RESEARCH PAPER

Knowledge, Clinical Practice, and Educational Exposure Related to Anticoagulant Therapy Among Critical Care Nurses in Saudi Arabia: A Cross-Sectional Study

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Abstract

Background: Anticoagulant therapy is widely used in critical care but is considered high-risk because inappropriate administration, inadequate monitoring, drug interactions, and delayed recognition of complications may cause serious patient harm. Critical care nurses have an essential role in the administration, monitoring, education, and coordination of anticoagulant therapy. However, evidence regarding nurses' knowledge and clinical practices related to anticoagulants in Saudi Arabia remains limited.

Purpose: This study assessed knowledge and clinical practice related to anticoagulant therapy among critical care nurses in Saudi Arabia and examined relationships among knowledge, practice, educational exposure, and selected demographic and professional characteristics.

Methods: A quantitative descriptive cross-sectional study was conducted among 362 critical care nurses in selected hospitals in the Western Region of Saudi Arabia. Data were collected using a structured self-administered electronic questionnaire assessing demographic characteristics, anticoagulant knowledge, nursing practices, and educational exposure. Descriptive statistics, Pearson correlation, and multiple linear regression were performed, with statistical significance set at $p < .05$.

Results: Participants had a mean age of 32.8 ± 7.4 years, and 78.5% held a bachelor's degree or higher. The mean knowledge score was 16.2 ± 3.8/25 (64.8%), indicating moderate knowledge. Important gaps were identified in recognition of idarucizumab as the reversal agent for dabigatran (39.2%), andexanet alfa for Factor Xa inhibitors (43.1%), appropriate management of missed warfarin doses (44.8%), and selected direct oral anticoagulant safety issues. The mean practice score was 89.50 ± 14.70/125, indicating moderate-to-good self-reported practice, with stronger performance in medication administration and clinical monitoring and lower performance in patient education and interprofessional collaboration. Only 48.6% had received anticoagulant-related education during the previous two years, whereas 83.4% reported needing additional education. Knowledge was positively correlated with practice ($r = 0.412$, $p < .001$), education exposure was correlated with knowledge ($r = 0.286$, $p < .001$) and practice ($r = 0.218$, $p < .001$). Education was the strongest predictor of knowledge ($\beta = 0.24$, $p < .001$), while knowledge was the strongest predictor of practice ($\beta = 0.39$, $p < .001$).

Conclusion: Critical care nurses demonstrated moderate knowledge and generally moderate-to-good self-reported practice, but important gaps existed in medication-specific safety, reversal strategies, and patient education. Structured, recurrent, competency-based anticoagulant education is recommended to strengthen nurses' knowledge and promote safer clinical practice.

Keywords: Anticoagulants; Critical Care Nurses; Knowledge; Nursing Practice; Medication Safety; Nursing Education

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.Introduction

Anticoagulant therapy is a fundamental component of contemporary healthcare and is widely used for the prevention and management of thromboembolic disorders (Kholmukhamedov, Subbotin, Gorin, & Ilyassov, 2025; Rodgers & Mahajerin, 2023; Wang, Xu, & Zhu, 2024). Anticoagulants reduce the formation or progression of blood clots by targeting different components of the coagulation cascade and are routinely used in conditions such as atrial fibrillation, venous thromboembolism (VTE), acute coronary syndromes, mechanical heart valve replacement, and thrombo-prophylaxis among hospitalized patients (Francavilla, 2008; Gee, 2018; Gee & Saul, 2021). Their importance is particularly pronounced in critical care settings, where patients frequently experience multiple risk factors for thrombosis, including prolonged immobility, systemic inflammation, invasive procedures, malignancy, cardiovascular disease, and the use of extracorporeal support devices. Appropriate anticoagulant management is therefore essential to balance the prevention of thromboembolic events against the risk of bleeding and other treatment-related complications (Abdel Rahman, 2023; Abeer Mohammed Abdalhamid Farag et al., 2017; Francavilla, 2008; Gee, 2018; Gee & Saul, 2021).

The pharmacological options available for anticoagulation have expanded considerably. Traditional anticoagulant therapy has relied primarily on vitamin K antagonists, particularly warfarin, and parenteral agents such as unfractionated heparin (UFH) and low-molecular-weight heparin (LMWH) (Ferdous, 2025; Heestermans, Poenou, Hamzeh-Cognasse, Cognasse, & Bertoletti, 2022; Kholmukhamedov et al., 2025). The introduction and increasing use of direct oral anticoagulants (DOACs), including dabigatran, rivaroxaban, apixaban, and edoxaban, have substantially changed anticoagulation practice. Compared with warfarin, DOACs generally provide more predictable anticoagulant effects, fewer dietary interactions, rapid onset of action, and reduced requirements for routine

laboratory monitoring (Gee, 2018; Magon et al., 2021). However, these advantages do not eliminate the need for careful clinical management. Each anticoagulant has medication-specific considerations related to mechanism of action, dosing, renal and hepatic function, drug interactions, contraindications, monitoring, and reversal strategies that healthcare professionals must understand to ensure safe and effective treatment (Gee & Saul, 2021; Subih et al., 2025; Villagracia et al., 2026).

Anticoagulants are classified as high-alert medications because inappropriate administration, dosing errors, inadequate monitoring, and failure to recognize complications can result in serious patient harm (Aldhaeefi et al., 2023; Wang et al., 2024). Bleeding is the most common and clinically important complication of anticoagulant therapy and may range from minor bleeding to potentially life-threatening hemorrhage. Additional safety concerns include medication errors, excessive anticoagulation, drug interactions, heparin-induced thrombocytopenia (HIT), and thromboembolic events associated with inadequate anticoagulation (Morgovan et al., 2026). These risks emphasize the importance of accurate medication administration, comprehensive patient assessment, appropriate laboratory monitoring, early recognition of adverse effects, and adherence to evidence-based anticoagulation practices (Alrowily, 2023; Gee, 2018; Gee & Saul, 2021).

Critical care nurses have a central role in the safe and effective management of patients receiving anticoagulant therapy. Their responsibilities extend beyond medication administration and include verifying prescriptions and doses, assessing bleeding and thrombotic risks, reviewing relevant laboratory results, monitoring therapeutic responses, identifying adverse effects and complications, implementing bleeding precautions, educating patients and families, and communicating clinically significant findings to the multidisciplinary healthcare team. Consequently, safe nursing practice requires adequate knowledge of anticoagulant mechanisms of action, therapeutic indications, benefits, adverse effects, monitoring requirements, reversal agents, and medication-specific precautions (Abdel Rahman, 2023; Abeer Mohammed Abdalhamid Farag et al., 2017; Al-Ghabeesh et al., 2026).

The increasing use of DOACs has added further complexity to anticoagulant management. Although these medications generally do not require routine coagulation monitoring, their safe use requires healthcare professionals to understand renal and hepatic considerations, drug interactions, medication-specific contraindications, perioperative management, adherence requirements, and available reversal strategies. Knowledge deficiencies in these areas may adversely affect clinical decision-making and increase the potential for preventable medication-related harm. Previous studies have identified variability in healthcare professionals' knowledge of anticoagulant therapy, particularly regarding mechanisms of action, indications, monitoring requirements, adverse effects, drug interactions, reversal agents, and patient education (Gee, 2018; Gee & Saul, 2021; Subih et al., 2025).

In Saudi Arabia, the growing burden of cardiovascular and thromboembolic conditions has increased the clinical use of anticoagulant therapy. Conditions such as atrial fibrillation, ischemic heart disease, stroke, VTE, obesity, and diabetes contribute to the need for anticoagulation across healthcare settings. At the same time, Saudi healthcare institutions increasingly use DOACs alongside traditional anticoagulant medications (Basilim, 2025; Ibrahim; Mohamed et al., 2020). Critical care nurses are consequently required to manage patients receiving a broad range of anticoagulant therapies in complex and rapidly changing clinical environments.

