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Nurses' Knowledge, Attitude and Practice in Preventing Lower Extremity Venous Thrombosis in Patients After Major Orthopedic Surgery: A Training Program Development

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Abstract:
Venous thromboembolism is a common complication and a leading cause of death following major orthopedic surgery. An electronic questionnaire will be developed to investigate the current nursing care practices related to preventing lower limb venous thrombosis after such surgeries in secondary and tertiary hospitals in Shandong Province. The questionnaire aims to assess nurses' knowledge, attitude, and practice regarding the prevention of lower limb venous thrombosis after major orthopedic surgery. In addition, the questionnaire will analyze factors that may influence these practices, identify any deficiencies in preventing lower limb venous thrombosis, and propose targeted interventions based on the study findings to enhance nurses' understanding, and compliance with VTE prevention guidelines, and ultimately optimize patient outcomes.

Keywords: major orthopedic surgery; lower extremity deep vein thrombosis; knowledge, attitude, practice

1. INTRODUCTION

Venous thromboembolism (VTE), which includes deep vein thrombosis (DVT) and pulmonary embolism (PE), represents a critical health concern among hospitalized patients. It is the third leading cause of mortality, following ischemic heart disease and stroke (Di Nisio, van Es, & Buller, 2016).Deep vein thrombosis (DVT) can occur in various parts of the body; however, this study specifically focuses on lower deep vein thrombosis (LDVT), which refers to thrombosis occurring in the lower extremities. LDVT is the most common form of DVT in postoperative orthopedic patients and is associated with significant morbidity and mortality if left untreated.Major orthopedic surgeries, such as Total Hip Arthroplasty (THA), Total Knee Arthroplasty (TKA), and Hip Fracture Surgery (HFS), are particularly high-risk factors for VTE, with DVT being the most common complication (Shen & Cheng, 2019). From 2012 to 2021, over 2.1 million THA and TKA procedures were performed in the United States, and approximately 1.07 million in China, with an annual growth rate of 20%. DVT in these surgeries predominantly occurs in the lower limbs, leading to swelling, pain, and potential functional impairment. If untreated, this can progress to post-thrombotic syndrome or result in PE, significantly increasing patient morbidity, mortality, and the associated economic and social burden.

Despite the serious risks, VTE is preventable. The implementation of updated thromboembolism prevention guidelines in 2016 has notably decreased the incidence of DVT following THA and TKA in China. However, effective prevention requires a combination of basic, physical, and pharmacological prophylaxis, each tailored to the patient's condition (Liu & Zhang, 2016). Nursing care plays a crucial role in this prevention strategy, yet challenges remain. Studies indicate that while Chinese nurses are highly motivated to prevent VTE, their knowledge of prevention measures, risk identification, and symptom recognition is often insufficient. Additionally, the current use of mechanical prophylaxis after THA and TKA is not optimal (Wang et al.).

The Knowledge-Attitude-Practice (KAP) model, a framework used to promote health behavior change, underscores the importance of knowledge acquisition, attitude formation, and the development of effective practices (Jiang et al., 2017). In the context of VTE prevention, this model suggests that nurses must first acquire comprehensive knowledge of LDVT, develop a strong sense of responsibility, and cultivate a positive attitude towards their role in postoperative care. These elements are crucial for the effective implementation of LDVT prevention practices.

Nurses are central to the prevention, early detection, and management of VTE, making specialized training essential for improving patient outcomes (Al-Mugheed et al., 2022). Proper prophylaxis not only reduces hospital stays and medical costs but also lowers the incidence of VTE (Al-Mugheed & Bayraktar, 2018). Evidence shows that when nurses educate patients, the morbidity and mortality rates associated with DVT significantly decrease (Lavall & Costello, 2015). However, inadequate knowledge and practices remain key contributors to the global prevalence of VTE (Silva et al., 2020). Therefore, increasing nurse knowledge and improving practices related to VTE prevention are critical to mitigating this public health issue.

In recognition of the importance of VTE management, healthcare systems worldwide have implemented specialized training programs for nurses. In the United States, these programs are often integrated into broader patient safety initiatives, emphasizing evidence-based protocols and continuous education. Similarly, the National Health Service (NHS) in the United Kingdom has developed comprehensive training programs that combine e-learning with practical workshops, ensuring nurses are proficient in VTE risk assessment and prevention strategies (Roberts et al., 2018).

In contrast, regions like China face challenges in the widespread implementation of nurse VTE training due to varying healthcare infrastructure levels. Nevertheless, large tertiary hospitals in China are pioneering comprehensive VTE prevention training for nurses, focusing on integrating these practices into routine patient care (Li et al., 2024).

The global focus on reducing VTE-related morbidity and mortality highlights the urgent need for effective nurse training programs. These programs are crucial not only for enhancing nurses' knowledge and skills but also for fostering a healthcare environment where VTE prevention is prioritized, leading to better patient outcomes and a reduction in the burden of this preventable condition.

2. STUDY OBJECTIVES

2.1. General Objective

To evaluate nurses' knowledge, attitudes, and practices in preventing lower limb venous thromboembolism post-major orthopedic surgery through analyzing influencing factors and finally proposing target interventions and training program based on the study findings to enhance nurses'

understanding, and compliance with VTE prevention guidelines, and ultimately optimize patient outcomes.

2.2. Specific Objectives

Guided by the overall objectives, this study answers the following questions：

1. To describe the respondents' demographic characteristics
2. To assess the level of nurses' knowledge regarding the prevention of LDVT in patients after orthopedic surgery
3. To evaluate nurses' current practice in preventing LDVT in patients after major orthopedic surgery
4. To propose targeted interventions based on the study findings to enhance nurses' understanding, compliance with VTE prevention guidelines, and ultimately optimize patient outcomes.

3. REVIEW OF RELATED LITERATURE

3.1. Current status of LDVT prevention in major orthopedic surgery

Relevant studies have shown that advanced age, smoking, hypertension, diabetes, hyperlipidemia, obesity, surgery, coagulation abnormalities, and anesthesia methods are high-risk causative factors for LDVT. The current preventive measures for DVT both at home and abroad, mainly include basic prevention, physical prevention, and drug prevention.

3.1.1. Basic Prevention:

Basic prevention includes encouraging patients to move early and elevate the affected limb, such as early ambulation, is fundamental in mitigating the risk of LDVT. Early mobilization post-surgery promotes blood circulation, reducing the likelihood of venous stasis and thrombus formation (Schünemann et al., 2019). It also involves protecting the veins of the affected limb and avoiding puncturing at the same site. Additional measures include promoting deep breathing and coughing, encouraging patients to increase fluid intake, and quitting smoking and alcohol consumption. Some guidelines emphasize that basic prevention encompasses various nursing measures. According to Lin JH(2019), the implementation of comprehensive nursing interventions for the prevention of LDVT after major orthopedic surgery resulted in a significantly lower incidence of lower limb swelling and LDVT in the observation group (10.0%, 6.67%) compared to the control group (30.0%, 23.33%), with a p-value < 0.05. Similarly, Sun YC and Zhang PL (2018) found that the use of PDCA cycle management to prevent DVT in patients undergoing major orthopedic surgery led to a lower incidence of DVT in the observation group, along with higher quality of specialty care and patient satisfaction compared to the control group. Furthermore, Chinese medicine nursing prevention has gained popularity in clinical practice in recent years. These findings collectively demonstrate that effective implementation of nursing prevention measures can reduce the incidence of DVT in patients undergoing major orthopedic surgery.

