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Assessing the Knowledge and Awareness of Community Pharmacists Regarding Warfarin Therapy in Jeddah and Taif, Saudi Arabia

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Abstract

Background/Objectives: Although warfarin remains an important oral anticoagulant for selected indications, careful monitoring is required due to its narrow therapeutic index and numerous interactions. As an integral part of anticoagulant monitoring systems globally, pharmacists play an important role in preventing warfarin-associated complications. The current study assessed the warfarin-related knowledge and awareness of community pharmacists in Jeddah and Taif, Saudi Arabia. Methods: This cross-sectional survey used convenience sampling to recruit 380 community pharmacists in Jeddah and Taif between October of 2024 and March of 2025. The questionnaire included 19 knowledge items covering warfarin's safety (eight items), drug interactions (six items), and knowledge related to patient counseling (five items). Percentage awareness scores (PASs) were calculated for each domain, as well as the overall PAS. A predefined PAS threshold of ≥60% was used for descriptive categorization only. Unadjusted comparisons used independent-samples t-tests, with Mann–Whitney U tests performed as sensitivity analyses. Multivariable linear regression analysis with robust standard errors was conducted to examine adjusted associations with the overall PAS. Results: Mean PAS values were 65.39% for safety, 61.18% for drug interactions, 74.26% for patient counseling knowledge, and 66.40% overall. A total of 258 participants (67.9%) exceeded the predefined PAS threshold of ≥60%. Gender, age, experience, board certification, and anticoagulation training were not significantly associated with PAS values. In the multivariable analysis, the combined non-BPharm group had higher overall PAS than BPharm holders (adjusted difference: 5.99 percentage points; 95% CI: 2.54–9.44; $p < 0.001$). Non-Saudi nationality was also associated with higher overall PAS (adjusted difference: 4.27 percentage points; 95% CI: 0.05–8.48; $p = 0.047$). Conclusions: Most participants met the predefined descriptive PAS threshold, although it should be noted that this does not establish clinically adequate knowledge. Nevertheless, gaps were identified in safety, interactions, and counseling. Targeted continuing professional education is warranted, and future studies should examine counseling practices and patient outcomes.

Keywords: warfarin; safety; awareness; community pharmacists; Saudi Arabia

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Academic Editor: Candis M. Morello

Received: 15 September 2026
Revised: 22 October 2026
Accepted: 28 October 2026
Published: 30 October 2026

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1. Introduction

Warfarin was first introduced into clinical practice in 1954 and subsequently became a cornerstone oral anticoagulant for preventing and treating thromboembolic disorders [1].

Although direct oral anticoagulants (DOACs) are now preferred for most patients with venous thromboembolism and atrial fibrillation, warfarin remains an important therapeutic option in patients with mechanical prosthetic heart valves, rheumatic mitral stenosis, or clinical circumstances in which DOACs are not suitable [2–4].

Warfarin therapy is highly challenging in clinical practice, as its efficacy and safety are mainly dependent on maintaining an optimal international normalized ratio (INR). Previous reports have shown that high INR variability is consistently accompanied by adverse outcomes [5,6]. Moreover, several factors—including drug–food interactions, use of herbal products, and patient understanding and compliance—affect anticoagulation control [5,7,8].

Warfarin therapy requires individualized dosing to achieve and maintain the target INR, which is essential for treatment safety and efficacy [9,10]. As warfarin has a narrow therapeutic index, close and regular monitoring of the INR and fine adjustment of the warfarin dose are essential to protect the patient from warfarin-induced bleeding [9]. Additionally, patients receiving less than the optimal dose can develop anticoagulation failure and are at a higher risk of thrombosis [11].

Treatment-associated adverse effects may be severe and, in some cases, can lead to hospitalization or death. Such complications increase with the concurrent administration of other drugs [5,12]; for example, evidence indicates an increased risk of clinically relevant bleeding if warfarin is co-administered with antiplatelet agents, certain antimicrobials, nonsteroidal anti-inflammatory drugs, cyclooxygenase-2 inhibitors, selective serotonin reuptake inhibitors, and other medications [5]. Food, herbal products, and dietary supplements may also potentiate or reduce the anticoagulant effect of warfarin, potentially causing clinically important changes in the INR or bleeding [7]. Therefore, patients' medications and dietary composition should be reviewed regularly, with closer INR monitoring if potentially interacting substances are initiated, discontinued, or substantially changed [12].

