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Outcomes of pharmacist-led patient education on oral anticoagulant therapy: A scoping review

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ABSTRACT

Background: Oral anticoagulants (OACs) are commonly used to prevent and treat thromboembolism and stroke prevention in patients with nonvalvular atrial fibrillation (NVAF). Vitamin K antagonist (VKAs) and direct oral anticoagulant (DOACs) therapies are challenging because of the possible risk of bleeding. Patient education by pharmacists could be beneficial for reducing the risk of adverse effects and improving therapeutic outcomes.
Objective: This scoping review aimed to investigate the outcomes of pharmacist-led patient education interventions regarding VKAs and DOACs therapies.
Method: Three databases (PubMed, Web of Science, and Scopus) were used following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews (PRISMA-ScR) guidelines to identify articles published between January 1, 2008, and December 31, 2024. The data were synthesized using Rayyan AI.
Results: A total of 1102 records were identified. After title and abstract screening, 77 studies were selected for full-text review, and 57 articles were ultimately included. The percentages of studies that examined VKAs, DOACs, and both (OACs) were 66.7 %, 19.3 %, and 14.0 %, respectively. At least one statistically significant outcome was detected in 81.6 % (31 out of 38) of the studies on VKAs, 36.4 % (4 out of 11) of the studies on DOACs and 50 % (4 out of 8) of the studies on OACs.
Conclusion: This review revealed that pharmacist-led patient education was particularly effective in cases of VKAs, while the outcomes in cases of DOACs were modest. Moreover, while the role of pharmacists in patient education on VKAs has been widely studied, limited research has focused on the effect of pharmacist-led education on DOACs.

1. Introduction

Oral anticoagulants (OACs) are commonly used for the prevention and treatment of thromboembolism and stroke prevention in patients with nonvalvular atrial fibrillation (NVAF). Anticoagulant therapy is the cornerstone for venous thromboembolism (VTE), which includes both pulmonary embolism (PE) and deep vein thrombosis (DVT) and is the third most common cause of vascular mortality after heart attack and stroke.[1,2] Approximately 20 % of individuals die within a year of being diagnosed with VTE, either due to VTE itself or the underlying conditions that triggered the event.[3,4]

OACs are widely used in clinical practice, and their use is steadily increasing globally. In the United States, OACs utilization among 436,864 patients with atrial fibrillation (AF) rose from 56.3 % in 2011 to 64.7 % in 2020, driven by an increase in DOAC use from 4.7 % to 47.9 %, while warfarin use declined from 52.4 % to 17.7 %.[5] Also, in the United States, over the five-year study period, among a total of 250,725 admissions, 463 anticoagulant (AC) - associated ADEs were reported. Of these AC - associated ADEs, 48.8 % were medication errors, 30.5 % were adverse drug reactions (ADRs), and 20.7 % involved both a medication error and ADR. 70 % of AC - associated ADEs were potentially preventable, underscoring the critical need for robust patient education and management strategies to mitigate these risks.[6] Similarly, data from the GLORIA-AF registry across multiple regions indicate that DOACs were prescribed to 59.5 % of patients with AF and VKAs were prescribed to 22.7 %.[7] Despite their benefits, OACs are high-risk medications,

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frequently associated with serious adverse drug events (ADEs) such as bleeding and thromboembolic complications. Studies of AF patients show that improved therapeutic management significantly reduces bleeding risks, emphasizing the value of effective interventions.[8]

For more than six decades, coumarin derivatives (e.g., warfarin) have been the cornerstone of anticoagulant treatment.[9] The challenge in warfarin treatment is not only due to its narrow therapeutic window and possible risk of bleeding but also because its effects can be greatly influenced by certain patient characteristics, the potential risk of drug–drug interactions, interactions with foods, and interactions with medicinal plants.[10]

Rivaroxaban and dabigatran were first approved in the European Union in 2008, followed by apixaban in 2011 and edoxaban in 2015.[11–14] In the USA, the Food and Drug Administration (FDA) approved dabigatran in 2010, followed by rivaroxaban in 2011, apixaban in 2012, and edoxaban in 2015.[15–18] DOACs have become leading therapeutic substitutes for VKAs in providing convenient, effective, safe treatment and prevention choices for patients with different thromboembolic disorders; stroke prevention in NVAF; and treatment and DVT and PE.[19]

The knowledge level of patients regarding anticoagulant therapy, to a large extent, affects anticoagulation control.[20] Healthcare providers (HCPs) play an essential role in patient counselling and education to improve the efficacy of anticoagulant therapy and reduce adverse events.[21] The hospitalization rate due to bleeding complications decreased substantially in patients who received medication instructions from a pharmacist, physician, or nurse.[22] Physicians and nurses perform interventions to improve patients' knowledge of OACs more often than do pharmacists.[23] However, it is crucial to recognise pharmacists' specialised knowledge of medications and their role in the management of drug therapy. Pharmacist are not only responsible for the distribution of drugs, but also play an essential role in ensuring the safe and effective use of drugs through various clinical services. Their participation significantly improves patient outcomes, drug safety and adherence to therapy. Regarding OAC therapy, pharmacists can have a positive impact on hospital stay duration, adherence to medications, values of the therapeutic international normalized ratio (INR), time in the therapeutic range (TTR), and cost of therapy.[24] In addition, pharmacists play a key role in patient education and counselling. They are often the most accessible health professionals and provide important information about the use of medications, possible side effects and interactions with foods and other drugs. This educational role is crucial to enhancing the patient's understanding and compliance with their medication regimens.[25] A systematic review and meta-analysis demonstrated that pharmacist-led interventions significantly improved the appropriateness of anticoagulant therapy, while also reducing bleeding and hospital readmissions.[26] Another meta-analysis confirmed that pharmacist-led anticoagulation management yielded significantly lower risks of haemorrhage and thrombosis compared to other models provided by physicians, nurses or other HCPs.[27] Furthermore, systematic reviews of randomized controlled trials affirm that pharmacist-led interventions enhance clinical outcomes and adherence, underscoring their pivotal role in ensuring the safety and efficacy of anticoagulant therapy.[28]