3.1.2. Mechanical Prophylaxis:

Mechanical Prophylaxis, including intermittent pneumatic compression devices (IPCD), gradient compression stockings (GCS), and venous foot pumps (VFP), are widely employed in clinical practice.Intermittent Pneumatic Compression (IPC) Devices: Advancements in IPCD have enhanced mechanical prophylaxis strategies (Kakkos et al., 2019). These devices intermittently apply pressure to the legs, facilitating venous return and preventing stasis. IPCD is particularly valuable for patients with contraindications to anticoagulant therapy. Gradient Compression Stockings (GCS): GCS plays a crucial role in preventing .LDVT (Kahn et al., 2020). These stockings exert pressure on the lower extremities, promoting venous return and reducing stasis. Recent studies reaffirm their effectiveness when used

alongside pharmacological measures. VFP is a device that delivers pulsed pressure gas to the bottom of the foot to increase the rate of arterial and venous blood return, thus preventing venous blood stagnation and accelerating arterial circulation. Studies have shown that the combination of IPCD (Intermittent Pneumatic Compression Devices) with GCS (Gradient Compression Stockings) is effective in reducing the incidence of DVT and D-dimer concentration in the prevention of prosthetic arthroplasty (Zhu et al., 2019).. Another study demonstrated that the use of IPCD in major orthopedic surgery significantly reduced the incidence of potentially lethal DVT to 3.92%, whereas conventional graduated compression stockings had a DVT rate of 9.84%.Dai, Li, Zhang, and Cao (2022) discuss the best evidence summary on the use of elastic stockings for the prevention and treatment of venous thromboembolism during the perioperative period, highlighting that Graduated Compression Stockings (GCS) have a significant effect on preventing lower extremity venous thrombosis in this context. A domestic study showed that VFP can reduce the incidence of postoperative DVT in elderly THA patients. According to the research by Chang B and Zhao JQ (2018), VFP used to prevent DVT in geriatric department fractures, the results showed that the incidence of DVT in the VFP group was 14.1%, which was significantly lower than that in the control group of 35.7% ($P < 0.05$), indicating a significant effect of VFP for the prevention of DVT in geriatric fractures. According to the study, the use of an arteriovenous foot pump during the perioperative period for calcaneal fractures significantly improves limb swelling, reduces patient pain, shortens hospital stays, and lowers the incidence of lower deep vein thrombosis (LDVT) (Lv, Tao, & Yang, 2019).

3.1.3. Pharmacological prophylaxis:

The advent of direct oral anticoagulants (DOACs), such as rivaroxaban and apixaban, has revolutionized the prevention of lower limb deep vein thrombosis (LDVT). DOACS offer the convenience of oral administration and have demonstrated both efficacy and safety in major orthopedic surgery procedures (Ginsberg et al., 2020). Low-Molecular-Weight Heparins (LMWH) Despite the rise of DOACs, low-molecular-weight heparins (LMWH) remain a reliable choice for LDVT prevention, especially in the immediate postoperative period (Gross et al., 2021).LMWH's subcutaneous administration and well-established safety profile contribute to its continued use. Some studies have confirmed that pharmacological prophylaxis combined with physical prophylaxis can effectively reduce the incidence of DVT complicating orthopedic trauma.However, the disadvantages of certain anticoagulant drugs also limit their clinical application, and many patients express dissatisfaction and even fear of low-molecular heparin due to its complications such as injection pain and subcutaneous sclerosis, and some patients even refuse to use it (Li JH, 2017).LDVT patient compliance with medication is affected by a variety of factors, such as age, literacy health insurance, income, etc. Therefore, nursing staff should intervene to address their major factors.

In conclusion, the prevention of LDVT in major orthopedic surgery should be a combination of all three, avoiding one preventive measure, doing a good job of prevention and control measures, and strengthening mechanical prophylaxis and pharmacological prevention along with basic prevention.

3.2. Current status of knowledge, practice, and attitude theory

The Knowledge-Attitude-Practice (KAP) model has been a pivotal framework in health education, nursing education, and management.This model emphasizes the interrelation between knowledge, attitudes, and practices, aiming to enhance health outcomes by improving these three components (Li, Wang, & Zhou, 2020). The KAP model has been effectively utilized to improve knowledge and practices related to the prevention of venous thromboembolism (VTE) in orthopedic patients. Chen, Liu, and Wang (2022)

demonstrated that applying the KAP model in orthopedic nursing significantly improved the implementation of VTE prophylaxis protocols. Their study highlighted how targeted education could enhance nurses' knowledge and adherence to preventive measures, ultimately reducing the incidence of lower extremity venous thrombosis.The application of the KAP model extends to various aspects of postoperative care, including pain management and rehabilitation.Zhu and An (2021) explored the impact of the KAP model on postoperative pain and rehabilitation in orthopedic patients. They found that the model not only reduced pain but also improved patient engagement in functional exercises, suggesting that integrating KAP-based education into postoperative care can enhance overall recovery outcomes.
By focusing on enhancing knowledge, attitudes, and practices, the KAP model provides a comprehensive framework for developing effective training programs aimed at reducing the incidence of VTE and improving overall patient care.

3.3. Current status of Nursing Training

3.3.1.Importance of Nursing Training Programs

Nursing training programs are meticulously designed to bridge existing knowledge gaps, sharpen clinical skills, and cultivate positive attitudes towards comprehensive patient care. In an era marked by rapid advancements in medical science, these programs serve as a vital conduit for updating nursing professionals on the latest evidence-based practices. They contribute significantly to improved patient outcomes, optimized healthcare resource utilization, and heightened job satisfaction among nurses.
In the specific context of LDVT prevention, the importance of such training programs cannot be overstated. Major orthopedic surgeries carry a high risk of thromboembolic complications, and without the proper training, nurses may find themselves ill-prepared to implement the preventive measures necessary to mitigate these risks effectively. This deficiency can lead to an increase in patient morbidity and mortality, underscoring the critical need for comprehensive training.

3.3.2.Structure and Content of Nursing Training Programs

The architecture of nursing training programs can vary widely, reflecting the diverse needs of different healthcare settings. However, the most effective programs are typically characterized by a blend of didactic instruction, hands-on clinical practice, and continuous assessment. According to a study by Smith et al. (2023), successful training programs seamlessly integrate theoretical knowledge with practical application, ensuring that nurses can translate what they have learned into real-world clinical practice with confidence and competence.
Moreover, these programs often include components of continuous professional development, which are essential for maintaining and enhancing nurses' competencies over time. In the realm of LDVT prevention, training programs must encompass a comprehensive curriculum that includes the pathophysiology of venous thromboembolism (VTE), the risk factors associated with orthopedic surgeries, and the most current guidelines for prophylaxis. Additionally, they should emphasize the crucial roles of early mobilization, the proper utilization of compression devices, and the provision of patient education, all of which are critical in preventing LDVT.