The involvement of healthcare team members—including physicians and their assistants, nurses, and pharmacists—in operating the anticoagulant monitoring system is essential. As an integral part of the majority of anticoagulant monitoring systems globally, pharmacists play an important role in preventing warfarin-associated complications [13,14]. Several studies have reported that pharmacist-involved warfarin management improved treatment outcomes, including better INR control and an increased likelihood of achieving a therapeutic INR [15,16]. Pharmacist-managed anticoagulation services are also associated with fewer warfarin-related hospital readmissions. Furthermore, multidisciplinary inpatient anticoagulation services are related to shorter hospital stays [17,18]. In addition, pharmacist interventions have been correlated with fewer potential drug–drug interactions among patients in cardiac care units, improved patient knowledge regarding warfarin therapy, and favorable patient satisfaction with outpatient venous thromboembolism management [15,19,20]. Recent pooled evidence has shown that anticoagulation management by nonphysician healthcare professionals—predominantly pharmacists—generally produces outcomes comparable with those under usual physician-led care; however, superiority has not been consistently demonstrated across all clinical outcomes [14].

Warfarin, a noncontrolled prescription-only medication, is dispensed in hospital and community pharmacies in Saudi Arabia [21]. In a multinational survey, pharmacists reported greater confidence in providing pharmaceutical care to patients receiving vitamin K antagonists than to those receiving DOACs [22]. Although adequate knowledge of warfarin-related adverse effects and drug–drug and drug–herb interactions is essential for preventing complications, knowledge gaps regarding these interactions have been reported among healthcare professionals in Saudi Arabia [23]. Saudi studies have also shown that pharmacist-managed anticoagulation clinics can improve INR control and other

patient outcomes [24,25]. A recent nationwide study assessed the knowledge of Saudi community pharmacists about DOACs and found an overall moderate awareness, with notable deficiencies in safety and patient counseling. Nonetheless, research specifically addressing their knowledge of warfarin remains limited [26]. Mohamed et al. directly assessed warfarin knowledge and counseling practices among hospital and community pharmacists in the Eastern Province; however, their study included only 56 community pharmacists [21]. Therefore, evidence specifically concerning warfarin-related knowledge among Saudi community pharmacists remains limited, particularly in the western region.

Pharmacists play essential roles in optimizing anticoagulation therapy, and only a few studies have assessed the knowledge of community pharmacists. Therefore, this study was conducted to assess the knowledge and awareness of community pharmacists regarding warfarin therapy in Jeddah and Taif, Saudi Arabia, and to examine whether their educational background, anticoagulation-related training, and professional experience are associated with knowledge scores.

2. Materials and Methods

2.1. Study Design and Setting

This cross-sectional survey assessed warfarin-related knowledge and awareness among community pharmacists practicing in Jeddah and Taif, Saudi Arabia. Data were collected between October of 2024 and March of 2025. Community pharmacies in both cities were approached using convenience sampling. Pharmacists were eligible if they were practicing in a community pharmacy in either city, agreed to participate in a face-to-face interview, and completed the questionnaire. Trained pharmacy students administered the standardized questionnaire. Before data collection, the interviewers received training on the study procedures, informed consent, and standardized administration of all questionnaire items. No incomplete questionnaires were received, and each pharmacist was enrolled only once; therefore, no duplicate responses were identified. Pharmacists who declined participation before starting the interview were not recorded. Consequently, the total number of pharmacists approached and the response rate could not be calculated. Participation was voluntary, and anonymity and confidentiality were maintained throughout the study.

2.2. Questionnaire Development and Measures

This study used a questionnaire developed based on a comprehensive review of the literature on warfarin management and pharmacist knowledge assessment [21,27,28]. It focused on key areas such as warfarin safety, drug interactions, and patient counseling practices. To ensure content validity, the draft questionnaire was evaluated by a panel of five experts specializing in pharmacy practice and anticoagulant therapy, who assessed each item for relevance, clarity, and comprehensiveness. In addition, facial validity was established by enrolling pharmacists from diverse backgrounds to review the questionnaire and validate that the questions were comprehensible and appropriate for the target population.

A pilot test was conducted with 15 randomly selected pharmacists representing various work settings and experience levels. Feedback from this pilot phase informed minor revisions to improve the clarity and relevance of the questions. Data from the pilot participants were excluded from the final analysis. The internal consistency of the questionnaire was assessed using Cronbach's alpha, with all domain scores exceeding the accepted threshold of 0.85, thereby indicating strong reliability.

The questionnaire comprised two main sections. The first gathered data on demographic characteristics and professional background, including gender, age, nationality, educational level, years of experience, board certification, participation in anticoagulant-related workshops, and frequency of dispensing warfarin. The second section assessed

the knowledge of pharmacists across three domains: warfarin safety (eight items), drug interactions (six items), and knowledge related to patient counseling (five items). The patient counseling items assessed knowledge of appropriate advice, rather than actual counseling or dispensing behaviors.

A binary scoring system was applied, awarding one point for correct answers (i.e., agreeing with true statements or disagreeing with false statements) and zero points for incorrect or uncertain responses. Percentage awareness scores (PASs) were calculated for each domain by dividing the number of correct responses by the total number of questions in that domain and multiplying the result by 100. The overall PAS was calculated by dividing each participant's total number of correct responses across all 19 knowledge items by 19 and multiplying by 100, giving equal weight to each item. Consistent with previous studies, participants with a score of ≥60% were categorized as having good knowledge, whereas those with a PAS of <60% were categorized as having poor knowledge [28,29]. This classification was used solely for descriptive purposes; the ≥60% threshold has not been clinically validated and does not establish clinical competence. The PASs were retained as continuous variables for group comparisons and multivariable analysis.

