participants.

To select participants, a two-stage random sampling method was utilized. Firstly, one Prefecture was randomly chosen from 13 prefecture-level cities and one Autonomous Prefecture in Hunan Province. In the second stage, one tertiary hospital and one secondary hospital were randomly selected from the previously determined prefecture-level city. Ultimately, a total of 549 nurses from these two hospitals were enrolled as survey subjects. The selection process adhered to the principles of informed consent and voluntary participation while considering the study's inclusion and exclusion criteria.

Ethical consideration

This study received ethical approval from the Medical Ethics Committee of government health sector in Riyadh city. Prior to data collection, informed consent was obtained from all participants, ensuring their understanding and agreement to participate. The confidentiality of participants' clinical data and basic information was strictly maintained. All procedures conducted in the study adhered to the principles outlined in the Declaration of Helsinki.

Instrument

The questionnaire utilized in this study underwent a rigorous development process. It was created through a comprehensive literature review, focus group discussions, pre-testing, and expert consultation using the Delphi method. The questionnaire consists of two sections: the General Information Collection Form (section one) and the Knowledge, Attitude, and Practice questionnaire (section two).

The Knowledge, Attitude, and Practice questionnaire in section two consists of three dimensions (55 items): Knowledge, attitude, and practice. The knowledge questionnaire comprises 25 items, covering seven aspects. Each item is a single-choice question, with correct answers awarded 1 point and wrong choices given 0 points. A higher score indicates a greater level of clinical nurses' knowledge mastery in CRT.

The attitude questionnaire includes 13 items, which are scored using the Likert 5-level scale. The options for scoring range from "strongly agree", "agree", "neutral", "disagree", and "strongly disagree" and are assigned values of 5, 4, 3, 2, and 1, respectively. A higher score indicates a more positive attitude among clinical nurses towards CRT.

The practice questionnaire consists of 17 items, all of which are related to the frequency of specific practices. Five response options are provided, ranging from "always", "often", "sometimes", "rarely", and "never" and are assigned values of 5, 4, 3, 2, and 1, respectively. A higher score indicates that clinical nurses are more proficient in the prevention and treatment of CRT.

During the preliminary survey, the questionnaire demonstrated good reliability and validity. The Cronbach's alpha coefficient was 0.939, indicating high internal consistency, and the content validity was 0.813. These findings confirm that the questionnaire is suitable for use in relevant research and practical applications.

Data collection

From January 1 to February 31, 2021, data collection for this study was carried out by a team of four postgraduate students affiliated with the research group. The data collection process involved the following steps:

> 1. Contacting nursing managers: The investigators reached out to the nursing managers of the two selected hospitals and provided a detailed explanation of the survey's purpose. This communication aimed to obtain permission and support for conducting the study.

2. Determining the total number of RNs: During this stage, the investigators collaborated with the nursing managers to ascertain the total number of registered nurses (RNs) employed in the two selected hospitals.

3. Participant selection: Eligible participants were selected based on the study's predefined inclusion and exclusion criteria. The investigators, with the assistance of head nurses, followed the principles of informed consent and voluntary participation to identify suitable participants.

4. Recruitment of participants: A total of 587 RNs who met the eligibility criteria were selected and recruited for the study. The investigators ensured that the selected participants understood the study's purpose and obtained their informed consent.

5. Questionnaire administration: The investigators used a popular online questionnaire platform called Wen Juan Xing, commonly used in China, to send the questionnaires to the 587 recruited RNs. Clear instructions were provided to the participants, directing them to complete the questionnaires through the online platform.

Quality control

To ensure the quality and validity of the study, several measures were taken before and during data collection. These measures aimed to minimize biases and encourage participation:

Before the actual data collection, a pretest of the questionnaire was conducted on 20 individuals. Necessary modifications were made based on their feedback. These individuals were then excluded from the actual study to avoid any influence on the results.

To reduce selection bias, clear and specific inclusion and exclusion criteria were established for selecting research participants. The criteria were strictly followed during the participant selection process.

The questionnaire was designed to be straightforward and did not involve sensitive or personal questions. This approach aimed to minimize the non-response rate and encourage participants to provide accurate and honest responses.

To control information bias, participants were required to answer all questions before submitting the questionnaire. This ensured that there were no missing responses and reduced the likelihood of incomplete or biased data.

To minimize observational bias, all investigators received comprehensive training on the study's inclusion and exclusion criteria, the content of the questionnaire, and how to administer it. This training aimed to ensure consistent data collection procedures among the investigators.