Despite the importance of anticoagulation in critical care, evidence regarding critical care nurses' comprehensive knowledge and clinical practice related to anticoagulant therapy in Saudi Arabia remains limited. Existing studies have generally examined selected aspects of anticoagulation or specific healthcare professional populations, with relatively limited assessment of nurses' knowledge across medication mechanisms, therapeutic benefits, adverse effects, complications, monitoring requirements, reversal strategies, and nursing responsibilities. Furthermore, limited evidence is available regarding the extent of nurses' exposure to anticoagulant-related education and whether previous education and professional characteristics are associated with knowledge and clinical practice. This gap is particularly important given the increasing diversity of anticoagulant medications and the high-risk nature of anticoagulant therapy in critical care settings.

Comprehensive assessment of nurses' knowledge and clinical practice may therefore identify specific competency gaps and inform the development of targeted educational and quality-improvement strategies. Understanding the relationship between knowledge, clinical practice, educational exposure, and professional characteristics may also help healthcare organizations design continuing professional development programs that address nurses' specific learning needs and strengthen anticoagulant safety practices.

Conceptual Framework

This study will be guided by a Knowledge–Practice Framework, which proposes that nurses' demographic characteristics, professional experiences, and educational exposure influence their level of knowledge regarding anticoagulant therapy, which subsequently affects their clinical practices (Figure 1). The framework is based on the assumption that nurses who possess adequate knowledge of anticoagulant pharmacology, therapeutic indications, potential complications, monitoring requirements, and nursing responsibilities are more likely to demonstrate safer and more effective clinical practices (Francavilla, 2008; Gee, 2018; Magon et al., 2021).

According to this framework, individual and professional characteristics, including age, gender, nationality, educational level, years of nursing experience, critical care experience, clinical position,

and working unit, may influence nurses' knowledge and competency related to anticoagulant therapy. In addition, educational factors, such as previous anticoagulant-related training and participation in continuing professional development activities, are expected to enhance nurses' understanding and preparedness for managing patients receiving anticoagulants (Francavilla, 2008; Gee, 2018; Magon et al., 2021; Omoush et al., 2022).

The framework further assumes that higher levels of knowledge regarding anticoagulant therapy contribute to improved nursing practices. Nurses with adequate knowledge are expected to demonstrate safer medication administration practices, more comprehensive patient assessments, effective monitoring of anticoagulant therapy and related complications, appropriate patient education, and enhanced collaboration with the multidisciplinary healthcare team (Francavilla, 2008; Gee, 2018; Gee & Saul, 2021; Magon et al., 2021).

The conceptual framework consists of three main components. The first component includes the independent variables, which represent nurses' demographic, professional, and educational characteristics. Demographic characteristics include age, gender, and nationality. Professional characteristics include educational level, years of nursing experience, critical care experience, clinical position, and working unit. Educational factors include previous anticoagulant-related training and participation in continuing education activities (Alharazi et al., 2024; Gee, 2018; Gee & Saul, 2021).

The second component represents knowledge regarding anticoagulant therapy, which is considered a key outcome variable in this framework. Nurses' knowledge will be assessed across five domains: (1) mechanisms of action and pharmacological properties of anticoagulants, (2) clinical indications and therapeutic benefits, (3) adverse effects and anticoagulant-related complications, (4) laboratory monitoring and reversal strategies, and (5) nursing responsibilities related to anticoagulant management (Gee & Saul, 2021; Omoush et al., 2022).

The third component represents nursing practice regarding anticoagulant therapy, which reflects the application of knowledge into clinical care. Nursing practice will be assessed across five domains: (1) safe medication administration, (2) patient assessment before and during anticoagulant therapy, (3) clinical monitoring and early recognition of complications, (4) patient and family education, and (5) interprofessional collaboration (Francavilla, 2008; Gee, 2018; Gee & Saul, 2021).

Overall, this framework suggests that nurses' demographic and professional characteristics, together with educational exposure, may influence their knowledge of anticoagulant therapy, and that improved knowledge may contribute to better clinical practices and safer anticoagulant management among critical care nurses.

Study Purpose and Objectives

The purpose of this study was to assess knowledge and clinical practice related to anticoagulant therapy among critical care nurses in Saudi Arabia, with emphasis on mechanisms of action, clinical indications and therapeutic benefits, adverse effects and complications, laboratory monitoring, reversal strategies, patient education, and nursing responsibilities. The study also aimed to determine nurses' exposure to anticoagulant-related educational programs, including the frequency, type, and duration of training; examine the relationships among knowledge, clinical practice, and educational exposure; identify demographic and professional factors associated with knowledge and practice, including age, gender, educational qualification, nursing and critical care experience, direct patient-care involvement, and previous anticoagulant-related education; and determine whether knowledge of anticoagulant therapy was independently associated with nursing practice after controlling for relevant demographic, professional, and educational characteristics.

Methodology

Study Design

A quantitative, descriptive cross-sectional study design was used to assess critical care nurses' knowledge and clinical practices related to anticoagulant therapy in Saudi Arabia. This design was appropriate for assessing nurses' current knowledge and reported clinical practices and for examining associations between demographic and professional characteristics, educational exposure, knowledge, and nursing practice. Data were collected at a single point in time using a structured, self-administered electronic questionnaire.

The study was guided by a Knowledge–Practice Framework, which assumed that nurses' demographic characteristics, professional background, and exposure to anticoagulant-related education may influence their knowledge regarding anticoagulant therapy and, subsequently, their clinical practices. Within this framework, higher educational attainment, greater clinical experience, direct involvement in patient care, and participation in anticoagulant-related training were expected to be associated with greater knowledge and better adherence to evidence-based anticoagulant management practices.

Study Setting

The study was conducted among critical care nurses working in selected hospitals in the Western Region of Saudi Arabia. The participating hospitals included governmental, private, university/teaching, and military healthcare facilities providing acute and critical care services.

The study included nurses working in intensive care units, coronary care units, cardiac intensive care units, emergency departments, and other specialized acute and critical care areas where patients receiving anticoagulant therapy were routinely managed. The inclusion of nurses from different healthcare institutions and clinical areas provided diversity in professional backgrounds and clinical exposure to anticoagulant therapy.

Study Population and Sampling Methods

The study population consisted of registered nurses working in critical care and acute care

environments in selected hospitals in the Western Region of Saudi Arabia. Eligible participants were nurses who provided direct patient care and were involved in the administration, monitoring, management, or education of patients receiving anticoagulant medications.

Critical care nurses were considered an appropriate population for the study because anticoagulant therapy is frequently used among critically ill patients with conditions such as venous thromboembolism, atrial fibrillation, cardiovascular diseases, and postoperative complications. Their clinical responsibilities place them in a central position for the safe administration and monitoring of anticoagulant therapy.

Inclusion Criteria

Participants were eligible if they were registered nurses currently employed in participating hospitals, worked in critical care or acute care clinical areas, had at least six months of clinical experience, provided direct patient care, and had experience caring for patients receiving anticoagulant therapy. Participation was voluntary, and only nurses who agreed to participate and provided informed consent were included.

Exclusion Criteria

Nurses were excluded if they worked exclusively in administrative positions without direct clinical responsibilities, were nursing interns, students, or trainees, did not provide direct patient care, or had no previous experience managing patients receiving anticoagulant therapy.

Sample Size

The required sample size was determined using an appropriate statistical approach for a cross-sectional study, taking into consideration the desired confidence level, margin of error, expected proportion of adequate knowledge, and estimated population of eligible critical care nurses. The final study sample consisted of 362 critical care nurses who met the eligibility criteria and completed the electronic questionnaire.

The electronic questionnaire was configured so that all required items had to be completed before submission. Consequently, the final dataset contained complete responses for the study variables, and incomplete questionnaires were not included in the analysis.

Sampling Technique

A convenience sampling technique was used to recruit eligible critical care nurses from participating hospitals. Nursing administrations of the selected hospitals were contacted to facilitate recruitment and to identify appropriate communication channels for eligible nurses.

Following administrative approval, the electronic questionnaire was distributed through approved professional communication channels used to reach eligible nurses. These channels included institutional nursing communication platforms and professional social media platforms, when available. The questionnaire was administered through Google Forms, allowing nurses from different hospitals and clinical areas to participate electronically.

Participation was voluntary, and eligible nurses were invited to access the questionnaire through the electronic survey link. No personally identifiable information was requested from participants.