2.3. Ethical Considerations

The Institutional Review Board of King Abdulaziz University approved this study (reference no. PH-1445-13). Participation was entirely voluntary, and informed consent was obtained from all respondents prior to data collection. The confidentiality and anonymity of the participants were strictly maintained throughout the study.

2.4. Sample Size

According to the most recent data from the Ministry of Health's 2023 Statistical Yearbook, Saudi Arabia has a total of 36,810 licensed pharmacists, of whom 24,711 are employed in the private sector [30]. Of these pharmacists, 21,648 were practicing in community pharmacies as of 2022 [31]. Official data on the number of community pharmacists practicing specifically in Jeddah and Taif were not available; therefore, the national community pharmacist population was used as the reference population for a conservative sample-size calculation.

Using the national community pharmacist population as the reference, the minimum required sample size for the study was calculated using the Raosoft sample size calculator (www.raosoft.com). The parameters used included a confidence level of 95%, a margin of error of 5%, and a response distribution of 50%. Based on these criteria, the minimum sample size required was 378. This calculation provided a recruitment target; however, convenience sampling precludes interpreting the achieved sample as representative or assuming that its estimates have a 5% margin of error. Accordingly, 380 community pharmacists were successfully recruited and participated in the study.

2.5. Data Analysis

Demographic characteristics, professional background, and individual questionnaire responses were treated as categorical data and summarized using frequencies and percentages, while PASs were treated as continuous variables and summarized using means and standard deviations. To compare differences based on gender, educational group (BPharm vs. non-BPharm), and other binary demographic factors, the PASs, treated as continuous variables, were analyzed using independent-samples *t*-tests. Educational qualifications were grouped as BPharm vs. non-BPharm for exploratory comparisons, as the master's and Ph.D. groups were small; this grouping does not imply equivalence between the non-BPharm qualifications. Unadjusted mean differences with 95% confidence intervals were calculated

using pooled variances, and standardized effect sizes are expressed as Cohen's d using the pooled standard deviation. Homogeneity of variance was assessed using median-centered Levene tests.

As the overall PAS distribution was negatively skewed, two-sided Mann–Whitney U tests were additionally performed as sensitivity analyses for all six binary group comparisons. An exploratory multivariable linear regression was performed with the overall PAS as the continuous dependent variable. Educational group, age (≤30 vs. >30 years), experience (≤5 vs. >5 years), gender, board certification, anticoagulation training, pharmacy setting, nationality, and weekly warfarin dispensing frequency (<10 vs. ≥10 prescriptions) were entered simultaneously, rather than selected according to their univariable statistical significance. Adjusted regression coefficients are expressed as differences in PAS percentage points with 95% confidence intervals. Residual distributions and variance inflation factor values were examined, and HC3 heteroscedasticity-robust standard errors were calculated for inference.

An additional sensitivity analysis excluded the vitamin E and grapefruit items due to potential ambiguity, for which the overall PAS was recalculated as the number of correct responses across the remaining 17 items divided by 17 and multiplied by 100. Descriptive summaries, binary group comparisons, and multivariable regression were repeated using this score. A p-value < 0.05 was considered to indicate statistically significant differences. The original analyses were performed using the Statistical Package for the Social Sciences software for Windows, version 29.0 (IBM Corp., Armonk, NY, USA). Additional sensitivity analyses and multivariable regression were performed in Python version 3.12 using NumPy and SciPy.

3. Results

3.1. Data on the Demographic Characteristics and Professional Background of the Pharmacists

In total, 380 community pharmacists from Jeddah and Taif, Saudi Arabia, participated in the survey (324 men and 56 women). Approximately 87.4% of the participants belonged to the 25–40-year-old age group. Of the participants, 141 (37.1%) were Saudi nationals and 239 (62.9%) were non-Saudi. The most common educational attainment was Bachelor of Pharmacy (BPharm; 50.5%), while only 2.4% had a Ph.D. degree. Moreover, 49.7% of participants only had ≤5 years of experience, 74.5% worked in chain pharmacies, and 25.5% worked in independent pharmacies. Additionally, 23.7% held board certification, and 27.4% had attended lectures and/or workshops on anticoagulants within the past year. Of the respondents, 93.9% dispensed <10 warfarin prescriptions weekly, while 6.1% dispensed ≥10 prescriptions weekly. Table 1 summarizes the demographic characteristics and professional backgrounds of the pharmacists.

Table 1. Baseline characteristics of the participants.