To address reporting bias, steps were taken to guarantee participant anonymity and data confidentiality. Participants were assured that their responses would remain anonymous, their information would be kept confidential, and the data would only be used for research purposes. It was also emphasized that their questionnaire scores would not impact their career or promotion, as their employers would not have access to individual responses.

By implementing these measures, the study aimed to enhance the reliability and validity of the data collected and minimize potential biases that could affect the study outcomes.

Data analysis

Data analysis was performed using SPSS version 25.0 software. Descriptive statistics, such as frequency, percentage, mean, and standard deviation, were utilized to summarize the characteristics of the participants and the Knowledge, Attitude, and Practice (KAP) scores related to CRT.

To compare the KAP scores among nurses with different characteristics, the Wilcoxon rank-sum test was used for two-group comparisons, while the Kruskal-Wallis H-test was employed for multiple comparisons.

Multiple linear regression analysis was conducted to identify the factors influencing nurses' KAP towards CRT. The inclusion criteria for variables were set at 0.05, and the exclusion criteria were set at 0.10. A p-value less than 0.05 was considered statistically significant.

The Pearson correlation coefficient was utilized to examine the relationships among the three dimensions of KAP. A p-value less than 0.05 was considered statistically significant.

In summary, SPSS version 25.0 software was utilized for data analysis, employing various statistical techniques to summarize participant characteristics, compare KAP scores among different groups, identify influencing factors using multiple linear regression analysis, and assess the correlations among the three dimensions of KAP using the Pearson correlation coefficient.

Results

Participation characteristics

Out of the total 587 eligible nurses, 549 nurses completed the questionnaire, resulting in a response rate of 93.53%. Among these 549 respondents, 239 nurses (43.5%) were from secondary hospitals, while 310 nurses (56.5%) were from tertiary hospitals. The majority of respondents were women, accounting for 97.1% of the total. The largest age group represented was those aged 40 and under, making up 89.6% of the respondents, followed by the age range of 41 to 50, which accounted for 9.5% of the respondents.

In terms of work experience, 52.3% of the respondents had been engaged in nursing work for less than 10 years, while 38.3% had worked for 10 to 20 years. The majority of respondents held an intermediate professional title (51.9%), and 80.5% had an undergraduate education level.

Regarding specialization, the majority of respondents were not specialized in intravenous therapy (91.4%). However, most had participated in training related to infusion catheter-related thrombosis. Among those who participated in the training, 54.3% had attended 1-2 sessions, 30.6% had attended 2-4 sessions, and only 15.1% had attended more than 4 sessions. For additional socio-demographic information, please refer to Table 1.

Table 1 Demographics of the Participants (N=549)

Category		Number	Percentage (%)
Hospital level			
	Tertiary	310	56.47
	Second level	239	43.53
Gender			
	Male	16	2.91
	Female	533	97.09
Age			
	≤40	492	89.61
	41–50	52	9.47

Category		Number	Percentage (%)
	≥51	5	0.92
Working years			
	<10	287	52.28
	10–20	210	38.25
	>20	52	9.47
Educational level			
	Junior college or below	87	15.84
	Bachelor's degree	442	80.51
	Master's degrees or above	20	3.65
Job title			
	Primary	239	43.53
	Intermediate	285	51.91
	Deputy senior and above	25	4.56
Specialized nurses in intravenous therapy			
	Yes	47	8.56
	No	502	91.44
Training times			
	<2	298	54.28
	2–4	168	30.60
	>4	83	15.12

Knowledge, Attitude, and Practice Towards CRT Among Participants

According to the questionnaire survey, the total score for clinical nurses' knowledge, attitude, and practice related to CRT was 138.11 ± 18.11, which accounted for an average of 78.92% of the total possible score. The individual scores for knowledge, attitude, and practice were 13.75 ± 3.15, 57.52 ± 8.42, and 66.83 ± 12.52, respectively. These scores represented an average achievement of 55.00%, 88.49%, and 78.62% of the total possible scores for each dimension. Descriptive statistical analysis was conducted on the scores of the individual items within the knowledge, attitude, and practice dimensions. The two items within the knowledge dimension that received the highest scores were "clinical manifestation" with a score of 3.28 ± 0.92 and "complication prevention and treatment" with a score of 1.17 ± 0.68. Within the attitude dimension, the two items with the highest scores were "knowledge training" with a score of 13.62 ± 2.02 and "patient education" with a score of 13.49 ± 2.02. In the practice dimension, the two items with the highest scores were "health education practice" with a score of 20.30 ± 4.11 and "prevention and treatment practice" with a score of 31.45 ± 5.98. These findings are summarized in Table 2, providing

a comprehensive overview of the scores in the secondary items within the knowledge, attitude, and practice dimensions.