There is a knowledge gap among patients on the use of OACs, which can threaten the safety and efficacy of treatment.[29] DOACs are thought to be safer and easier to use than VKAs, which can lead to an underestimation of the possible risk associated with the use of DOACs. Patients receiving DOACs have significantly more knowledge gaps than patients receiving VKAs in terms of how to take their medication and the consequences of overdosage.[30] Furthermore, patients on VKAs had a substantially greater level of knowledge of the drug and underdosing than those on DOACs.[31]

Despite the advantages of the convenience, effectiveness, and safety of DOACs over VKAs in VTE therapy, bleeding continues to be a significant adverse event, especially among cancer patients.[1] Additionally, bleeding occurred more frequently in patients taking DOACs than in those receiving warfarin.[32] Therefore, despite their fewer drug interactions and lack of need for dose titration and monitoring, DOACs still require patient education regarding appropriate dosage regimens and the administration and management of serious adverse effects.[24] Furthermore, most of the studies involving pharmacists regarding patient education about OACs have focused primarily on warfarin.[33,34] This review provides a comprehensive overview of patient education outcomes by broadening the scope to include both VKAs and DOACs across diverse healthcare environments; primary (community) and secondary (hospital outpatient) care settings. By providing patients with information on DOACs and VKAs, pharmacists may be able to improve patient comprehension and therapeutic outcomes.[30] This scoping review aimed to investigate the outcomes of pharmacist-led patient education interventions for OACs, including VKAs and DOACs.

2. Methods

2.1. Study design

A literature search was conducted, and articles published between January 01, 2008, and December 31, 2024, were included in this study. This scoping review was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews (PRISMA-ScR) guidelines.[35] The PCC information consisted of population (P): patients receiving oral anticoagulants; concept (C): pharmaceutical counselling and education outcomes; and context (C): diverse health settings, including community pharmacies, hospital outpatient clinics, home visits and specialised anticoagulation clinics. All curated studies were imported into Zotero software to identify and remove duplicate records.

2.2. Search strategy

A literature search was performed using the PubMed, Scopus, and Web of Science databases. The search strategy used a combination of keywords and Medical Subject Headings (MeSH) terms related to OACs therapy and patient education (Appendix 1). The specific keywords used were ("pharmacist") AND ("anticoagulant" OR "warfarin" OR "acenocoumarol" OR "phenprocoumon" OR "rivaroxaban" OR "apixaban" OR "edoxaban" OR "dabigatran") AND ("patient") AND ("education" OR "consultation" OR "counselling" OR "counselling") to conduct a scoping review following the PRISMA-ScR guidelines[35]

2.3. Eligibility criteria

Studies documenting the outcomes of pharmacist-led patient education in relation to OACs were included if they met the following criteria: involved pharmacists as the main educator for patients on OACs, focused on patient education intervention outcomes conducted in an inpatient setting as well as community pharmacies, and were written in English. Studies including low-molecular-weight heparin (LMWH) with OACs without separating interventions and outcomes, abstracts or conference proceedings, systematic reviews, meta-analyses or other types of reviews, or articles not available in full-text format were excluded. We chose these exclusion criteria to ensure that the included studies were relevant to our research question.

2.4. Study selection

To ensure optimal study selection, two independent reviewers (AAAO and IYK) screened the titles and abstracts of all identified articles for eligibility using predefined inclusion and exclusion criteria. If the information required to determine these criteria was not found in the abstract, the full-text article was reviewed. Rayyan AI software[36] was used to screen and extract information on the study design, participant characteristics, intervention details, and outcomes. Discrepancies were

resolved through discussion and consensus.

The same two reviewers then reviewed the full texts of potentially eligible articles using the same criteria. The data were independently extracted by both reviewers, cross-checked, and compiled by AAAO. The study characteristics were summarized descriptively, and the outcomes were analysed thematically using a standardised template in Microsoft Office Excel 2019. Data extracted included author, year of publication, country, type of oral anticoagulant, study design, intervention/control group, measurements, follow-up period, number of participants, and outcomes.

In accordance with the PRISMA-ScR,[37,38] no quality assessment was performed, since the primary objective of a scoping review is to map and comprehensively identify all available evidence and emphasise main characteristics, regardless of quality.

3. Results

Fig. 1 shows the flow chart of the study selection process. The process started with the identification of potential studies from three databases, and 1102 articles were found: PubMed (n = 94), Web of Science (n = 226), and Scopus (n = 782). After removing duplicate records (n = 258), 844 articles were screened for eligibility based on their titles and abstracts. The next stage of the process involved screening the records based on predefined inclusion and exclusion criteria. A total of 767 records were excluded based on various criteria, including inappropriate study design, nontarget population, drugs, and outcomes, published twice,[39] not written in English, and irrelevant studies; unrelated to pharmacist-led educational interventions on OACs, surveys, reviews, and reports. After the initial screening, 77 articles were assessed for eligibility for full-text screening. Seven of these reports were excluded because they could not be retrieved in full text, ten were excluded because they did not involve an intervention study, and three were excluded because they consisted of LMWH and OACs without separate interventions or outcomes. Finally, 57 studies were included in the scoping review based on their relevance to the research questions and inclusion criteria.

3.1. Study participants and duration of the studies

The total number of participants was 15022; in the intervention arm, 11097 patients received pharmacist education on OACs, while 3925 participants received usual care (UC) in the control arm. Approximately, two third of the studies were published in or after 2020 (30 of 57, 59.6 %).[20,30–32,39–64]

3.2. Study design and type of OAC studied

Half of the studies were prospective studies (49.1 %), including prospective non randomized control studies,[40,41,60,65–68] prospective non randomized pre- and post-intervention studies,[31,39,42,43,59,69–74] prospective cohort studies,[10,20–22,30,61,75–78] retrospective cohort studies,[49–55,57,79–84] and randomized control trials (RCTs),[32,44–48,56,58]