Data Collection Instrument

Data were collected using a structured self-administered questionnaire. The questionnaire was developed based on relevant literature, clinical practice recommendations, evidence-based guidelines related to anticoagulant therapy, patient-safety recommendations, and established nursing responsibilities in the management of patients receiving anticoagulant medications (Al-Ghabeesh et al., 2026; Francavilla, 2008; Gee, 2018; Gee & Saul, 2021; Ibrahim; Subih et al., 2025).

The questionnaire was administered electronically using Google Forms to facilitate data collection from critical care nurses working in different hospitals and clinical areas. The electronic format allowed participants to complete the questionnaire remotely while maintaining anonymity and confidentiality.

The questionnaire consisted of four main sections addressing participants' demographic and work-related characteristics, knowledge regarding anticoagulant therapy, nursing practices related to anticoagulant management, and exposure to anticoagulant-related educational programs.

Section I: Demographic and Work-Related Characteristics

The first section collected demographic and professional information that could potentially influence nurses' knowledge and clinical practices related to anticoagulant therapy. The variables included age, gender, nationality, highest nursing qualification, current professional position, hospital type, current clinical working unit, years of nursing experience, years of critical care experience, involvement in direct patient care, previous formal education or training related to anticoagulant therapy, and the number of anticoagulated patients managed weekly.

Section II: Knowledge Regarding Anticoagulant Therapy

The second section assessed nurses' knowledge regarding anticoagulant therapy using multiple-choice questions covering essential aspects of anticoagulant pharmacology and clinical management. The knowledge assessment comprised four domains: anticoagulants used in clinical practice; mechanisms of action and therapeutic benefits; adverse effects, contraindications, and complications; and nursing responsibilities and patient education.

The first domain assessed knowledge regarding commonly used anticoagulants, including warfarin, unfractionated heparin, low-molecular-weight heparin, DOACs, and other anticoagulant agents. It also assessed knowledge of medication-specific monitoring requirements and the pharmacological classification of commonly used anticoagulants.

The second domain evaluated knowledge of the mechanisms of action and therapeutic benefits of anticoagulant medications. This included understanding the mechanism of warfarin, identification of direct

Factor Xa inhibitors and direct thrombin inhibitors, the primary therapeutic purpose of anticoagulants, major clinical indications for anticoagulation, and advantages associated with DOACs.

The third domain assessed knowledge regarding adverse effects, contraindications, and complications of anticoagulant therapy. This included recognition of bleeding as a major complication, identification of clinically important bleeding manifestations, understanding of heparin-induced thrombocytopenia, and knowledge of appropriate reversal agents for different anticoagulants.

The fourth domain assessed knowledge related to nursing responsibilities and patient education. Items addressed appropriate assessment before anticoagulant administration, laboratory monitoring, bleeding-related patient education, dietary considerations for patients receiving warfarin, timing and monitoring of warfarin therapy, management of missed doses, medications that increase bleeding risk, and the safety of warfarin during pregnancy.

Each knowledge item had one correct response, with correct answers assigned one point and incorrect answers assigned zero points. The total knowledge score was calculated by summing the number of correct responses, with higher scores indicating greater knowledge regarding anticoagulant therapy. Domain-specific knowledge scores were also calculated.

Section III: Nursing Practice Regarding Anticoagulant Therapy

The third section assessed nurses' self-reported clinical practices related to anticoagulant therapy using a five-point Likert scale ranging from **one (Never) to five (Always)**. The items assessed the frequency with which nurses performed recommended anticoagulant-related activities in their routine clinical practice.

The practice scale consisted of five domains: medication administration, patient assessment, clinical monitoring, patient education, and interprofessional collaboration. The medication administration domain assessed practices related to verifying prescriptions, confirming patient identity, checking prescribed doses, following institutional protocols, and double-checking high-alert anticoagulant medications.

The patient assessment domain assessed practices related to evaluating patients' bleeding history, renal and liver function, relevant laboratory investigations, and potential medication interactions before anticoagulant administration. The clinical monitoring domain assessed monitoring for signs and symptoms of bleeding, platelet counts among patients receiving heparin, INR among patients receiving warfarin, aPTT among patients receiving unfractionated heparin, and documentation of anticoagulant-related adverse drug reactions.

The patient education domain assessed nurses' practices related to explaining the purpose and benefits of anticoagulant therapy, providing bleeding precautions, promoting medication adherence, providing dietary counseling for patients receiving warfarin, and teaching patients to recognize warning signs requiring immediate medical attention. The interprofessional collaboration domain assessed communication with healthcare professionals regarding abnormal coagulation results, suspected bleeding complications, anticoagulant dosing and interactions, reversal agents, multidisciplinary decision-making, and documentation of patient education.

Each practice item was scored from one to five, with higher scores indicating more frequent performance of the recommended practice. The total practice score ranged from 25 to 125, with higher scores representing greater adherence to evidence-based nursing practices related to anticoagulant therapy. Domain-specific practice scores were also calculated.

Section IV: Exposure to Educational Programs

The fourth section assessed participants' previous exposure to anticoagulant-related educational and continuing professional development activities. Participants were asked whether they had attended an anticoagulant-related educational program during the previous two years and about the number of educational activities they had attended.

The section also assessed the types of educational activities received, including hospital-based in-service education, continuing nursing education, online learning, workshops, and simulation-based training. Participants reported the approximate duration of their educational activities and their perceived need for additional education related to anticoagulant therapy.

Instruments Validity and Reliability

The content validity of the questionnaire was established through evaluation by experts with academic and clinical expertise relevant to critical care nursing, anticoagulant therapy, pharmacology, and nursing education. The experts evaluated the questionnaire items for relevance, clarity, comprehensiveness, and appropriateness for assessing nurses' knowledge and clinical practices related to anticoagulant therapy. Their recommendations were considered in refining the questionnaire before its use in the study.

A pilot assessment was conducted among nurses with characteristics similar to those of the target population who were not included in the final study sample. The pilot assessment was used to evaluate the clarity and comprehensibility of the questionnaire items, appropriateness of response options, ease of completion, estimated completion time, and functionality of the electronic survey format.

The internal consistency of the nursing practice scale and its domains was assessed using Cronbach's alpha coefficient. The reliability analysis demonstrated acceptable internal consistency for the practice measure.

Data Collection Procedure

Following ethical approval from the Umm Al-Qura University College of Nursing Ethical Committee and administrative permissions from the participating hospitals, the final questionnaire was converted into an electronic survey using Google Forms.

The nursing administrations of participating hospitals facilitated access to appropriate communication channels for eligible nurses. The survey link was distributed electronically through approved nursing communication platforms and professional social media channels, where available.

Before accessing the questionnaire, participants received an electronic information sheet explaining the purpose of the study, study procedures, voluntary nature of participation, confidentiality measures, and their right to decline participation. Completion and submission of the questionnaire indicated informed consent to participate.

No personally identifiable information was collected. The questionnaire was configured so that all required items had to be completed before submission, resulting in complete responses for the variables included in the final analysis.

Ethical Considerations

Ethical approval was obtained from the Ethical Committee of the College of Nursing at Umm Al-Qura University before commencement of the study. Administrative permissions were also obtained from the participating healthcare institutions. The study was conducted in accordance with the ethical principles of the Declaration of Helsinki and applicable requirements for the protection of research participants.

Participation was voluntary. Before completing the questionnaire, participants received information regarding the study purpose, procedures, confidentiality measures, and their right to decline participation. Completion and submission of the electronic questionnaire constituted informed consent.

No personally identifiable information, such as participants' names, employee numbers, telephone numbers, or personal contact information, was collected. The electronic questionnaire was designed to maintain participant anonymity, and the collected data were used exclusively for research purposes.

All study data were handled confidentially and stored securely. Access to the dataset was restricted to the research team. Results were reported in aggregate form, ensuring that individual participants and healthcare facilities could not be identified from the findings.

Data Analysis

Data collected through Google Forms were exported into statistical software for analysis. Descriptive and inferential statistical procedures were used in accordance with the study objectives and the measurement levels of the variables.

Categorical variables were summarized using frequencies and percentages, while continuous variables were presented as means and standard deviations. Knowledge and practice scores were compared across relevant demographic and professional groups using appropriate inferential statistical tests.

