

## Nurses' knowledge, attitude, and practice in peripherally inserted central catheter-related thrombosis prophylactic practices A multicentric cross-sectional study

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## Abstract

Peripherally inserted central catheter (PICC)-related thrombosis is preventable, and nurses play a play a crucial role in its prevention. The implementation of nurses' preventive practice is key to reducing the occurrence of PICC-related thrombosis. The level of nurses' knowledge, attitude, and practice can influence the prevention of PICC-related thrombosis, which is important for reducing patient suffering. The aim of this study was to assess nurses' knowledge, attitude, and practice level regarding PICC-related thrombosis prevention based on evidence-based guidelines. Data were collected using a self-designed anonymous electronic questionnaire, which measured nurses' scores in knowledge, attitude, and practice level of PICC-related thrombosis prevention. The study included 5544 clinical nurses who were in contact with the maintenance department of PICC in tertiary general hospitals in 5 regions of China. The scores of nurses' knowledge, attitude, and practice in all dimensions of PICC-related thrombosis prevention belonged to a non-normal distribution. Approximately 55.01% of nurses achieved or exceeded the median knowledge score of 15 (range 0-20) with an accuracy rate of 75%. Knowledge regarding the assessment of risk factors, signs and symptoms, and extubation and treatment was limited. Additionally, 61.99% of nurses had attended continuing education training courses. More than 97% of nurses had a positive attitude towards preventing PICC-related thrombosis, with only 76.79% having a strong positive attitude. Over 58% of nurses did not always perform well in risk factor assessment. Furthermore, there was a significant positive correlation between nurses' knowledge, attitude, and practice scores in PICC-related thrombosis prevention. Chinese nurses demonstrated enthusiasm for PICC-related thrombosis prevention. The findings of this study highlight the need to improve the knowledge, attitude, and practice of nurses in PICC-related thrombosis prevention. It was observed that nurses had weak practice enthusiasm in risk factor assessment, which corresponds to the low correct rate in answering certain some risk factor assessment items of knowledge dimension. Therefore, more attention should be devoted to the aspect of assessment of risk factors, signs and symptoms, and extubation and treatment, including the update of the content and diversifying the training forms. Further research should explore the reasons for these findings from multiple perspectives.

**Abbreviations:** I-CVI = item-level content validity index, IQR = interquartile range, KAP = knowledge, attitude, and practice, PICC = peripherally inserted central catheter, S-CVI = scale-level content validity index.

Keywords: attitude, catheter-related thrombosis, knowledge, nurses, peripherally inserted central catheter, practice, prevention

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## 1. Introduction

Peripherally inserted central catheter (PICC) is widely used in clinical practice due to its operability, low trauma and high safety.<sup>[1-3]</sup> However, the unavoidable puncture injury, toxic effects of drugs, and the patient's own condition leading to vascular endothelial damage, altered blood flow status, and hypercoagulability of the blood, making the incidence of PICC-related thrombosis incidence up to 75%.<sup>[4,5]</sup> In recent years, with the increasing number of patients using PICC catheters, the growing awareness of medical staff regarding PICC-related complications, and the increased detection rate of asymptomatic thrombosis, the incidence of PICC-related thrombosis in China has been steadily rising.<sup>[6]</sup> This not only poses a threat to patient safety but also leads to prolonged or interrupted treatment,<sup>[7]</sup> unplanned extubation of the PICC,<sup>[8]</sup> longer hospital stays, and increased burden on society.<sup>[9]</sup>

However, PICC-related thrombosis is preventable. A number of studies have confirmed that prevention is the key to reducing the incidence of PICC-related thrombosis, and scientific and effective prevention can significantly reduce the incidence of PICC-related thrombosis.[10,11] Liu et al conducted ball-holding exercise training for patients with PICC catheterization, which significantly reduced the incidence of PICC-related thrombosis.<sup>[12]</sup> Furthermore, both guidelines and expert consensus have emphasized the essential role of nurses in the prevention and treatment of PICC-related thrombosis, outlining key prevention strategies such as personnel training, risk assessment, and physical measures.<sup>[13,14]</sup> Nurses are on the frontline in health service delivery and play a central role in improving patients' outcomes.<sup>[15]</sup> Moreover, nurses are authorized to perform PICC catheterization procedures in China. Therefore, the implementation of PICC-related thrombosis prevention practice among nurses is crucial for ensuring high-quality nursing care.