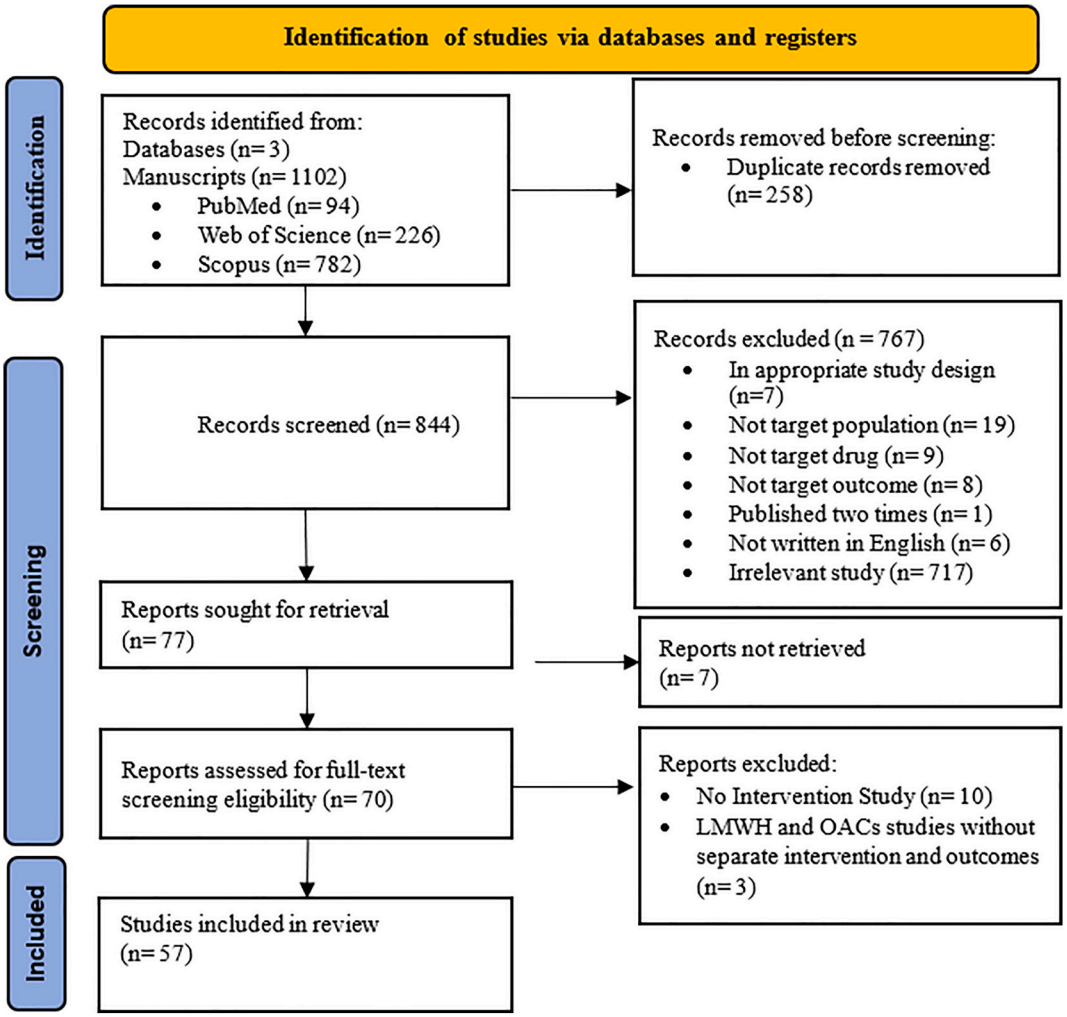

Fig. 1. Flowchart diagram demonstrating the results of the literature screening of the role of pharmacists in patient education about oral anticoagulant.

,62–64,85–88 (Table 1). Two-thirds of the studies focused on VKAs, particularly warfarin (Table 2). Fewer studies have examined patient education on DOACs, while some studies have examined both VKAs and DOACs.

3.3. Continental and country view

Table 3 indicates that the majority of studies were carried out in Asia (42.1 %),[10,20,21,32,39–43,45,47,50,52,53,61–64,67,69,73,76,80,85] and North America (28 %),[22,48,49,51,54–56,65,68,71,72,79,81,83,84,88] Europe (15.8 %),[30,31,44,46,60,66,74,86,87] Australia (8.8 %),[57,58,75,77,78] South America (3.5 %)[59,82] and Africa (1.8 %).[70] In terms of countries, most of the studies were conducted in the United States of America (USA),[22,48,51,54–56,65,68,71,72,79,81,83,84] followed by China,[10,20,40,41,45,50,64] and Australia[57,58,75,77,78]

3.4. Outcome measurement metrics

The evaluations of the effectiveness of pharmacist interventions in educating patients on OACs included many metrics, including the evaluations of patients' knowledge levels about OACs through their responses to validated questionnaires; evaluations of medication adherence, bleeding rates and readmission rates for both DOACs and VKAs; and specific metrics for VKAs, such as measuring INR and TTR (Table 4).

Table 1
The design of the included studies.

Study design	No of studies, (%)	Citations
Randomized control trials (RCTs)	15 (26.3)	(R et al., 2013), (Verret et al., 2012), (Falamić et al., 2018), (Falamić et al., 2019), (Falamić et al., 2021), (Liang et al., 2020), (Karaoui et al., 2021), (Young et al., 2021), (Merks et al., 2022), (Shiga et al., 2022), (Pham et al., 2022), (Wilson et al., 2023), (Thomas et al., 2024), (Wongkornrat et al., 2024), (W. Xu et al., 2024).
Prospective non randomized control studies	7 (12.3)	(Winans et al., 2010), (Duran-Parrondo et al., 2011), (Hasan et al., 2011), (Brunetti et al., 2018), (Li et al., 2020), (Dreijer et al., 2020), (Jiang et al., 2021)
Prospective non randomized pre- and post-intervention studies	11 (19.3)	(Wong et al., 2011), (Ahmed et al., 2017), (Putriana et al., 2017), (Heinrich et al., 2019), (Patino et al., 2019), (Izzettin et al., 2019), (Roseau et al., 2020), (Shilbayeh, 2020), (Kanafileskookalayeh & Bhojan, 2021), (Marcatto et al., 2021), (Lin et al., 2021)
Prospective cohort studies	10 (17.5)	(Metlay et al., 2008), (Stafford et al., 2011), (Stafford et al., 2012), (Masnoon et al., 2016), (Chedepudi et al., 2017), (Zhang et al., 2017), (Choumane et al., 2018), (Cao et al., 2020), (Metaxas et al., 2020), (Dhande P et al., 2024)
Retrospective cohort studies	14 (24.6)	(Patel-Naik et al., 2010), (Lee et al., 2013), (Shore et al., 2015), (Chu & Limberg, 2017), (de Lima Silva et al., 2017), (Ohgushi et al., 2019), (Lim et al., 2020), (Patel et al., 2020), (Saw et al., 2020), (Alhmoud et al., 2021), (Bakey & Nguyen, 2022), (Jiang et al., 2022), (Navin et al., 2022), (Bonsu et al., 2023)
Total	57 (100)	

Table 2
The proportion of studies that examined different oral anticoagulant groups.