Pearson correlation analysis was conducted to examine the relationships among knowledge scores, nursing practice scores, and exposure to anticoagulant-related educational programs. Multiple linear regression analyses were performed to identify independent predictors of nurses' knowledge and nursing practice scores while accounting for relevant demographic, professional, and educational characteristics.

For the regression analyses, variables of demographic, professional, educational, and clinical relevance were entered into the respective models. The results were presented using regression coefficients, standard errors, standardized beta coefficients, and corresponding significance levels. The coefficient of determination and adjusted coefficient of determination were used to describe the proportion of variance explained by each regression model. Statistical significance was established at a p-value of less than .05.

Results

Demographic and Work-Related Characteristics

A total of 362 critical care nurses participated in the study. The mean age of the participants was 32.8 ± 7.4 years. The largest age group was 30–39 years (40.3%), followed by nurses younger than 30 years (39.2%) and those aged ≥40 years (20.4%). Most participants were female (61.6%), while 38.4% were male. Saudi nurses constituted 54.7% of the sample, compared with 45.3% who were non-Saudi. Regarding educational attainment, the majority held a bachelor's degree (78.5%), followed by a master's degree (12.7%), diploma (7.7%), and doctorate (1.1%). Most participants were staff nurses (76.2%), while 12.7% were charge nurses, 5.5% were nurse educators, and 5.5% were nurse managers.

More than half of the participants worked in governmental hospitals (51.9%), followed by private hospitals (23.8%), university/teaching hospitals (17.1%), and military hospitals (7.2%). Half of the nurses worked in intensive care units (50.3%), while 16.0% worked in emergency departments, 14.4% in coronary care units, 13.3% in cardiac intensive care units, and 6.1% in other critical care areas. Regarding professional experience, 34.3% had more than 10 years of nursing experience, whereas 29.8% had 6–10 years of experience. Similarly, 27.6% had more than 10 years of critical care experience, followed by 28.7% with 6–10 years and 28.2% with 2–5 years of critical care experience.

Nearly all participants (93.1%) were directly involved in patient care. However, only 48.6% reported having received formal education or training related to anticoagulant therapy, whereas 51.4% had not received such training. Regarding weekly exposure to anticoagulated patients, 39.8% managed 5–10 patients per week, 26.5% managed 11–20 patients, 18.8% managed fewer than five patients, and 14.9% managed more than 20 patients per week (Table 1).

Knowledge Regarding Anticoagulant Therapy

The item-level findings demonstrated variability in nurses' knowledge across the four knowledge domains (Table 2). In the domain addressing anticoagulants used in clinical practice, recognition of low-molecular-weight heparin (enoxaparin) was the highest (79.0%), followed by recognition of unfractionated heparin (76.8%) and warfarin as an anticoagulant requiring INR monitoring (74.0%). Recognition of fondaparinux (39.2%) and edoxaban (46.4%) was comparatively lower. Knowledge regarding the appropriate monitoring test for unfractionated heparin was demonstrated by 68.5% of participants, while 61.3% correctly identified dabigatran as a direct thrombin inhibitor.

For the mechanism of action and therapeutic benefits domain, the highest proportion of correct responses was observed for the primary purpose of

anticoagulant therapy, with 77.9% correctly identifying prevention of clot formation and extension. Atrial fibrillation was correctly identified as an indication for long-term oral anticoagulation by 72.9% of nurses. Approximately two-thirds correctly identified warfarin's mechanism of action (68.5%), the absence of routine INR monitoring as an advantage of DOACs (68.5%), and Factor Xa inhibitors (65.2%). However, knowledge regarding the predictable anticoagulant effect (59.1%) and fewer food interactions (54.7%) was lower. Importantly, 20.4% of participants incorrectly believed that DOACs have no bleeding risk, indicating a potential knowledge gap regarding the safety profile of these medications.

In the domain of adverse effects, contraindications, and complications, 77.9% correctly identified bleeding as the most common complication of anticoagulant therapy, while 72.9% recognized melena as a sign requiring urgent assessment. However, only 54.7% correctly identified the characteristic features of heparin-induced thrombocytopenia. Knowledge of reversal strategies was particularly variable: 70.7% correctly identified vitamin K as the reversal agent for warfarin, whereas only 39.2% correctly identified idarucizumab as the specific reversal agent for dabigatran and 43.1% identified andexanet alfa as the reversal agent for Factor Xa inhibitors.

Regarding nursing responsibilities and patient education, the highest proportion of correct responses was observed for recognizing the need to report bleeding immediately (79.0%), followed by assessment of bleeding history and medication review before administration (76.2%) and maintaining a consistent intake of vitamin K-containing foods during warfarin therapy (74.0%). In contrast, fewer nurses correctly identified the appropriate response to a missed warfarin dose (44.8%) and the recommended INR monitoring frequency for stable warfarin therapy (54.7%). The preferred evening administration time for warfarin was correctly identified by 60.2% of participants, while 68.5% correctly identified ibuprofen as a medication that may increase bleeding risk.

Overall, the mean knowledge score was 16.2 ± 3.8 out of 25, corresponding to 64.8% of the maximum possible score. The mean scores for the individual domains were 3.39 ± 0.73 for anticoagulants used in clinical practice, 3.34 ± 0.69 for mechanisms of action and therapeutic benefits, 3.58 ± 0.97 for adverse effects and complications, and 5.90 ± 1.27 for nursing responsibilities and patient education. These findings indicate an overall moderate level of knowledge, with notable deficiencies particularly in specific reversal agents, missed-dose management, and selected DOAC-related safety issues (Table 2).

Nursing Practice Regarding Anticoagulant Therapy

The findings indicated that nurses generally reported frequent adherence to recommended anticoagulant-related practices, although the frequency varied across individual activities and domains (Table 3). Within medication administration, the highest mean score was observed for verifying patient identity using two identifiers (4.18 ± 0.79), followed by verifying the physician's prescription (4.12 ± 0.81). Verification of the prescribed dose had a mean score of 3.89 ± 0.90, while following institutional protocols scored 3.78 ± 0.95. The lowest score in this domain was observed for double-checking high-alert anticoagulant medications (3.23 ± 1.08), suggesting an area where practice improvement may be warranted. The overall medication administration domain score was 19.20 ± 3.10.

For patient assessment, the highest mean score was reported for assessing bleeding history before anticoagulant administration (3.72 ± 0.96), followed by reviewing relevant laboratory investigations (3.70 ± 0.94). Assessment of renal function before DOAC administration had a mean score of 3.46 ± 1.02, while liver function assessment and medication-interaction review had mean scores of 3.38 ± 1.05 and 3.54 ± 0.99, respectively. The overall patient assessment domain score was 17.80 ± 3.50.

Within the clinical monitoring domain, monitoring patients for signs and symptoms of bleeding had the highest mean score (3.90 ± 0.88). Monitoring INR among patients receiving warfarin had a mean score of 3.70 ± 0.95, while platelet monitoring during heparin therapy scored 3.65 ± 0.97. Monitoring aPTT among patients receiving unfractionated heparin had a mean score of 3.42 ± 1.03, and documentation of anticoagulant-related adverse drug reactions had a mean score of 3.43 ± 0.98. The overall clinical monitoring domain score was 18.10 ± 3.40.

Patient education practices were comparatively less frequent. Educating patients about bleeding precautions had the highest mean score in this domain (3.60 ± 0.92), followed by explaining the purpose and expected benefits of anticoagulant therapy (3.48 ± 0.98). Counseling regarding medication adherence had a mean score of 3.42 ± 0.99, whereas teaching patients to recognize warning signs requiring immediate medical attention scored 3.35 ± 1.02. The lowest practice score across this domain was observed for educating patients taking warfarin about maintaining a consistent vitamin K intake (3.05 ± 1.10), indicating a potentially important patient-education gap. The overall patient education domain score was 16.90 ± 3.80.

Regarding interprofessional collaboration, nurses reported the highest frequency for immediately reporting suspected bleeding complications to the treating physician (3.92 ± 0.84), followed by promptly communicating abnormal coagulation laboratory results (3.74 ± 0.92). Consultation with pharmacists regarding dosing, interactions, or reversal agents had a mean score of 3.18 ± 1.08, while participation in multidisciplinary decision-making had a mean score of 3.22 ± 1.04. The overall interprofessional collaboration domain score was 17.50 ± 3.60.

