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Nurses' knowledge, attitudes, and practices regarding deep vein thrombosis and the nursing management

Suzhen Hu[1], Jinyin Huang[1]✉, Hua Wang[2] & Yan Wang[1]

Deep vein thrombosis (DVT) remains a significant challenge in healthcare settings, with proper nursing management playing a crucial role in patient outcomes. Deep vein thrombosis (DVT) remains a significant challenge in healthcare settings, with proper nursing management playing a crucial role in patient outcomes. To assess the knowledge, attitudes, and practices (KAP) of nurses regarding deep vein thrombosis (DVT) and its nursing management. A cross-sectional survey was conducted in Zhejiang Province between August and September 2024. Data were collected using a researcher-developed questionnaire that was validated through expert consensus and pilot testing (Cronbach's α = 0.949). A total of 568 valid questionnaires were analyzed. Among the participants, 272 (47.9%) reported having experience in caring for DVT patients. The mean scores showed that 75.9% of participants achieved adequate knowledge levels, 82.5% demonstrated positive attitudes, and 83.9% exhibited proactive practices. All indicating satisfactory levels within their respective ranges. Multivariate logistic regression showed that involving in the care of DVT patients, with relative have a history of DVT, and participation in the training of DVT care were independently associated with knowledge. Concurrently, knowledge was independently associated with attitude. Moreover, knowledge and attitude were independently associated with proactive practice (All $P < 0.05$). Nurses demonstrated adequate knowledge, positive attitudes, and proactive practices regarding DVT and its nursing management. Targeted training programs and experiential opportunities, particularly for nurses with limited exposure to DVT care, should be prioritized to further enhance their knowledge and practices, ultimately improving patient outcomes.

Keywords Venous thrombosis, Nursing care, Health knowledge, attitudes, practice, Cross-sectional studies, Nursing education, Education, nursing, continuing

Venous thromboembolism (VTE), encompassing deep vein thrombosis (DVT) and pulmonary embolism (PE), is a condition characterized by the formation of blood clots in deep veins[1,2]. Globally, VTE ranks as the third most frequent acute cardiovascular syndrome, following myocardial infarction and stroke[3]. The annual incidence of PE ranges from 39 to 115 cases per 100,000 population, while DVT occurs at a rate of 53 to 162 cases per 100,000 population[4,5].

Hospitalization is a significant risk factor for VTE, contributing to nearly half of all cases[6,7]. In China, VTE accounts for up to 2.1% of deaths among hospitalized patients[8]. Recent national multicenter studies have shown that VTE prophylaxis rates in Chinese hospitals vary significantly across different regions and departments, ranging from 14 to 47%, which is substantially lower than the recommended guidelines[9]. The implementation of VTE prevention protocols faces unique challenges in the Chinese healthcare system, including resource constraints, varying levels of staff training, and differences in hospital protocols. Despite the availability of guidelines for VTE prevention, the translation of these guidelines into routine nursing practice remains a challenge. Numerous studies have reported that many hospitalized patients do not receive appropriate prophylaxis, thereby jeopardizing patient safety and outcomes[10,11]. Recent reviews have highlighted that aging populations present unique challenges in VTE prevention and management, requiring specific nursing considerations[12].

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Nurses play a pivotal role in translating VTE prevention guidelines into clinical practice, thereby enhancing patient safety and reducing the overall burden of VTE[13,14]. Studies have demonstrated that orthopedic nurses exhibit competent practices in both mechanical and pharmacological prophylaxis for VTE patients[15–17]. Quality nursing care has been shown to drive improvements in clinical outcomes and foster changes in nursing practices[18]. However, adherence to VTE prevention guidelines can be inconsistent due to the complex and demanding nature of clinical settings, with both doctors and nurses sometimes underestimating the risks of VTE[19,20].

To address these gaps, quality and safety indicators for VTE prevention and management have been implemented as measures of hospital performance and are integral to several pay-for-performance programs[21,22]. These measures aim to ensure that best practices are consistently delivered in clinical settings, ultimately improving patient safety.

While previous studies have examined nurses' knowledge of VTE prevention, there is limited research specifically investigating the relationship between nurses' KAP and their actual clinical practice in Chinese healthcare settings. Additionally, few studies have explored how organizational factors and training programs influence nurses' adherence to VTE prevention guidelines. This study aims to address these gaps by providing a comprehensive assessment of nurses' KAP regarding DVT management in Chinese hospitals. The Knowledge-Attitude-Practice (KAP) model offers a framework for understanding and shaping health behaviors, particularly in healthcare domains[23]. The KAP questionnaire is frequently used to evaluate the knowledge, attitudes, and practices of healthcare providers, while also assessing their demand for and acceptance of specific clinical content[24]. Central to this model is the premise that knowledge positively influences attitudes, which in turn shape individual practices[25]. Given these complexities, this study aimed to assess the KAP of nurses regarding DVT and its nursing management to identify gaps and opportunities for enhancing the translation of guidelines into practice.