Oral anticoagulants group	No of studies (%)	No of participants (%)
VKAs	38 (66.7)	8205 (54.6)
DOACs	11(19.3)	3738 (24.9)
VKAs and DOACs (OACs)	8 (14.0)	3079 (20.5)
Total	57 (100)	15022 (100)

Table 3
Geographical distribution of studies.

Continent	Country	No of Studies (%)
Asia	China	7 (12.30)
	India	5 (8.77)
	Singapore	2 (3.51)
	Lebanon	2 (3. 51)
	Japan	2 (3. 51)
	Indonesia	1 (1.75)
	Saudi Arabi	1 (1.75)
	Qatar	1 (1. 75)
	Taiwan	1 (1. 75)
	Malaysia	1 (1. 75)
	Thailand	1 (1. 75)
North America	USA	14 (24.60)
	Canada	2 (3. 51)
Europe	Croatia	3 (5.26)
	Spain	1 (1. 75)
	Turkey	1 (1. 75)
	Netherlands	1 (1. 75)
	Switzerland	1 (1. 75)
	France	1 (1. 75)
	Poland	1 (1. 75)
Australia	Australia	5 (8.77)
South America	Brazil	2 (3. 51)
Africa	Sudan	1 (1. 75)
Total		57 (100)

3.5. Pharmacist-led patient education outcomes

At least one statistically significant outcome was detected in 81.6 % (31 of 38) of the studies on VKAs, 36.4 % (4 of 11) of the studies on DOACs and 50 % (4 of 8) of the studies on OACs (Appendix 2). In many studies, the outcomes of the pharmacist intervention were measured with more than one metric. Analysis of studies that focused on pharmacist-led patient education on VKAs yielded positive outcomes over UC, which was demonstrated in all metrics with varying percentages, with the highest positive outcomes rates found in the INR within the therapeutic range and knowledge level (90.9 % and 88.2 %, $p < 0.05$), respectively. However, there were studies that reported nonsignificant differences in outcomes between the pharmacist intervention groups and the UC groups ($p > 0.05$), with varying percentages across metrics (Table 4). Despite these non-significant outcomes, the positive impact of pharmacist-led interventions remains substantial, as 81.6 % of the studies on VKAs reported at least one statistically significant positive outcome, underscoring the significant role of pharmacist-led patient education in optimizing outcomes associated with VKAs therapy.

Pharmacist interventions pertaining to DOACs showed modest effects on outcomes in comparison with UC groups. Only 36.4 % of studies on DOACs assessing pharmacist-led interventions demonstrated at least one statistically significant impact on patient education. When assessing medication adherence, only 2 studies out of 5 showed significantly higher adherence in the pharmacist-led group. In the context of readmission, measured in two studies, both showed statistically nonsignificant differences between the intervention groups and the UC groups ($P > 0.05$), (Table 4).

Studies on OACs, including both VKAs and DOACs, have shown that pharmacist interventions effectively improved patient knowledge levels (4 of 4, 100 %, $p < 0.05$). However, pharmacist-led interventions did not

Table 4
Summary of the pharmacist-led educational intervention outcomes in studies dealing with VKAs, DOACs and OACs (P value, 95 % CI).

Type of anticoagulant	Measurement metrics	Total no of studies	Studies with significant outcomes (P < 0.05)	Citation	Studies with nonsignificant outcomes (P > 0.05)	Citation
	Knowledge level	17	15 (88.2)	(Winans et al., 2010), (Stafford et al., 2012), (Verret et al., 2012), (Masnoon et al., 2016), (Chedepudi et al., 2017), (Choumane et al., 2018), (Heinrich et al., 2019), (Izzettin et al., 2019), (Cao et al., 2020), (Shilbayeh, 2020), (Liang et al., 2020), (Jiang et al., 2021), (Lin et al., 2021), (Dhande P et al., 2024), (Thomas et al., 2024)	2 (11.8)	(Hasan et al., 2011), (Young et al., 2021)
	INR within therapeutic range	11	10 (90.9)	(Patel-Naik et al., 2010), (Hasan et al., 2011), (Wong et al., 2011), (Verret et al., 2012), (Ahmed et al., 2017), (Choumane et al., 2018), (Izzettin et al., 2019), (Cao et al., 2020), (Kanafileskookalayeh & Bhojan, 2021), (Thomas et al., 2024)	1 (9.1.)	(Alhmoud et al., 2021)
VKAs	TTR	11	6 (54.5)	(Falamić et al., 2018), (Ohgushi et al., 2019), (Cao et al., 2020), (Jiang et al., 2021), (Marcatto et al., 2021), (Jiang et al., 2022)	5 (45.5)	(Verret et al., 2012), (Saw et al., 2020), (Liang et al., 2020), (Alhmoud et al., 2021), (Wongkornrat et al., 2024)
	Bleeding rate	4	3 (75.0)	(Duran-Parrondo et al., 2011), (Stafford et al., 2011), (Ahmed et al., 2017)	1 (25.0)	(Jiang et al., 2022)
	Readmission	4	2 (50.0)	(Ahmed et al., 2017), (Brunetti et al., 2018)	2 (50.0)	(Stafford et al., 2011), (Jiang et al., 2022)
	Medication adherence	4	3 (75.0)	(Stafford et al., 2011), (Marcatto et al., 2021), (Putriana et al., 2017)	1 (25.0)	(Jiang et al., 2021)
	Incidence of adverse events	1	1 (100.0)	(Falamić et al., 2019)	–	–
	Mean in clinic visit times	1	1 (100.0)	(Patino et al., 2019)	–	–
	Health-related quality of life (HRQoL)	1	1 (100.0)	(Falamić et al., 2021)	–	–
DOACs	Bleeding rate	1	1 (100.0)	(Li et al., 2020)	–	–
	Readmission	2	–	–	2 (100.0)	(Chu & Limberg, 2017), (Bakey & Nguyen, 2022)
	Medication adherence	5	2 (40.0)	(Patel et al., 2020), (Merks et al., 2022)	3 (60.0)	(Chu & Limberg, 2017), (Shiga et al., 2022), (Wilson et al., 2023)
	Rate of medication errors	1	1 (100.0)	(Bakey & Nguyen, 2022)	–	–
OACs	Knowledge level	4	4 (100.0)	(R et al., 2013), (Metaxas et al., 2020), (Roseau et al., 2020), (W. Xu et al., 2024)	–	–
	Bleeding rate	2	1 (50,0 %)	(W. Xu et al., 2024)	1 (50.0)	(Karaoui et al., 2021)
	Readmission	2	–	–	2 (100.0)	(Patel et al., 2020), (Karaoui et al., 2021)
	Medication Satisfaction	1	1 (100)	(W. Xu et al., 2024)	–	–
	Medication adherence	3	1 (33.3)	(W. Xu et al., 2024)	2 (66.7)	(Patel et al., 2020), (Bonsu et al., 2023)