3.3.3.Impact of Training Programs on Nurses' Knowledge, Attitude, and Practice

Extensive research has demonstrated that well-structured training programs can profoundly enhance nurses' KAP across a variety of clinical domains. For instance, a study by Jones et al. (2021) found that a targeted educational intervention significantly bolstered nurses' knowledge and adherence to VTE prevention protocols within a hospital setting. Similarly, findings from a study by Wang et al. (2020)

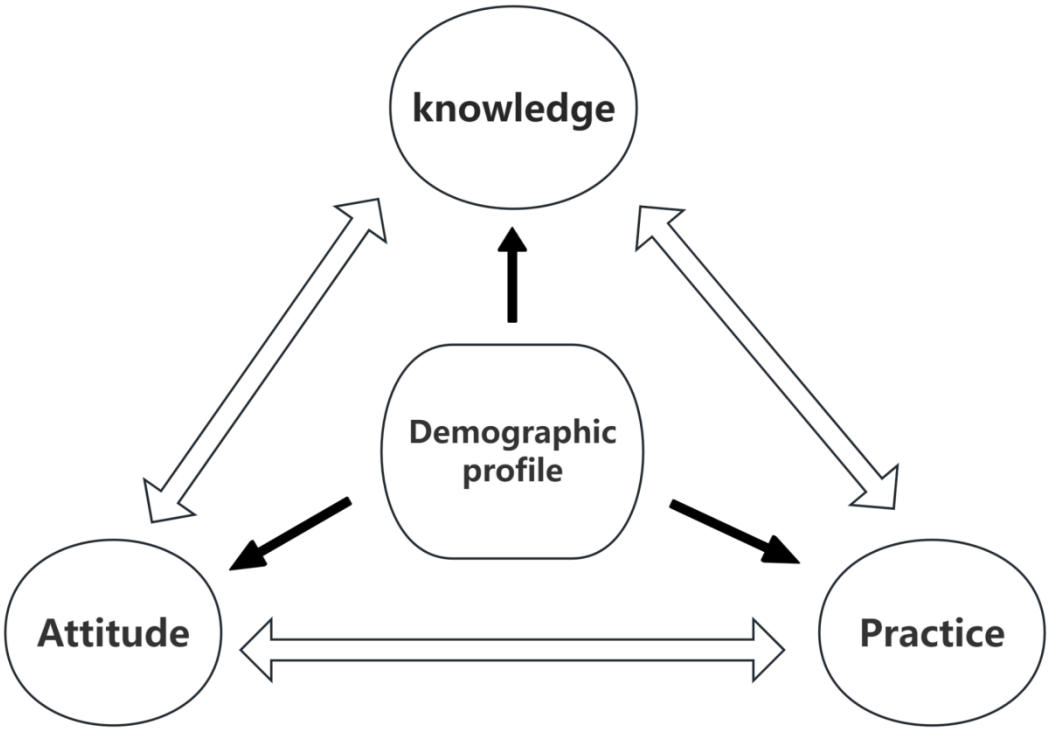
revealed that training programs not only deepened nurses' understanding of VTE prevention but also positively influenced their attitudes towards the importance of preventive measures.

When applied to LDVT prevention, these training programs have been shown to markedly increase compliance rates with prophylactic guidelines, reduce the incidence of thrombotic events, and improve overall patient outcomes. The effectiveness of these programs, however, hinges on several factors, including the mode of delivery, the relevance and applicability of the content to clinical practice, and the degree of participant engagement.

In conclusion, nursing training programs are indispensable in the prevention of LDVT in patients undergoing major orthopedic surgery. These programs should be designed to not only enhance nurses' knowledge but also positively influence their attitudes and equip them with the practical skills needed to implement effective preventive measures. Despite the clear benefits, there remains a pressing need for standardized, continuous education that addresses both the clinical and psychological dimensions of care. By addressing these gaps, training programs can better prepare nurses to prevent LDVT, ultimately leading to improved patient outcomes and a higher standard of care.

3.4. Conceptual framework

The study utilizes four distinct questionnaires: Demographic Profile, Knowledge Questionnaire, Attitude Questionnaire, and Behavior Questionnaire. In this conceptual framework, the Demographic Profile—which includes factors such as gender, hospital level, highest educational attainment, years of nursing experience, frequency of training sessions attended related to VTE prevention, awareness of VTE-related guidelines, the existence of a VTE team, and the development of a nursing process—serves as the independent variables. The dependent variables are represented by the knowledge, behavior, and attitudes of the participants.



3.5. Future Research Perspectives

This study aims to assess nurses' knowledge, attitudes, and practices regarding LDVT prevention following major orthopedic surgery. The findings will provide a theoretical basis for future intervention studies, promoting preventive care for LDVT and improving postoperative care. The development of a comprehensive nursing process for LDVT prevention, based on the best available evidence, is a key objective. Additionally, the study will seek to construct a training system for LDVT prevention in patients after major orthopedic surgery, utilizing the KAP theory. Establishing an in-hospital prevention and control management system for LDVT, supported by information technology, is also envisioned.

3.6.Research Limitations

This study acknowledges the need for a larger sample size in future research and the application of the KAP theory model to work intervention studies for nursing staff. The current study focuses on analyzing the factors influencing nursing staff's knowledge, attitudes, and practices without delving deeper into other potential influencing factors. Future studies should undertake comprehensive analyses to develop scientific interventions that promote healthy practices, reduce the occurrence of LDVT, and improve the quality of care.

4. METHODS

4.1. Study Design and Locale

The study is a correlational investigation aimed at assessing the knowledge, attitude, and practice of postoperative orthopedic nurses in preventing lower extremity deep vein thrombosis (LDVT) in secondary and tertiary hospitals in Shandong Province. These hospitals are representative of the level of care in eastern China and have a sufficient number of postoperative orthopedic patients and nursing staff, providing a robust and diverse data sample.The selection of these hospitals ensures that the study results will be both generalizable and representative of the broader healthcare context in the region.

4.2. Study Participants

4.2.1. Sample Size and Sampling

The target sample size for this study was determined to be 419 nurses, calculated using a statistical formula to ensure representativeness and accuracy. The sample size was computed using the following formula for estimating sample size in population-based studies:

$$n = \frac{Z^2 \times p(1-p)}{E^2}$$

N= required sample size
Z = Z-value corresponding to the 95% confidence level (1.96)
p = estimated proportion of the population (0.5 for maximum variability)
E= margin of error (0.05)
The required sample size was 385 nurses. To account for a possible 10% non-response rate, the sample size was adjusted to 419 nurses, ensuring that the study could collect sufficient data for meaningful analysis.
A convenience sampling will be conducted among orthopedic nurses and operating room nurses across eight secondary and tertiary general hospitals in Shandong Province. This method ensures that every

eligible nurse has an equal chance of being selected, thereby minimizing selection bias and enhancing the generalizability of the findings.