Demographic Characteristics (n = 380)	Frequency (%)
Gender	
Male	324 (85.3)
Female	56 (14.7)
Age group	
<25 years old	23 (6.1)
25–30 years old	179 (47.1)
31–40 years old	153 (40.3)

Table 1. *Cont.*

Demographic Characteristics (n = 380)	Frequency (%)
41–50 years old	22 (5.8)
≥51 years	3 (0.8)
Nationality	
Saudi	141 (37.1)
Non-Saudi	239 (62.9)
Highest degree of education	
Bachelor of pharmacy (BPharm)	192 (50.5)
Doctor of pharmacy (PharmD)	161 (42.4)
Master's degree	18 (4.7)
Ph.D.	9 (2.4)
Years of experience	
≤5	189 (49.7)
>5	191 (50.3)
Type of pharmacy setting	
Chain community pharmacy	283 (74.5)
Independent community pharmacy	97 (25.5)
Board certification	
Having board certification	90 (23.7)
Participation in anticoagulant-related workshops	
Attending any lecture or workshop about anticoagulants within the past year	104 (27.4)
Dispensing warfarin per week	
≥10 prescriptions	23 (6.1)
<10 prescriptions	357 (93.9)

Background shading and bold text distinguish table headings and demographic categories.

3.2. Knowledge and Awareness of Pharmacists About Warfarin Safety, Drug Interactions, and Patient Counseling

Table 2 presents a summary of the level of awareness concerning warfarin safety, drug interactions, and knowledge related to patient counseling among the participating community pharmacists. Table 3 provides the PAS results for the tested domains.

The PAS for knowledge of warfarin safety was 65.39%, and 277 pharmacists (72.9%) had a score of ≥60% (Table 3). This domain included questions related to the risk of bleeding, therapeutic index, drug interactions, contraindications, target INR, warfarin use during pregnancy, and the effect of genetic variation on warfarin metabolism. Most participants answered these questions correctly, except those concerning the target INR and contraindications in patients with renal insufficiency, for which only 53.9% and 15.5% provided correct responses, respectively (Table 2).

The PAS for warfarin drug interactions was 61.18%, and 64.5% of the pharmacists had a score of ≥60% (Table 3). This domain included questions regarding warfarin's interactions with other drugs, supplements, herbs, and food. Most interaction items were answered correctly; however, only 16.8% and 44.5% of participants correctly answered the amlodipine and vitamin E items, respectively (Table 2).

Table 2. Survey awareness domains, questions, and responses.

Do You Agree with the Following Statement? (Correct Response)	Agree (%)	Disagree (%)	I Do Not Know (%)
Knowledge about warfarin safety			
1. Warfarin is associated with a high risk of major bleeding. (A)	357 (93.9)	10 (2.6)	13 (3.4)
2. Warfarin is contraindicated in patients with renal insufficiency (creatinine clearance: 15–29 mL/min). (D)	247 (65.0)	59 (15.5)	74 (19.5)
3. Warfarin is considered safe for pregnant women. (D)	43 (11.3)	296 (77.9)	41 (10.8)
4. The maximum period for checking INR in a patient with a stable INR is 12 weeks. (A)	217 (57.1)	53 (13.9)	110 (28.9)
5. Warfarin has several drug interactions that can affect its efficacy and safety. (A)	354 (93.2)	10 (2.6)	16 (4.2)
6. Warfarin has a wide therapeutic window. Hence, the dose can be adjusted without significant risk. (D)	58 (15.3)	305 (80.3)	17 (4.5)
7. The target INR range for patients taking warfarin for the diagnosis of PE is from 2 to 3. (A)	205 (53.9)	74 (19.5)	101 (26.6)
8. The anticoagulant effect of warfarin can be influenced by genetic variations in drug metabolism. (A)	326 (85.8)	9 (2.4)	45 (11.8)
Knowledge about warfarin drug interactions			
9. Medications such as aspirin interact with warfarin, and they may increase the risk of bleeding. (A)	348 (91.6)	19 (5.0)	13 (3.4)
10. Garlic supplements can potentially interact with warfarin. (A)	261 (68.7)	67 (17.6)	52 (13.7)
11. Amlodipine can interact with warfarin and increase the risk of bleeding. (D)	226 (59.5)	64 (16.8)	90 (23.7)
12. Bactrim can interact with warfarin and increase the risk of bleeding. (A)	244 (64.2)	44 (11.6)	92 (24.2)
13. Vitamin E-containing foods can interact with warfarin. (D)	142 (37.4)	169 (44.5)	69 (18.2)
14. Grapefruit juice can interact with warfarin and should be consumed in moderation by patients on warfarin therapy. (A)	309 (81.3)	32 (8.4)	39 (10.3)
Knowledge related to patient counseling			
15. Patients on warfarin should be advised to completely avoid vitamin K-containing foods. (D)	257 (67.6)	109 (28.7)	14 (3.7)
16. Patients on warfarin can use OTC pain relievers such as NSAIDs without consulting their healthcare provider. (D)	63 (16.6)	297 (78.2)	20 (5.3)
17. It is important to inform healthcare providers and dentists about warfarin therapy before any medical or dental procedures. (A)	352 (92.6)	9 (2.4)	19 (5.0)
18. It is appropriate to stop taking this medication once the patient feels better. (D)	51 (13.4)	308 (81.1)	21 (5.5)
19. Engaging patients and encouraging them to ask questions are important to ensure their comprehensive understanding of and adherence to warfarin therapy. (A)	345 (90.8)	9 (2.4)	26 (6.8)
Satisfied with their knowledge of warfarin, *n* (%)		280 (73.7)	

