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Factors influencing nurses' knowledge and competence in warfarin-drug and nutrient interactions and patient counseling practices

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Abstract

Background Warfarin therapy is commonly used to prevent thromboembolic events and cardiovascular disorders, but its effectiveness can be influenced by interactions with drugs and foods. Nurses play a crucial role in managing warfarin therapy and counseling patients on these interactions. This study aimed to assess the predictors of nurses' knowledge regarding warfarin-nutrient and drug interactions and their competence in counseling patients on warfarin therapy.

Methodology : A cross-sectional study design was used to evaluate nurses' knowledge and counseling practices related to warfarin therapy across various healthcare institutions in Amman, Jordan. Participants included 176 registered nurses with at least one year of experience, recruited through convenience sampling from governmental, private, and educational hospitals. Data were collected through a self-administered questionnaire that assessed demographic characteristics, work-related factors, exposure to health education, and knowledge of warfarin-drug and food interactions, as well as counseling practices.

Results The study found that most participants were female (58.6%) and held a bachelor's degree (72.7%). Nurses demonstrated moderate knowledge of warfarin–drug interactions, with a mean score of 8.76 ± 2.26 out of 26. Knowledge was better for cardiac agents like atenolol (53.4%) and gastrointestinal agents (53.4%), but gaps were observed for anti-inflammatory and CNS drugs. The mean score for knowledge of warfarin–food interactions (out of 18) was 12.27 ± 3.84, with strong knowledge of non-interfering foods, but gaps in understanding foods like leafy greens, high in vitamin K. Nurses' knowledge of counseling practices for warfarin therapy was moderate, with a mean score of 8.07 ± 2.31 out of 15. While knowledgeable about diet and adherence, gaps existed in counseling patients on missed doses and dietary restrictions. Regression analysis identified key predictors of knowledge, including education, work experience, direct patient care, self-confidence, exposure to health education, and anticoagulant training, explaining 35% of the variance in knowledge scores. A postgraduate degree, work experience, and confidence in

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warfarin care positively impacted knowledge, while demographic factors like age, gender, and job position had no significant effect. The findings highlight the need for educational programs and confidence-building initiatives.

Conclusion The study highlights significant gaps in nurses' knowledge of warfarin interactions, particularly with certain drugs and foods, and underscores the need for targeted education and training. However, the study is limited by its reliance on self-reported data and a convenience sampling approach, which may impact generalizability. Strengthening nurses' understanding of warfarin management, especially regarding high-risk interactions, is essential for improving patient safety and the efficacy of anticoagulant therapy. Future initiatives should focus on structured educational programs, introducing interactive e-learning modules, regular workshops, and case-based training, as well as promoting multidisciplinary teamwork to enhance nurses' competency in warfarin counseling and patient care.

Keywords Warfarin, Drug-food interactions, Nursing knowledge, Patient counseling, Anticoagulant therapy, Healthcare settings, Jordan

Introduction

Warfarin is a widely prescribed oral anticoagulant used for the prevention and treatment of thromboembolic disorders, including deep vein thrombosis, pulmonary embolism, and atrial fibrillation [1, 2]. It also plays a critical role in managing patients with acute coronary syndrome (ACS) and those with prosthetic heart valves [3]. Despite its clinical significance, warfarin presents unique challenges due to its narrow therapeutic index and high susceptibility to interactions with various drugs, nutrients, and foods. These interactions can significantly affect its safety and efficacy, making continuous monitoring and patient counseling critical components of effective warfarin therapy [4, 5]. Without proper management, patients are at risk of severe complications, including life-threatening bleeding events [6].

Nurses play a pivotal role in managing warfarin therapy. As frontline healthcare providers, they are often the primary point of contact for patients on anticoagulants. Their responsibilities extend beyond routine care to include monitoring patients' International Normalized Ratio (INR) levels, educating them on the importance of maintaining dietary consistency—particularly concerning vitamin K-rich foods like leafy greens—and providing guidance on potential drug interactions [1]. This education is essential because certain medications, such as antibiotics and non-steroidal anti-inflammatory drugs (NSAIDs), can significantly increase bleeding risks even when INR levels appear stable [7]. Effective counseling requires that nurses possess a thorough understanding of warfarin's pharmacological properties, potential interactions, and the factors that can influence therapeutic outcomes. Research consistently highlights the importance of nurses' knowledge in this area, as it directly impacts patient adherence to treatment regimens, awareness of adverse reactions, and overall safety [8].

In Jordan and other Arab countries, the demand for comprehensive anticoagulation management is increasing. This growth places additional pressure on nurses to expand their knowledge and refine their clinical skills to meet the complex needs of patients on warfarin [9]. Several factors influence nurses' knowledge and practices related to warfarin therapy. Educational attainment plays a significant role, as higher levels of education often provide a stronger theoretical foundation, enhancing nurses' understanding of pharmacological principles, including drug-food interactions [10, 11]. Additionally, clinical experience contributes to practical knowledge, allowing nurses to develop competencies through firsthand exposure to managing warfarin-related complications and patient counseling scenarios [12, 13]. Formal anticoagulation training further strengthens this knowledge by providing specialized instruction, evidence-based guidelines, and case-based learning opportunities. This combination of theoretical knowledge, practical experience, and specialized training equips nurses with the confidence and competence needed to apply best practices in patient care [9, 10, 14].

Despite the critical role nurses play in anticoagulation management, several studies have identified significant gaps in healthcare professionals' knowledge of warfarin therapy, particularly regarding drug and food interactions. In Saudi Arabia, Al-Arifi et al. (2016) found that while pharmacists demonstrated a stronger understanding of warfarin interactions, nurses and physicians often lacked awareness, especially concerning herbal and dietary interactions [15]. Similarly, Alhubail et al. (2023) reported limited knowledge of anticoagulant-food interactions among healthcare professionals and students in the Eastern Region of Saudi Arabia, underscoring the urgent need for structured educational programs [16]. Al-Najim et al. (2018) identified comparable deficiencies among primary healthcare physicians, reinforcing the necessity for continuous professional development to bridge these knowledge gaps [14]. Similarly, in Egypt, Elshenawi and Elazeem (2020) documented widespread deficiencies in nurses' knowledge of drug interactions, with many lacking formal training and demonstrating

poor awareness of food-drug interactions [17]. Moreover, in the United States, Enwerem and Okunji (2015) revealed that many nurses, regardless of their years of clinical experience, had significant knowledge deficits regarding food-drug interactions [18]. A notable number of nurses had never encountered or managed such interactions in their practice, highlighting the critical need for regular in-house training. These findings emphasize the need for targeted educational interventions, improved access to drug interaction resources, and the integration of computerized alert systems in clinical settings to support safer anticoagulation management.

While these studies provide valuable insights, there remains a notable gap in research concerning the knowledge and counseling practices of Jordanian nurses in managing warfarin therapy. Most existing literature focuses on other regions, and studies involving Jordanian healthcare professionals often lack detailed assessments of their knowledge levels and the factors that influence them. Moreover, there is limited understanding of how variables such as years of clinical experience, educational background, and specific warfarin-related training impact nursing practices in Jordan [19, 20].