4.2.2. Inclusion and Exclusion Criteria

The study will recruit nurses with at least 1-year of experience in managing post-operative orthopedic patients from secondary and tertiary hospitals in Shandong Province. The inclusion of nurses with varying levels of experience, from different hospital types, aims to ensure a representative sample.

Exclusion Criteria

Nurses who are on vacation during the study period or explicitly express disinterest in participating will be excluded. However, recognizing that these exclusion criteria may unintentionally omit certain demographics, such as more experienced nurses or those with particular attitudes towards the research topic, steps will be taken to minimize bias. For example, nurses on vacation are excluded due to logistical constraints, but efforts will be made to accommodate different schedules where possible.

To prevent the introduction of bias from excluding disinterested nurses, the study will ensure that all nurses are thoroughly informed about the purpose and significance of the research. Participation will be entirely voluntary, with no undue pressure applied. Informed consent will be obtained from all participants to ensure they fully understand their rights and the importance of their involvement. Nurses who do not wish to participate will have their decision respected, without any negative repercussions or pressure to reconsider.

4.3. Research Instruments

literature review and with reference to the Knowledge-Attitude-Behavior Questionnaire developed by Hao Minjiang (2020) for Operating Room Nurses on Preventing Intraoperative VTE in Patients. The questionnaire was validated for its high reliability in the study by Hao (2020). The scale was adapted to suit the specific characteristics of major orthopedic surgery. Content validity was ensured through a comprehensive literature review and expert consultation. Reliability was assessed using Cronbach's Alpha, with the results showing Alpha values of 0.824 for knowledge, 0.824 for practice, and 0.915 for attitude, all indicating good reliability.

There are four questionnaires:Demographic profile， knowledge questionnaire, attitude questionnaire and behavior questionnaire.The knowledge questionnaire included 14 items answered in judgment form. Each correct answer was scored as 1 point, resulting in a score range from 0 to 14. A higher score indicated better knowledge about VTE. The attitude questionnaire comprised nine items scored using a Likert scale ranging from "Strongly Disagree, Disagree,Neutral,Agree,Absolutely agree" with scores assigned as "1, 2, 3, 4, 5." The total score ranged from 9 to 45, a higher score reflected more positive attitudes among nurses towards preventing VTE in surgical patients. The practice questionnaire contained twelve items that were assessed based on whether they were not done ("Not doing it"), partially done ("Do it partially "), or completely done ("Do it completely"). Scores were calculated as "1,2,3", resulting in a range from 12 to 36. Higher scores indicate better implementation of nurses' nursing measures to prevent VTE.

4.4. Specific Procedures Based on Study Objectives

4.4.1. Procedure 1：Communication Letters

The researchers intend to seek approval from the hospital to include nursing staff in the study. A formal letter will be submitted to the Medical and Nursing Director to request this approval. Personal consent

will be obtained from participants as part of the electronic questionnaire, ensuring that they provide consent before proceeding with the survey.

4.4.2. Procedure 2：Floating of Questionnaire

The official questionnaire will be imported using the "Questionnaire Star" e-platform to obtain the QR code. The questionnaires will be distributed, collected, and organized through the use of electronic questionnaires.

4.5. Ethical Considerations

4.5.1. Informed Consent Process, Duration of Participation, and Withdrawal Criteria

The informed consent process is a vital component of this study. Participants will receive a comprehensive explanation of the study's purpose, which is to evaluate nurses' knowledge, attitudes, and practices in preventing lower extremity venous thromboembolism (VTE) in patients following major orthopedic surgery. This will involve completing a questionnaire that assesses various aspects of VTE prevention.

While the study poses minimal risks, some participants may experience discomfort when discussing their knowledge gaps. Nonetheless, participation will significantly contribute to the enhancement of nursing practices and patient care. Participants will also receive feedback on the study results.

Before providing consent, participants will have the opportunity to ask questions and seek clarification about the study. The researcher will be readily available to address any concerns.The consent process will be interactive; participants will review the informed consent document. They can then indicate their consent by signing the form, ensuring they fully understand their rights and the nature of the study. Participation is entirely voluntary, and participants may withdraw at any time without facing any repercussions.

4.5.2. Risks and inconveniences

While the risks associated with this study are minimal, it is important to acknowledge that some participants may experience psychological discomfort when discussing their knowledge gaps related to venous thromboembolism (VTE) prevention.In the event that such discomfort arises, the following measures will be implemented to effectively manage these risks:Access to Psychological Support: Should participants experience distress during or after the study, they will be provided access to psychological support.Immediate Withdrawal Option: In cases of significant psychological discomfort, participants will be allowed to withdraw immediately, and any data they have provided will be excluded from the analysis. Additionally, there may be reputational risks if confidentiality is not adequately maintained. Participants will be informed of these potential risks and reassured that measures are in place to protect their anonymity and data confidentiality.

4.5.3. Benefits of this study

Participants in this study will not receive monetary compensation; however, the findings will provide valuable insights into nurses' knowledge, attitudes, and practices (KAP) related to venous thromboembolism (VTE) prevention. These insights could inform the development of targeted training programs and policies. By participating, nurses will contribute to a better understanding of knowledge gaps and attitudes towards VTE prevention, which could ultimately lead to improved patient outcomes. While these improvements may not be immediate, the study's results have the potential to enhance nursing education and, over time, contribute to better patient care practices within the nursing community.

4.5.4. Privacy, confidentiality and data management

The study will implement a robust data management plan to ensure privacy and confidentiality. All coll-

ected data will be anonymized, with identifying information removed. Sensitive data will be securely stored in password-protected files accessible only to the researcher. Data will be retained for a period of three years after the study's conclusion for verification purposes and then securely destroyed. Additionally, all efforts will be made to safeguard participants' confidentiality in any publicly available datasets, ensuring that no identifying information is disclosed.

4.5.5. Conflict of interest

The researchers are committed to maintaining independence from the hospitals involved in the study. To minimize potential biases, a clear separation will be upheld between the researcher and hospital administration, ensuring that the findings are not subject to external pressures. All data collection activities will be conducted solely by the researchers, without any involvement or oversight from hospital administrators, thereby preventing any undue influence on participant responses. Participant data will be fully anonymized, and hospital administration will have no access to any identifiable information, preserving both confidentiality and participant autonomy.Furthermore, the researchers will disclose any relationships that could be perceived as conflicts of interest and will take proactive steps to mitigate any potential biases throughout.

5. STATISTICAL ANALYSIS OF DATA

The collected data was checked by two people and then entered into Excel, and SPSS will be used to process and analyze the data. The general characteristics of the respondents, as well as their scores on the knowledge, attitude, and practice questionnaires, were statistically described using the mean, standard deviation, and percentage distribution. Univariate analysis was performed using independent sample t-tests and analysis of variance (ANOVA). These tests help identify whether there are statistically significant differences in the knowledge, attitude, or practice scores based on different demographic factors. For multiple factor analysis, stepwise multiple linear regression was employed, allowing for the identification of factors that significantly predict scores on the knowledge, attitude, or practice questionnaires while controlling for other variables. Pearson correlation analysis was utilized to examine the relationships between variables, which is critical for understanding the interrelationships between knowledge, attitudes, and practices. This analysis helps determine whether a change in one variable is associated with a change in another, providing insight into potential patterns or trends in the data.