According to the theory of knowledge, attitude, and practice (KAP), the process of changing prophylactic practices can be divided into 3 continuous stages: acquiring knowledge, generating beliefs, and forming practices.<sup>[16]</sup> These stages directly influence the level of prevention practices among nurses. At present, the theoretical model has been widely and successfully applied to investigate the knowledge, attitude, and practice of nurses in the fields of patient pain management, infection control and prevention standards.<sup>[17,18]</sup> Currently, there is a lack of multicentric data on the knowledge, attitude, and practice of PICC-related thrombosis prevention resulting in an inability to understand the clinical practice of nurses in helping patients to prevent PICC-related thrombosis.

Therefore, this study will conduct a multicentric crosssectional scientific investigation on nurses' knowledge, attitude, and practice regarding the prevention of PICC-related thrombosis. This research will lay the foundation for subsequent clinical interventions, aiming to improve the level of nurses' prophylaxis against PICC-related thrombosis, promote the implementation of preventive measures, and ultimately reduce the incidence of PICC-related thrombosis in patients.

## 2. Methods

The reporting of this study was done following the STROBE statement.

## 2.1. Design and setting

This study used a multicentric cross-sectional survey design in tertiary public hospitals with more than 500 beds, which tend to be representative of the level of care in each region and where PICC lines can be placed. The aim of the study was to examine the nurses' knowledge, attitude, and practice in PICC-related thrombosis prophylactic practices in China.

## 2.2. Sampling strategy

To ensure a diverse sample, a convenience sampling method based on bed size and number of nurses per hospital was utilized to select hospitals. Tertiary general hospitals in 5 regions of China (Northeast China, North China, Central China, East China, and Southwest China) were selected as the research hospitals, and clinical nurses who had been in contact with the PICC maintenance department were selected as research subjects.

The inclusion criteria for nurse participants were as follows: registered professional nurses; currently employed in the participating wards; had at least 1 year of experience in PICC maintenance and usage; understood the objectives of the study and signed the consent form. Nurses who were part-time employees, refresher nurses, or in-training nurses were excluded from the study.

## 2.3. Data collection

From April to May 2023, an electronic questionnaire was distributed to the leadership of each participating hospital. Informed consent and standardized instructions for completing the questionnaire were provided, and data were collected through the electronic questionnaire. Each IP address was limited to 1 submission, and the questionnaire could only be submitted when all items were completed to prevent duplicate entries and ensure data integrity. After the questionnaire data were collected, the data could be automatically exported to an Excel datasheet through the system to avoid the bias of manual data entry. Then the screening data were conducted by 2 individuals, who carefully reviewed and checked each item of the questionnaire. Options with clear patterns, identical options, or contradictory options were eliminated. The details of the questionnaire sections are as follows:

Section 1: *Demographic information*: A self-designed questionnaire was utilized to collect general information about the nurses, including age, gender, region, education, professional title, years of work experience, nursing experience, leadership roles and so on.

Section 2: Nurses' knowledge, attitude, and practice assessment tool: A self-administered structured questionnaire was developed to collect data from nurses regarding PICC-related thrombosis prevention. Practice strategies for improving care should be based on evidence. Through systematic literature analysis, the pool of items was constructed according to the thrombosis items related to PICC in guidelines or consensus, combined with the existing thrombosis nursing experience of the research group, including 60 items. Subsequently, a preliminary version of the questionnaire was constructed based on the KAP theoretical model.<sup>[19]</sup> This was achieved by conducting seminars to downplay, combine or break down the entries. Two-rounds Delphi letter consultation were carried out using the initial version of the questionnaire, which was modified to combine expert opinion and research team discussions. Then, a pre-survey was conducted with 30 clinical nurses to test whether the expression of each entry was easy to understand and free of ambiguity to form the final version of the questionnaire. Therefore, a questionnaire on nurses' knowledge, attitude, and practice of PICC-related thrombosis prevention was designed, with a total of 40 items were divided into 3 parts: knowledge (20 items), attitude (10 items), and practice (10 items). The knowledge part included 4 dimensions: risk factor assessment, clinical manifestations, preventive measures, extubation and treatment. Each correct answer was assigned 1 point, and uncertainty and error were assigned 0 point, with a total score of 20. Knowledge scores of 16 and above indicate relatively high scores. The attitude and practice dimensions were scored using a 5-point Likert scale with a full score of 50 points. Attitude and practice scores of 40 and above indicate positive attitudes and good practice. The attitude section is scored as follows: 1 = strongly disagree,