A, agree; D, disagree; INR, international normalized ratio; NSAIDs, nonsteroidal anti-inflammatory drugs; OTC, over-the-counter; PE, pulmonary embolism. Background shading and bold text distinguish table headings and knowledge domains.

Table 3. Tested domains and scores.

Domains	No. of Items Tested	PAS (SD)	Participants with PAS ≥ 60%, *n* (%)
Knowledge about safety	8	65.39 (17.13)	277 (72.9)
Knowledge about drug–drug interactions	6	61.18 (19.37)	245 (64.5)
Knowledge about counseling	5	74.26 (23.47)	321 (84.5)
Total	19	66.40 (15.32)	258 (67.9)

PAS, percentage awareness score; SD, standard deviation.

In addition, the PAS for knowledge of warfarin counseling was 74.26%, and 84.5% of the pharmacists scored ≥60% (Table 3). This domain included questions regarding dietary advice, compliance, and patient awareness. Most participants answered correctly, except for the item regarding complete avoidance of vitamin K-containing food, for which only 28.7% of participants answered accurately.

Across the 19 knowledge items, the overall mean PAS was 66.40%, and 258 participants (67.9%) met the predefined threshold of ≥60% (Table 3). In addition, 280 participants (73.7%) reported being satisfied with their knowledge regarding warfarin (Table 2).

3.3. Impacts of Demographic Factors and Educational Attainment on PASs

The effects of different demographic factors—including gender, age, years of experience, and having board certification or attending any lecture or workshop about anticoagulants within the past year—on the PASs were examined, as summarized in Table 4. Statistical analyses revealed that these factors did not significantly affect the PASs of the participants. In contrast, educational level was associated with the overall PASs; in particular, the combined non-BPharm group (PharmD, master's, and Ph.D.) showed a higher overall PAS than the BPharm group (68.65% vs. 64.20%; $p = 0.005$). Sensitivity analyses using Mann–Whitney U tests showed the same significance pattern as the t-tests: PASs were higher in the combined non-BPharm group ($p < 0.001$), while the remaining comparisons were not statistically significant (all $p > 0.05$). In the multivariable analysis, the combined non-BPharm group remained associated with higher overall PAS than the BPharm group (adjusted difference: 5.99 percentage points; 95% CI: 2.54–9.44; $p < 0.001$) (Table 5). Non-Saudi pharmacists also had higher adjusted PASs than Saudi pharmacists (adjusted difference: 4.27 percentage points; 95% CI: 0.05–8.48; $p = 0.047$). No statistically significant associations were observed for the remaining covariates. The model explained 4.7% of the variation in the overall PAS (adjusted $R^2 = 0.024$). After excluding the vitamin E and grapefruit items, the mean 17-item PAS was 66.81% (SD 15.23), and 254 participants (66.8%) achieved PAS ≥60%. The significance pattern of the unadjusted group comparisons remained unchanged. The adjusted education association remained consistent (difference: 5.94 percentage points; 95% CI: 2.59–9.30; $p < 0.001$), whereas the nationality association was attenuated and was no longer statistically significant (difference: 3.72 percentage points; 95% CI: −0.35–7.80; $p = 0.073$).

Table 4. Effect of baseline and professional characteristics on overall percentage awareness score.

Variables	PAS, Mean % (SD)	Mean Difference (95% CI) [1]	Cohen's d	*p*-Value [2]
Gender				0.710
Male	66.52 (15.14)	Reference	——-	
Female	65.70 (16.43)	−0.82 (−5.19 to 3.54)	−0.05	

Table 4. *Cont.*

Variables	PAS, Mean % (SD)	Mean Difference (95% CI) [1]	Cohen's d	*p*-Value [2]
Age (years)				0.348
≤30	67.09 (14.09)	Reference	——-	
>30	65.61 (16.61)	−1.48 (−4.58 to 1.62)	−0.10	
Highest degree of education				0.005
Bachelor of Pharmacy	64.20 (14.60)	Reference	——-	
Others [3]	68.65 (15.74)	4.45 (1.38 to 7.51)	0.29	
Years of experience				0.490
≤5	66.95 (15.02)	Reference	——-	
>5	65.86 (15.63)	−1.09 (−4.18 to 2.01)	−0.07	
Board certification				0.274
Yes	64.85 (16.43)	−2.02 (−5.66 to 1.61)	−0.13	
No	66.88 (14.95)	Reference	———	
Attending any lecture or workshop about anticoagulants within the past year				0.527
Yes	65.59 (15.57)	−1.12 (−4.59 to 2.35)	−0.07	
No	66.70 (15.24)	Reference	——-	