significantly impact readmission rate, as reported in all studies assessing this metric, while moderate impact was shown on bleeding rate and medication adherence (Table 4). Notably, the impact of pharmacist interventions in educating patients about OACs resulted in moderate outcomes, representing 50.0 % of the studies on OACs with at least one statistically significant outcome.

The comprehensive details of the studies included in this review, including the authors, year of publication, type of oral anticoagulant, intervention, control, measurement, follow-up period, participants and outcomes, are provided in (Appendix 2).

4. Discussion

The results of this study draw attention to the differences in the effectiveness of pharmacist-led patient education between patients on VKAs and those on DOACs. Studies that focused on VKAs have consistently demonstrated positive outcomes in terms of enhancing patient knowledge levels, INR within the therapeutic range, TTR, and many other metrics. This aligns with the recognized expertise of pharmacists in medication management and underscores the significance of their role in patient education. The relatively high success rate of pharmacist-led interventions in the case of VKAs may be explained by the fact that VKAs have been used for many decades and are considered potentially risky; therefore, great emphasis has been placed on developing and implementing effective patient education programmes.

Unlike the results of pharmacist-led education on VKAs, the outcomes of pharmacist-led interventions for patients receiving DOACs were modest. These findings can be interpreted from different perspectives. DOACs are thought to be safer and easier to use than VKAs, which may lead HCPs , as well as patients, to underestimate the possible associated risk. Additionally, the use of DOACs is more comfortable due to the absence of INR monitoring; however, there is a risk involved, as it may impede the evaluation of adherence.[89]

The comparison between VKAs and DOACs is, to a large extent,

sophisticated and has highlighted significant differences in outcomes and measurement metrics. VKAs were assessed using a broader range of metrics that reflect the complexity of managing these medications, which require frequent monitoring and dose adjustments, including INR therapeutic range, TTR, bleeding rates, readmission, adherence, and knowledge levels. In contrast, the lack of need of regular monitoring of DOACs may explain their narrower focus on fewer metrics like adherence, bleeding rates, and readmission.

Notably, the metric of patient knowledge, critical for therapy optimization, was measured in 44.7 % of VKAs studies but was absent in DOACs studies, therefore, incorporating the knowledge level to measure the outcomes in future DOACs research could improve patients understanding and strengthen educational strategies and therapeutic outcomes. Furthermore, a limited number of studies that focus on pharmacist-led patient education on DOACs may have contributed to the differences in the outcomes between VKAs and DOACs therapies. Outcomes like adherence and readmission rates were not significant for DOACs, they were also not consistently significant for VKAs, suggesting further research is needed to identify the factors that influence these outcomes. Shared measurement metrics between VKAs and DOACs, such as adherence, bleeding rates, readmissions, knowledge level and rate of medication errors can provide common ground for future research to enable direct comparisons of interventions for both VKAs and DOACs.

The review of interventions for VKAs highlighted that face-to-face pharmacist-led education, including sessions and lectures, often consists of personalized education and discussions with pharmacists were the most effective strategies, with numerous studies demonstrating significant improvements in key outcomes such as INR control, TIR, adherence, and patient knowledge.[20–22,42–44,65,66,68,70,73,74,76,79,86–88] The use of educational materials such as written materials, booklets, leaflets, or checklists to complement education either alone or as complementary tools, was also shown to be an effective intervention by improving knowledge level.[20,21,39,61,62,68,71,75,76,90] Video-based educational methods emerged as another successful approach for enhancing patient understanding.[39,71,72] Pharmaceutical care counselling, including INR monitoring, medication review, and adherence promotion, yielded considerable effectiveness.[45,59,62,67,69,77,78,80] Digital tools through the use of applications, online platforms for continuous education and monitoring provided accessibility for patients, albeit with mixed outcomes.[10,41,50,63] Remote education through teleconsultation, video calls, or phone calls was found to be the least effective approach.[52,53,58]

For DOACs, face-to-face pharmacist-led education and counselling focused on dosing, adherence, side effects, drug interactions, and storage emerged as the most frequently used approach, yielding positive results in some studies.[40,46,51,55] However, many studies indicated that these interventions were less effective.[47,56,57,81,83,84] The interventions also incorporated practical strategies, such as Starter Packs™ (a blister pack with dose instructions) or after-hours packs (pre-prepared medication packages containing OAC doses) with patient information booklets, to simplify initial treatment and reinforce understanding and enhance medication adherence showed modest benefits,[48,57,81] (Appendix 2).

To our knowledge, this is the first review to study the outcomes of pharmacist-led patient education on VKAs and DOACs. Furthermore, this review included studies on DOACs published since their first approval in 2008.

Although the scoping review provided valuable insight, it is essential to acknowledge certain limitations. First, the study populations were from different continents, countries, and settings; as a result, the health care system, usual care practices and pharmacist roles may vary greatly, similar to the variability in study designs and outcome measurements. Second, we searched for literature only in relevant major databases, which could lead to miss data not being published in scientific journals or not being published in English. Third, the varying follow-up periods of the studies may have had an impact on their capacity to determine the influence of pharmacists on patients' education on anticoagulant therapy.

To provide a more comprehensive view, more research to refine education strategies, expand the measurement metrics, evaluate pharmacist interventions for DOACs education, and identify areas that need to be improved to optimize patient outcomes related to DOACs could lead to improved therapeutic outcomes. Additionally, further research should include data from countries with local databases and a wider geographic representation of study populations. By addressing these gaps, pharmacists can continue to enhance the safety and efficacy of oral anticoagulant treatment.