Addressing this research gap is essential for improving anticoagulation management and enhancing patient outcomes in Jordan [17, 18, 20]. This study aims to investigate the predictors of Jordanian nurses' knowledge regarding warfarin-nutrient and drug interactions, with a specific focus on their counseling effectiveness. By examining the influence of educational background, clinical experience, and warfarin-specific training [20, 21]. this research seeks to identify key determinants that can inform the development of targeted educational programs and policies. Ultimately, these findings will support efforts to enhance anticoagulation management practices and improve patient safety in Jordan.

Study purpose and objectives

The study aims to assess nurses' knowledge regarding critical aspects of warfarin management, focusing on identifying knowledge gaps that could affect patient safety. Specifically, the objectives are to evaluate: (1) participants' knowledge of drug interactions with warfarin, covering common medications that may alter its effectiveness and safety; (2) participants' understanding of food and beverage interactions with warfarin, particularly those high in vitamin K and frequently consumed beverages; (3) participants' knowledge of patient counseling practices related to safe warfarin management, such as advising on lifestyle modifications, adherence, and monitoring; and (4) the predictors of participants' overall knowledge scores on warfarin interactions and patient counseling, using regression analysis to explore demographic or educational factors linked to knowledge levels. This comprehensive analysis will inform targeted educational interventions to enhance nurses' knowledge and improve patient outcomes.

Methodology

Study design

A cross-sectional study design was employed to assess predictors of nurses' knowledge regarding warfarin interactions with nutrients and drugs, as well as their competence in counseling patients on warfarin therapy. This design was chosen to obtain a snapshot of knowledge levels and factors associated with this knowledge among nurses working in different healthcare settings.

Study setting and sample

This study was conducted in the capital city of Amman, Jordan, across four hospitals, which were randomly selected from a list of hospitals found through a Google search. The hospitals were chosen based on their provision of comprehensive healthcare services and their capacity to accommodate at least 200 beds. The selected hospitals represented a range of healthcare settings, including two governmental hospitals, one educational hospital, and one private hospital. These hospitals were equipped with full healthcare services, including critical care units, to ensure a broad representation of nursing practices in various clinical settings. By selecting hospitals from different sectors, the study aimed to include a diverse sample of nurses working in various healthcare environments, thereby enhancing the generalizability and applicability of the findings to different hospital types and their respective care models.

Participants were recruited through convenience sampling, targeting registered nurses actively involved in patient care. Eligible nurses had been providing direct patient care for at least three months prior to data collection, with an emphasis on those frequently involved in managing patients on anticoagulation therapy. The study included a diverse sample of nurses with at least one year of experience, covering various ages, genders, and education levels (diploma, bachelor's, and postgraduate degrees). Participants held roles such as bedside registered nurses, advanced nurse practitioners, and administrative nurses, with experience across medical-surgical wards and critical care units, representing a range of clinical settings.

The required sample size was determined through G*Power software, aiming for a power of 80%, a confidence level of 95%, and an estimated effect size of 0.30, to suit linear regression analysis. This calculation indicated a minimum of 148 participants to achieve adequate statistical power. Ultimately, 176 nurses consented to participate in the study, providing a robust dataset and allowing for potential attrition. This sample size strengthened the

study's capacity to identify predictors of nurses' knowledge regarding warfarin-nutrient and drug interactions and patient counseling on warfarin therapy.

Data collection procedure

Data collection took place from March to May 2023. Eligible nurses were invited to participate voluntarily, with informed consent obtained before participation. Nurses completed a self-administered questionnaire either in paper format or electronically, depending on their preference.

To ensure consistency in the data collection process across institutions, standardized briefing protocols were implemented. The co-authors, who were responsible for data collection, met with participants individually to explain the study's purpose and objectives, using a uniform script to maintain consistency in the information provided. This approach ensured that all participants received the same level of detail and clarity regarding the study.

The researchers collaborated with nursing department heads at each study site to gather names and schedules of eligible nurses. After the standardized briefing, participants were invited to complete the questionnaire. Nurses who opted for the paper format were instructed to submit their completed questionnaires in a designated, secure box in the head nurse's office. For those preferring the electronic option, a QR code linking to the Google Forms survey was provided, allowing them to complete it at their convenience.

Ethical considerations

Ethical approval for this study was obtained from the Institutional Review Board at Al Zaytoonah University of Jordan (IRB No. 03/190/2022–2023) and the Ministry of Health in Jordan. Additionally, formal agreements were secured from the managers of the participating private and educational hospitals to conduct the research within their institutions.

Participants were thoroughly informed about the purpose and objectives of the study, and confidentiality was rigorously maintained by anonymizing all responses. Participation was entirely voluntary; completion of the questionnaire implied consent, ensuring respect for the autonomy of each participant. The questionnaire tool used in this study was also approved by the original author, granting permission for its use in this research. The study adhered to the ethical principles outlined in the Declaration of Helsinki, ensuring participants' rights and well-being were protected throughout the research process.

Instrument

The study employed a structured, self-administered questionnaire specifically developed to assess nurses' knowledge of warfarin–nutrient and warfarin–drug interactions, as well as their patient counseling practices related to warfarin therapy. Drawing from pharmacology and medical-surgical nursing textbooks [22, 23] and validated tools from previous studies [15, 24], the questionnaire was designed to ensure clinical relevance and real-world applicability. Its development focused on common clinical scenarios, such as counseling on vitamin K-rich foods, recognizing warfarin toxicity, and identifying interactions with medications like antibiotics and NSAIDs. Questions were selected based on their relevance to anticoagulation guidelines and expert feedback. Sample questions from each subscale are provided in the appendix to demonstrate the questionnaire's practical focus. The questionnaire comprised four main sections:

Demographic and Work-Related information This section collected essential demographic and professional details, including age, gender, education level, years of nursing experience, job title, hospital type (e.g., private, government, or specialized hospital), and previous training related to anticoagulant management. These variables were included to analyze how individual characteristics, professional background, and specific work environments might influence nurses' knowledge and counseling practices regarding warfarin. By examining these demographic and work-related factors, the study aimed to identify potential correlations between nurses' backgrounds and their familiarity with warfarin management.

Exposure to health education about warfarin therapy This sub-scale explored participants' exposure to educational resources and their self-assessed confidence in managing patients on warfarin therapy. Nurses were asked whether they had provided direct care to patients receiving warfarin in the past two weeks, with responses recorded as "yes" or "no." Additionally, participants were asked to rate their self-confidence in managing warfarin-related care (categorized as high, moderate, or low). Other questions assessed prior exposure to health education specifically focused on warfarin interactions, as well as whether they had received any on-the-job training related to anticoagulants. This sub-scale aimed to capture the influence of recent experience and health education on nurses' confidence, knowledge, and counseling practices, allowing the study to evaluate how such factors impact nurses' warfarin-related competencies.

Knowledge of Warfarin–Drug and Warfarin–Food interactions This section aimed to assess nurses' under-

standing of warfarin interactions with various drugs and foods. It included two distinct sub-components to address knowledge of drug interactions and food interactions, both critical to safe and effective warfarin therapy management.