6.RESULTS

6.1 General information of the respondents

6.1.1 General information of the respondents

There were 419 subjects in this study, including 396 females (94.5%) and 23 males (5.5%). 212 from secondary hospitals accounted for 50.6%, and 207 from tertiary hospitals accounted for 49.4%. 91 nurses (21.7%) had less than 5 years of nursing work, 129 nurses (30.8%) had 6-10 years of nursing work, 108 nurses (25.8%) had 11-15 years of nursing work, 68 nurses (16.2%) had 16-20 years of nursing work, and 23 nurses (5.5%) had more than 20 years of nursing work. There were 143 nurses with the highest education level of junior college or below, accounting for 34.1%, 147 nurses with bachelor's degree, accounting for 35.1%, 129 nurses with master's degree or above, accounting for 30.8%. 41 (9.8%) were charge nurses and 378 (90.2%) were nurses. (See Table 1 for other details)

Table 1: Demographic Characteristics of Respondents (N=419)

Variables	Classification	Frequency	Percentage (%)
Gender	female	396	94.5
	male	23	5.5
Hospital level	Secondary hospitals	212	50.6
	Tertiary hospitals	207	49.4
The number of years you have been in nursing	≤5 years	91	21.7
	6 to 10 years	129	30.8
	11 to 15 years	108	25.8
	16 to 20 years	68	16.2
	>20 years	23	5.5
Highest educational attainment	College and below	143	34.1
	Undergraduate	147	35.1
	Master's degree or above	129	30.8
Your position	charge nurse	41	9.8
	Nurse	378	90.2
Are you aware of guidelines related to VTE	Yes	199	47.5
	No	220	52.5
The number of training sessions you have attended involving VTE-related content	0 times	85	20.3
	1 or 2 times	123	29.4
	3 to 4 times	106	25.3
	≥5 times	105	25.0
Ways of acquiring VTE-related knowledge	Out-of-hospital training and academia	101	24.1
	Departmental business learning	107	25.5
	Related pharmaceutical company training	105	25.1
	School education	106	25.3
Whether your hospital department has developed a nursing process to prevent postoperative VTE	Yes, the nursing procedures are scientific and reasonable	175	41.8
	Yes, but the care procedures need to be improved	107	25.5
	No	137	32.7

6.1.2 Equipment for nurses to prevent VTE in patients after orthopedic surgery

The study found that intermittent pneumatic compression devices were the most commonly used physical prevention tool (73.51%), followed by gradient compression stockings (70.88%). In contrast, fewer nurses

reported using plantar venous pumps (12.17%), and 12.65% did not utilize any physical prevention equipment.. (See Figure 1 for details)

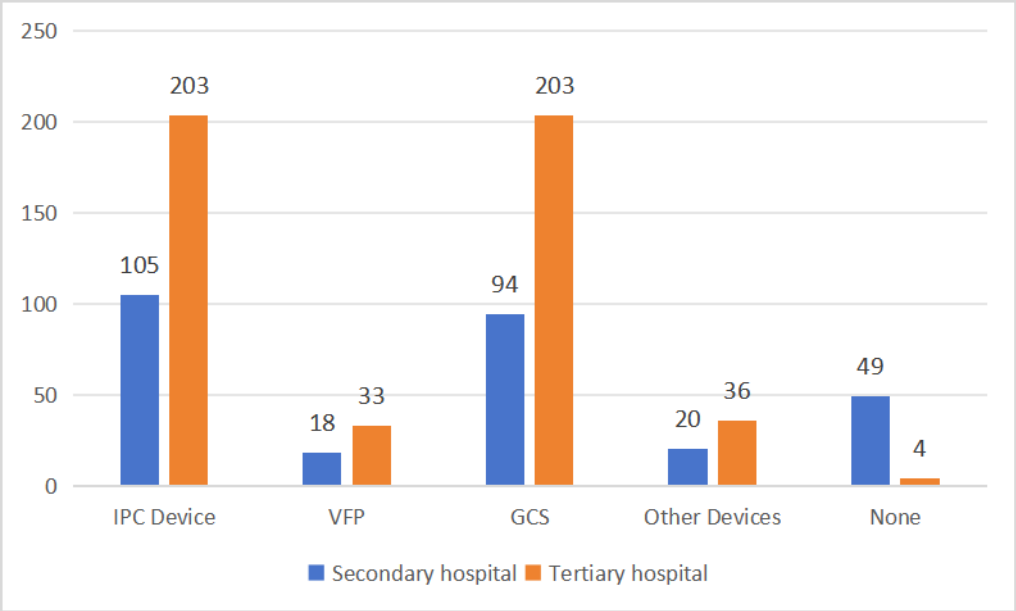


Figure 1 Usage of Physical Prevention Equipment Among Nurses

Figure 1 shows that the most commonly used physical prevention equipment among nurses is intermittent pneumatic compression devices (73.51%), followed by gradient compression stockings (70.88%).

6.1.3 Common assessment tools for nurses to prevent VTE risk in patients after orthopedic surgery

The results of this study showed that 73.03% of nurses used a Caprini risk assessment tool for risk screening, but 11.46% of nurses had not used any risk assessment tool. (See Figure 2 for details)

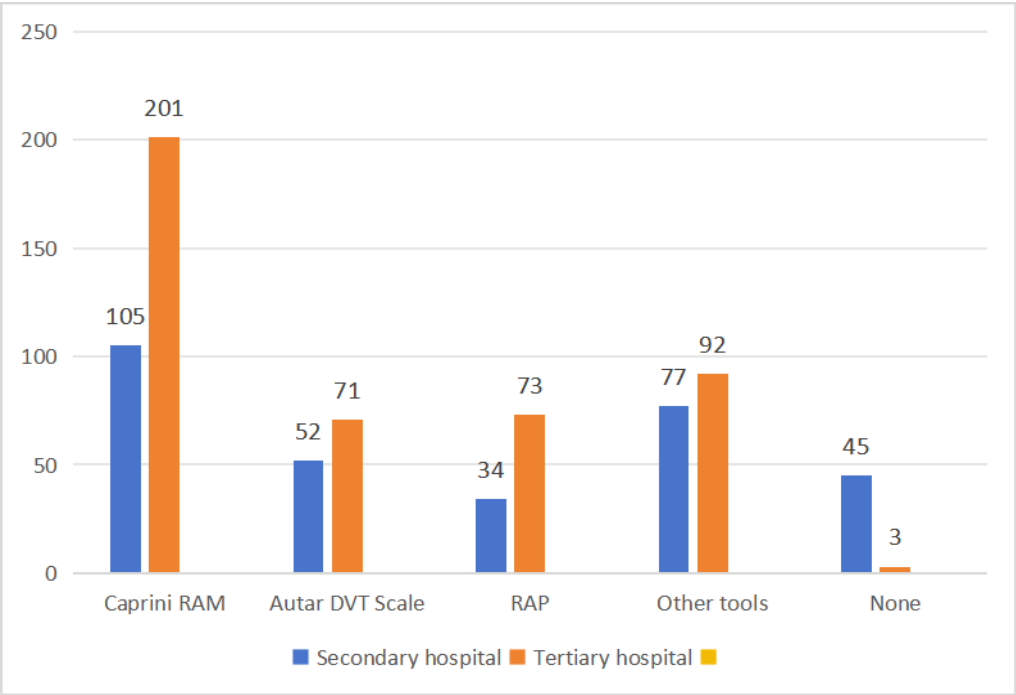


Figure 2 Use of common VTE risk assessment tools

Figure 2 reveals that the Caprini risk assessment tool is the most commonly employed method for VTE risk screening, with 73.03% of nurses utilizing it. However, 11.46% of nurses reported not using any risk assessment tool, indicating a potential gap in standardized risk evaluation practices.