5. Conclusion

This review revealed that pharmacist-led patient education was particularly effective in cases of VKAs, while the outcomes in cases of DOACs were modest. Moreover, while the role of pharmacists in patient education on VKAs has been widely studied, limited research has focused on the effect of pharmacist-led education on DOACs. These results highlight that specific pharmacist-led educational programs on DOACs should be tailored to improve outcomes, and further studies are needed to evaluate the effectiveness of these programs.

CRediT authorship contribution statement

Ahmed A.A. Omer: Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Ikhwan Yuda Kusuma:** Writing – review & editing, Methodology, Investigation, Formal analysis. **Dezső Csupor:** Writing – review & editing, Validation, Investigation, Funding acquisition. **Péter Doró:** Writing – review & editing, Validation, Supervision, Methodology, Investigation, Funding acquisition, Conceptualization.

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Conflict of interest

The authors declare that there are no conflicts of interest.

Acknowledgements

Not applicable.

Appendix 1. Full electronic search strategy updated search following the PRISMA-ScR guidelines

Database	PubMed
No of studies	94
MeSH term	(((pharmacist[Title/Abstract]) AND ((anticoagulant[Title/Abstract] OR warfarin[Title/Abstract] OR acenocoumarol[Title/Abstract] OR phenprocoumon[Title/Abstract] OR rivaroxaban[Title/Abstract] OR apixaban[Title/Abstract] OR edoxaban[Title/Abstract] OR dabigatran[Title/Abstract]))) AND (patient[Title/Abstract])) AND ((education[Title/Abstract] OR consultation[Title/Abstract] OR counselling[Title/Abstract] OR counselling[Title/Abstract])) AND (2008:2024[pdat])
Online link	https://pubmed.ncbi.nlm.nih.gov/?term=%28%28%28pharmacist%5BTitle%2FAbstract%5D%29+AND+%28%28anticoagulant%5BTitle%2FAbstract%5D+OR+warfarin%5BTitle%2FAbstract%5D+OR+acenocoumarol%5BTitle%2FAbstract%5D+OR+phenprocoumon%5BTitle%2FAbstract%5D+OR+rivaroxaban%5BTitle%2FAbstract%5D+OR+apixaban%5BTitle%2FAbstract%5D+OR+edoxaban%5BTitle%2FAbstract%5D+OR+dabigatran%5BTitle%2FAbstract%5D%29%29%29+AND+%28patient%5BTitle%2FAbstract%5D%29%29+AND+%28%28education%5BTitle%2FAbstract%5D+OR+consultation%5BTitle%2FAbstract%5D+OR+counseling%5BTitle%2FAbstract%5D+OR+counselling%5BTitle%2FAbstract%5D%29%29+AND+%282008%3A2024%5Bpdat%5D%29
Database	Web of Science
No of studies	226
MeSH term	TS=((Pharmacist) AND (anticoagulant OR warfarin OR acenocoumarol OR phenprocoumon OR rivaroxaban OR apixaban OR edoxaban OR dabigatran) AND (patient) AND (education OR consultation OR counselling OR counselling))
Online link	https://www.webofscience.com/wos/woscc/summary/6e255182-f069-4d22-b08a-7e9b22559b69-0141b490b2/relevance/1
Database	Scopus
No of studies	782
MeSH term	TITLE-ABS-KEY (pharmacist) AND TITLE-ABS-KEY (anticoagulant OR warfarin OR acenocoumarol OR phenprocoumon OR rivaroxaban OR apixaban OR edoxaban OR dabigatran) AND TITLE-ABS-KEY (patient) AND TITLE-ABS-KEY (education OR consultation OR counselling OR counselling) AND PUBYEAR >2007 AND PUBYEAR <2024
Online link	https://www.scopus.com/results/results.uri?sort=plf-f&src=s&sid=836974c3786cd2ef09ab8509dd63a90f&sot=a&sdt=cl&sl=241&s=%28TITLE-ABS-KEY%28pharmacist%29+AND+TITLE-ABS-KEY%28anticoagulant+OR+warfarin+OR+acenocoumarol+OR+phenprocoumon+OR+rivaroxaban+OR+apixaban+OR+edoxaban+OR+dabigatran%29+AND+TITLE-ABS-KEY%28patient%29+AND+TITLE-ABS-KEY%28education+OR+consultation+OR+counseling+OR+counselling%29%29&origin=resultslist&editSaveSearch=&txGid=538570a5d65bdb868f588eb9fb40b8c8&sessionSearchId=836974c3786cd2ef09ab8509dd63a90f&limit=10&yearFrom=2008&yearTo=2024

Appendix 2. Characteristics of the included studies; author, type of oral anticoagulant, intervention, control, measurement, follow-up period, participants and outcomes