Methods

Study design and participants

This cross-sectional study was conducted in medical institutions across Zhejiang Province from August 27, 2024, to September 23, 2024, targeting nursing staff as the study population. hejiang Province, located in eastern China with a population of over 60 million, has a well-developed healthcare system comprising 34 tertiary hospitals, 256 secondary hospitals, and numerous primary healthcare facilities. These institutions provide comprehensive medical services including specialized vascular care, surgical services, and intensive care units where DVT prevention and management are routinely practiced. The participating hospitals were selected to represent different levels of healthcare delivery, including both urban and rural settings, to ensure a comprehensive representation of nursing practice across the region. Inclusion criteria: (1) Voluntary participation in the study; (2) Currently employed during the study period; (3) Engaged in clinical frontline nursing work in hospitals within Zhejiang Province. Those declined to participate in the study were excluded. Ethics approval was waived by the Institutional Review Board of NingBo College of Health Sciences as the study did not involve direct patient intervention or collection of sensitive personal information (**Appendix 1**), while the informed consent was obtained from all participants.

Questionnaire

A researcher-developed questionnaire was created specifically for this study through a rigorous development process. The questionnaire was developed with reference to relevant guidelines, including the Protocol for Diagnosis and Treatment of Influenza (2020 Version) by the General Office of the National Health Commission, and expert consensus documents such as the Expert Consensus on the Prevention, Nursing, and Management of Venous Thromboembolism in Hospitalized Patients (Nursing Professional Committee of the China Branch of the International Vascular Federation) and the Group Standards of the Chinese Nursing Association: T/CNAS 28-2023 Preventive Nursing of Venous Thrombosis in Adult Inpatients. Content validity was assessed by an expert panel comprising 8 senior nurses and 2 vascular specialists, with the content validity index (CVI) of 0.92. A pilot test involving 30 participants was conducted to assess the reliability of the questionnaire, yielding a high overall Cronbach's α coefficient of 0.949, with subscale coefficients of 0.975, 0.904, and 0.954 for the knowledge, attitude, and practice sections, respectively, indicating strong internal consistency. The normality of data distribution was assessed using the Kolmogorov-Smirnov test, which confirmed normal distribution ($P > 0.05$).

The final questionnaire, designed in Chinese (a version translated into English was attached as an **Appendix 2**), consisted of five dimensions and a total of 39 items. Basic demographic information comprised 12 items, while the knowledge, attitude, and practice dimensions included 15, 9, and 7 items, respectively. Scoring for statistical analysis was based on assigned values for each response option. In the knowledge section, responses were scored as 2 for "well understood," 1 for "heard of," and 0 for "unclear." The attitude and practice dimensions utilized a five-point Likert scale, with scores ranging from very positive (5 points) to very negative (1 point), depending on the nature of the item. For the attitude dimension, items 1–7 and 9 were scored a = 5, b = 4, c = 3, d = 2, e = 1, while item 8 was reverse-scored (a = 1, b = 2, c = 3, d = 4, e = 5). The possible score range for the attitude dimension was 9 to 45. For the practice dimension, items 1–7 were scored a = 5, b = 4, c = 3, d = 2, e = 1, with a possible score range of 7 to 35.

Knowledge scores were categorized as adequate if the mean score was ≥ 21. For the attitude dimension, scores between 9 and 22 were classified as negative, 23 to 31 as neutral, and 31 to 45 as positive. In the practice dimension, scores between 7 and 17 were defined as negative practice, 18 to 24 as moderate practice, and 25 to 35 as positive practice. Participants completed the attitude and practice sections after responding to the knowledge items, allowing for comprehensive assessment across all dimensions.

Data collection and quality control

The Questionnaire Star platform was utilized to distribute the online survey. Six research assistants, who received standardized training, facilitated the distribution process. Researchers introduced themselves in the nursing work groups, provided instructions for completing the questionnaire, and then shared the survey link. Responses with a completion time of less than 70 s were excluded from the analysis to ensure data quality. The formal questionnaire demonstrated strong internal consistency across the entire scale and its subscales. The overall Cronbach's α coefficient was 0.9776, with subscale coefficients of 0.9767, 0.9696, and 0.9888 for the knowledge, attitude, and practice sections, respectively. Additionally, the Kaiser-Meyer-Olkin (KMO) value for the total scale was 0.9660, indicating excellent sampling adequacy for factor analysis.

Sample size

Sample size was calculated using the formula for cross-sectional studies: $\alpha = 0.05$, $n = \left(\frac{Z_{1-\alpha/2}}{\delta}\right)^2 \times p \times (1-p)$ where $Z_{1-\alpha/2}$=1.96 when $\alpha = 0.05$, the assumed degree of variability of p=0.5 maximizes the required sample size, and δ is admissible error (which was 5% here). The theoretical sample size was 480 which includes an extra 20% to allow for subjects lost during the study.