6.2 To investigate the scores of knowledge, attitude and behavior of nurses in preventing VTE in patients after orthopedic surgery

The results of this study showed that the scores of nurses' knowledge, attitude and practice in preventing VTE after orthopedic surgery were (7.09±2.06), (27.43±6.36), (24.26±3.73), and the total score of knowledge, attitude and practice was (58.77±10.23) (see Table 2 for details).

Table 2 Nurses' knowledge, attitude and practice of preventing VTE after orthopedic surgery (n=419)

Items	Number of items	Minimum	Maximum	Score
Knowledge	14	1	13	7.09±2.06
Attitude	9	9	45	27.43±6.36
Practice	12	13	35	24.26±3.73
Total score	35	26	87	58.77±10.23

6.3 To investigate the results of univariate analysis of nurses' knowledge scores on preventing VTE in patients after orthopedic surgery

The results of this study show that, There were statistically significant differences in the nurses' knowledge of preventing postoperative VTE in patients with orthopedic surgery in different hospital levels, years of nursing work, highest education, understanding of VFT-related guidelines, the number of training involving VFT-related content attended, and whether the hospital departments formulated nursing procedures to prevent postoperative VTE (P<0.05). (See Table 3 for details)

Table 3 Results of univariate analysis of nurses' knowledge scores on preventing VTE after orthopedic surgery

Variables	Classification	$M \pm SD$	*t/F* value	*P*-value
Gender	female	7.08±1.81	-0.107	0.915
	male	7.13±2.16		
Hospital level	Secondary hospital	6.29±1.99	-8.737	<0.001
	Tertiary hospitals	7.90±1.79		
The number of years you have been in nursing	≤5 years	6.56±2.16	3.038	0.017
	6 to 10 years	7.03±2.07		
	11 to 15 years	7.24±2.05		
	16 to 20 years	7.35±1.88		
	>20 years	7.96±1.72		
Highest educational attainment	College and below	6.83±2.08	3.384	0.035
	Undergraduate	7.01±1.89		
	Master's degree or above	7.46±2.17		

Your position	charge nurse	7.39±2.05	0.998	0.319
	Nurse	7.05±2.06		
Are you aware of guidelines related to VTE	Yes	7.96±1.75	9.100	<0.001
	No	6.29±2.00		
The number of training sessions you have attended involving VTE-related content	0 times	6.13±2.12	17.057	<0.001
	1 or 2 times	6.72±1.83		
	3 to 4 times	7.36±2.03		
	≥5 times	8.02±1.85		
Ways of acquiring VTE-related knowledge	Out-of-hospital training and academia	7.26±2.11	0.394	0.758
	Departmental business learning	7.05±1.94		
	Related pharmaceutical company training	6.95±1.93		
	School education	7.09±2.25		
Whether your hospital department has developed a nursing process to prevent postoperative VTE	Yes, the nursing procedures are scientific and reasonable	7.33±2.21	6.796	0.001
	Yes, but the care procedures need to be improved	7.36±1.76		
	No	6.56±1.98		

6.4 Multiple linear regression analysis of nurses' knowledge scores on preventing VTE after orthopedic surgery

In this study, nurses' knowledge score of preventing VTE in patients after orthopedic surgery was set as the dependent variable, and variables with statistical significance in univariate analysis (see Table 4 for the assignment of independent variables) were used as independent variables for multiple linear regression analysis.

Table 4 Assignment methods of independent variables

Independent variables	Assignment method
hospital level	Secondary hospital =1; Tertiary hospital =2
The number of years you have been in nursing	≤5 years =1; 6-10 years =2; 11-15 years =3; 16~20 years =4; >20 years =5
Highest educational attainment	College and below =1; Undergraduate; Master's or above =3
Are you aware of guidelines related to VTE	Yes =1; No =2

The number of training sessions you have attended involving VTE-related content	0 times =1; 1-2 times =2; 3-4 times =3; ≥5 times =4
Whether your hospital department has developed a nursing process to prevent postoperative VTE	Yes, the nursing procedures are scientific and reasonable =1; Yes, but care processes need to be improved =2; No=3

The results of multiple linear regression analysis showed that the level of the hospital, the years of nursing work, the highest education, whether to understand the guidelines related to VTE, and the number of training involving VTE-related content attended were important factors affecting the knowledge of nurses in preventing VTE in patients after orthopedic surgery (P<0.05). R2 = 0.367, R2= 0.347, after adjusting the fit of the regression equation is good. (See Table 5 for details)

Table 5 Multiple linear regression analysis of nurses' knowledge scores on preventing VTE in patients after orthopedic surgery

Variables	*Beta.*	*SE*	*Beta*	*t*	*P*
Constant	5.876	0.307	——	19.126	<0.001
Hospital level	1.243	0.169	0.303	7.346	<0.001
The number of years you have been in nursing	0.534	0.239	0.114	2.240	0.026
Highest educational attainment	0.628	0.205	0.141	3.063	0.002
Are you aware of guidelines related to VTE	-1.289	0.168	-0.313	-7.675	<0.001
The number of training sessions you have attended that cover VTE-related content	1.278	0.251	0.270	5.083	<0.001
Does your hospital department have a nursing process to prevent postoperative VTE	-0.317	0.193	-0.072	-1.638	0.102

6.5 To investigate the results of single factor analysis of nurses' attitude of preventing VTE in patients after orthopedic surgery

The results of this study show that there are statistically significant differences in the attitudes of the surveyed nurses towards preventing VTE in orthopedic patients after surgery in terms of the level of the hospital, years of nursing experience, highest educational attainment, whether they are familiar with the guidelines related to VTE, the number of trainings they have participated in that involve VTE-related content, and whether the hospital department has established a nursing process for preventing postoperative VTE (P < 0.05). (See Table 6 for details)

Table 6 Results of univariate analysis of nurses' attitude scores to prevent VTE after orthopedic surgery