References	Anticoagulant type- Intervention- Control- Measurement	Follow up period	Participants	Outcomes
(Metlay et al., 2008) (12)	**Anticoagulant type:** Warfarin **Intervention:** Patients received medication instructions from pharmacist plus either a physician or nurse. **Control:** No control **Measurement:** Hospitalizations for possible warfarin related bleeding.	24 Months	2346	Pharmacist led group had a 60 % reduction in hospitalization rate due to serious bleeding over the next 2 years (adjusted incidence rate ratios (IRR) 0.40, 95 % CI 0.24–0.68).
(Patel-Naik et al., 2010) (57)	**Anticoagulant type:** Warfarin **Intervention:** Pharmacists offered thorough education on therapy adherence, monitoring, side effects, and lifestyle changes during a 60-min visit. They discussed INR results, assessed doses, and provided take-home cards with relevant information. **Control:** Received usual care before transitioning to pharmacist-managed anticoagulation **Measurement:** INR value in goal range.	12 Months	35	The number of INR values in the goal range was significantly higher for patients receiving pharmacist-managed anticoagulation monitoring ($P < 0.05$), compared with usual care group.
(Winans et al., 2010) (45)	**Anticoagulant type:** Warfarin **Intervention:** Patients received structured warfarin education program provided by a pharmacist. **Control:** Received usual care **Measurement:** Oral Anticoagulation Knowledge (OAK) test was administered Prior to discharge.	1 day	Intervention group: 20 Control group: 20	The intervention group scored significantly higher the OAK test than the usual care group (74 % vs 55 %, $p = 0.004$).
(Duran-Parrondo et al., 2011) (46)	**Anticoagulant type:** Warfarin & Acenocoumarol **Intervention:** Pharmacotherapeutic follow-up program (PTP): The pharmacist educated patients verbally and in writing conveyed crucial information on treatment necessity, dosage, administration, and risks, emphasizing therapeutic compliance and guidelines for omissions. **Control:** Received usual care **Measurement:** Hazard of a haemorrhage. Number of medical consultations.	12 Months	Intervention group: 272 Control group: 460	Pharmacist led intervention group had a 72 % reduction in hazard of a haemorrhage (HR = 0.28; 95 % CI 0.20, 0.40), ($P < 0.001$). - Pharmacist led intervention group demonstrated an 8 % reduction (OR = 0.92; 95 % CI 0.88, 0.96) in the number of medical consultations needed to maintain individual patients' INR within the correct range.
(Hasan et al., 2011) (47)	**Anticoagulant type:** Warfarin **Intervention:** MTAC (Medication therapy adherence clinic) managed by Pharmacist. **Control:** MTAC managed by physician. **Measurement:** - Validated interviewer administered questionnaire - Assessment of INR Control	24 Months	Intervention group: 81 Control group: 77	No significant difference in the knowledge of mechanism of action of warfarin (67.1 % ± 5.1 % vs 65.8 % ± 37.2 %; P = 0.919), interaction between alcohol and warfarin (42.0 % ± 42.0 % vs 44 % ± 47.9 %; P = 0.903), and side effects of warfarin (49.8 % ± 20.7 % vs 48.5 % ± 21.6 %; P = 0.636) between those in MTAC and non-MTAC groups.

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References	Anticoagulant type- Intervention- Control- Measurement	Follow up period	Participants	Outcomes
				- MTAC patients had better INR control than non-MTAC when compared for mean percentage days in range (63.4 % ± 18.9 % vs 52.5 % ± 18.2 %; P < 0.006).
(Wong et al., 2011) (49)	**Anticoagulant type:** Warfarin **Intervention:** Post implementation of inpatient anticoagulation service patients received counselling on their warfarin therapy prior to discharge. **Control:** Patients received standard care before implementation of inpatient anticoagulation service. **Measurement:** Percentage of INRs achieved therapeutic range within 5 days - INRs more than 4 during titration and - Subtherapeutic INRs on discharge.	15 Months	Intervention group: 144 Control group: 26	Provision of pharmacist consult resulted in (88 % vs 38 %, P < 0.001) of INR values achieving therapeutic range within 5 days. There was a reduction in INR values of more than 4 during titration from (27 %–2 %, P < 0.001), and subtherapeutic INR values on discharge without low molecular weight heparin from (15 %–0 % (P < 0.001).
(Stafford et al., 2011) (63)	**Anticoagulant type:** Warfarin **Intervention:** Patients receive post discharge warfarin management service by pharmacist involved a medication review, point-of-care INR monitoring and comprehensive warfarin education. **Control:** Received usual care (UC) **Measurement:** Incidence of major and minor haemorrhagic events in the 90 days post discharge, incidences of thrombotic events, combined haemorrhagic and thrombotic events, persistence with warfarin therapy and Warfarin-related hospital readmissions and death.	90 Days	Intervention group: 108 Control group:128	Rates of major and minor haemorrhagic were statistically significantly decreased on day 90 post discharge. (5.3 % vs 14.7 %; p = 0.03) The rate of combined haemorrhagic and thrombotic events to day 90 also decreased (6.4 % vs 19.0 %; p = 0.008). Persistence with warfarin therapy improved (95.4 % vs 83.6 %; p = 0.004). No significant differences in readmission and death rates (27.5 % vs 27.1 %, p = 0.95) and (1.6 % vs 2.8 %, p = 0.54), respectively.
(Stafford et al., 2012) (64)	**Anticoagulant type:** Warfarin **Intervention:** Patients receive post discharge warfarin management service involved a medication review, point-of-care INR monitoring and comprehensive warfarin education. **Control:** Patients receive normal community-based postdischarge care **Measurement:** Oral Anticoagulation Knowledge test (OAK).	90 Days	Intervention group: 129 Control group:139	There was a significant difference between the usual care and intervention patients' mean OAK test score on day 8 (P < 0.001). There was a statistically significant difference between the intervention group's mean OAK test score prior to the provision of warfarin education by pharmacist and their day 8 score after pharmacist education (P < 0.001). On day 90, there was no statistically significant difference in the mean OAK test scores between the groups (P = 0.07).
(Verret et al., 2012) (68)	**Anticoagulant type:** Warfarin **Intervention:** - All patients receive lecture on anticoagulation. - The intervention group received practical training to use the CoaguChek XS device and the self-management algorithm **Control:** Continue their management at the anticoagulation clinic **Measurement:** Oral Anticoagulation Knowledge (OAK) test, the number of INRs measured/patient and TTRs.	4 Months	Intervention group: 58 Control group: 56	Significant improvement in knowledge was observed within each group after the training session (p < 0.001 for both groups). The number of INR measured/patient in the Intervention group was greater than in the control group (17.4 ± 1.3 vs 4.0 ± 1.5, p < 0.001). The TTR in the intervention group was 73.9 ± 24.5 % vs 67.4 ± 34.8 %, in the control group, p = 0.79).
(R et al., 2013) (65)	**Anticoagulant type:** OAC **Intervention:** Patients received counselling on anticoagulation therapy, ADRs, compliance, and INR monitoring, along with informational booklets **Control:** Received usual care. **Measurement:** Patient's knowledge on oral anticoagulation was assessed using a questionnaire and the percentage of INRs within the therapeutic range.	6 Months	Intervention group: 40 Control group: 40	Patient's knowledge score on anticoagulation increased from an average of (5.6 ± 3.2 to 13.8 ± 0.94, P = 0.000) in intervention group. In control group there was no significant improvement in knowledge score (8.0 ± 1.59 to 8.3 ± 2., P = 0.218). In intervention group, 73.45 % of INR test results were within the therapeutic range compare with 53.2 % in control group.
(Lee et al., 2013) (62)	**Anticoagulant type:** Dabigatran **Intervention:** Anticoagulation clinic (ACC) pharmacist provide initial education on adherence (i.e., the rationale for a twice-daily dosing regimen), tolerance issues, refill procedures, and storage considerations. **Control:** Received usual care **Measurement:** Medication possession ratio (MPR) averaged across each group over three months and Dabigatran related bleeding and incident stroke and VTE.	6 Months	Intervention group: 20 Control group:48	The ACC group had a slightly higher mean MPR at three months (93.1 %) than the UC group (88.4 %). The ACC group had a smaller proportion of nonadherent patients at three months relative to the UC group (10 % versus 25 %), the difference was not significant (p = 0.16). There were no thromboembolic events or strokes in either group.
(Shore et al., 2015) (61)	**Anticoagulant type:** Dabigatran **Intervention:** Education included appropriate storage, indication, adverse effects, importance of adherence, management of missed doses, drug interactions and appropriate daily dosing. **Control:** No control **Measurement:** First evaluated the extent of variation in patient adherence followed by identify variation in site-level practices after education.	24 Months	1530	The proportion of adherent patients was higher at sites performing appropriate education (76 % vs 66 %). There was no statistically significant association between the provision of pharmacist led education prior to dabigatran initiation and adherence (adjusted relative risk [RR], 0.94; 95 % CI, 0.83–1.06).