Statistical methods

Data analysis was conducted using SPSS 22.0 (IBM, Armonk, NY, USA). Descriptive statistics were performed for demographic data and attitude (A) and practice (P) scores. Variables following a normal distribution (e.g., A and P scores) were presented as means ± standard deviations (SD), along with their minimum and maximum values. Categorical data, including demographic characteristics and responses to each question, were expressed as n (%). Comparisons of A and P scores across groups with different demographic characteristics were conducted. For normally distributed continuous variables, data were presented as means ± SD, and the t-test was employed for comparisons between two groups. For non-normally distributed variables, the Mann-Whitney U test was used. When comparing three or more groups, one-way analysis of variance (ANOVA) was applied to normally distributed data with homogeneity of variance. Pearson correlation analysis was used to examine the relationships between dimensions. Multivariate logistic regression analysis was performed to investigate the association between demographic characteristics and KAP. Variables that were statistically significant in univariate analysis were included in the multivariate model. Path analysis was conducted to explore the pathway relationships and mediating effects between A, P, and demographic characteristics. A two-sided P-value of less than 0.05 was considered statistically significant.

Results

Basic information on the population

A total of 647 participants were initially enrolled, of whom 79 cases with response times shorter than 70 s were excluded. This yielded a final dataset of 568 valid cases. Among the participants, 518 (91.2%) were female, 355 (62.5%) were aged 30 years or below, 402 (70.8%) had attained a bachelor's degree or higher, and 299 (52.6%) held a primary professional title. Additionally, 252 (44.4%) had been employed for no more than 5 years, 435 (76.6%) worked in teaching hospitals, and 480 (84.5%) were from departments unrelated to peripheral vascular diseases. Furthermore, 272 (47.9%) participants had experience caring for DVT patients, and 360 (63.4%) had participated in DVT care training. The mean scores showed that 75.9% of participants achieved adequate knowledge levels, 82.5% demonstrated positive attitudes, and 83.9% exhibited proactive practices. Specifically, in the knowledge dimension, more nurses were familiar with DVT prevention measures (89.7%) than risk assessment tools (73.2%). For attitudes, 82.5% strongly agreed with the importance of DVT prevention. Regarding practices, 79.9% reported regularly implementing DVT prevention protocols. Analysis of demographic characteristics indicated that participants' knowledge, attitude, and practice scores varied significantly by age, education level, professional title, years of work experience, type of medical institution, hospital classification, department, experience in DVT patient care, history of DVT among relatives, and DVT care training ($P < 0.05$). Additionally, participants from non-public hospitals demonstrated significantly higher practice scores ($P = 0.018$) (Table 1).

Distribution of responses to knowledge, attitude, and practice

The distribution of knowledge dimensions showed that the three questions with the highest number of participants choosing the "Unclear" option were "The commonly used DVT risk assessment tools include Caprini scale, Autar scale, Wells scale, etc." (K10) with 11.3%, "According to the time of onset, DVT is divided into acute, subacute and chronic stages. Early DVT includes acute stage and subacute stage." (K4) with 7%, and "For adult inpatients, if there is no contraindications, the lower limbs can be elevated 20 to 30 cm above the heart plane to prevent DVT." (K13) with 6.2% (Table S1). Responses to the attitudinal dimension showed that 40.7% strongly agreed that the education and guidance of nurses on DVT and its nursing management is insufficient (A3), 46.1% strongly agreed that patient compliance as the biggest barrier to the implementation of DVT and its nursing management, also, 32.6% had a very pessimistic attitude towards patient compliance (A8) (Table S2). When it comes to related practices, 27.8% were only moderately knowledgeable about DVT and its nursing management (P1), and 20.1% of the participants were not very or relatively proactive and consistently learning about the latest research and guidelines in fields related to DVT to improve the quality of care (P4) (Table S3).