Variables	Classification	M±SD	*t/F* value	P-value
Gender	female	27.46±6.02	0.500	0.618
	male	26.78±10.79		
Hospital level	Secondary hospital	25.62±6.39	-6.132	<0.001
	Tertiary hospitals	29.28±5.79		
The number of years you have been in nursing	≤5 years	25.92±6.79	2.617	0.035
	6 to 10 years	27.14±6.99		
	11 to 15 years	28.02±6.34		
	16 to 20 years	28.31±5.07		
	>20 years	29.61±1.47		
Highest educational attainment	College or below	26.46±6.45	5.261	0.006
	Undergraduate	27.10±5.83		
	Master's degree or above	28.87±6.61		
Your position	charge nurse	28.49±6.39	1.125	0.261
	Nurse	27.31±6.35		
Are you aware of guidelines related to VTE	Yes	29.21±5.89	5.645	<0.001
	No	25.82±6.35		
The number of training sessions you have attended involving VTE-related content	0 times	24.29±6.56	33.221	<0.001
	1 or 2 times	25.51±5.39		
	3 to 4 times	27.88±6.15		
	≥5 times	31.75±4.91		
Ways of acquiring VTE-related knowledge	Out-of-hospital training and academia	27.33±6.66	0.150	0.929
	Departmental business learning	27.63±6.29		
	Related pharmaceutical company training	27.62±5.95		
	School education	27.13±6.60		
Whether your hospital department has developed a nursing process to prevent postoperative VTE	Yes, the nursing procedures are scientific and reasonable	29.07±6.56	14.360	<0.001
	Yes, but the care procedures need to be improved	27.45±4.64		
	No	25.31±6.66		

6.6 Multiple linear regression analysis of nurses' attitude score on preventing VTE in patients after orthopedic surgery

In this study, the score of nurses' attitude to preventing VTE in patients after orthopedic surgery was set as the dependent variable, and variables with statistical significance in univariate analysis (the assignment method of independent variables is shown in Table 7) were used as independent variables for multiple linear regression analysis.

Table 7 Assignment methods of independent variables

Independent variables	Assignment method
Hospital level	Secondary hospital =1; Tertiary hospital =2
The number of years you have been in nursing	≤5 years =1; 6-10 years =2; 11-15 years =3; 16~20 years =4; >20 years =5
Highest educational attainment	College and below =1; Undergraduate; Master's or above =3
Are you aware of guidelines related to VTE	Yes =1; No =2
The number of training sessions you have attended involving VTE-related content	0 times =1; 1-2 times =2; 3-4 times =3; ≥5 times =4
Whether your hospital department has developed a nursing process to prevent postoperative VTE	Yes, the nursing procedures are scientific and reasonable =1; Yes, but care processes need to be improved =2; No=3

The results of multiple linear regression analysis showed that the level of the hospital, the years of nursing work, the highest education, whether to understand the guidelines related to VTE, the number of training related to VTE attended and whether the hospital department had formulated the nursing process to prevent postoperative VTE were important factors affecting the attitude of nurses to prevent postoperative VTE in patients with orthopedic surgery ($P<0.05$) in the department. $R2=0.331$, adjusted $R2=0.309$, the regression equation fitted well. (See Table 8 for details)

Table 8 nurses prevent orthopaedic patients with postoperative VTE attitude score of multivariate linear regression analysis

Variables	*Beta.*	*SE*	*Beta*	*t*	*P*
Constant quantity	24.104	0.977	——	24.674	<0.001
Hospital level	2.375	0.538	0.187	4.412	<0.001
The number of years you have been in nursing	1.627	0.759	0.112	2.144	0.033
Highest educational attainment	1.967	0.652	0.143	3.016	0.003

Are you aware of guidelines related to VTE	-2.189	0.534	-0.172	-4.100	<0.001
The number of training sessions you have attended that cover VTE-related content	5.996	0.799	0.409	7.501	<0.001
Does your hospital department have a nursing process to prevent postoperative VTE	-2.465	0.615	-0.182	-4.011	<0.001

6.7 To investigate the single factor analysis results of nurses' behavior score of preventing VTE in patients after orthopedic surgery

The results of this study showed that, There were statistically significant differences in the behavior of nurses in preventing postoperative VTE in patients with orthopedic surgery in different levels of hospitals, years of nursing work, highest education, understanding of VFT-related guidelines, the number of training involving VFT-related content attended, and whether hospital departments formulated nursing procedures to prevent postoperative VTE (P<0.05). (See Table 9 for details)

Table 9 Results of univariate analysis of nurses' behavior scores to prevent VTE after orthopedic surgery were investigated

Variables	Classification	M±SD	*t/F* value	P-value
Gender	female	24.24±3.65	-0.237	0.813
	male	24.43±4.98		
Hospital level	Secondary hospital	23.22±3.67	-5.977	<0.001
	Tertiary hospitals	25.31±3.49		
The number of years you have been in nursing	≤5 years	23.76±3.86	3.480	0.008
	6 to 10 years	23.90±4.02		
	11 to 15 years	24.31±3.45		
	16 to 20 years	24.69±3.44		
	>20 years	26.70±2.55		
Highest educational attainment	College and below	23.69±3.75	3.413	0.034
	Undergraduate	24.27±3.49		
	Master's degree or above	24.87±3.89		
Your job title	charge nurse	25.49±3.57	1.881	0.061
	Nurse	24.14±3.73		
Are you aware of guidelines related to VTE	Yes	25.13±3.74	4.655	<0.001
	No	23.47±3.55		
The number of training sessions you have attended	0 times	22.09±3.71	20.685	<0.001
	1 or 2 times	23.86±3.15		
	3 to 4 times	24.73±3.70		

involving VTE-related content	≥5 times	25.99±3.47		
Ways of acquiring VTE-related knowledge	Out-of-hospital training and academia	24.18±3.86	0.046	0.987
	Departmental business learning	24.36±3.78		
	Related pharmaceutical company training	24.24±3.98		
	School education	24.24±3.33		
Whether your hospital department has developed a nursing process to prevent postoperative VTE	Yes, the nursing procedures are scientific and reasonable	24.93±4.01	4.973	0.007
	Yes, but the care procedures need to be improved	23.83±3.04		
	No	23.73±3.74		

6.8 Multiple linear regression analysis of nurses' behavior scores in preventing VTE in patients after orthopedic surgery

In this study, the score of nurses' behavior in preventing VTE in patients after orthopedic surgery was set as the dependent variable, and variables with statistical significance in univariate analysis (see Table 10 for the assignment of independent variables) were used as independent variables for multiple linear regression analysis.