2 = disagree, 3 = neutrality, 4 = agree, and 5 = strongly agree, and the practice section is scored as follows: 1 = never, 2 = seldom, 3 = sometimes, 4 = usually, and 5 = always.

Development of the questionnaire was based on established guidelines and consensus from reputable sources: The 8th edition of infusion therapy standards of practice and consensus on prevention and treatment of catheter-related thrombosis.[13,14] Content validity was determined by 14 experts with extensive experience (more than 10 years) in the field, including nurses and doctors (8 nurses and 6 doctors) specializing in PICC or thrombosis, who reviewed and provided ratings on the questionnaire. Item-level content validity index (I-CVI) and scale-level content validity index (S-CVI) were calculated based on expert ratings. After 2 rounds of expert reviews and modification, the final version of the questionnaire was proven to be reliable and valid with an I-CVI scores between 0.857 and 1.000, an average S-CVI scores of 0.984, and an universal agreement S-CVI scores of 0.850.<sup>[20]</sup> Internal reliability was assessed using Cronbach  $\alpha$  coefficient, which measures the consistency of responses within the questionnaire. The total Cronbach  $\alpha$  coefficient of the questionnaire was 0.895, indicating good internal reliability. Additionally, the Cronbach  $\alpha$  coefficients for the 3 dimensions of knowledge, attitude, and practice were 0.752, 0.954, and 0.938, respectively, demonstrating high internal consistency within each dimension. Stability or test-retest reliability was assessed by administering the questionnaire to participants on 2 separate occasions and comparing their responses. The total test-retest reliability of the questionnaire was 0.966 (P < .01), indicating a high level of stability and consistency over time. The testretest reliability of the 3 dimensions of knowledge, attitude, and practice were 0.939, 0.728, and 0.983, respectively, further confirming the stability of the questionnaire. Overall, these scores indicate that the questionnaire is reliable and valid for assessing knowledge, attitude, and practice related to the topic.<sup>[21]</sup> The survey was designed to be completed within a short timeframe of 3 to 10 minutes.

## 2.4. Ethical considerations

The study protocol was approved by the Human Research Ethics Committee from the hospital of China, Peking Union Medical College Hospital (I-22PJ836). Nurses were given an informed consent that provided a comprehensive description of the study. They were informed of their right to withdraw from the study at any time, and written informed consent was obtained prior to the commencement of the study. All data were treated as confidential and processed anonymously.

#### 2.5. Statistical analysis

The data were automatically exported into Excel and then imported into IBM SPSS version 26.0 for statistical analysis. Descriptive statistics were used to summarize the demographic characteristics of the participating nurses, including frequency and percentage. For the judgmental knowledge assessment questions, the percentage of correct answers for each question was calculated. Knowledge scores for each item were summarized, and the total knowledge score was calculated by summing the scores. The mean  $\pm$  standard deviation was used to describe the normal distribution of continuous variables, such as nurses' attitude and practice scores related to PICCrelated thrombosis prevention. The median and interquartile range (IQR) were used to describe non-normal distributions. Categorical variables were presented as frequency and percentage. The knowledge, attitude, and practice scores were tested for normality. In case of conforming to the normal distribution, the Pearson statistical method was adopted, while in case of not conforming to the normal distribution, the Spearman correlation was employed to analyze the correlations among

the scores of knowledge, attitude, and practice. A 2-sided P values of <.05 was considered statistically significant in this study.

## 3. Results

## 3.1. Demographics of the study participants

All survey data were entered and checked twice for consistency and accuracy. The survey was distributed to 7103 nurses in 5 regions of China. After excluding unqualified questionnaires, 5544 questionnaires were deemed valid, resulting in a response rate of 78.05%. The median age of participants was 32 years (interquartile range [IQR]: 28 to 37), with female predominance (5337 of 5544, 96.27%). The majority of nurses held a bachelor's degree or above (84.18%) and had received continuing education on PICC-related thrombosis (61.99%). The median working experience of participants was 10 years (IQR: 5–15). Table 1 presents the demographic characteristics of the participating nurses.