The overall nursing practice score was 89.50 ± 14.70 out of a possible 125 points, indicating generally moderate-to-good adherence to recommended anticoagulant-related nursing practices. The pattern of domain scores suggested relatively stronger performance in medication administration and clinical monitoring and comparatively lower performance in patient education and selected interprofessional activities (Table 3).

Exposure to Anticoagulant-Related Educational Programs

Nearly half of the nurses (48.6%) reported attending an anticoagulant-related educational program during the previous two years, whereas 51.4% had not participated in such education. Among those who had received education, 23.2% had attended one activity, 18.8% had attended two to three activities, and only 6.6% had attended more than three activities. Hospital in-service education was the most common educational format (63.6%), followed by continuing nursing education (53.4%), online learning (40.9%), workshops (33.0%), and simulation-based training (23.9%).

Regarding training duration, 43.2% of nurses reported receiving 2–4 hours of education, while 36.4% received less than two hours. Only 15.9% reported 5–8 hours of training and 4.5% reported more than eight hours. Despite the relatively limited exposure to formal anticoagulant education, a substantial majority of nurses (83.4%) agreed or strongly agreed that additional education regarding anticoagulant therapy was needed (Table 4).

Correlations Among Knowledge, Nursing Practice, and Educational Exposure

Correlation analysis demonstrated significant positive relationships among knowledge, nursing practice, and exposure to anticoagulant-related educational programs (Table 5). Knowledge scores were moderately and positively correlated with nursing practice scores ($r = 0.412$, $p < 0.001$), indicating that higher levels of anticoagulant knowledge were associated with more frequent performance of recommended nursing practices. Educational exposure was also positively correlated with knowledge scores ($r = 0.286$, $p < 0.001$) and nursing practice scores ($r = 0.218$, $p < 0.001$). Although these correlations were statistically significant, the relationships between educational exposure and both knowledge and practice were relatively modest.

Predictors of Knowledge Regarding Anticoagulant Therapy

Multiple linear regression analysis identified several significant predictors of nurses' knowledge regarding anticoagulant therapy (Table 6). The overall regression model was statistically significant ($R^2 = 0.28$, adjusted $R^2 = 0.26$, $p < 0.001$), explaining approximately 28% of the variance in knowledge scores.

Previous anticoagulant-related education or training was the strongest predictor of knowledge ($\beta = 0.24$, $B = 1.86$, $SE = 0.38$, $p < 0.001$), followed by having a bachelor's degree or higher ($\beta = 0.19$, $B = 1.42$, $SE = 0.41$, $p < 0.001$). Greater critical care experience was also positively associated with knowledge ($\beta = 0.15$, $B = 0.18$, $SE = 0.07$, $p = 0.010$), as were years of nursing experience ($\beta = 0.12$, $B = 0.11$, $SE = 0.05$, $p = 0.030$). Direct involvement in patient care was another significant predictor ($\beta = 0.11$, $B = 1.06$, $SE = 0.45$, $p = 0.020$). Age and gender were not significant independent predictors of knowledge scores ($p = 0.140$ and $p = 0.100$, respectively).

Predictors of Nursing Practice Regarding Anticoagulant Therapy

The multiple linear regression model predicting nursing practice was statistically significant and explained 31% of the variance in practice scores ($R^2 = 0.31$, adjusted $R^2 = 0.29$, $p < 0.001$) (Table 7).

Knowledge score was the strongest independent predictor of nursing practice ($\beta = 0.39$, $B = 1.42$, $SE = 0.21$, $p < 0.001$), demonstrating that nurses with higher anticoagulant knowledge tended to report better clinical practices. Previous anticoagulant-related education or training was also significantly associated with better practice scores ($\beta = 0.15$, $B = 3.16$, $SE = 1.12$, $p = 0.005$). Critical care experience ($\beta = 0.13$, $B = 0.38$, $SE = 0.16$, $p = 0.019$), having a bachelor's degree or higher ($\beta = 0.10$, $B = 2.18$, $SE = 1.02$, $p = 0.034$), and direct patient care involvement ($\beta = 0.10$, $B = 2.74$, $SE = 1.34$, $p = 0.042$) were also significant predictors of nursing practice.

In contrast, age, gender, and total years of nursing experience were not significant independent predictors of practice scores ($p = 0.280$, 0.185, and 0.110, respectively). Overall, the regression findings suggest that educational preparation, critical care experience, direct clinical involvement, and particularly anticoagulant-related knowledge are important factors associated with safer and more consistent anticoagulant-related nursing practices.

Discussion

Overall Knowledge of Anticoagulant Therapy

The present study found that critical care nurses demonstrated a moderate overall level of knowledge regarding anticoagulant therapy, with a mean knowledge score corresponding to approximately two-thirds of the maximum possible score. Although nurses showed relatively good recognition of commonly used anticoagulants, the purpose of anticoagulation, major bleeding complications, and basic nursing safety responsibilities, important knowledge gaps were identified in several clinically critical areas. In particular, knowledge was limited regarding specific reversal agents, heparin-induced thrombocytopenia, missed warfarin doses, monitoring requirements, and selected safety characteristics of DOACs. These findings are consistent with previous evidence demonstrating that nurses may possess basic knowledge of anticoagulant therapy while having important deficiencies in more complex pharmacological and safety-related aspects. For example, Oterhals et al. (2014) reported variation in European cardiac nurses' knowledge of anticoagulation, while Ferguson et al. (2016) identified poor knowledge of anticoagulant-drug interactions and underuse of risk-assessment tools among cardiovascular nurses in Australia and New Zealand. Similarly, Ehsani et al. (2022) found that cardiovascular nurses had insufficient knowledge of warfarin, particularly regarding drug interactions. In Jordan, Omoush et al. (2022) also reported poor baseline knowledge of anticoagulation therapy among nurses before an educational intervention. Collectively, these findings suggest that routine clinical exposure to anticoagulant medications does not necessarily translate into comprehensive pharmacological knowledge, particularly as anticoagulant therapy becomes

increasingly complex with the expanding use of DOACs.

Specific Knowledge Gaps and Patient-Safety Concerns

The item-level findings provide important insight into the specific areas in which nurses require further education. Knowledge was strongest for commonly encountered medications such as enoxaparin and unfractionated heparin and for fundamental principles such as the prevention of clot formation and recognition of bleeding. However, substantially lower knowledge was observed for fondaparinux, edoxaban, dabigatran reversal, Factor Xa inhibitor reversal, heparin-induced thrombocytopenia, and appropriate management of missed warfarin doses. Particularly concerning was the finding that approximately one-fifth of nurses incorrectly believed that DOACs do not carry a risk of bleeding. This misconception may have important clinical implications because DOACs, although generally associated with predictable pharmacokinetics and fewer routine monitoring requirements than warfarin, remain high-risk medications requiring careful assessment, monitoring, patient education, and recognition of adverse effects (Gee & Saul, 2021). The findings are also consistent with Alrowily et al. (2022), who identified healthcare professionals' knowledge, confidence, access to guidelines, patient factors, organizational processes, and medication-related issues as contributors to DOAC-related medication errors in Saudi Arabian hospitals. The limited recognition of specific reversal agents in the present study is particularly relevant because rapid identification and management of serious anticoagulant-related bleeding require nurses to understand the available reversal strategies and communicate effectively with physicians and pharmacists. Similar knowledge deficiencies concerning warfarin-drug and nutrient interactions and patient counseling were reported by Subih et al. (2025), who found moderate knowledge and identified important predictors including education, work experience, direct patient care, confidence, health education exposure, and anticoagulant training.