Warfarin–Drug interactions This sub-component consisted of 26 multiple-choice questions covering six categories of drugs that commonly interact with warfarin. These categories included anti-inflammatory agents, cardiac medications, gastrointestinal agents, vitamin supplements, central nervous system (CNS) medications, and other relevant drugs. Each question presented different drugs within these categories, focusing on their potential effects on warfarin anticoagulation. For each drug, response options included "enhance," "inhibit," "no effect," or "don't know." Correct responses were coded as 1, while incorrect responses were coded as 0. A higher cumulative score indicated greater knowledge of warfarin-drug interactions, highlighting a nurse's capability to anticipate and manage potential drug interactions in clinical practice.

Warfarin–Food interactions This sub-component included 18 questions about specific food items that could impact warfarin's effectiveness. Participants were asked about food items, such as carrots and cabbage, which may interact with warfarin. Similar to the drug interaction questions, response options were "enhance," "inhibit," "no effect," or "don't know," with correct responses coded as 1 and incorrect responses as 0. This section aimed to measure nurses' knowledge of dietary considerations essential for educating patients on how to avoid foods that could potentiate or diminish warfarin's therapeutic effect.

Patient counseling knowledge The final section assessed nurses' knowledge and understanding of recommended counseling practices for patients on warfarin. Through 15 multiple-choice questions, nurses' familiarity with best practices in patient education was evaluated, focusing on diet, medication adherence, and management of missed doses. This sub-scale included questions about dietary advice, guidance on medication schedules, and appropriate actions for patients to take if they missed a dose of warfarin. By assessing knowledge in this area, the study aimed to evaluate whether nurses were adequately prepared to educate patients on safe and effective warfarin use, thus reducing the likelihood of adverse events related to poor adherence or unintentional interactions.

To assess participants' knowledge of warfarin–drug and warfarin–food interactions, as well as their patient counseling knowledge, a scoring system was utilized to categorize knowledge levels based on the percentage of correct responses. The classification criteria were as follows: participants who scored less than 60% correct answers were categorized as having failed knowledge; scores between 60 and 69% were classified as poor (low) knowledge; scores between 70 and 79% indicated good (moderate) knowledge; scores between 80 and 89% reflected very good (high-moderate) knowledge; and scores above 90% were considered excellent knowledge.

Instrument development and validation

The development of the questionnaire was grounded in a comprehensive review of relevant literature, clinical pharmacology guidelines, and established textbooks to ensure both clinical relevance and contextual appropriateness. Key sources included Textbook of Clinical Pharmacology and Brunner & Suddarth's Textbook of Medical-Surgical Nursing [22, 23], as well as validated studies on warfarin management [15, 24]. Questions were carefully adapted from previous research, particularly from studies conducted by Oterhals et al. (2014) and Al-Arifi et al. (2016), to comprehensively address warfarin-drug and warfarin-food interactions [15, 24]. These modifications were designed to reflect the unique cultural and professional needs of the target population, ensuring the questionnaire's applicability within the Jordanian and broader Arab healthcare context.

The questionnaire's development followed a structured process aimed at enhancing methodological rigor and ensuring alignment with real-world nursing practices. The construction of subscales was guided by the need for clinical relevance, with a focus on practical scenarios frequently encountered by nurses. This included managing patient counseling related to vitamin K-rich foods, recognizing signs of warfarin toxicity, and identifying potential drug interactions with commonly prescribed medications such as antibiotics and NSAIDs. The inclusion criteria for each question were based on its relevance to clinical anticoagulation management guidelines, its reflection of real-life clinical situations, and its potential to assess key competencies required for effective warfarin management.

To validate the content and ensure clarity, relevance, and cultural appropriateness, a panel of four experts—comprising two clinical pharmacists and two experienced nurse educators—was convened. A direct validation session was conducted, during which each questionnaire item was critically reviewed. The panel engaged in detailed discussions to evaluate the clarity, accuracy, and contextual suitability of each question. Modifications were made to refine the wording, improve the structure, and adjust response options to better align with Jordanian cultural norms and the educational backgrounds of nurses in the region. This iterative review process helped ensure that the questionnaire was both comprehensive and culturally sensitive, enhancing its validity and applicability to the target population.

The questionnaire was organized into subscales focusing on three key areas: knowledge of warfarin-drug interactions, knowledge of warfarin-food interactions, and patient counseling practices related to warfarin management. Each subscale was subjected to rigorous content validation, with expert feedback incorporated to optimize the questionnaire's effectiveness. The final version was meticulously reviewed for alignment with current best practices in anticoagulation management and tailored to meet the specific educational and clinical contexts of the study population. Additionally, the questionnaire was refined and translated to meet English language standards, ensuring clarity and ease of understanding for both participants and researchers.

To promote transparency and support the replicability of the study, the complete questionnaire has been included in the manuscript's appendix. The comprehensive development and validation process, driven by expert input and evidence-based guidelines, reinforces the questionnaire's reliability and relevance as a tool for assessing nurses' knowledge and practices regarding warfarin management. This rigorous approach ensures that the instrument effectively captures the critical competencies needed to improve patient safety and optimize anticoagulation therapy outcomes.

Pilot study

A pilot study was conducted with a sample of 28 eligible nurses to assess the clarity, usability, and reliability of the English-language questionnaire adapted from prior studies and relevant textbooks [22, 23]. These nurses were recruited from similar healthcare settings to those targeted in the main study to ensure the questionnaire's applicability to the intended population. The primary goals of the pilot study were to evaluate the ease with which participants could understand and complete the questionnaire and to verify the internal reliability of its sub-scales.

Feedback from participants indicated that the questionnaire was clear, straightforward, and easy to complete within the allotted time, suggesting its suitability for larger-scale administration. Additionally, internal reliability was evaluated using Cronbach's Alpha. Results demonstrated strong reliability for key sub-scales: the knowledge of warfarin–drug and warfarin–food interactions sub-scale achieved a Cronbach's Alpha of 0.87, while the patient counseling knowledge sub-scale recorded a Cronbach's Alpha of 0.85. These reliability scores confirm that the questionnaire is both consistent and reliable for assessing the targeted knowledge areas among nurses in the main study.

The positive results of the pilot study supported the use of this adapted questionnaire for further data collection, as it was deemed to be an effective tool for capturing essential information on nurses' knowledge and counseling practices regarding warfarin therapy.

Data analysis

Data analysis was carried out using IBM SPSS Statistics (version 26) to provide a thorough understanding of both the demographic and professional characteristics of the participating nurses. Descriptive statistics, such as means, standard deviations, frequencies, and percentages, were calculated to summarize the demographic profiles and work-related factors, including age, gender, education level, years of experience, and job titles.