PAS, percentage awareness score; SD, standard deviation. [1] Mean differences are expressed in PAS percentage points relative to the indicated reference group. Confidence intervals use pooled variances. Cohen's d is the mean difference divided by the pooled standard deviation. [2] Two-sided independent-samples Student's *t*-tests; $p < 0.05$ was considered statistically significant. [3] PharmD, master's, and Ph.D. degrees. Bold text distinguishes participant characteristic headings.

Table 5. Multivariable linear regression of factors associated with overall PAS.

Predictor and Comparison	Adjusted Difference in PAS (95% CI), Percentage Points	*p*-Value
Non-BPharm vs. BPharm	5.99 (2.54 to 9.44)	<0.001
Age >30 vs. ≤30 years	−2.75 (−8.86 to 3.36)	0.377
Experience >5 vs. ≤5 years	0.36 (−5.52 to 6.24)	0.904
Female vs. male	−0.53 (−5.68 to 4.62)	0.840
Board certification: yes vs. no	−2.10 (−6.24 to 2.03)	0.318
Anticoagulation training: yes vs. no	−0.33 (−4.18 to 3.51)	0.864
Independent vs. chain pharmacy	−2.11 (−5.55 to 1.32)	0.227
Non-Saudi vs. Saudi	4.27 (0.05 to 8.48)	0.047
≥10 vs. <10 warfarin prescriptions weekly	−2.56 (−11.10 to 5.98)	0.556

Coefficients represent adjusted differences in PAS percentage points. All listed predictors were entered simultaneously. Confidence intervals and *p*-values were calculated using HC3 robust standard errors. N = 380; $R^2 = 0.047$; adjusted $R^2 = 0.024$. CI, confidence interval; PAS, percentage awareness score; BPharm, Bachelor of Pharmacy.

4. Discussion

The mean overall PAS among participating community pharmacists in Jeddah and Taif was 66.40%, with substantial variation across domains and individual items. The counseling domain had the highest mean PAS (74.26%), followed by safety (65.39%) and drug–drug interactions (61.18%). Nevertheless, important item-specific deficiencies were identified,

particularly regarding the target INR, the use of warfarin in patients with renal impairment, selected drug–supplement interactions, and dietary vitamin K-related counseling. Importantly, meeting the predefined overall PAS threshold of ≥60% does not establish competence in every clinically relevant area; for example, only 15.5% and 16.8% of the participants correctly answered the renal impairment and amlodipine items, respectively. Renal impairment alone is not an absolute contraindication to warfarin, although individualized assessment and closer INR monitoring are required [32]. The amlodipine prescribing information states that co-administration does not affect warfarin's prothrombin response time, supporting the designated answer to this item [33]. These misconceptions could contribute to inappropriate advice about treatment suitability or unnecessary concerns about concomitant medicines; however, it should be noted that their effects on actual practice and patient outcomes were not evaluated in this study.

Several reports have documented the fundamental roles of pharmacists in achieving the therapeutic goals associated with warfarin treatment. A systematic review and meta-analysis found that pharmacist-led interventions improved the appropriateness of anticoagulant therapy, and that they were associated with reductions in overall bleeding and hospitalization or readmission [34]. In the warfarin subgroup, pharmacist-led interventions were associated with a 35% reduction in bleeding; however, no statistically significant decreases in thromboembolic events or mortality were identified. Similarly, Sharow et al. have reported that ambulatory warfarin management delivered predominantly by pharmacists and other nonphysician healthcare providers produced outcomes comparable with those under usual medical care regarding time in the therapeutic range, thrombosis, hemorrhage, mortality, and patient satisfaction [14]. This implies that pharmacists—either clinical or community—acquire a sufficient level of education and knowledge that qualifies them to act effectively in the process of warfarin administration and monitoring, thus attaining the therapeutic goal while preventing drug-related adverse events.

Awareness of the factors affecting the safety of warfarin is essential to achieve the intended aim of anticoagulation therapy with minimal complications. Therefore, the participants were asked eight questions concerning warfarin safety. While most participants answered most of these questions correctly, only 53.9% were aware of the target INR. Although more than half of the participants answered this question correctly, this finding indicates an important knowledge gap and may reflect limited exposure to INR monitoring in community pharmacy practice; as such, this observation should be investigated in future studies. These results are comparable with those of a previous study conducted in Jordan, where only 48.6% of pharmacists were found to be knowledgeable regarding the most important monitoring parameter for warfarin (INR). Furthermore, only 14.3% of the pharmacists surveyed in that study accurately identified the most common INR range [27].