N = 568	*N* (%)	Knowledge , mean ± SD	*P*	Attitude , mean ± SD	*P*	Practice , mean ± SD	*P*
Total score	568 (100.0)	22.78 ± 7.83		37.13 ± 4.48		29.39 ± 5.24	
Gender			0.112		0.317		0.960
Male	50(8.8)	21.42 ± 7.43		37.68 ± 4.60		29.38 ± 5.13	
Female	518(91.2)	22.91 ± 7.86		37.08 ± 4.46		29.39 ± 5.25	
Age			0.011		0.006		0.007
Age 30 and under	355(62.5)	22.21 ± 7.80		36.66 ± 4.68		28.90 ± 5.24	
31–40 years old	165(29.0)	23.42 ± 8.01		37.98 ± 4.01		30.32 ± 5.16	
Age 40 and older	48(8.5)	24.79 ± 7.03		37.71 ± 4.07		29.73 ± 5.16	
Education			0.001		< 0.001		0.015
College or below	166(29.2)	21.04 ± 8.17		36.03 ± 4.24		28.64 ± 5.28)	
Bachelor degree or above	402(70.8)	23.50 ± 7.58		37.59 ± 4.50		29.69 ± 5.20	
Professional title			0.001		< 0.001		0.003
None	78(13.7)	20.83 ± 8.48		36.01 ± 4.88		28.67 ± 5.49	
Primary	299(52.6)	22.38 ± 7.87		36.68 ± 4.70		28.85 ± 5.44	
Intermediate	154(27.1)	23.71 ± 7.59		38.14 ± 3.72		30.23 ± 4.74	
Senior (including deputy senior)	37(6.5)	26.24 ± 5.33		39.00 ± 3.31		31.73 ± 3.93	
Years of working			0.007		0.005		0.018
≤ 5 years	252(44.4)	22.06 ± 7.79		36.50 ± 4.59		28.83 ± 5.11	
6–10 years	151(26.6)	22.75 ± 7.81		37.16 ± 4.78		29.22 ± 5.53	
11–15 years	89(15.7)	22.96 ± 8.29		37.96 ± 3.90		30.64 ± 4.79	
≥ 16 years	76(13.4)	25.03 ± 7.10		38.22 ± 3.75		30.09 ± 5.36	
Level of medical and health institution			< 0.001		< 0.001		< 0.001
Tertiary	431(75.9)	23.59 ± 7.38		37.56 ± 4.30		29.99 ± 5.02	
Secondary/Primary	137(24.1)	20.22 ± 8.63		35.78 ± 4.77		27.47 ± 5.46	
Hospital type			0.822		0.085		0.018
Public sector	191(33.6)	22.99 ± 7.61		36.76 ± 4.58		28.67 ± 5.31	
Non-public	377(66.4)	22.67 ± 7.95		37.32 ± 4.42		29.75 ± 5.17	
Nature of staffing			0.142		0.772		0.410
Staff in office	114(20.1)	23.98 ± 7.21		37.28 ± 4.39		29.04 ± 5.16	
Personnel on contract	454(79.9)	22.48 ± 7.95		37.10 ± 4.50		29.47 ± 5.26	
Teaching hospital			< 0.001		0.013		0.012
No	133(23.4)	19.98 ± 8.00		36.42 ± 4.02		28.32 ± 5.39	
Yes	435(76.6)	23.64 ± 7.58		37.35 ± 4.59		29.71 ± 5.15	
Department			< 0.001		0.010		< 0.001
Peripheral vascular disease related departments	88(15.5)	26.45 ± 6.10		38.28 ± 4.02		31.18 ± 4.27	
Non-peripheral vascular disease related departments	480(84.5)	22.11 ± 7.93		36.92 ± 4.53		29.06 ± 5.34	
With experience of care for DVT patients			< 0.001		< 0.001		< 0.001
No	296(52.1)	19.46 ± 8.18		36.03 ± 4.65		27.75 ± 5.50	
Yes	272(47.9)	26.39 ± 5.51		38.33 ± 3.95		31.17 ± 4.29	
With relative have a history of DVT			< 0.001		< 0.001		< 0.001
No	417(73.4)	23.51 ± 7.23		37.56 ± 4.15		29.72 ± 5.09	
Yes	33(5.8)	24.67 ± 6.47		38.58 ± 4.26		31.94 ± 4.21	
No idea	118(20.8)	19.67 ± 9.32		35.23 ± 5.09		27.50 ± 5.49	
Participation in the training of DVT care			< 0.001		< 0.001		< 0.001
No	208(36.6)	17.59 ± 8.21		35.18 ± 4.80		26.93 ± 5.61	
Yes	360(63.4)	25.78 ± 5.77		38.26 ± 3.86		30.81 ± 4.43	

Table 1. Baseline characteristics.

Correlations between KAP

In the correlation analysis, significant positive correlations were found between knowledge and attitude ($r = 0.536$, $P < 0.001$), knowledge and practice ($r = 0.612$, $P < 0.001$), as well as attitude and practice ($r = 0.724$, $P < 0.001$), respectively (Table S4).

Factors associated with KAP

The median of the knowledge, attitude, and practice scores were used as the cut-off value for each dimension to divided the groups, and the number of participants above the cut-off value were 330 (58.10%), 347 (61.09%), and

402 (70.77%), respectively (Table S5). Multivariate logistic regression showed that involving in the care of DVT patients (OR = 2.861, 95% CI: [1.781,4.595], $P < 0.001$), with relative have a history of DVT (OR = 0.430, 95% CI: [0.190,0.973], $P = 0.043$), no idea about the DVT history of relative (OR = 0.536, 95% CI: [0.330,0.870], $P = 0.012$), and participation in the training of DVT care (OR = 3.390, 95% CI: [2.087,5.507], $P < 0.001$) were independently associated with knowledge (Table 2). Concurrently, knowledge (OR = 1.172, 95% CI: [1.131,1.214], $P < 0.001$) and no idea about the DVT history of relative (OR = 0.565, 95% CI: [0.343,0.929], $P = 0.024$) were independently associated with attitude (Table 3). Moreover, knowledge (OR = 1.071, 95% CI: [1.032,1.111], $P < 0.001$) and attitude (OR = 1.309, 95% CI: [1.223,1.400], $P < 0.001$) were independently associated with proactive practice (Table 4).