To identify key predictors of nurses' knowledge about warfarin interactions, a multiple The variables included in the analysis were all collected demographic and work-related data, which were pre-determined based on a literature review regarding factors influencing knowledge of warfarin interactions and counseling. Specifically, these variables included age, gender (with male as the reference), education level (specifically for those holding a postgraduate degree), years of working experience, type of hospital (with governmental hospitals as a reference category), job title (particularly those at the staff nurse level), and working unit (focusing on nurses in medical-surgical wards). Additionally, factors such as direct care experience with patients receiving warfarin, self-confidence in implementing warfarin interaction care (with high confidence as a reference), exposure to health education on warfarin interactions, and specific training related to anticoagulants were also examined.

This model allowed for a focused assessment of the demographic and work-related factors that might significantly predict knowledge and counseling practices related to warfarin. The statistical significance level for each predictor was set at $p < 0.05$, enabling the identification of the most influential factors in nurses' understanding and patient counseling regarding warfarin therapy.

Results

Demographic and work-related data

The demographic and work-related data highlight several notable trends among participants (Table 1). The majority of participants were in the 30–40 age group (37.5%) and predominantly female (58.6%). In terms of education, a substantial proportion held a Bachelor's degree (72.7%), reflecting a generally high educational attainment within the sample.

Most participants had between 1 and 5 years of work experience (34.1%), with a nearly equal distribution in the 6–10 years (32.9%) and over 11 years (32.9%) categories. Governmental hospitals were the primary employment sector (47.2%), followed by the private sector (32.4%), with the educational sector accounting for the remaining participants (20.4%). In terms of job roles, the majority

Table 1 Demographic and work-related data

Variables	*n* (%)
Age (years)	
21–29	52 (29.5%)
30–40	66 (37.5%)
> 41	58 (32.9%)
Gender	
Male	72 (41.4%)
Female	102 (58.6%)
Education level	
Diploma degree	14 (8%)
Bachelor degree	128 (72.7%)
Postgraduate degree	34 (19.3%)
Working experience (years)	
1–5	60 (34.1%)
6–10	58 (32.9%)
> 11	58 (32.9%)
Type of hospital	
Governmental sector	83 (47.2%)
Private sector	57 (32.4%)
Educational sector	36 (20.4%)
Job title position	
Staff nurse (bedside registered nurse)	121 (68.8%)
Advance nurse practitioner	29 (16.5%)
Administrative nurse	26 (14.9%)
Working unit	
Medical- surgical ward	110 (62.5%)
Critical care unit	66 (37.5%)
Prior 2 weeks ago, provide direct care for patients receiving warfarin	
Yes	136 (84%)
No	26 (16%)
Self-confidence in implementing warfarin interaction care	
High	72 (40.9%)
Moderate	80 (45.5%)
Low	24 (13.6%)
Exposure to health education related to warfarin interaction	
Yes	96 (54.5%)
No	80 (45.5%)
Training regarding anticoagulants during work experience	
Yes	82 (46.6%)
No	94 (53.4%)

(68.8%) were staff nurses working directly with patients, particularly in medical-surgical wards (62.5%). A high percentage (84%) had provided direct care to patients on warfarin within the previous two weeks.

Regarding self-confidence in managing warfarin interactions, 45.5% of participants rated their confidence as moderate, while a considerable portion (40.9%) reported high confidence. Just over half (54.5%) had received health education related to warfarin interactions, yet slightly fewer (46.6%) had formal training regarding anticoagulants in their work experience, indicating areas for potential improvement in targeted training and support.

Participants' knowledge of warfarin–drug interactions

The results highlight a range of knowledge among participants regarding the effects of various medications on warfarin anticoagulation, with a mean knowledge score of 8.76 out of a possible 26 (SD = 2.26), suggesting moderate awareness overall (Table 2).

Anti-Inflammatory agents Participants demonstrated mixed knowledge of anti-inflammatory agents' interactions with warfarin. Awareness of aspirin's anticoagulation enhancement was relatively balanced, with 50.6% answering correctly. In contrast, only 34.1% recognized ibuprofen's interaction with warfarin, with a higher proportion (65.9%) answering incorrectly. Similarly, only around one-third of participants correctly identified the effects of topical salicylates (35.2%) and naproxen (33.5%). Knowledge of acetaminophen and celecoxib interactions was also limited, with correct response rates of 37.5% and 34.1%, respectively.

Cardiac agents Knowledge of cardiac agents varied. Atenolol was the most accurately identified, with 53.4% of participants correctly recognizing its lack of interaction with warfarin. By contrast, only 43.8% of participants correctly identified propranolol's effect, while recognition of amiodarone and diltiazem interactions was lower, at 38.6% and 34.7%, respectively. Lovastatin presented a relatively even distribution of responses, with 46% answering correctly.

Gastrointestinal agents Among gastrointestinal agents, Proton Pump Inhibitors (PPIs) were the most accurately identified, with 53.4% of participants correctly recognizing their lack of interaction with warfarin. However, knowledge of antacid and sucralfate interactions was more limited, with only 40.9% and 35.2% answering correctly, respectively.

Vitamin supplements Recognition of vitamin supplement interactions with warfarin was modest. Only 36.9% correctly identified the impact of multivitamins, and 40.9% were aware of the effect of antioxidant formulas, suggesting some awareness but also notable gaps in understanding.

CNS drugs Among CNS drugs, phenytoin had the highest recognition rate, with 52.8% of participants answering

Table 2 Participants' knowledge of Warfarin–Drug interactions

Variables	Correct Answers *n* (%)	Incorrect Answers *n* (%)
How do these anti-inflammatory agents affect warfarin anticoagulation?		
Aspirin	89 (50.6%)	87 (49.4%)
Ibuprofen	60 (34.1%)	116 (65.9%)
Topical salicylates	62 (35.2%)	114 (64.8%)
Naproxen	59 (33.5%)	117 (66.5%)
Acetaminophen	66 (37.5%)	110 (62.5%)
Celecoxib	60 (34.1%)	116 (65.9%)
How do these cardiac agents affect warfarin anticoagulation?		
Propranolol (Inderal)	77 (43.8%)	99 (56.2%)
Atenolol (Tenormin)	94 (53.4%)	82 (46.6%)
Amiodarone	68 (38.6%)	108 (61.4%)
Diltiazem	61 (34.7%)	115 (65.3%)
Lovastatin	81 (46.0%)	95 (54.0%)
How do these gastrointestinal agents affect warfarin anticoagulation?		
Antacids	72 (40.9%)	104 (59.1%)
Proton Pump Inhibitor	94 (53.4%)	82 (46.6%)
Sucralfate (Carafate)	62 (35.2%)	114 (64.8%)
How do these vitamin supplements affect warfarin anticoagulation?		
Multivitamin	65 (36.9%)	111 (63.1%)
Antioxidant formula	72 (40.9%)	104 (59.1%)
How do these other medications that affect warfarin anticoagulation?		
Clofibrate (Lipofen)	92 (52.3%)	84 (47.7%)
Azathioprine (Imuran)	60 (34.1%)	116 (65.9%)
Antithyroid medication	66 (37.5%)	110 (62.5%)
Carbamazepine (Tegretol)	71 (40.3%)	105 (59.7%)
Dicloxacillin	69 (39.2%)	107 (60.8%)
Haloperidol	65 (36.9%)	111 (63.1%)
Oral contraceptives	66 (37.5%)	110 (62.5%)
How do these drugs active on the CNS that affect warfarin anticoagulation?		
Phenobarbital	74 (42.0%)	102 (58.0%)
Phenytoin	93 (52.8%)	83 (47.2%)
Propofol	60 (34.1%)	116 (65.9%)
Mean of total score of participants' knowledge about warfarin–Drug Interactions (out of 26)		**Mean (SD)**
		8.76 (2.26)

correctly. Phenobarbital's effects were correctly identified by 42%, while propofol had the lowest correct response rate in this category at 34.1%, indicating less familiarity with its interaction.