The majority of this study's participants were conservative regarding the use of warfarin in patients with renal insufficiency, probably because of insufficient knowledge. Renal impairment is not an absolute contraindication to warfarin, and warfarin dosing is not adjusted solely according to renal function. Nevertheless, patients with renal impairment may have altered warfarin dose requirements and an increased risk of bleeding. Therefore, individualized dosing and close INR monitoring are required [35]. Knowledge deficiencies regarding target INR values and warfarin administration in patients with renal impairment may have important clinical implications, including inadequate dosing and an increased risk of hemorrhagic or thrombotic events. Attending educational workshops on warfarin safety, involvement in patient monitoring programs, and gaining greater experience in dispensing warfarin prescriptions may improve the knowledge of pharmacists.

Six items in the present questionnaire assessed knowledge of the interactions of warfarin with medicines, supplements, herbs, and foods, including aspirin, amlodipine,

trimethoprim–sulfamethoxazole, garlic, vitamin E-containing foods, and grapefruit juice. Most items were answered correctly; however, only 16.8% and 44.5% of participants correctly answered the amlodipine and vitamin E items, respectively. Responses to the vitamin E item should be interpreted cautiously, as the wording did not distinguish usual dietary intake from high-dose supplementation, which can increase bleeding risk with warfarin [36]. The grapefruit item also requires cautious interpretation; although a small clinical study found no significant INR change, clinical guidance recommends avoiding grapefruit juice during warfarin treatment [37,38]. The questionnaire's reference to consumption "in moderation" should therefore not be interpreted as establishing a safe intake level. Moreover, misconceptions about common drug–drug and drug–food interactions can lead to unnecessary medication changes, patient non-adherence, or possible harmful outcomes. These findings identify potential topics for educational modules, the effects of which on pharmacists' knowledge and confidence require further evaluation.

Recent studies involving DOACs have also reported knowledge gaps concerning anticoagulant interactions. A recent study found that several community pharmacists rarely or never routinely checked for rivaroxaban interactions, and that previous anticoagulation training was associated with better knowledge [39]. Although warfarin and rivaroxaban have different interaction profiles, these findings support the need for structured educational programs addressing clinically important anticoagulant interactions. In this regard, developing educational modules focusing on drug–food interactions could enhance the knowledge and confidence of pharmacists.

The counseling domain had the highest mean PAS, with 84.5% of participants achieving the predefined descriptive threshold. Knowledge of warfarin counseling was assessed using five questions, including whether they should advise patients to completely avoid vitamin K-containing foods, stop taking nonsteroidal anti-inflammatory drugs without consulting their healthcare provider, inform healthcare providers and dentists about warfarin therapy, discontinue this medication once they feel better, and ask questions to ensure their comprehensive understanding of and adherence to warfarin therapy. Most answers were correct, except that most participants believed that patients should be counseled to avoid vitamin K-containing foods. This conservative advice could lead to unnecessary dietary restrictions and potentially variable INR control [40]. Therefore, pharmacist counseling should emphasize dietary consistency, adherence, INR monitoring, recognition of bleeding or thrombotic symptoms, and consultation with healthcare professionals before starting or discontinuing medications or supplements. Incorporating patient counseling simulations and evidence-based counseling tools into continuing education may help pharmacists to provide more accurate advice, particularly regarding consistent intake of vitamin K.

A previous study examined hospital and community pharmacists, where only 36.6% of the participants were from community pharmacies. Their results indicated inadequate knowledge and inappropriate practices among the study participants, particularly community pharmacists [21]. In contrast, the present study found a higher overall score; this difference may reflect variation in the study populations, questionnaires, and scoring methods, and direct comparison between the studies should therefore be made cautiously. According to the study of Basilim et al., the score for warfarin knowledge was higher than that for knowledge regarding DOACs among community pharmacists in Saudi Arabia [26]. This result may reflect the greater familiarity of pharmacists with warfarin due to its longer history of clinical use and established monitoring requirements. Once more, direct comparisons should be interpreted with caution because the studies examined different anticoagulants and used various questionnaires and scoring systems.

The analysis in this study revealed that different demographic factors—including gender, age, years of experience, and board certification—did not significantly affect the PASs.

The absence of a relationship with years of experience indicates that professional experience alone may not ensure the retention of specialized anticoagulation knowledge. Educational group remained associated with PAS after adjustment for the measured demographic and professional characteristics. Non-Saudi nationality also showed an association with higher PAS, although its confidence interval approached zero and, thus, this finding should be interpreted cautiously. The nationality association was no longer statistically significant after excluding the two ambiguous items, whereas the education association remained consistent. The model explained only a small proportion of variation in the scores, and these exploratory cross-sectional associations cannot establish causality or exclude residual confounding. These findings are in accordance with those of previous studies on the knowledge of community pharmacists regarding DOACs, showing that pharmacists with PharmD degrees were more knowledgeable about anticoagulant safety than those with bachelor's degrees. However, the design of the present study precludes any conclusions regarding whether the observed association reflects differences in the curriculum, clinical training, or other characteristics of the educational groups.