# 3.2. Nurses' knowledge of PICC-related thrombosis prevention

Out of a maximum score of 20, the median knowledge score for participants in the study was 15, with an interquartile range (IQR) of 12 to 17. The accuracy rate, or the percentage of correct responses, was 75%, with an IQR of 60% to 85%. Approximately 44.99% of participants scored below the median knowledge score. Whereas the correct rate was predominantly distributed between 60% and 90%. A total of 40.38% of participants (2239 out of 5544) achieved a score of 16 points or higher, with an accuracy rate of at least 80%. The range of accuracy rates varied from 0% to 100%. Figure 1 provides a detailed illustration of the distribution of correct rates for knowledge about prevention of PICC-related thrombosis. Nurses had a relatively high score rate on the items of risk

Demographic characteristics of the study participants.

Variables	Number (%)
Gender	
Male	207 (3.73%)
Female	5337 (96.27%)
Age (yr)	
≤30	2301 (41.50%)
31 to 40	2425 (43.75%)
>40	818 (14.75%)
Experience in nursing (yr)	
1 to 5	1497 (27.01%)
6 to 10	1584 (28.57%)
11 to 15	1216 (21.93%)
>15	1247 (22.49%)
Education	
College degree	877 (15.82%)
Bachelor's degree or above	4667 (84.18%)
Leadership roles	
Yes	2314 (41.74%)
No	3230 (58.26%)
Regions	
Northeast China	420 (7.58%)
North China	836 (15.08%)
Central China	1615 (29.13%)
East China	1471 (26.53%)
Southwest China	1202 (21.68%)
Continuing education	
No	2107 (38.01%)
Yes	3437 (61.99%)

Table 1



Figure 1. The distribution of correct rate among participants.

factor assessment, with a relatively low score rate in aspects of extubation and treatment. The correct rate of nurses' knowledge of PICC-related thrombosis prevention is presented in Table 2.

The observed practice of PICC-related thrombosis prevention is detailed in Figure 2.

## 3.3. Nurses' attitude of PICC-related thrombosis prevention

Out of a maximum score of 50, the median (IQR) attitude score for PICC-related thrombosis prevention was 50 (50–50). Approximately 76.79% nurses who strongly agreed with all items related to attitudes towards PICC-related thrombosis prevention. Over 97% of nurses had a positive attitude that were agreed or strongly agreed with all items related to attitudes towards PICC-related thrombosis prevention. Only a very small percentage of nurses (no more than 0.5%) disagreed or strongly disagreed with all items related to attitude towards PICC-related thrombosis prevention. The rates of nurses' attitude towards PICC-related thrombosis prevention are presented in Table 3.

# 3.4. Nurses' practice of PICC-related thrombosis prevention

Out of a maximum score of 50, the median (IQR) practice score for PICC-related thrombosis prevention was 42 (35–50). A total 4674 nurses (84.31%) always or usually provided instructions to patients for PICC maintenance as required. It is important for nurses to proactively assess the risk of PICC-related thrombosis and implement preventive measures in clinical practice. However, over 58% of nurses did not always explain the risk factors or assess the risk of PICC-related thrombosis in patients with catheters. Additionally, 43.25% of the nurses did not always or usually use a risk assessment tool to assess patients' risk of PICC-related thrombosis. On a positive note, over 74% of nurses always or usually implemented non-pharmacological preventive measures for PICC-related thrombosis prevention.

## 3.5. Correlation among nurses' knowledge, attitude, and practice in PICC-related thrombosis prevention

According to the results of Spearman correlation analysis (P < .001), there was a significant positive correlation between nurses' knowledge, attitude, and practice scores in PICC-related thrombosis prevention. The result was shown in Table 4.

## 4. Discussion

This study revealed that Chinese nurses had a low level of knowledge regarding PICC-related thrombosis prevention, as indicated by the results of the knowledge questionnaire survey. The median knowledge score was 15 (range 0–20), and the accuracy rate was 75%. However, the accuracy rate in knowledge was higher compared to a study that found Chinese cancer nurses had a low level of knowledge on the prevention and treatment of PICC-related thrombosis, with a correct rate of <50%.<sup>[22]</sup> This indicates that the knowledge level of PICC-related thrombosis prevention among Chinese nurses has improved in recent years.