	Univariate analysis		Multivariate analysis	
Knowledge	**OR (95% CI)**	***P***	**OR (95% CI)**	***P***
Gender				
Male				
Female	1.564 (0.873, 2.812)	0.132		
Age				
Age 30 and under				
31–40 years old	1.359 (0.934, 1.988)	0.111	1.002 (0.450, 2.231)	0.996
Age 40 and older	2.260 (1.183, 4.567)	0.017	1.359 (0.347, 5.328)	0.660
Education				
College or below				
Bachelor degree or above	1.708 (1.186, 2.463)	0.004	1.206 (0.725, 2.009)	0.471
Professional title				
None				
Primary	1.314 (0.797, 2.169)	0.284	0.906 (0.474, 1.731)	0.765
Intermediate	1.791 (1.033, 3.120)	0.038	0.889 (0.332, 2.379)	0.814
Senior (including deputy senior)	3.816 (1.609, 9.905)	0.004	0.872 (0.205, 3.707)	0.853
Years of working				
≤ 5 years				
6–10 years	1.178 (0.785, 1.773)	0.430	0.944 (0.530, 1.681)	0.844
11–15 years	1.276 (0.784, 2.094)	0.330	0.923 (0.320, 2.661)	0.883
≥ 16 years	2.270 (1.313, 4.046)	0.004	1.359 (0.379, 4.870)	0.638
Level of medical and health institution				
Tertiary				
Secondary/Primary	0.503 (0.340, 0.741)	0.001	0.701 (0.420, 1.170)	0.174
Hospital type				
Public sector				
Non-public	1.066 (0.748, 1.515)	0.723		
Nature of staffing				
Staff in office				
Personnel on contract	0.699 (0.453, 1.066)	0.100		
Teaching hospital				
No				
Yes	2.438 (1.644, 3.636)	< 0.001	1.324 (0.801, 2.190)	0.274
Department				
Peripheral vascular disease related departments				
Non-peripheral vascular disease related departments	0.304 (0.171, 0.515)	< 0.001	0.567 (0.304, 1.057)	0.074
With experience of care for DVT patients				
No				
Yes	5.937 (4.107, 8.683)	< 0.001	2.861 (1.781, 4.595)	< 0.001
With relative have a history of DVT				
No				
Yes	1.068 (0.519, 2.294)	0.862	0.430 (0.190, 0.973)	0.043
No idea	0.449 (0.295, 0.678)	< 0.001	0.536 (0.330, 0.870)	0.012
Participation in the training of DVT care				
No				
Yes	7.124 (4.889, 10.495)	< 0.001	3.390 (2.087, 5.507)	< 0.001

Table 2. Univariate and multivariate analysis for knowledge dimension.

Attitude	Univariate analysis		Multivariate analysis	
	OR (95%CI)	*P*	OR (95%CI)	*P*
Knowledge	1.171 (1.137, 1.206)	< 0.001	1.172 (1.131, 1.214)	< 0.001
Gender				
Male				
Female	0.873 (0.469, 1.580)	0.659		
Age				
Age 30 and under				
31–40 years old	1.539 (1.049, 2.277)	0.029	0.953 (0.412, 2.203)	0.910
Age 40 and older	1.647 (0.878, 3.222)	0.130	0.617 (0.142, 2.674)	0.518
Education				
College or below				
Bachelor degree or above	1.982 (1.373, 2.865)	< 0.001	1.567 (0.938, 2.616)	0.086
Professional title				
None				
Primary	0.965 (0.581, 1.591)	0.888	0.587 (0.302, 1.141)	0.116
Intermediate	1.872 (1.061, 3.304)	0.030	1.359 (0.476, 3.878)	0.566
Senior (including deputy senior)	2.404 (1.031, 6.016)	0.049	1.382 (0.296, 6.464)	0.681
Years of working				
≤ 5 years				
6–10 years	1.319 (0.875, 1.998)	0.188	1.108 (0.621, 1.975)	0.729
11–15 years	1.497 (0.911, 2.493)	0.115	0.666 (0.217, 2.045)	0.477
≥ 16 years	2.095 (1.211, 3.735)	0.010	0.920 (0.224, 3.784)	0.908
Level of medical and health institution				
Tertiary				
Secondary/Primary	0.680 (0.461, 1.004)	0.052	1.009 (0.619, 1.645)	0.971
Hospital type				
Public sector				
Non-public	1.206 (0.845, 1.720)	0.301		
Nature of staffing				
Staff in office				
Personnel on contract	0.705 (0.453, 1.082)	0.115		
Teaching hospital				
No				
Yes	1.291 (0.869, 1.912)	0.205		
Department				
Peripheral vascular disease related departments				
Non-peripheral vascular disease related departments	0.653 (0.395, 1.053)	0.087	1.485 (0.825, 2.673)	0.187
With experience of care for DVT patients				
No				
Yes	2.816 (1.985, 4.021)	< 0.001	1.143 (0.677, 1.928)	0.618
With relative have a history of DVT				
No				
Yes	2.044 (0.912, 5.210)	0.103	2.029 (0.755, 5.452)	0.161
No idea	0.434 (0.285, 0.655)	< 0.001	0.565 (0.343, 0.929)	0.024
Participation in the training of DVT care				
No				
Yes	3.165 (2.221, 4.532)	< 0.001	0.850 (0.491, 1.469)	0.560

Table 3. Univariate and multivariate analysis for attitude dimension.