Nursing Practice and the Knowledge–Practice Relationship

Although knowledge was only moderate, nurses reported relatively frequent adherence to recommended anticoagulant-related practices, particularly in medication administration, patient assessment, bleeding surveillance, and clinical monitoring. The strongest practices involved verifying patient identity and prescriptions, assessing bleeding history, reviewing laboratory results, monitoring for bleeding, and reporting suspected complications. Nevertheless, lower practice scores were observed for double-checking high-alert anticoagulants, assessing renal and liver function, patient education, consultation with pharmacists, and participation in multidisciplinary decision-making. This pattern is consistent with previous research showing that nurses may perform routine medication-safety activities more consistently than higher-level educational and collaborative practices. Farag et al. (2017), for example, identified gaps between nurses' knowledge and practice in relation to high-alert medications, including anticoagulants. Ehsani et al. (2022) similarly found that cardiovascular nurses' warfarin knowledge was insufficient and that their practice quality was poor, with a significant relationship between knowledge and practice. D'Souza (2015) also demonstrated inadequate baseline knowledge and practice among ICU nurses caring for patients receiving anticoagulants. Importantly, the present study demonstrated a moderate positive correlation between knowledge and practice, and knowledge emerged as the strongest independent predictor of practice in the regression analysis. This finding strengthens the interpretation that improving nurses' pharmacological and clinical knowledge may contribute to safer and more consistent anticoagulant-related care, although the cross-sectional and self-reported nature of the study prevents establishing a causal relationship.

Educational Exposure and Predictors of Knowledge

A notable finding was that more than half of the participating nurses had not received formal anticoagulant-related education or training during the previous two years, despite nearly all participants being directly involved in patient care and most routinely caring for anticoagulated patients. Moreover, the majority of those who had received training reported relatively short educational exposure, while most nurses expressed a need for additional education. Educational exposure was positively associated with both knowledge and practice, and previous anticoagulant-related education was the strongest independent predictor of knowledge. These findings provide further evidence that continuing professional education is an important component of anticoagulant medication safety. Omoush et al. (2022) demonstrated a substantial improvement in nurses' anticoagulation knowledge following an educational course, while D'Souza (2015) reported significant improvements in both knowledge and practice following planned teaching among ICU nurses. Similar improvements were reported by Varghese (2024) among nursing students following a structured teaching program. The present findings extend this evidence by demonstrating that the association between educational exposure and knowledge persists in a relatively large sample of practicing critical care nurses. However, the modest correlation between educational exposure and knowledge suggests that simply attending an educational activity may not be sufficient. The content, duration, frequency, delivery method, and clinical relevance of education are likely important determinants of its effectiveness. Therefore, education should move beyond occasional brief in-service sessions toward structured, repeated, competency-based programs incorporating case scenarios, medication-safety exercises, and assessment of learning outcomes.

Influence of Educational Preparation and Clinical Experience

The regression findings further demonstrated that educational attainment, years of nursing experience, critical care experience, and direct patient-care involvement were positively associated with knowledge, while age and gender were not significant

independent predictors. Similarly, practice was independently associated with knowledge, previous anticoagulant education, critical care experience, higher educational attainment, and direct patient-care involvement, whereas age, gender, and overall nursing experience were not significant predictors. These findings indicate that professional exposure and relevant clinical preparation may be more important determinants of anticoagulant competency than demographic characteristics. The positive association between critical care experience and knowledge may reflect repeated exposure to complex anticoagulant regimens, laboratory monitoring, bleeding complications, and multidisciplinary decision-making in critically ill patients. The findings are broadly consistent with Subih et al. (2025), who identified education, work experience, direct patient care, confidence, and anticoagulant training as significant predictors of nurses' warfarin-related knowledge. Ehsani et al. (2022) likewise found significant relationships between knowledge and educational level and between practice and both age and professional experience. The current findings also complement research from Saudi Arabia showing that nursing knowledge and practice in medication safety and thromboembolism prevention require continued strengthening despite nurses' clinical exposure (Alharazi et al., 2024; Villagracia et al., 2026). Nevertheless, the finding that total nursing experience was not an independent predictor of practice after adjustment suggests that experience alone may not guarantee evidence-based anticoagulant practice; rather, experience accompanied by specialized education, current knowledge, and direct clinical involvement may be more important.

Comparison With Previous Evidence and Clinical Significance

Taken together, the present findings are consistent with the broader literature indicating persistent gaps in nurses' anticoagulation knowledge and practice across different countries and clinical settings. Oterhals et al. (2014), Ferguson et al. (2016), Ehsani et al. (2022), and Subih et al. (2025) each identified deficiencies in nurses' knowledge of anticoagulant therapy, although the specific areas of weakness varied according to the anticoagulants and clinical contexts examined. The present study adds to this literature by examining a broader range of anticoagulants and integrating pharmacological knowledge, clinical practice, educational exposure, and professional characteristics among critical care nurses in Saudi Arabia. The findings are particularly important because critical care nurses frequently care for patients at high risk of thrombosis and bleeding and are directly involved in medication administration, laboratory monitoring, assessment for complications, patient education, and communication with other healthcare professionals. The combination of moderate knowledge, incomplete educational exposure, and identifiable gaps in patient education and interprofessional collaboration suggests that anticoagulant safety should be addressed as an ongoing quality-improvement priority. The positive association between knowledge and practice and the finding that knowledge was the strongest predictor of practice further support the need for systematic educational strategies integrated into institutional medication-safety programs. Such strategies should also address newer anticoagulants and reversal agents rather than focusing exclusively on traditional warfarin and heparin therapy.

Implications for Nursing Education and Clinical Practice

Implications for Nursing Education

The findings highlight the need to strengthen both undergraduate and continuing nursing education related to anticoagulant therapy. Educational curricula and professional development programs should provide comprehensive coverage of traditional and newer anticoagulants, including mechanisms of action, indications, contraindications, adverse effects, laboratory monitoring, drug and food interactions, reversal agents, and management of missed doses and bleeding complications. Particular attention should be given to the knowledge gaps identified in this study, including DOAC safety, idarucizumab and andexanet alfa, heparin-induced thrombocytopenia, warfarin monitoring, and patient counseling. Because previous anticoagulant-related education was the strongest predictor of knowledge, hospitals should establish structured and recurring anticoagulation competency programs rather than relying primarily on occasional brief in-service sessions. Evidence from Omoush et al. (2022), D'Souza (2015), and Varghese (2024) demonstrates that structured educational interventions can significantly improve anticoagulation-related knowledge. Educational strategies could incorporate case-based learning, simulation, interactive e-learning, medication-error scenarios, and competency assessments to ensure that knowledge is translated into clinical decision-making and practice.

Implications for Clinical Practice

In clinical practice, healthcare institutions should integrate anticoagulant safety into medication-management and continuing professional development systems. Standardized protocols and readily accessible clinical guidelines should reinforce safe medication administration, independent double-checking of high-alert anticoagulants, assessment of renal and hepatic function, laboratory monitoring, recognition of bleeding and heparin-induced thrombocytopenia, and appropriate escalation of abnormal findings. The relatively lower scores for patient education and pharmacist consultation indicate an opportunity to strengthen interprofessional anticoagulation management, with nurses, physicians, and pharmacists working collaboratively to review medication regimens, identify interactions, educate patients, and respond to complications. This is particularly relevant to DOAC therapy, where medication errors may arise from dosing, patient characteristics, communication problems, and organizational factors (Alrowily et al., 2022). Regular auditing of anticoagulant-related nursing practices, competency reassessment, and feedback at the unit level may help translate educational improvements into sustained clinical performance.

Implications for Patient Safety and Quality Improvement

From a patient-safety perspective, the findings support the development of institutional anticoagulation-safety initiatives that combine education, standardized procedures, clinical decision support, and multidisciplinary collaboration. Given that most nurses in the present study routinely cared for anticoagulated patients but more than half had not received recent formal training, hospitals should consider mandatory periodic anticoagulation competency training for nurses working in critical care and other high-risk areas. Educational programs should be linked to measurable outcomes, such as knowledge assessment, observed competency, adherence to monitoring protocols, quality of patient education, and rates of anticoagulant-related medication errors or adverse events. This approach would be consistent with evidence showing that structured educational interventions can improve nurses' knowledge and practice (D'Souza, 2015; Omoush et al., 2022) and with Saudi Arabian evidence emphasizing the multifactorial nature of anticoagulant medication errors and the importance of professional training, medication review, and organizational safety systems (Alrowily et al., 2022).

Limitations

This study has several limitations that should be considered when interpreting its findings. First, the cross-sectional design captures knowledge, clinical practice, and educational exposure at a single point in time; therefore, temporal relationships and causal associations cannot be established. Although educational exposure was associated with higher knowledge and practice, the findings cannot confirm that education caused these improvements. Cross-sectional studies are also susceptible to differences in participant characteristics and other unmeasured factors that may influence observed associations (Baumeister et al., 2026; Hunziker & Blankenagel, 2021; Chirico, 2023).