In this study, it was found that the correct rate for assessing conventional risk factors (items K1–K6) was higher than 74%. However, the correct rate was <66% for catheter and daily life risk assessment (items K7–K10). Only 22.98% of nurses chose false option for the item K11 (there must be obvious signs and symptoms after PICC-related thrombosis). Itkin et al documented that 94.5% of PICC-related thrombosis cases did not exhibit obvious signs and symptoms.<sup>[23]</sup> The correct rate of nurses' knowledge scores was higher than 68% in the preventive measures dimension, particularly in physical prevention, which reached 92.42%. Besides, this study revealed that nurses' knowledge level regarding extubation and treatment after PICC-associated thrombosis was not optimistic, with accuracy rates of 29.22% and 45.09% for 2 items, respectively. Therefore, there

Table 2

The correct rate of nurses' knowledge of PICC-related thrombosis prevention.

No.	Questions	Correct rate (%)
K1	History of thrombosis is a risk factor for PICC-related thrombosis	92.91
K2	Malignancy is a risk factor for PICC-related thrombosis	80.63
K3	Chemotherapy is a risk factor for PICC-related thrombosis	74.42
K4	Immobilization of the upper limb on the PICC side is a risk factor	85.30
K5	PICC line infection is a risk factor	84.07
K6	Limb compression on the PICC side is a risk factor	88.29
K7	The risk of thrombosis is lower when the PICC tips in the lower third of the superior vena cava (SVC) or cavoatrial junction	63.80
K8	The elbow and below puncture sites have a higher risk of PICC- related thrombosis than the above elbow puncture sites	65.87
K9	The catheter-to-vessel ratio prior to insertion ≤ 45% is associated with a lower risk of PICC-related thrombosis	58.37
K10	Lifting heavy objects on the PICC side of the limb does not increase the risk of PICC-related blood thrombosis	61.94
K11	There must be obvious signs and symptoms after PICC-related thrombosis	22.98
K12	The signs and symptoms of PICC-related thrombosis may be manifested as pain and swelling of the catheterization side of the limb	92.42
K13	Removing unnecessary PICC as early as possible is an important aspect of preventing PICC-related thrombosis	87.75
K14	Routine use of anticoagulants to prevent PICC-related thrombosis is not recommended	68.29
K15	Elevation of the upper limb on the catheterization side can prevent the occurrence of PICC-related thrombosis	70.33
K16	Adequate hydration can prevent the formation of PICC-related thrombosis	81.06
K17	If the condition permits, appropriate repeated loosening and clenching of an elastic ball is one of the measures to prevent PICC-related thrombosis	90.64
K18	Patients with PICC-related thrombosis should be removed immediately	45.09
K19	Patients with PICC-related thrombosis and retaining the catheter should continue anticoagulant therapy	77.06
K20	If the anticoagulation therapy is <3 mo and the PICC-related thrombus has been completely ablated, the anticoagulation therapy can be stopped	29.22

PICC = peripherally inserted central catheter, SVC = superior vena cava.

is a need to improve nurses' knowledge of PICC-related thrombosis prevention. Sun et al reported that most Chinese nurses had a certain understanding of PICC maintenance knowledge, but the degree of mastery was generally low, highlighting the urgent need for targeted continuing education.<sup>[22]</sup> Studies have shown that training is an important way to improve the working ability of nurses.<sup>[24]</sup> Furthermore, it has been stated that the incidence of complications during the entire length of stay with a PICC is related to the knowledge and expertise of care providers.<sup>[25]</sup> Therefore, it is a need to focus on these factors when conducting continuing education.