Table 2 Score of Secondary Items in Each Dimension of CRT Knowledge, Attitude and Practice

Projects	Category	Score Range	Score (X±S)	Scoring Rate (%)
CRT knowledge	25	0–25	13.75±3.15	55.00
	Concept	0–2	0.95±0.66	48.00
	Clinical manifestation	0–4	3.28±0.92	82.00
	Diagnosis	0–2	0.77±0.67	38.50
	Risk factors	0–3	1.39±0.76	46.33
	Preventive measure	0–3	1.72±0.71	57.33
	Treatment measures	0–9	4.45±1.48	49.44
	Prevention and treatment of complications	0–2	1.17±0.68	58.50
CRT attitude	13	13–65	57.52±8.42	88.49
	Knowledge training	3–15	13.62±2.02	90.80
	Skill improvement	4–20	17.94±2.66	89.70
	Patient Education	3–15	13.49±2.02	89.93
	Disease prognosis	3–15	12.47±2.87	83.13
CRT practice	17	17–85	66.83±12.52	78.62
	Learning practice	4–20	15.08±3.45	75.40
	Prevention practice	8–40	31.45±5.98	78.62
	Health education practice	5–25	20.30±4.11	81.20
Total	55	30–175	138.11±18.11	78.92

Factors Associated with Knowledge, Attitude, and Practice Towards CRT Among Participants

The results indicate that there is statistically significant differences in the CRT knowledge scores among clinical nurses based on the hospital level, educational level, job title, and whether they were specialized nurses in intravenous therapy ($p < 0.05$). Similarly, significant differences were observed in the CRT attitude scores based on the educational level, professional title, and the number of training sessions attended related to CRT ($p < 0.05$). Regarding CRT practice scores, significant differences were found based on job title, whether they were specialized nurses in intravenous therapy, and the number of training sessions attended related to CRT ($p < 0.05$). These findings are summarized in Table 3, highlighting the significant differences in the scores of clinical nurses' CRT knowledge, attitude, and practice based on various factors.

Table 3 Analysis on the Current Situation of CRT Knowledge, Attitude and Practice of Nurses with Different Characteristics

General Information	n	CRT Knowledge			CRT Attitude			CRT Practice		
		Score	z/H	p	Score	z/H	p	Score	z/H	p
Hospital level										
Tertiary	310	14.14±3.15	12.253	0.002	56.90±9.11	2.277	0.320	66.72±12.41	2.955	0.228
Second level	239	13.06±2.54			59.28±6.28			63.81±11.58		
Male										
Female	16	12.56±4.31	−0.801	0.423	56.00±10.20	−0.170	0.865	70.18±11.58	−0.920	0.357
Male	533	13.79±3.11			57.56±8.36			66.73±12.54		
Age										
≤40	492	13.71±3.11			57.43±8.58			66.57±12.44		
41–5	52	14.46±3.32	4.807	0.090	58.13±6.91	0.285	0.867	69.48±12.50	2.930	0.231
≥51	5	10.80±3.96			59.40±6.80			64.80±19.25		
Working years										
<10	287	13.44±3.06			57.17±8.83			66.65±12.06		
10–20	210	14.01±3.19	5.375	0.068	57.77±8.21	0.988	0.610	66.74±12.99	1.227	0.542
>20	52	14.42±3.34			58.44±6.85			68.23±13.19		
Educational level										
Junior college or below	87	12.80±3.72			56.93±7.66			67.19±12.77		
Bachelor's degree	442	13.88±2.96	9.101	0.011	57.45±8.64	7.317	0.026	66.69±12.55	0.965	0.617
Master's degrees or above	20	15.10±3.68			61.60±5.15			68.45±11.08		
Job title										
Primary	239	13.31±3.03			56.54±9.09			66.23±11.99		
Intermediate	285	13.91±3.11	20.272	<0.001	58.19±7.89	6.236	0.044	66.85±12.93	6.413	0.041
Deputy senior and above	25	16.20±3.55			59.24±6.56			72.36±11.75		
Specialized nurses in intravenous therapy										
Yes	47	15.45±3.75	−3.558	<0.001	58.85±8.18	−1.616	0.106	70.48±14.13	−2.347	0.019
No	502	13.59±3.04			57.39±8.43			66.49±12.31		
Training times										
<2	298	13.52±3.23	5.342	0.069	56.25±8.61	23.246	<0.001	64.25±12.62	36.555	<0.001

General Information	n	CRT Knowledge			CRT Attitude			CRT Practice		
		Score	z/H	p	Score	z/H	p	Score	z/H	p
2–4	168	13.77±2.93			58.35±7.86			68.32±12.11		
>4	83	14.54±3.21			60.38±8.02			73.08±10.14		