Other medications affecting warfarin Awareness of other medication interactions with warfarin showed mixed results. Clofibrate was the most accurately recognized, with 52.3% of participants identifying its enhancing effect on warfarin. However, knowledge of azathioprine's interaction was limited, with only 34.1% answering correctly. Awareness of other medications, such as antithyroid drugs and dicloxacillin, was moderate, with correct response rates just below 40%.

Overall, these results indicate variable knowledge across different categories of medications, with the lowest awareness in anti-inflammatory and CNS agents' interactions with warfarin. This suggests a need for enhanced education and training on specific drug interactions to promote safer warfarin management in clinical settings.

Participants' knowledge of warfarin–food interactions

The analysis of participants' knowledge of warfarin–food and beverage interactions reveals both strengths and gaps in understanding (Table 3). Participants demonstrated a high level of accuracy in identifying non-interfering foods. For instance, over 90% correctly identified that rice and potato do not interfere with warfarin, while similarly high accuracy was observed for dairy products (86.4% correct), meat (85.2% correct), and tomatoes (88.1% correct). This reflects a strong baseline understanding of commonly consumed foods that are less likely to affect warfarin.

Table 3 Participants' knowledge of Warfarin–Food and beverage interactions

Which of the following food items would interfere with warfarin medication?	**Correct Answers** ***n*** **(%)**	**Incorrect Answers** ***n*** **(%)**
1. Carrots	26 (14.8%)	150 (85.2%)
2. Cabbage	35 (19.9%)	141 (80.1%)
3. Parsley	81 (46.0%)	95 (54.0%)
4. Lettuce	82 (46.6%)	94 (53.4%)
5. Green tea	72 (40.9%)	104 (59.1%)
6. Black tea	143 (81.3%)	33 (18.7%)
7. Orange juice	144 (81.8%)	32 (18.2%)
8. Cola	138 (78.4%)	38 (21.6%)
9. Rice	162 (92.0%)	14 (8.0%)
10. Grapefruit juice	130 (73.9%)	46 (26.1%)
11. Spinach	107 (60.8%)	69 (39.2%)
12. Tomato	155 (88.1%)	21 (11.9%)
13. Potato	167 (94.9%)	9 (5.1%)
14. Dairy products	152 (86.4%)	24 (13.6%)
15. Meat	150 (85.2%)	26 (14.8%)
16. Fish	129 (73.3%)	47 (26.7%)
17. Poultry	118 (67.7%)	58 (32.3%)
18. Fats	26 (14.8%)	150 (85.2%)
Mean total score of participants' knowledge of Warfarin–food and beverages interactions (out of 18)		**Mean (SD)**
		12.27 (3.84)

In contrast, there were notable gaps in knowledge for certain foods with known interactions, especially leafy greens, which are high in vitamin K and can influence warfarin's effectiveness. For example, only 60.8% correctly identified spinach as a food that may interfere with warfarin, with 39.2% of participants incorrectly responding. Similarly, just under half of the participants recognized parsley (46.0% correct) and lettuce (46.6% correct) as interacting foods, and only 19.9% correctly identified cabbage, with 80.1% incorrectly assuming it does not interfere. These responses highlight a need for improved awareness regarding specific leafy greens and their potential to counteract warfarin.

For beverages, participants also demonstrated varying levels of understanding. While 73.9% correctly recognized grapefruit juice as an interacting beverage, only 40.9% knew that green tea could interfere with warfarin, with the remaining 59.1% responding incorrectly. This suggests a misconception about certain beverages that could have important implications for patient education on warfarin.

Confusion around specific items such as carrots and fats also emerged, with only 14.8% correctly identifying that these items do not interfere with warfarin. This misconception implies that participants might overestimate the number of foods that interact with warfarin, potentially leading to overly cautious or restrictive dietary advice.

Overall, participants scored an average of 12.27 out of 18 (SD = 3.84) on knowledge of warfarin-food interactions, indicating a moderate level of understanding. However, the variability in scores suggests differing levels of knowledge among individuals. These findings underscore the importance of targeted educational efforts to strengthen knowledge of specific food and beverage interactions with warfarin, especially regarding items that are frequently misunderstood. Enhanced training in this area could better equip nurses to provide accurate dietary guidance for patients on warfarin therapy.

Participants' knowledge of patient counselling on warfarin management

In a study assessing participants' knowledge of patient counseling on warfarin management, several key questions were posed to gauge their understanding of best practices and potential interactions associated with the medication (Table 4). The first question addressed how patients should manage their spinach consumption while on warfarin. A noTable 43.2% of participants correctly responded that patients should eat spinach regularly but in a consistent amount each week. However, misconceptions were evident, as 28.4% believed patients should avoid spinach completely.

Regarding the effect of alcohol on a patient's INR while taking warfarin, over half of the participants (52.3%) correctly indicated that alcohol increases INR. Meanwhile, 30.7% thought it had no effect, highlighting a significant gap in understanding. Participants were also queried about the optimal time for taking warfarin. A majority (56.3%) correctly stated that the best time is in the evening, while only 22.7% believed lunchtime was appropriate. When asked how often a PT/INR blood test should