It is shown that 61.99% of the participants had attended continuing education training. This suggests that the coverage of continuing education on PICC-related thrombosis prevention in China is not comprehensive. The effectiveness of PICC-related thrombosis prevention education is influenced by relevant system policies and policy support. The Chinese National Health Commission launched the National Program for Prevention and Management of Pulmonary Embolism and Deep Venous Thrombosis in October 2018, which aims to promote timely diagnosis, prevention, and treatment of thrombosis, including PICC-related thrombosis, especially in primary hospitals, through medical alliances.<sup>[26]</sup> This policy will continue until 2023, indicating that the Chinese government continues to attach importance to the management of thrombosis prevention and treatment. However, the potential benefits of this policy are limited because nursing care was not taken into consideration. Delivering quality nursing care presents an opportunity for nurses to facilitate improvements in clinical practices and drive improvements in nursing care and patients' clinical outcomes.<sup>[27]</sup> Therefore, policymakers and hospital managers should strive for a practical multidisciplinary approach to prevent PICC-related thrombosis and actively encourage nurses to take ownership of these efforts.

Nurses demonstrated a generally positive attitude towards the prevention of PICC-related thrombosis. More than 97% of nurses expressed a positive attitude towards PICC-related thrombosis prevention. This may be attributed to the larger number of nurses in continuing education programs in this study, indicating the effectiveness of training to some extent. Although nurses' knowledge on the subject remained low even after participating in the training, their attitude towards prevention significantly improved. However, most nurses believed that hospitals should establish specific nursing standards for PICC-related thrombosis prevention due to inconsistencies in educational content among different nurses and within individual education sessions. Studies have shown that standardized catheterization operation, standardized use and maintenance of catheters, and professional nursing teams are important prerequisites for reducing catheter-related complications, including PICC-related thrombosis.<sup>[28]</sup> Therefore, it is necessary to construct standardized nursing programs and procedures for PICCrelated thrombosis prevention. Additionally, according to the theory of knowledge, attitude, and practice, there is a gradual relationship between knowledge and attitude.<sup>[16]</sup> Therefore, it is essential to address the existing knowledge issues of nurses regarding this topic and encourage them to participate in continuing education programs, enabling them to develop a positive attitude in clinical practice. Meanwhile, a feedback mechanism and practice guidance groups should be established to allow nurses to promptly report the problems and difficulties encountered in practice, to give full play to their enthusiasm for prevention and thus implement preventive behaviors.

Nurses typically implemented PICC-related thrombosis prevention measures generally. However, there were still weak links in practice of health guidance, which may be related to the lack of comprehensive knowledge of PICC-related thrombosis prevention despite the positive attitude of nurses. More than 74% of nurses had a high practice enthusiasm in informing patients to carry out PICC maintenance as required and instructing patients on non-pharmaceutical prevention of PICC-related thrombosis. It prompted that nurses' practice in routine operation of PICC nursing and PICC-related thrombosis prevention was relatively standardized. However, the results of this study showed that nurses had weak practice enthusiasm in risk assessment, consistent with the low knowledge correct rate of some risk assessment items. In guidelines,<sup>[13]</sup> risk assessment is the focus of PICC-related thrombosis prevention, which it is also the first line of defense of prevention quality control.<sup>[29-31]</sup> The use of simple and effective tools for early assessment and preventive measures for patients with PICC catheterization is of great significance to reduce the incidence of PICC-related thrombosis risk, reduce medical costs, and save medical resources. However, there is a lack of authoritative assessment tools specifically for PICC-related thrombosis, and most nurses rely on the international commonly used assessment tools for venous thrombosis. In addition, this study showed that the practice level of nurses actively evaluating patients' mastery of PICC-related thrombosis prevention methods was relatively weak. It suggests that nurses focus on the implementation of nursing activities, which neglecting the importance of evaluation.

In this study, significant positive correlations were observed between nurses' knowledge and attitude, knowledge and practice, and attitude and practice regarding PICC-related thrombosis prevention (P < .001). This finding was consistent with the