Interactions between KAP and other factors

The SEM model demonstrated a good fit (RMSEA = 0.063, SRMR = 0.046, TLI = 0.923, CFI = 0.930) (Table S6), with effect estimates for various pathways detailed in Table S7 and Fig. 1. Mediation analysis revealed that medical institution level (β = − 0.077, $P = 0.048$), experience (β = 0.196, $P < 0.001$), DVT (β = − 0.139, $P < 0.001$), and training (β = 0.330, $P < 0.001$) directly influenced knowledge. Attitude was directly influenced by knowledge (β = 0.521, $P < 0.001$), medical institution level (β = − 0.097, $P = 0.013$), and DVT (β = − 0.089, $P = 0.014$). Practice was directly influenced by knowledge (β = 0.149, $P < 0.001$), attitude (β = 0.704, $P < 0.001$),

Practice	Univariate analysis		Multivariate analysis	
	OR (95% CI)	*P*	OR (95% CI)	*P*
Knowledge	1.142 (1.110, 1.174)	< 0.001	1.071 (1.032, 1.111)	< 0.001
Attitude	1.373 (1.294, 1.458)	< 0.001	1.309 (1.223, 1.400)	< 0.001
Gender				
Male				
Female	0.661 (0.315, 1.281)	0.242		
Age				
Age 30 and under				
31–40 years old	1.489 (0.982, 2.292)	0.065	1.792 (0.818, 3.926)	0.145
Age 40 and older	1.014 (0.538, 1.991)	0.967	0.627 (0.189, 2.083)	0.446
Education				
College or below				
Bachelor degree or above	1.462 (0.989, 2.151)	0.055	0.964 (0.552, 1.685)	0.898
Professional title				
None				
Primary	1.045 (0.605, 1.769)	0.872	0.777 (0.383, 1.576)	0.485
Intermediate	1.258 (0.690, 2.268)	0.449	0.395 (0.136, 1.143)	0.087
Senior (including deputy senior)	2.437 (0.948, 7.143)	0.079	1.013 (0.189, 5.417)	0.988
Years of working				
≤ 5 years				
6–10 years	1.056 (0.683, 1.645)	0.808		
11–15 years	1.365 (0.797, 2.407)	0.268		
≥ 16 years	1.174 (0.672, 2.109)	0.581		
Level of medical and health institution				
Tertiary				
Secondary/Primary	0.455 (0.305, 0.682)	< 0.001	0.669 (0.403, 1.111)	0.120
Hospital type				
Public sector				
Non-public	1.309 (0.896, 1.907)	0.161		
Nature of staffing				
Staff in office				
Personnel on contract	1.092 (0.693, 1.697)	0.698		
Teaching hospital				
No				
Yes	1.388 (0.913, 2.094)	0.121		
Department				
Peripheral vascular disease related departments				
Non-peripheral vascular disease related departments	0.371 (0.191, 0.666)	0.002	0.540 (0.255, 1.143)	0.107
With experience of care for DVT patients				
No				
Yes	3.219 (2.190, 4.791)	< 0.001	1.497 (0.825, 2.718)	0.185
With relative have a history of DVT				
No				
Yes	2.133 (0.873, 6.397)	0.128	1.980 (0.595, 6.587)	0.266
No idea	0.596 (0.389, 0.918)	0.018	1.207 (0.698, 2.088)	0.501
Participation in the training of DVT care				
No				
Yes	3.179 (2.189, 4.639)	< 0.001	0.871 (0.476, 1.594)	0.654

Table 4. Univariate and multivariate analysis for practice dimension.

and experience (β = 0.078, *P* = 0.020). Indirect effects were also observed: experience (β = 0.102, *P* < 0.001), DVT (β = − 0.072, *P* < 0.001), and training (β = 0.172, *P* < 0.001) indirectly affected attitude. Knowledge (β = 0.367, *P* < 0.001), medical institution level (β = − 0.108, *P* = 0.002), experience (β = 0.085, *P* = 0.032), DVT (β = − 0.134, *P* < 0.001), and training (β = 0.209, *P* < 0.001) indirectly affected practice (Table S8).