Table 4 Participants' knowledge of patient counseling on warfarin management

Question	Answer Options	*n* (%)
When a patient is taking warfarin, how should they manage eating spinach?	Avoid eating spinach completely	50 (28.4%)
	Eat spinach only once a month	30 (17.0%)
	Eat as much spinach as they want, whenever they want	20 (11.4%)
	Eat spinach regularly, but in the same consistent amount each week*	76 (43.2%)
What effect does alcohol have on a patient's INR when taking warfarin?	It decreases INR	30 (17.0%)
	It increases INR*	92 (52.3%)
	It has no effect on warfarin	54 (30.7%)
What is the best time of day for a patient to take warfarin?	At lunchtime	40 (22.7%)
	In the evening*	99 (56.3%)
	In the morning before breakfast	30 (17.0%)
	Any time of day	7 (4.0%)
How often should a PT/INR blood test be done once a patient's warfarin dose is stable?	Once a year	25 (14.2%)
	Every 3 months	40 (22.7%)
	At least once every 4 weeks*	92 (52.3%)
	It doesn't need to be checked once the dose is stable	19 (10.8%)
	Don't know	
What should a patient do if they forget to take their warfarin dose in the evening?	Skip the missed dose*	102 (58.0%)
	Take the missed dose immediately	34 (19.3%)
	Take two doses of warfarin the next evening	22 (12.5%)
	Take half of the missed dose right now	18 (10.2%)
How long does it take for warfarin to completely leave the system once stopped?	5 h	29 (16.5%)
	5 days*	107 (60.8%)
	5 weeks	25 (14.2%)
	5 months	15 (8.5%)
How long will a patient typically need to stay on warfarin?	1 year	30 (17.0%)
	1 month	20 (11.4%)
	It depends on individual needs*	94 (53.4%)
	For the rest of their life	32 (18.2%)
What advice should be given to a pregnant woman regarding warfarin use?	She should not take warfarin*	100 (56.8%)
	Warfarin is safe during the second and third trimesters	30 (17.0%)
	She can take warfarin every other day	24 (13.6%)
	Pregnancy reduces the need for warfarin	22 (12.5%)
How does fish oil affect a patient's INR while on warfarin?	It enhances the INR*	110 (62.5%)
	It inhibits the INR	40 (22.7%)
	It has no effect on INR	26 (14.8%)
	Don't know	
Which food item should patients be cautious of while on warfarin due to its high vitamin K content?	Broccoli*	98 (55.7%)
	Apples	28 (15.9%)
	Chicken	25 (14.2%)
	Cheese	25 (14.2%)
Which over-the-counter pain medication is safest for patients on warfarin?	Ibuprofen	29 (16.5%)
	Acetaminophen*	110 (62.5%)
	Aspirin	25 (14.2%)
	Any over-the-counter medication	12 (6.8%)
How does green tea interact with warfarin?	It increases the effect of warfarin*	98 (55.7%)
	It decreases the effect of warfarin	30 (17.0%)
	It has no effect on warfarin	30 (17.0%)

Table 4 (continued)

Question	Answer Options	*n* (%)
	It increases the risk of bleeding	18 (10.2%)
What should a patient do if they are prescribed antibiotics while taking warfarin?	Stop taking warfarin	36 (20.5%)
	Monitor their INR more frequently*	99 (56.3%)
	Increase their warfarin dose	22 (12.5%)
	No action is needed	19 (10.8%)
Which vitamin should patients be most careful about while on warfarin?	Vitamin A	15 (8.5%)
	Vitamin D	25 (14.2%)
	Vitamin K*	115 (65.3%)
	Vitamin C	21 (11.9%)
Which substance can increase the risk of bleeding when taken with warfarin?	Fish oil*	110 (62.5%)
	Calcium supplements	28 (15.9%)
	Multivitamins without vitamin K	20 (11.4%)
	Caffeine	18 (10.2%)
Mean score of participants' Knowledge of Patient Counseling on Warfarin Management (out of 15)		**Mean (SD)**
		8.07 (2.31)

* Indicates the correct answer

be performed once a patient's warfarin dose is stable, 52.3% of participants correctly answered at least once every four weeks. Conversely, 14.2% thought it was sufficient to test once a year.

In cases where a patient forgets to take their evening dose of warfarin, 58.0% of participants correctly advised that the missed dose should be skipped, demonstrating a solid understanding of medication management. Regarding the duration for which a patient might need to stay on warfarin, 53.4% acknowledged that it depends on individual needs, while 17.0% mistakenly thought it was limited to one year.

When it came to counseling pregnant women on warfarin use, 56.8% correctly advised that women should not take warfarin during pregnancy, illustrating awareness of the medication's risks. Knowledge about food interactions was also assessed. For instance, 62.5% of participants correctly indicated that fish oil enhances the effect of warfarin, and 55.7% identified broccoli as a food to be cautious of due to its high vitamin K content.

In terms of over-the-counter medications, 62.5% recognized acetaminophen as the safest option for patients on warfarin, while 65.3% understood the importance of being cautious with vitamin K supplements. Additionally, when discussing the interaction between green tea and warfarin, 55.7% of participants accurately noted that green tea increases the effect of warfarin. They also showed a good understanding of the need for closer monitoring of INR when prescribed antibiotics, with 56.3% advocating for more frequent INR checks.

Overall, participants exhibited a mean score of 8.07 (SD = 2.31) out of 15, indicating a moderate level of knowledge regarding patient counseling on warfarin management. These findings underscore the necessity for continued education and training to enhance understanding and ensure patient safety in anticoagulation therapy.

Predictors participants' total knowledge score on warfarin interactions and counselling

The regression analysis revealed several significant predictors of participants' knowledge regarding warfarin interactions and counseling (Table 5). A multiple linear regression model was employed to assess whether specific variables could significantly predict nurses' knowledge scores on these topics. The model incorporated various predictors, including education level, work experience, direct care for patients on warfarin, self-confidence in warfarin care, exposure to health education regarding warfarin interactions, and training related to anticoagulants.

The overall regression model was statistically significant, with a R2 value of 0.35, indicating that the model accounted for 35% of the variance in knowledge scores. Additionally, the F-test results were significant ($F = 31.62$, $p = 0.003$), suggesting that the predictor variables collectively have a substantial relationship with the outcome variable. This underscores the importance of key factors, such as educational attainment, relevant experience, direct patient care, self-confidence, and specialized training, in enhancing nurses' knowledge levels regarding warfarin interactions. The findings highlight the necessity for structured educational programs and confidence-building initiatives to improve warfarin-related knowledge among nursing professionals.

Among the significant predictors, educational level, particularly the attainment of a postgraduate degree, was associated with higher knowledge scores ($\beta = 0.204$, $p = 0.032$). This finding suggests that advanced academic training may enhance nurses' comprehension of warfarin

Table 5 Regression analysis summary of predictors for total knowledge score on warfarin interactions and counseling

Variables	Beta	t value	*p* value*	Confidence Interval (CI 95%)	
				Lower Bound	Upper Bound
Age	0.088	0.572	0.572	-0.184	0.333
Gender (Male)	0.083	-0.989	0.326	-3.348	1.115
Education level (Postgraduate degree)	0.204	2.243	**0.032**	0.268	4.271
Working experience	0.210	1.426	**0.016**	0.503	3.082
Type of hospital (Governmental)	-0.046	-0.532	0.591	-1.684	0.970
Job title position (Staff nurse)	-0.070	-0.715	0.484	-2.180	1.023
Working unit (Critical care unit)	0.064	0.751	0.452	-1.346	2.994
Direct care for patients receiving warfarin (Yes)	0.181	1.908	**0.045**	0.110	4.126
Self-confidence in implementing warfarin interaction care (high)	0.681	3.913	**0.015**	0.121	6.321
Exposure to health education related to warfarin interaction (Yes)	0.252	2.121	0.0252	0.315	3.120
Training regarding anticoagulants (Yes)	0.149	1.726	**0.039**	0.270	3.977

* Significant p-values (< 0.05) are bolded

interactions. Similarly, work experience emerged as a significant positive predictor (β = 0.210, $p = 0.016$), indicating that accumulated years of practice contribute to a better understanding of this topic.