Second, the study used a self-administered electronic questionnaire, and nursing practice was assessed through self-report rather than direct observation or objective clinical measures. Consequently, responses may have been affected by recall bias and social desirability bias, with participants potentially reporting practices that more closely reflect recommended standards than their actual behavior. This limitation is particularly relevant to medication administration, monitoring, patient education, and interprofessional collaboration, where self-reported practice may not fully represent routine clinical performance. Cross-sectional survey research is also vulnerable to measurement and response biases that may affect the accuracy and generalizability of findings (Baumeister et al., 2026; Chirico, 2023).

Third, participants were recruited from selected hospitals in the Western Region of Saudi Arabia, which may limit the generalizability of the findings to critical care nurses working in other regions, hospital types, or healthcare systems in Saudi Arabia. Differences in institutional policies, availability of clinical pharmacists, anticoagulant protocols, continuing professional development opportunities, and patient populations may influence nurses' knowledge and practice. In addition, unmeasured organizational and individual factors may have contributed to the observed relationships between educational exposure, knowledge, and practice.

Finally, the study assessed educational exposure primarily through participants' reported history of anticoagulant-related education and did not objectively evaluate the content, duration, quality, or effectiveness of previous educational programs. Future longitudinal and multicenter studies should incorporate larger and more diverse samples, objective assessment of clinical practice, and evaluation of specific educational interventions to determine whether improvements in knowledge translate into sustained changes in clinical practice and patient safety outcomes. These approaches would provide stronger evidence regarding the effectiveness of anticoagulant education among critical care nurses (Baumeister et al., 2026; Hunziker & Blankenagel, 2021; Chirico, 2023).

Conclusion

This study demonstrated that critical care nurses in selected hospitals in the Western Region of Saudi Arabia had moderate knowledge and generally moderate-to-good self-reported clinical practice regarding anticoagulant therapy. However, important knowledge gaps were identified in medication-specific safety issues, particularly recognition of reversal agents for dabigatran and Factor Xa inhibitors, management of missed warfarin doses, and selected direct oral anticoagulant safety considerations. Practice was relatively stronger in medication administration and clinical monitoring but comparatively lower in patient education and interprofessional collaboration. Notably, less than half of the nurses had received anticoagulant-related education during the previous two years, despite most reporting a need for additional education.

The significant positive association between knowledge and clinical practice, together with knowledge being the strongest independent predictor of practice, highlights the importance of strengthening nurses' anticoagulant-related knowledge to promote safe clinical care. Previous anticoagulant-related education was the strongest predictor of knowledge, further emphasizing the value of continuing professional development. Healthcare institutions should therefore implement structured, recurrent, and competency-based anticoagulant education programs focusing on high-risk medications, reversal strategies, laboratory monitoring, medication interactions, patient education, and interprofessional collaboration. These initiatives may enhance nurses' competencies and support safer anticoagulant management among critically ill patients.

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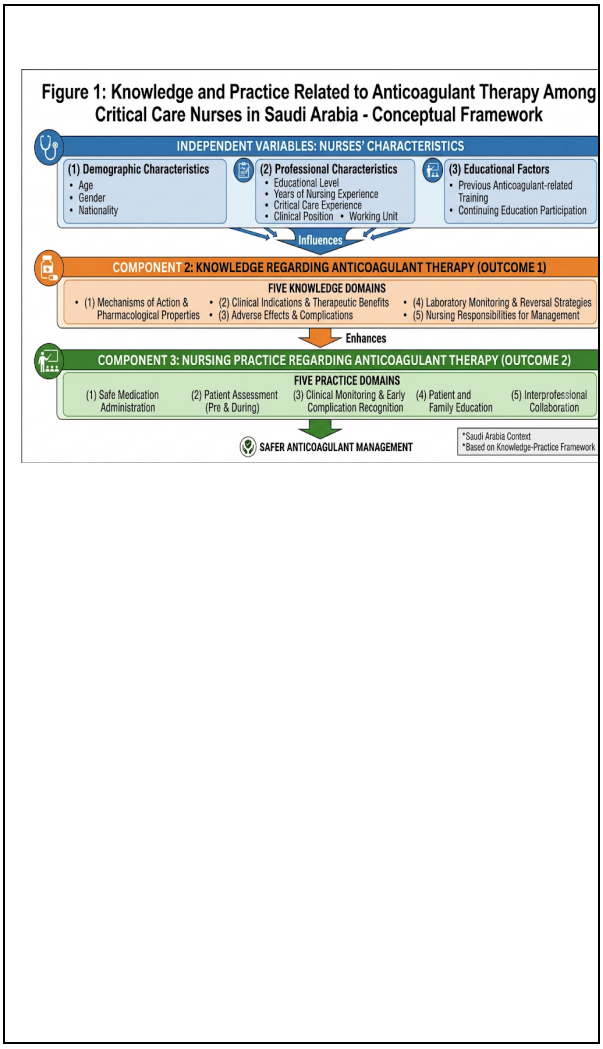

Tables

Table 1. Demographic and Work-Related Characteristics of Critical Care Nurses (N = 362)

Demographic and Work-Related Characteristics	Mean ± SD n (%%)
Age (years)	32.8 ± 7.4
Age group	
<30 years	142 (39.2%)
30–39 years	146 (40.3%)
≥40 years	74 (20.4%)
Gender	
Male	139 (38.4%)
Female	223 (61.6%)
Nationality	
Saudi	198 (54.7%)
Non-Saudi	164 (45.3%)
Highest Nursing Qualification	
Diploma	28 (7.7%)
Bachelor's degree	284 (78.5%)

Master's degree	46 (12.7%)
Doctorate	4 (1.1%)
Current Position	
Staff Nurse	276 (76.2%)
Charge Nurse	46 (12.7%)
Nurse Educator	20 (5.5%)
Nurse Manager	20 (5.5%)
Hospital Type	
Governmental hospital	188 (51.9%)
Private hospital	86 (23.8%)
University/Teaching hospital	62 (17.1%)
Military hospital	26 (7.2%)
Current Working Unit	
Intensive Care Unit	182 (50.3%)
Coronary Care Unit	52 (14.4%)
Cardiac ICU	48 (13.3%)
Emergency Department	58 (16.0%)
Other critical care areas	22 (6.1%)
Years of Nursing Experience	
<2 years	38 (10.5%)
2–5 years	92 (25.4%)
6–10 years	108 (29.8%)
>10 years	124 (34.3%)
Years of Critical Care Experience	
<2 years	56 (15.5%)
2–5 years	102 (28.2%)
6–10 years	104 (28.7%)
>10 years	100 (27.6%)
Providing direct patient care	
Yes	337 (93.1%)
No	25 (6.9%)
Received formal anticoagulant training	
Yes	176 (48.6%)
No	186 (51.4%)
Number of anticoagulated patients managed weekly	
<5 patients	68 (18.8%)
5–10 patients	144 (39.8%)
11–20 patients	96 (26.5%)
>20 patients	54 (14.9%)

Table 2. Nurses' Knowledge Regarding Anticoagulants

Knowledge Items / Domains	**Correct Response**	**n (%)**
Domain 1: Knowledge Regarding Anticoagulants Used in Clinical Practice		
Which anticoagulants are commonly used in your unit? *	Warfarin	252 (69.6%)
	Unfractionated heparin	278 (76.8%)
	Low-molecular-weight heparin (Enoxaparin%%)	286 (79.0%)
	Dabigatran	218 (60.2%)
	Rivaroxaban	244 (67.4%)
	Apixaban	232 (64.1%)
	Edoxaban	168 (46.4%)
	Fondaparinux	142 (39.2%)
Anticoagulant requiring INR monitoring	Warfarin	268 (74.0%)
Monitoring test for unfractionated heparin	Activated partial thromboplastin time (aPTT%%)	248 (68.5%)
Direct thrombin inhibitor	Dabigatran	222 (61.3%)
Domain 2: Knowledge Regarding Mechanism of Action and Therapeutic Benefits		
Warfarin mechanism of	Inhibits vitamin K-dependent clotting factors	248 (68.5%)

action		
Factor Xa inhibitors correctly identified	Apixaban/Rivaroxaban/Edoxaban	236 (65.2%)
Main purpose of anticoagulants	Prevent formation and extension of blood clots	282 (77.9%)
Long-term anticoagulation indication	Atrial fibrillation	264 (72.9%)
Direct oral anticoagulants (DOACs) advantage:	No routine INR monitoring	248 (68.5%)
	Predictable anticoagulant effect	214 (59.1%)
	Fewer food interactions	198 (54.7%)
Incorrectly believing DOACs have no bleeding risk		74 (20.4%)