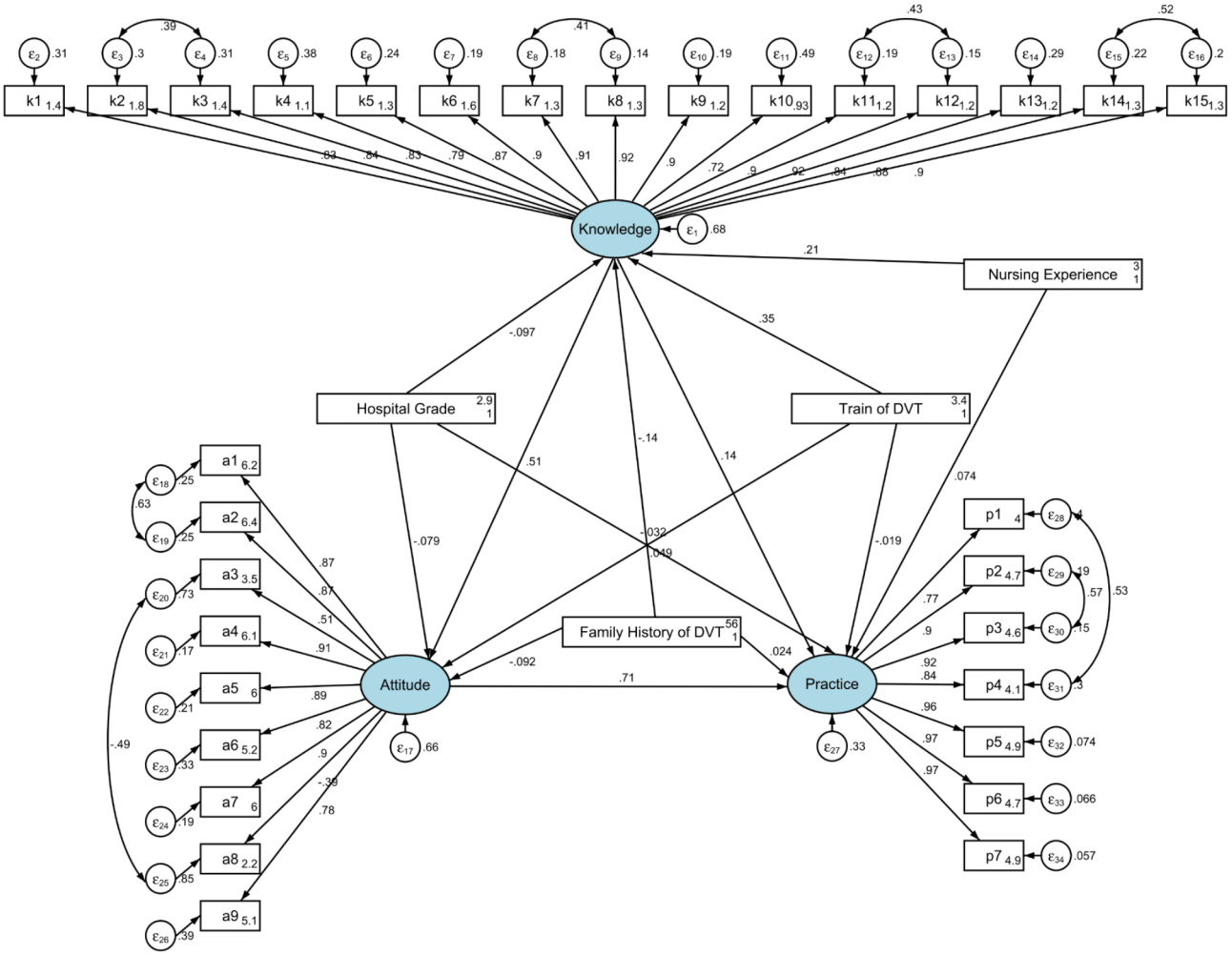

Fig. 1. SEM path diagram.

Discussion

Nurses demonstrated moderate knowledge, positive attitudes, and proactive practices regarding DVT and its nursing management, with significant interrelationships observed among these dimensions. Enhancing targeted training programs, particularly focusing on knowledge gaps and practical skills, is essential to further improve nursing competencies in DVT management and optimize patient care outcomes.

While their attitudes and practices reflect an overall understanding of the importance of DVT prevention and care, the moderate knowledge scores suggest gaps in comprehension of essential concepts, such as risk assessment tools, staging, and evidence-based management protocols. These findings align with prior studies, which have similarly noted that while nurses often express willingness and positivity towards patient care, their limited knowledge base may compromise effective implementation of clinical guidelines[26,27]. Such deficiencies could contribute to persistently low adherence rates to DVT preventive measures and suboptimal patient outcomes, as reported in broader clinical contexts[28,29].

The moderate knowledge scores observed in this study are consistent with findings from research conducted in other regions, which frequently highlight that healthcare professionals lack familiarity with advanced diagnostic tools and preventive strategies for DVT. For instance, studies have shown that despite training, many nurses remain unaware of widely used risk assessment tools such as the Caprini and Wells scales, reflecting the findings of this study where nearly half of the respondents could not identify these tools[30,31]. Similarly, understanding of DVT staging and chronic complications was limited, suggesting that these areas are universally challenging in nursing education. These gaps are particularly concerning, as they may result in delayed recognition and management of high-risk patients, potentially increasing the incidence of complications like pulmonary embolism.

By contrast, the positive attitudes observed in this study mirror findings from previous research, where nurses expressed strong recognition of DVT as a serious complication and emphasized the importance of preventive measures[32,33]. However, this study also highlighted pessimism regarding patient compliance, with a significant proportion of nurses identifying it as a barrier to effective care. This aligns with prior literature

suggesting that patient-related factors, including lack of education and poor adherence to preventive measures, remain significant obstacles to successful DVT management[34,35].

The study identified several variables associated with differences in KAP scores, including professional experience, education level, and training. Nurses with higher education levels, senior professional titles, or prior DVT-related training demonstrated significantly better scores across all dimensions, as confirmed by both multivariate logistic regression and SEM analyses. These findings are supported by evidence that advanced education and structured training programs significantly enhance both theoretical knowledge and practical application in clinical settings[36,37]. For example, training workshops focusing on risk assessment and anticoagulation strategies have been shown to improve nurses' confidence and accuracy in implementing evidence-based practices[38,39]. Additionally, nurses actively involved in DVT patient care had higher KAP scores, likely due to their firsthand exposure to real-world cases, which reinforces the importance of experiential learning.