In the current study, attendance of an anticoagulation-related lecture or workshop within the past year was not significantly associated with knowledge. This differs from the nationwide Saudi DOAC study, in which workshop attendance was associated with significantly higher knowledge scores, and a Sudanese study, in which previous DOAC-specific training was the strongest predictor of adequate knowledge (adjusted odds ratio = 3.40, 95% confidence interval: 2.10–5.52) [26,39]. The absence of such an association in the current study may reflect the relatively small proportion of participants who attended recent training (27.4%) and differences in the content, duration, quality, and timing of the educational activities. Based on these findings, the efficacy of structured, anticoagulation-specific training should be evaluated, rather than assuming that attendance at any lecture or workshop necessarily improves knowledge.

This study has several limitations. First, the participants were recruited only from Jeddah and Taif; therefore, the findings may not be representative of community pharmacists in other regions of Saudi Arabia. The pharmacy selection process and any unavailable response rate data may have introduced selection bias. Convenience sampling limits representativeness, even within Jeddah and Taif. Achieving the calculated sample size does not necessarily overcome this limitation, and the findings should not be generalized to all community pharmacists in the Western region or Saudi Arabia. The questionnaire was not externally validated, and the predefined 60% threshold has not been clinically validated. The vitamin E item did not specify intake quantity or explicitly distinguish foods from supplements, potentially affecting participants' interpretation and the resulting knowledge scores. Similarly, the grapefruit item combined recognition of a potential interaction with an imprecise recommendation about moderation, which may have affected responses. Face-to-face administration may also have introduced interviewer or social desirability bias. In addition, the cross-sectional design measured knowledge and self-reported satisfaction, rather than actual counseling behavior or patient outcomes. Finally, although multivariable adjustment was performed, residual confounding remains possible as relevant factors may have been unmeasured or incompletely captured by the grouped variables. Combining PharmD, master's, and Ph.D. qualifications may have also obscured differences between educational pathways; as such, the observed association should be interpreted only as a comparison between BPharm and the combined non-BPharm group. Nevertheless, the study exceeded its calculated minimum sample size and evaluated clinically important aspects of safety, interactions, and counseling relating to warfarin.

Recommendations and Future Directions

Targeted continuing professional development should focus on the knowledge gaps identified in this study, including indication-specific INR targets, the use of warfarin in patients with renal impairment, clinically important drug and supplement interactions, and appropriate counseling regarding dietary vitamin K intake. Case-based workshops, standardized counseling materials, and access to reliable interaction screening resources may strengthen the competence of community pharmacists. Future studies should include pharmacists from multiple regions of Saudi Arabia and should evaluate actual counseling practices, dispensing behaviors, and patient-related outcomes in addition to knowledge.

5. Conclusions

Among the community pharmacists surveyed in Jeddah and Taif, the mean overall PAS was 66.40%, and 67.9% achieved the predefined descriptive threshold of ≥60%; note that this threshold does not establish clinically adequate knowledge. Nevertheless, the findings indicate the need for an increased focus on education regarding particular domains of knowledge, including INR thresholds and warfarin–drug interactions. This study's findings identify priorities for continuing professional education, while future studies should evaluate whether educational interventions improve counseling practices and patient outcomes.

Author Contributions: Conceptualization, A.B., F.A., L.A. and S.A.; methodology, A.B.; validation, A.B. and F.A.; formal analysis, A.B. and L.A.; data curation, F.A., L.A. and S.A.; writing—original draft preparation, F.A., L.A. and S.A.; writing—review and editing, A.B., F.A., L.A. and S.A.; visualization, A.B. and S.A.; supervision, A.B.; project administration, A.B.; funding acquisition, A.B. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki and was officially approved by the local Research Ethics Committee at King Abdulaziz University (approval number: PH-1445-13).

Informed Consent Statement: Informed consent was obtained from all participants involved in the study.

Data Availability Statement: The data supporting the findings of this study are available from the corresponding author upon reasonable request.

Conflicts of Interest: The authors declare no conflicts of interest. The funders had no role in the study design, data collection, analysis, interpretation, manuscript writing, or decision to publish the results.

Abbreviations

The following abbreviations are used in this manuscript:

Abbreviation	Definition
BPharm	Bachelor of Pharmacy
DOACs	Direct oral anticoagulants
DSR	Deanship of Scientific Research
INR	International normalized ratio
KAU	King Abdulaziz University
NSAIDs	Nonsteroidal anti-inflammatory drugs
OTC	Over-the-counter
PAS	Percentage awareness score

PE	Pulmonary embolism
PharmD	Doctor of Pharmacy
SD	Standard deviation

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