Domain 3: Knowledge Regarding Adverse Effects, Contraindications, and Complications		
Most common complication of anticoagulants	Bleeding	282 (77.9%)
Recognizing melena as urgent bleeding sign	Yes	264 (72.9%)
Understanding HIT	Low platelets with thrombosis	198 (54.7%)
Warfarin reversal agent	Vitamin K	256 (70.7%)
Dabigatran reversal agent	Idarucizumab	142 (39.2%)
Factor Xa inhibitor reversal agent	Andexanet alfa	156 (43.1%)

Domain 4: Knowledge Regarding Nursing Responsibilities and Patient Education		
Assessment before anticoagulant administration	Bleeding history and medication review	276 (76.2%)
Laboratory assessment before heparin	Platelet count	244 (67.4%)
Correct patient education regarding bleeding	Report bleeding immediately	286 (79.0%)
Warfarin dietary advice	Maintain consistent vitamin K intake	268 (74.0%)
Preferred warfarin administration time	Evening	218 (60.2%)
Stable warfarin INR monitoring frequency	Every 4 weeks	198 (54.7%)
Advice regarding missed warfarin dose	Skip missed dose	162 (44.8%)
Medication increasing bleeding risk	Ibuprofen	248 (68.5%)
Warfarin pregnancy safety	Generally contraindicated	236 (65.2%)
Overall Knowledge Scores Regarding Anticoagulant Therapy		
Overall Knowledge Domain		**Mean ± SD**
Average of anticoagulants used in clinical practice domain		3.39 ± 0.73
Average of mechanism of action and benefits domain		3.34 ± 0.69
Average of adverse effects and complications domain		3.58 ± 0.97
Average of nursing responsibilities domain		5.90 ± 1.27
Total knowledge score (25 items)		**16.2 ± 3.8**

* Multiple responses allowed.

Table 3. Item-Level Nursing Practice Scores Regarding Anticoagulant Therapy

Practice domains/Item	**Mea**

	n ± SD
A. Medication Administration Domain	
1. Verify the physician's prescription before administering anticoagulants.	4.12 ± 0.81
2. Verify the patient's identity using two identifiers before administering anticoagulants.	4.18 ± 0.79
3. Verify the prescribed anticoagulant dose before administration.	3.89 ± 0.90
4. Follow institutional protocols for anticoagulant administration.	3.78 ± 0.95
5. Double-check high-alert anticoagulant medications before administration.	3.23 ± 1.08
Overall mean score of medication administration domain	19.20 ± 3.10
B. Patient Assessment Domain	
6. Assess the patient's history of bleeding before administering anticoagulants.	3.72 ± 0.96
7. Assess renal function before administering DOACs.	3.46 ± 1.02
8. Assess liver function when clinically indicated.	3.38 ± 1.05
9. Review relevant laboratory investigations before anticoagulant administration.	3.70 ± 0.94
10. Review the patient's concurrent medications for potential drug interactions.	3.54 ± 0.99
Overall mean score of patient assessment domain	17.80 ± 3.50
C. Clinical Monitoring Domain	
11. Monitor patients for signs and symptoms of bleeding after anticoagulant administration.	3.90 ± 0

	.88
12. Monitor platelet counts in patients receiving heparin therapy.	3.65±0.97
13. Monitor the International Normalized Ratio (INR) in patients receiving warfarin.	3.70±0.95
14. Monitor activated partial thromboplastin time (aPTT) in patients receiving unfractionated heparin.	3.42±1.03
15. Document anticoagulant-related adverse drug reactions promptly and accurately.	3.43±0.98
Overall mean score of clinical monitoring domain	18.10±3.40
D. Patient Education Domain	
16. Explain the purpose and expected benefits of anticoagulant therapy to patients.	3.48±0.98
17. Educate patients about bleeding precautions while receiving anticoagulants.	3.6
	0±0.92
18. Counsel patients regarding adherence to the prescribed anticoagulant regimen.	3.42±0.99
19. Educate patients taking warfarin about maintaining a consistent dietary intake of vitamin K.	3.05±1.10
20. Teach patients to recognize warning signs that require immediate medical attention.	3.35±1.02
Overall mean score of patient education domain	16.90±3.80
E. Inter-professional Collaboration Domain	
21. Communicate abnormal coagulation laboratory results promptly to the healthcare team.	3.74±0.92
22. Report suspected bleeding complications immediately to the treating physician.	3.92±0.

	84
23. Consult pharmacists regarding anticoagulant dosing, interactions, or reversal agents when needed.	3.18 ± 1.08
24. Participate in multidisciplinary decision-making regarding anticoagulant therapy.	3.22 ± 1.04
25. Document patient education related to anticoagulant therapy in the medical record.	3.44 ± 0.99
Overall mean score of inter-professional collaboration domain	17.50 ± 3.60
Overall nurses' practice score Regarding Anticoagulant Therapy (25 items)	89.50 ± 14.70

Table 4. Exposure to Anticoagulant Educational Programs (N = 362)

Educational Characteristics	**n (%)**
Attended anticoagulant education during past two years	
Yes	176 (48.6%)
No	186 (51.4%)
Number of educational activities	
None	186 (51.4%)
One	84 (23.2%)
Two–three	68 (18.8%)
More than three	24 (6.6%)
Type of education received*	
Hospital in-service education	112 (63.6%)
Continuing Nursing Education	94 (53.4%)
Online learning	72 (40.9%)
Workshop	58 (33.0%)
Simulation training	42 (23.9%)
Average duration	
<2 hours	64 (36.4%)
2–4 hours	76 (43.2%)
5–8 hours	28 (15.9%)
>8 hours	8 (4.5%)
Need for additional anticoagulant education (Agree/Strongly agree)	302 (83.4%)
* Multiple responses allowed.	

Table 5. Correlations Among Knowledge, Nursing Practice, and Exposure to Anticoagulant-Related Educational Programs

Variables	**1. Knowledge Score**	**2. Nursing Practice Score**	**3. Educational Exposure**
1. Knowledge score	1	**0.412 (<0.001)**	**0.286 (<0.001)**
2. Nursing practice score	**0.412 (<0.001)**	1	**0.218 (<0.001)**
3. Educational exposure	**0.286 (<0.001)**	**0.218 (<0.001)**	1

Table 6. Predictors of Knowledge Regarding Anticoagulant Therapy Among Critical Care Nurses

Predictor	B	SE	β	*p*-value
Age (years)	0.06	0.04	0.09	0.140
Female gender	0.48	0.29	0.08	0.100
Bachelor's degree or higher	1.42	0.41	0.19	**<0.001**
Years of nursing experience	0.11	0.05	0.12	0.030
Critical care experience	0.18	0.07	0.15	0.010
Direct patient care	1.06	0.45	0.11	0.020
Previous anticoag	1.86	0.38	0.24	**<0.001**

ulant-related education/training				
Model summary	**R^2 = 0.28**	**Adjusted R^2 = 0.26**		**<0.001**

Table 7. Predictors of Nursing Practice Regarding Anticoagulant Therapy Among Critical Care Nurses

Predictor	B	SE	β	*p*-value
Age (years)	0.14	0.13	0.07	0.280
Female gender	1.21	0.91	0.07	0.185
Bachelor's degree or higher	2.18	1.02	0.10	0.034
Years of nursing experience	0.24	0.15	0.09	0.110
Critical care experience	0.38	0.16	0.13	0.019
Direct patient care	2.74	1.34	0.10	0.042
Previous anticoagulant-related education/training	3.16	1.12	0.15	**0.005**
Knowledge score	**1.42**	**0.21**	**0.39**	**<0.001**
Model summary	**R^2 = 0.31**	**Adjusted R^2 = 0.29**		**<0.001**