Furthermore, providing direct care to patients on warfarin was linked to increased knowledge (β = 0.181, $p = 0.045$), likely due to the practical experience gained in anticoagulation care. High self-confidence in implementing warfarin-related care was a particularly strong predictor (β = 0.681, $p = 0.015$), reflecting that nurses who feel more assured in their abilities tend to possess greater knowledge, possibly as a result of their proactive engagement in patient care. Additionally, exposure to health education focused on warfarin interactions significantly improved knowledge scores (β = 0.252, $p = 0.0252$), emphasizing the effectiveness of targeted educational interventions.

Training related to anticoagulants also significantly influenced knowledge (β = 0.149, $p = 0.039$), highlighting the role of professional training programs in enhancing nurses' understanding of warfarin management. In contrast, demographic factors such as age, gender, job position, and type of hospital did not significantly predict knowledge scores, suggesting that these characteristics alone do not have a substantial impact on warfarin-related knowledge.

In conclusion, the findings illustrate that advanced education, relevant work experience, direct patient care, self-confidence, and targeted training are key factors associated with higher knowledge levels among nurses regarding warfarin interactions and counseling. These results advocate for structured training and confidence-building initiatives as effective strategies to enhance warfarin-related knowledge among nursing professionals.

Discussion

The safe and effective management of warfarin remains a significant challenge in clinical practice due to its narrow therapeutic index and susceptibility to interactions with a wide range of foods and medications. Nurses play an essential role in mitigating these risks through patient education, monitoring, and ensuring adherence to therapy. However, despite their critical position in patient care, persistent gaps in healthcare professionals' knowledge of warfarin interactions continue to be reported [9, 25]. This study aimed to assess nurses' knowledge of warfarin-related drug and nutrient interactions, as well as their counseling practices, while identifying key predictors that influence their competency in this crucial area of medication management.

The findings of this study revealed that while nurses demonstrated a moderate level of overall knowledge regarding warfarin interactions, there were significant deficiencies in specific areas, particularly concerning the interactions between warfarin and certain drug classes such as anti-inflammatory agents, CNS drugs, and vitamin K-rich foods. Many nurses correctly identified common interactions with widely used drugs like aspirin, yet there was limited awareness regarding NSAIDs such as ibuprofen and naproxen, which can also potentiate warfarin's anticoagulant effect and increase the risk of bleeding. These findings align with previous research indicating that healthcare providers often struggle with the complex pharmacology of anticoagulants like warfarin [19, 26]. This lack of comprehensive knowledge is particularly concerning, given that insufficient understanding of drug interactions can lead to serious adverse outcomes, including bleeding complications, thromboembolic events, and inadequate patient counseling.

Key predictors of nurses' knowledge identified in this study included educational background, years of clinical experience, direct involvement in patient care involving warfarin therapy, self-confidence in managing

anticoagulant therapy, and exposure to specialized training programs. While personal attributes such as education and self-confidence were found to be significant predictors, broader institutional and systemic factors also appear to influence nurses' knowledge levels. These systemic factors include the availability of clinical resources, the presence of institutional support for continuing professional development, and the degree to which anticoagulation management is emphasized within healthcare systems. Limited access to updated clinical guidelines, inconsistent provision of in-service training, and the absence of standardized protocols across healthcare facilities may contribute to persistent knowledge gaps [25]. Addressing these systemic barriers through improved institutional support and continuous professional development initiatives could significantly enhance nurses' competency in warfarin management.

Furthermore, this study highlighted notable gaps in nurses' knowledge of food-drug interactions related to warfarin. While nurses generally understood that non-interfering foods such as rice and potatoes do not significantly affect warfarin's efficacy, there was a limited awareness of the impact of vitamin K-rich vegetables, such as spinach, parsley, and lettuce. Less than two thirds of participants correctly identified spinach as a food that can interfere with warfarin's anticoagulant effect, with additional misconceptions observed regarding beverages like green tea, which can also influence warfarin metabolism. These findings are consistent with previous studies that have reported healthcare professionals' limited understanding of food-drug interactions involving warfarin [9, 11]. This knowledge gap may result in inconsistent dietary guidance provided to patients, potentially compromising therapeutic outcomes, as fluctuations in dietary vitamin K intake can significantly alter warfarin's anticoagulant activity. One potential reason for these deficiencies is the limited integration of nutrition-based pharmacology into nursing curricula, resulting in inadequate training on the role of dietary factors in anticoagulant therapy. Moreover, a lack of interdisciplinary collaboration between nurses, pharmacists, and dietitians in patient education may hinder comprehensive counseling on dietary restrictions [20, 27]. To address these gaps, nursing curricula could be enhanced by incorporating modules on nutrition-based pharmacology, while interdisciplinary workshops involving pharmacists, dietitians, and nurses could foster a more holistic approach to patient education.

In addition to knowledge gaps related to drug and food interactions, the study also found deficiencies in nurses' warfarin counseling practices. While nurses demonstrated moderate knowledge in this area, significant gaps were identified in critical aspects of counseling, such as the recommended frequency of INR monitoring, appropriate dose adjustments, and the precautions required during pregnancy. These findings are in line with existing literature, which suggests that healthcare providers' counseling skills regarding warfarin management are often underdeveloped [12, 28]. A key contributing factor appears to be the lack of structured, standardized training programs on anticoagulant counseling, leading nurses to rely heavily on informal learning experiences and on-the-job training rather than evidence-based protocols [29]. Additionally, demanding workloads and time constraints commonly faced in clinical settings may limit nurses' ability to provide comprehensive patient education, resulting in inconsistent and sometimes insufficient counseling practices. These gaps can have serious implications for patient safety, as inadequate counseling may lead to poor adherence to therapy, unrecognized signs of bleeding, and failure to maintain therapeutic INR levels [11, 29].

The regression analysis conducted in this study further highlighted the factors influencing nurses' knowledge of warfarin management. Nurses with higher educational qualifications, greater clinical experience, direct patient care exposure, higher self-confidence, and prior warfarin-specific training demonstrated significantly better knowledge. These findings are consistent with previous research, which has shown that advanced education and extensive clinical experience are associated with improved medication management competencies [11, 13]. Interestingly, self-confidence emerged as a particularly strong predictor of knowledge, suggesting that nurses who feel more confident in their ability to manage warfarin therapy are also more likely to possess the necessary knowledge and skills. This finding aligns with other studies indicating that self-confidence is closely linked to proactive patient care and higher clinical competence [29–31]. Therefore, in addition to formal education and training, fostering nurses' self-confidence through mentorship programs, peer-support networks, and hands-on clinical experiences may be essential for improving warfarin management practices.

While this study's findings are consistent with those of other research highlighting low to moderate knowledge of anticoagulant-drug and food interactions among healthcare providers, some discrepancies were observed in the literature. For instance, while certain studies report a significant association between nurses' knowledge and factors such as educational level and work unit, others have found no such correlation [12, 18]. These variations may be attributed to differences in study settings, participant populations, and healthcare system structures. Regardless, the overall trend points to a need for standardized curricula and training programs that integrate anticoagulant pharmacology, practical patient counseling techniques, and routine competency assessments.

Hospital-based refresher courses and continuous professional development programs could also help ensure that nurses remain up to date with the latest evidence-based guidelines for warfarin management [29, 32].