The results of the multiple linear regression analysis revealed several factors associated with the knowledge, attitude, and practice of clinical nurses regarding CRT. For knowledge, the regression analysis indicated that job title (β: 1.069, $p < 0.001$), educational level (β: 0.094, $p < 0.05$), and training times (β: 0.085, $p < 0.05$) were positive factors, meaning they positively influenced the knowledge scores. On the other hand, being specialized nurses in intravenous therapy (β: -0.126, $p < 0.05$) and hospital level (β: -0.101, $p < 0.05$) were identified as negative factors, meaning they had a negative impact on the knowledge scores. Regarding attitude, the regression analysis indicated that training times (β: 0.166, $p < 0.001$), job title (β: 0.099, $p < 0.019$), and hospital level (β: 0.090, $p < 0.05$) were factors associated with attitude scores. In terms of practice, the only factor associated with practice scores was training times (β: 0.255, $p < 0.001$). Furthermore, the Pearson correlation coefficient analysis revealed that there was a significant positive correlation between attitude and knowledge ($r = 0.092$, $p < 0.05$) as well as between attitude and practice ($r = 0.418$, $p < 0.05$). These results are summarized in Table 4 and Table 5, providing insights into the factors influencing clinical nurses' knowledge, attitude, and practice regarding CRT and the correlations among these dimensions.

Table 4 Multiple Linear Regression Analysis of Influencing Factors of CRT Knowledge, Attitude and Practice of Clinical Nurses with Different Characteristics

Variable	B	SE	β	t	p
CRT knowledge					
Constant	14.523	1.333		10.892	<0.001
Job title	0.582	0.236	0.106	2.460	0.014
Whether they are Specialized nurses in intravenous therapy	−1.416	0.475	−0.126	−2.980	0.003
Hospital level	−0.611	0.260	−0.101	−2.354	0.019
Educational level	0.697	0.323	0.094	2.160	0.031
Training times	0.363	0.179	0.085	2.022	0.044
CRT attitude					
Constant	50.028	1.639		30.529	<0.001
Training times	1.896	0.482	0.166	3.934	<0.001
Job title	1.459	0.622	0.099	2.346	0.019
Hospital level	1.448	0.681	0.090	2.127	0.034
CRT practice					
Constant	59.858	1.244		48.118	<0.001
Training times	4.339	0.703	0.255	6.168	<0.001

Table 5 Pearson Correlation Coefficient of CRT Knowledge, Attitude and Practice Scores

Category	Knowledge	Attitude	Practice
Knowledge	1		
Attitude	0.092*	1	
Practice	−0.035	0.418**	1

Notes: *The correlation is significant at the 0.05 level (two-tailed).**At the 0.01 level (two-tailed), the correlation is significant.

Discussion

In this survey conducted in Saudi Arabia, 549 nurses from two hospitals were examined to assess their knowledge, attitude, and practice (KAP) regarding central venous catheter-related thrombosis (CRT). The study aimed to identify influencing factors and provide insights for formulating policies and measures to improve nurses' KAP and enhance patient outcomes.

The findings indicated that clinical nurses had a positive attitude toward CRT, but their knowledge and practice were insufficient, which aligned with previous studies(Oh et al., 2017). Factors such as job title, training times, educational level, specialization in intravenous therapy, and hospital level were associated with knowledge scores. Similarly, job title, training times, and hospital level were associated with attitude scores. Training times emerged as the sole factor associated with practice.

The study revealed that clinical nurses' knowledge of CRT was inadequate, possibly due to the rapid development of central venous catheter insertion technology and a lack of alignment between hospital nursing education resources and clinical operations. Insufficient training in catheter insertion technology, prevention of complications, and the absence of comprehensive practice guidelines in local hospitals were identified as possible reasons(Geerts, 2014). Nurses' knowledge primarily focused on concepts and clinical manifestations, while areas such as CRT diagnosis, risk factors, preventive measures, and treatment measures lacked comprehensive understanding. Early identification of CRT risk factors, prevention, and diagnosis were shown to significantly reduce the incidence rate(Khan et al., 2021). Clinical nurses were found to play a crucial role in educating patients about venous thromboembolism prevention.

Regarding attitude, clinical nurses displayed a positive outlook toward CRT. They expressed a willingness to enhance CRT knowledge training and believed that medical staff should actively participate in such training. They also expected improvements in catheterization, maintenance, and evaluation skills, recognizing the importance of these skills in reducing CRT occurrences. Strengthening patient health education, including teaching catheter maintenance timing and proper limb exercise methods, was considered beneficial for prevention and treatment.