Interestingly, nurses working in lower-tier medical institutions or non-teaching hospitals scored lower on all dimensions. These disparities likely reflect systemic differences in resource availability, professional development opportunities, and institutional emphasis on continuing education. Previous research has similarly noted that nurses in less-resourced settings are less likely to participate in advanced training, limiting their ability to apply evidence-based guidelines effectively[40,41]. These results underscore the need for targeted interventions in under-resourced hospitals to ensure equitable training opportunities.

In the knowledge dimension, certain areas showed particularly poor results. For instance, a substantial proportion of nurses could not correctly identify the stages of DVT or the appropriate use of risk assessment tools. Similar gaps have been reported in other studies, where unfamiliarity with standardized assessment scales was attributed to insufficient emphasis on these tools during training[42,43]. Additionally, a notable number of participants were unaware of evidence-based preventive measures, such as elevating the lower limbs or using antithrombotic stockings. This aligns with previous research highlighting that procedural guidelines are often underutilized in clinical practice due to a lack of comprehensive training[44,45].

Addressing these knowledge gaps requires multifaceted and context-specific interventions. First, hospitals should implement structured and mandatory training programs focused on high-priority areas such as risk assessment tools, staging, and evidence-based prevention and management strategies for DVT. These programs should incorporate case-based learning to contextualize theoretical knowledge and facilitate practical application. For nurses in lower-tier hospitals, online platforms offering interactive modules can provide an accessible alternative, allowing them to complete training at their convenience. Moreover, simulation-based learning, such as virtual reality scenarios, can offer experiential learning opportunities, especially for those with limited direct experience in DVT care[46,47].

In addition to enhancing knowledge, targeted strategies are needed to address attitudinal and practice-related barriers. For example, motivational interviewing techniques could be integrated into communication training to help nurses address patient compliance issues. Furthermore, implementing a mentorship model, where senior nurses with extensive DVT care experience guide less experienced colleagues, could foster confidence and reinforce good practices. Hospitals could also introduce quality improvement initiatives, such as feedback mechanisms, to track patient adherence and outcomes, enabling nurses to refine their approaches based on real-world effectiveness.

Specific deficiencies highlighted in this study, such as the lack of understanding of risk assessment tools and pessimism regarding patient compliance, require focused attention. Incorporating DVT management into nursing curricula at an early stage and providing continuous professional development opportunities could help address knowledge deficits. For patient compliance, developing culturally sensitive educational materials for patients and families may empower them to take an active role in their care, thus alleviating nurses' concerns about adherence. Additionally, integrating multidisciplinary care teams involving nurses, physicians, and patient educators could ensure a more cohesive approach to DVT management[48,49].

The strong correlations observed among knowledge, attitudes, and practices reaffirm the interconnected nature of these dimensions. SEM analysis confirmed that knowledge significantly influences attitudes, which in turn drive practices, a finding consistent with other studies in healthcare settings[50,51]. This underscores the importance of addressing knowledge gaps, as doing so is likely to have a cascading positive effect on attitudes and practices. For example, improving understanding of DVT staging and management not only enhances nurses' confidence but also encourages proactive behaviors, such as educating patients and adhering to evidence-based guidelines.

This study has several limitations. First, as a cross-sectional survey, it captures data at a single time point, limiting the ability to infer causality among knowledge, attitudes, and practices. Second, the study relied on self-reported data, which may be subject to social desirability bias, potentially leading to an overestimation of positive responses. Third, the study was conducted in Zhejiang Province, and the findings may not be generalizable to nurses in other regions or healthcare settings with differing resources and practices. Future research should consider longitudinal designs and broader sampling to address these limitations.

In conclusion, this study provides comprehensive insights into nurses' KAP regarding DVT management in Chinese healthcare settings. The findings highlight that while nurses generally demonstrate adequate knowledge and positive attitudes, there are specific areas requiring improvement, particularly in risk assessment tools and practical implementation. The study identifies key factors influencing nurses' KAP, including training experience, institutional support, and direct patient care exposure. These findings have important implications for nursing education and hospital policy development, suggesting the need for targeted training programs and standardized protocols to enhance DVT prevention and management. Nurses demonstrated adequate knowledge, positive attitudes, and proactive practices regarding DVT and its nursing management, with significant interrelations among these dimensions. Targeted training programs, particularly for nurses with limited experience in DVT

care, are essential to further enhance knowledge and translate it into improved attitudes and practices in clinical settings.

Data availability

All data generated or analyzed during this study are included in this published article.

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Author contributions
Hua Wang, and Yan Wang carried out the studies, participated in collecting data. Suzhen Hu and Jinyin Huang performed the statistical analysis and participated in its design. Suzhen Hu and Jinyin Huang participated in acquisition, analysis, or interpretation of data and draft the manuscript. All authors read and approved the final manuscript.

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Declarations

Competing interests
The authors declare no competing interests.

Ethics approval and consent to participate
The study was waived by the Institutional Review Board of Ningbo College of Health Sciences. All participants were informed about the study protocol and provided informed consent to participate in the study. I confirm that all methods were performed in accordance with the relevant guidelines. All procedures were performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments.

Additional information
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