Table 10 Assignment methods of independent variables

Independent variables	Assignment method
hospital level	Secondary hospital =1; Tertiary hospital =2
The number of years you have been in nursing	≤5 years =1; 6-10 years =2; 11-15 years =3; 16~20 years =4; >20 years =5
Highest educational attainment	College and below =1; Undergraduate; Master's or above =3
Are you aware of guidelines related to VTE	Yes equal to 1; No =2
The number of training sessions you have attended involving VTE-related content	0 times =1; 1-2 times =2; 3-4 times =3; ≥5 times =4
Whether your hospital department has developed a nursing process to prevent postoperative VTE	Yes, the nursing procedures are scientific and reasonable =1; Yes, but care processes need to be improved =2; No=3

The results of multiple linear regression analysis showed that the level of the hospital, the highest education level, whether they knew the guidelines related to VTE and the number of training related to VTE that they participated in were important factors affecting the attitude of nurses to prevent VTE in patients after orthopedic surgery (P<0.05). R2=0.242, adjusted R2=0.217, the regression equation fitted well. (See Table 11 for details)

Table 11 Multiple linear regression analysis of nurses' behavior scores for preventing VTE in patients after orthopedic surgery

Variables	*Beta.*	*SE*	*Beta*	*t*	*P*
Constant	21.884	0.610	——	35.879	<0.001
Hospital level	1.468	0.336	0.197	4.367	<0.001
The number of years you have been in nursing	0.291	0.474	0.034	0.613	0.540
Highest educational attainment	1.024	0.407	0.127	2.514	0.012
Are you aware of guidelines related to VTE	-1.129	0.333	-0.151	-3.387	0.001
The number of training sessions you have attended that cover VTE-related content	3.161	0.499	0.368	6.333	<0.001
Does your hospital department have a nursing process to prevent postoperative VTE	-0.791	0.413	-0.093	-1.914	0.056

6.9 Correlation analysis of knowledge, attitude and practice scores of nurses in preventing VTE after orthopedic surgery

According to Pearson correlation analysis, there was a positive correlation between nurses' knowledge score and attitude score in preventing VTE after orthopedic surgery, with a correlation coefficient of 0.579. There was a positive correlation between nurses' knowledge score and practice score in preventing VTE after orthopedic surgery, and the correlation coefficient was 0.433. The nurses' attitude score was positively correlated with their behavior score in preventing VTE after orthopedic surgery, and the correlation coefficient was 0.512.

Table 12 Correlation analysis of knowledge, attitude and practice scores of nurses in preventing VTE after orthopedic surgery

Items	Pearson correlation coefficient (r)	*P*
Protection knowledge and protection attitude	0.579 * *	<0.001

Protection knowledge and protection behavior	0.433 * *	<0.001
Protective attitude and protective behavior	0.512 * *	<0.001

7.DISCUSSION

This study examined the knowledge, attitudes, and practices (KAP) of nurses in preventing lower deep venous thrombosis (LDVT) in postoperative orthopedic patients. The findings underscore key areas for improvement and provide a framework for a targeted training program.

7.1 Current Status of Nurses' Knowledge

The results indicated that nurses had moderate knowledge of LDVT prevention, which aligns with findings from Ahmed et al. (2020). Deficiencies were noted in understanding pharmacological prophylaxis and mechanical interventions, such as intermittent pneumatic compression devices.This highlights the need to integrate detailed VTE guidelines into nursing education to enhance understanding and application in practice.

7.2 Current Status of Nurses' Attitudes

Nurses generally exhibited positive attitudes toward LDVT prevention, similar to trends reported by Yan et al. (2021). However, variability in confidence levels suggests a need for interventions that reinforce nurses' roles and responsibilities in thrombosis prevention. Educational strategies that emphasize the impact of nursing care on patient outcomes could enhance attitudes further.

7.3 Current Status of Nurses' Practices

The study revealed inconsistencies in nurses' practices, often influenced by systemic factors such as institutional policies and resource availability. For instance, Nurses in tertiary hospitals exhibited significantly higher adherence to prevention protocols (mean score: 7.90) compared to those in secondary hospitals (mean score: 6.29, $p < 0.001$), consistent with findings by Wang et al. (2021). Addressing institutional disparities and providing accessible resources are critical steps toward standardizing LDVT prevention practices.

7.4 Correlation Between Knowledge, Attitude, and Practice

The Pearson correlation analysis in this study identified a strong positive correlation between nurses' knowledge, attitudes, and practices in preventing LDVT ($P < 0.001$). This finding underscores the importance of comprehensive understanding and awareness of VTE, including its complications and potentially fatal consequences. Nurses who are well-informed and recognize the severity of VTE are more likely to develop proactive attitudes and beliefs, which in turn translate into the implementation of effective preventive strategies during clinical practice. Such strategies ultimately contribute to reducing the incidence of VTE among postoperative patients and improving surgical outcomes.

To maximize the benefits of this correlation, hospital administrators and nursing leaders should prioritize ongoing education and training initiatives that emphasize professional knowledge of VTE prevention. These efforts should aim to foster risk awareness and encourage the proactive adoption of evidence-based nursing measures. Establishing a positive feedback loop—where knowledge acquisition strengthens beliefs, leading to improved preventive behaviors—can create a sustainable and effective approach to reducing VTE rates.

7.5 Development of a VTE Nursing Training System Based on the Knowledge-Attitude-Practice (KAP) Theory

The findings inform the development of a structured training program with the following key components:
Knowledge Enhancement: This component focuses on providing nurses with evidence-based guidelines for LDVT prevention. Training materials should include up-to-date information on pharmacological interventions, such as low molecular weight heparins and direct oral anticoagulants, as well as mechanical strategies like intermittent pneumatic compression devices and compression stockings. Case studies and simulations can be utilized to demonstrate the practical application of these guidelines in various clinical scenarios.
Attitude Improvement: Workshops and seminars should be designed to strengthen nurses' confidence and reinforce their pivotal role in thrombosis prevention. Interactive sessions could include role-playing, group discussions, and testimonials from patients who benefited from effective LDVT prevention. These activities aim to cultivate a sense of accountability and motivation among nurses, emphasizing how their efforts directly impact patient outcomes.
Skill-Based Training: Practical sessions are essential to ensure nurses develop proficiency in utilizing preventive devices and implementing protocols. Hands-on training with equipment, such as pneumatic compression devices, should be complemented by scenario-based exercises where nurses apply preventive strategies to hypothetical patients. Regular competency assessments can help reinforce these skills and ensure their consistent application in clinical practice.
Systemic Support: Collaboration with healthcare administrators is critical to address systemic barriers that hinder LDVT prevention. Efforts should focus on ensuring adequate resource allocation, such as providing sufficient preventive devices and staffing levels. Additionally, institutional policies should be updated to support standardized practices across all hospital departments. The establishment of a VTE prevention committee can further enhance oversight and ensure continuous quality improvement.
The program's success relies on its adaptability to varying institutional contexts and its ability to engage nurses through interactive and practical methodologies.

8.CONCLUSIONS AND RECOMMENDATIONS

This study highlights critical gaps in nurses' knowledge, attitudes, and practices regarding LDVT prevention in postoperative orthopedic patients. While nurses generally demonstrated a positive attitude toward prevention, deficiencies in knowledge and variability in practices underscore the need for targeted interventions. The proposed training program prioritizes knowledge enhancement, attitude strengthening, and practical skill development to address these gaps effectively.
By equipping nurses with comprehensive knowledge and practical tools, the program aims to improve adherence to LDVT prevention protocols and optimize patient outcomes. Future research should evaluate the program's effectiveness in reducing LDVT incidence and identify additional factors influencing nursing practices. These findings contribute to the broader goal of enhancing nursing care quality and reducing preventable complications in postoperative orthopedic patients.

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