A notable limitation of this study is that it did not evaluate the direct impact of nurses' knowledge on patient outcomes. Understanding this relationship is crucial, as improved knowledge and counseling skills are likely to enhance patient safety, reduce adverse events such as bleeding complications, and optimize therapeutic outcomes [11, 29, 30]. Future research should explore this association to provide more robust evidence for the development of targeted educational interventions aimed at improving both nurse competency and patient outcomes. Additionally, qualitative studies exploring nurses' perceptions of their knowledge gaps and barriers to effective warfarin management could offer valuable insights for designing more effective training programs [29, 32].

In conclusion, this study underscores that while nurses possess a moderate level of knowledge regarding warfarin interactions with drugs and foods, as well as counseling practices, significant gaps persist in critical areas. Educational attainment, clinical experience, and specialized training were identified as key predictors of knowledge levels. These findings highlight the urgent need for targeted educational interventions to enhance nurses' competency in warfarin management, minimize adverse outcomes, and strengthen patient-centered care. Future efforts should prioritize structured, evidence-based training programs, interdisciplinary collaboration, and mentorship initiatives to facilitate comprehensive knowledge acquisition and practical application. Integrating standardized anticoagulation management education into nursing curricula and hospital-based training programs is essential to ensure consistent, high-quality care for patients receiving warfarin therapy [31–33]. By addressing both individual and systemic factors, these strategies have the potential to promote safer medication practices, reduce the risk of adverse events, and ultimately improve patient outcomes in anticoagulation therapy.

Research implications and recommendations

The findings of this study underscore important implications for clinical practice, nursing education, and policy in relation to warfarin management. First, the moderate knowledge levels observed among nurses regarding warfarin-drug and warfarin-food interactions suggest a need for more comprehensive and targeted educational programs [11, 15, 28]. Such programs could include detailed instruction on pharmacokinetics, potential adverse interactions, and dietary guidelines specific to anticoagulant therapy, ensuring that nurses can confidently provide accurate and thorough counseling to patients on warfarin. Furthermore, integrating warfarin management training into nursing curricula would prepare nurses with essential knowledge early in their careers, ultimately contributing to safer patient outcomes [25, 34].

The study's findings also highlight the role of direct patient care experience and specific training in enhancing nurses' understanding of warfarin interactions. Hospital administrators and healthcare organizations should consider implementing continuous professional development programs focusing on anticoagulation management, particularly for nurses working with high-risk patient populations. These programs could include workshops, simulations, and interactive case studies on real-world scenarios, enhancing nurses' ability to recognize and manage warfarin-related complications [21, 24, 27]. Additionally, incorporating regular refresher courses in hospitals and clinical settings could bridge existing knowledge gaps and reinforce critical skills, ensuring nurses stay updated with the latest evidence-based practices in anticoagulant therapy [5, 31, 32].

Given that self-confidence emerged as a significant predictor of warfarin knowledge, institutions might consider mentorship or peer support initiatives that promote nurses' self-efficacy in medication management. Empowering nurses with the confidence to make informed decisions about patient counseling and monitoring may enhance adherence to safety protocols and improve patient satisfaction. These support structures could involve senior nurses mentoring less experienced staff or dedicated training sessions where nurses can practice counseling skills and medication management under guided supervision [25, 29, 33].

Policymakers and nursing educators may also look at establishing standardized protocols for warfarin counseling, especially regarding interactions with commonly used medications and vitamin K-rich foods. Clear, consistent guidelines across healthcare institutions would provide a reliable framework for nurses, reducing the variability in counseling practices and improving the overall quality of care for patients on warfarin therapy [13, 16, 18]. Standardized training modules that address high-risk drug and dietary interactions, as well as monitoring and communication strategies, could be adopted across diverse healthcare settings to ensure consistent practice standards.

Future research should investigate the long-term impact of specific training on nurses' knowledge retention and its effect on patient outcomes. Studies could explore the efficacy of various training modalities, such as online courses, in-person workshops, and simulation-based learning, to identify the most effective approach for enhancing knowledge and counseling skills. Additionally, research could examine the impact of improved knowledge on actual clinical outcomes, such as reduced

adverse events and hospital readmissions due to warfarin-related complications [7, 26, 29].

Study limitations

This study has several limitations. Its cross-sectional design prevents an analysis of changes in knowledge over time. The use of convenience sampling may have introduced selection bias, limiting the generalizability of findings to a wider nursing population. Additionally, reliance on self-reported data may have led to response bias, as participants could have overestimated their knowledge. Future research should incorporate objective assessments to enhance accuracy. The study's focus on a single setting further restricts applicability to other regions or healthcare systems, emphasizing the need for broader, multi-center studies. While key predictors of knowledge were identified, other potential influences, such as institutional resources, were not explored. Moreover, the study did not examine how nurses' knowledge impacts patient outcomes, an important area for future investigation to assess the clinical significance of warfarin-related education.

Conclusion

This study reveals that while Jordanian nurses possess moderate knowledge of warfarin-drug and warfarin-food interactions, significant gaps remain, particularly regarding anti-inflammatory agents, CNS drugs, and vitamin K-rich foods. Although nurses demonstrated good awareness of non-interfering foods and cardiac drug interactions, deficiencies in knowledge and counseling practices were evident. Advanced education, years of experience, direct patient care, self-confidence, and exposure to health education were identified as significant predictors of knowledge, while demographic factors like age, gender, and job position had no notable impact. However, these findings should be interpreted with caution due to limitations such as reliance on self-reported data, which may have led to an overestimation of knowledge, and the use of convenience sampling, which limits generalizability. Despite these limitations, the study highlights the need for targeted educational interventions and structured training programs focusing on specific drug and food interactions and patient counseling best practices. Future research should explore practical, context-specific training and interdisciplinary collaboration to enhance nurses' competence and confidence in managing warfarin therapy, ultimately improving patient outcomes and promoting safer anticoagulant care.

Supplementary Information

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Supplementary Material 1

Author contributions

M.S., F.S.A., M.A., Z.T.S., G.S.A., W.T.A., and R.A.E. had primary roles in designing the study, analyzing, and interpreting the data. M.S., F.S.A., M.A., M.R., M.H.A., T.F.A., Z.T.S., R.A.E., G.S.A., and W.T.A. contributed to drafting the article and critically revising it for significant intellectual content. All authors reviewed and approved the final version of the manuscript.

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Data availability

Data is provided within the manuscript or supplementary information files.

Declarations

Ethics approval and consent to participate

The study adhered to rigorous ethical standards, receiving IRB approval from Al Zaytoonah University of Jordan (IRB No. 03/190/2022–2023) and formal agreements from participating hospitals. It followed the Declaration of Helsinki principles, with all participants providing written informed consent after being fully briefed on the study's purpose, procedures, risks, and benefits. Confidentiality was strictly maintained by anonymizing participant data, ensuring privacy throughout the research. Participation was voluntary, with informed consent implied upon questionnaire completion. The questionnaire tool was approved for use by the original author, reinforcing the study's commitment to ethical standards and participant well-being.

Consent for publication

Not Applicable.

Competing interests

The authors declare no competing interests.

Clinical trial number

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