#### Table 3

#### The rate of nurses' attitude of PICC-related thrombosis prophylaxis.

No.	Items of attitude	Strongly agree	Agree	Neutrality	Disagree	Strongly disagree
A1	I believe that the prevention of PICC-related thrombosis is important	89.81%	8.87%	1.08%	0.00%	0.23%
A2	I believe that nurses play an important role in the prevention of PICC-related thrombosis	85.77%	12.28%	1.55%	0.16%	0.23%
A3	I think it is necessary for hospitals to formulate standardized and unified PICC maintenance nursing standards	87.70%	10.75%	1.26%	0.07%	0.22%
A4	I think the hospital should be developed specifically for prevention of PICC-related thrombosis nursing standard	86.87%	11.56%	1.33%	0.04%	0.20%
A5	I think hospitals or departments should organize PICC-related thrombo- sis prevention nursing training courses	84.45%	14.09%	1.23%	0.09%	0.14%
A6	I would like to attend PICC-related thrombosis prevention care related training course	81.78%	15.82%	2.04%	0.16%	0.20%
A7	I am willing to apply the theory and skills of PICC-related thrombosis prevention and nursing in clinical practice	83.55%	14.99%	1.26%	0.05%	0.14%
A8	I am willing to assess the risk of PICC-related thrombosis in patients	82.45%	15.44%	1.66%	0.25%	0.20%
A9	I am willing to instruct patients to take physical precautions to prevent PICC-related thrombosis	83.13%	15.10%	1.55%	0.07%	0.14%
A10	I would like to guide patients to take basic precautions (including drink- ing water, daily activities, etc) to prevent PICC-related thrombosis	83.37%	15.03%	1.30%	0.13%	0.18%

PICC = peripherally inserted central catheter.



Figure 2. Nurses' practice regarding prevention for PICC-related thrombosis. PICC = peripherally inserted central catheter.

theoretical model of knowledge-attitude-practice, which elaborated a progressive relationship between people's attitude and practice after acquiring theoretical knowledge.<sup>[16]</sup> In the premise of establishing attitude orientation and regulating practice, rich knowledge and positive attitude have internal motivation to promote the generation of practice. Therefore, it is very important to improve nurses' knowledge of PICC-related thrombosis prevention. With extensive knowledge and positive attitude, clinical nurses can standardize the nursing practice of PICCrelated thrombosis prevention in patients with catheterization, thereby reducing the incidence of PICC-related thrombosis.

## 5. Limitations

This study incorporates several limitations that must be considered. Firstly, like all cross-sectional studies, data were collected only once, providing a snapshot in time and limiting the ability to draw valid conclusions about any association or possible causality. Secondly, the questionnaire that was strictly developed according to the guidelines only had "true and false" answers in the knowledge dimension, with few items having "false" responses. This forced choice may have artificially inflated the proportion of correct responses and affected the interpretation of the data. Thirdly, the attitude of nurses can be influenced by social desirability bias, so caution should be used when interpreting attitude scores. The survey did not offer nurses the opportunity to express their views qualitatively, and there may be some value in examining if nurses are willing to advocate. Furthermore, the use of the convenience sampling method inevitably introduced potential biases, especially regional biases. For example, there may be differences among different regions in terms of medical resource allocation, nursing practice standards, and potential risk factors related to patients' thrombosis formation (such as lifestyle and environmental factors). This poses limitations on the universality and representativeness of the research results.

## Table 4

Correlation of nurses' knowledge, attitude, and practice in PICC-related thrombosis prevention.

	Summed knowledge scores	Summed attitude scores	Summed practice scores
Summed knowledge scores	1		
Summed attitude scores	.297**	1	
Summed practice scores	.295**	.356**	1

 $\label{eq:PICC} \mathsf{PICC} = \mathsf{peripherally} \text{ inserted central catheter}.$ 

\*\* P < .01 (2-tailed), significant correlation.

## 6. Conclusions

This study provides the first comprehensive map of Chinese nurses' knowledge, attitude, and practice of PICC-related thrombosis prevention. PICC-related thrombosis has insidious onset and can lead to a variety of complications and even endanger life. Despite the nurses' enthusiasm towards PICC-related thrombosis prevention, their knowledge on identification of risk assessment, signs and symptoms, especially for extubation and treatment was low. Moreover, the current prevention practice for PICC-related thrombosis prevention is not optimistic. After accumulating correct and rich prevention knowledge, nurses can form positive attitudes and concepts of PICC-related thrombosis prevention, and then actively implement prophylactic practices for patients with PICC in clinical work. Therefore, it is crucial to improving the knowledge level of nurses. Further studies should analysis the causes from multiple perspectives, including the availability of resources, the knowledge and attitude of doctors, nurses and patients. Nursing intervention strategies should be developed to prompt evidence-based nursing practices.

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## **Author contributions**

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