In terms of practice, clinical nurses' performance in CRT-related activities was inadequate. The theoretical support for carrying out CRT knowledge dissemination and education to patients and caregivers was lacking. Hospital managers provided limited training on advanced catheterization technology and complication prevention. Insufficient guidelines, rules, and regulations pertaining to CRT further contributed to low scores in practice. Standardized and strengthened training was suggested to improve nurses' comprehension of guidelines and reduce venous thromboembolism occurrences.

Hospital level positively correlated with nurses' CRT knowledge scores, while specialization in intravenous therapy and hospital level negatively correlated with

knowledge. This might be attributed to variations in medical resources and technology among hospitals of different levels. Providing additional support to secondary and lower-level hospitals, both in terms of resources and policies, was recommended. Tertiary hospitals could take a leadership role and establish online and offline training mechanisms to facilitate knowledge exchange and bridge regional gaps in CRT understanding.

Higher education levels were associated with higher knowledge and attitude scores, likely due to increased practical training and theoretical knowledge during nursing education. Professional title and training times were also linked to higher scores in knowledge, attitude, and practice, highlighting the role of experience and continuous learning. Emphasizing hierarchical and stage-based training, leveraging the expertise of experienced nurses to educate less-experienced colleagues, and focusing on improving the knowledge levels of junior nurses were suggested strategies.

Surprisingly, no significant differences were observed in the KAP of clinical nurses across different age groups and years of experience, contrary to previous studies. This result may be influenced by the small and non-representative sample size. However, it was noted that older nurses with more experience may display less motivation to learn and absorb new knowledge, leading to a decline in their engagement with CRT-related topics.

The findings also demonstrated a significant positive correlation between nurses' attitudes and knowledge, as well as between attitudes and practice. This suggests that a stronger understanding of CRT corresponds to more positive attitudes and more active engagement in practice. Education was identified as a means to influence nurses' attitudes and improve knowledge and practice.

Overall, the study highlighted the need for interventions to enhance clinical nurses' KAP regarding CRT, with a focus on improving knowledge, attitude, and practice through targeted training, standardized guidelines, and enhanced education efforts.

Strength and Limitation

The present study has several strengths. It is the first of its kind to provide data on the knowledge, attitudes, and practices of clinical nurses regarding CRT in Hunan province. Additionally, the survey instrument developed for this study has the potential to be used in evaluating nurses' KAP of CRT in hospitals across other regions of China and even in other countries with appropriate translation and validation.

However, there are some limitations to consider. Firstly, since the survey relied on self-reported data, there is a possibility of information bias. Despite implementing quality control procedures during data collection and entry, the accuracy of the information may be influenced. Additionally, although the nurses' attitudes toward CRT were reported as extremely positive, it is important to consider the potential impact of social desirability bias, which may have influenced their responses. To validate the results of this study, future qualitative research should be conducted to explore nurses' actual attitudes toward CRT.

Furthermore, this study was conducted as a cross-sectional study specifically in Hunan province, China. While the sample size of 549 participants was large enough to ensure statistical power and the response rate was excellent, it is unclear whether the results can be generalized to nurses in hospitals located in other regions of China. It is recommended to conduct similar studies in different geographical areas to gain a broader understanding of nurses' KAP regarding CRT.

Conclusion and Future Recommendations

Central venous catheterization is an essential medical technology, but it carries the risk of complications such as CRT, which can be life-threatening due to the potential development

of pulmonary embolism. The study revealed that clinical nurses have inadequate knowledge about CRT, although their attitude towards it is generally positive. However, their practical application of CRT-related procedures is lacking. The knowledge, attitude, and practice (KAP) model suggests that practice is influenced by an individual's attitude and knowledge.

Based on the findings of the study, it is recommended that hospital managers take measures to improve clinical nurses' understanding of CRT. This can be achieved by enhancing training and assessment of CRT knowledge, optimizing the training process and content, and improving nurses' comprehension of CRT. Nursing managers should encourage nurses to integrate their knowledge into practice, fostering self-awareness, initiative, and predictability in their care of CRT patients. This includes understanding the psychological characteristics of patients, conducting evaluations and health education before, during, and after catheterization, and delivering targeted and timely publicity and education to ensure high-quality nursing services and minimize patient discomfort.

Establishing a dedicated central venous catheter quality control team can be beneficial. This team can collect data on patients with central venous catheters, monitor the incidence of CRT in the hospital, and provide evidence for controlling CRT in clinical practice. Furthermore, hospitals can develop detailed processes and systems for managing CRT to standardize the flow of CRT management and reduce the occurrence rate of CRT.

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