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References	Anticoagulant type- Intervention- Control- Measurement	Follow up period	Participants	Outcomes
(Masnoon et al., 2016) (55)	**Anticoagulant type:** Warfarin **Intervention:** Patients receive checklist of information about warfarin therapy, indication and duration of therapy, mechanism of action of warfarin, INR monitoring, adverse effects, diet interactions, drug interactions, brand awareness, dosing, and alcohol moderation. **Control:** No control **Measurement:** Structured knowledge evaluation questionnaire was used immediately after counselling and 6-week post counselling.	6 Weeks	22	Participants demonstrated an ability to recall: 79.9 ± 14.6 % (Mean ± SD) of key information elements immediately after counselling, which significantly decreased 6 weeks after counselling (71.0 ± 11.7 %) $p = 0.02$.
(Ahmed et al., 2017) (50)	**Anticoagulant type:** Warfarin **Intervention:** Patients received comprehensive education on warfarin, covering dosage, effects, interactions, and management strategies, including diet, INR testing, and the importance of adherence. Additionally, the clinical pharmacist adjusted warfarin dosage based on INR results during each visit. **Control:** No control **Measurement:** INR control, bleeding events and hospitalization due to warfarin.	24 Months	135	The intervention led to a rise in INR tests within the therapeutic range, increasing from (51.5 %–68.3 %, $P < 0.01$). Decrease in bleeding incidence from (39.2 %–27.4 %, $P < 0.05$). Rate of hospitalization due to warfarin-related complications dropped from (10.4 %–3.7 %, $P = 0.001$).
(Chedepudi et al., 2017) (56)	**Anticoagulant type:** Acenocoumarol **Intervention:** Patients were undergoing to a deep patient education orally and with leaflets prepared specifically for the study in English and vernacular language Tamil. Patient received three sessions of education session (30 min) and was done till discharge (3–5 days). **Control:** No control **Measurement:** Patients were made to answer the questionnaire specially developed for the study, consisted of eight questions at the baseline. Again, patients answered the same questionnaire after the education session on the day of discharge.	5 Days	70	Improvement in their diagnosis awareness, drugs that they were taking at present, purpose of taking the drug acenocoumarol, purpose of INR testing and its timing, possible side effects of the drug acenocoumarol and awareness about reporting and side effects when observed ($p < 0.0001$).
(Zhang et al., 2017)(7)	**Anticoagulant type:** Warfarin **Intervention:** A QQ discussion group was created as OAC group (Tencent QQ is a popular instant messaging system in China), a pharmacist can educate through conversation with one or more patients, and share photos, documents and practical experience of warfarin therapy. Establishment of Medicago Anticoagulation Club (MACC), with regular meetings through which all patients could listen to medical presentations about warfarin. **Control:** No control **Measurement:** TTR, minor and major bleeding events, and Thromboembolisms.	29 Months	113	The mean TTR was 73.1 ± 14.3 No major bleeding or thromboembolic attacks occurred. Only, minor bleeding happened in nine patients.
(Putriana et al., 2017) (53)	**Anticoagulant type:** Warfarin **Intervention:** Patients received counselling on warfarin therapy. **Control:** Received basic care **Measurement:** Patient compliance assessed by questionnaire of compliance, employing Morisky scale.	NA	Intervention group:40 control group: 40	Patients' compliance of warfarin therapy had increased after receiving the counselling service (72.5 %–90 % in counselling group compared to (60 %–62.5 % in control group) ($p < 0.05$).
(de Lima Silva et al., 2017) (60)	**Anticoagulant type:** Warfarin **Intervention:** Include face-to-face appointments for patients' education, warfarin-dosing adjustments and monitoring of drug interactions. **Control:** No control **Measurement:** The median TTR.	12 Months	554	The median TTR was 64.3 % and 344 (61.6 %) patients had TTR ≥60 %.
(Chu & Limberg, 2017) (59)	**Anticoagulant type:** Rivaroxaban **Intervention:** Patients received education on compliance, drug interaction, INR monitoring and encourage the use of Starter Pack™ (a blister pack with dose instructions for each of the first thirty days of VTE treatment) to minimize confusion. **Control:** Received usual care **Measurement:** Medication adherence and 90-day readmissions for recurrent VTE due to nonadherence or treatment failure.	90 Days	Intervention group: 41 Control group: 34	Medication adherence was numerically higher in the intervention group (67 % vs 53 %, $p = 0.2$). 90-day readmissions were numerically lower in the intervention group (3 % vs 12 %, $p = 0.16$).
(Brunetti et al., 2018) (48)	**Anticoagulant type:** Warfarin **Intervention:** Warfarin discharge education program (WDEP): A pharmacist provided a 20-min bedside session, explaining warfarin therapy and giving an	90 Days	Intervention group: 203 Control group: 203	The prevalence of readmission within 90 days in WDEP group was (15.8 % vs 27.6 %, $p = 0.004$). Admission due to warfarin related problem was lower in WDEP group (5.4 %) compared to the usual

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References	Anticoagulant type- Intervention- Control- Measurement	Follow up period	Participants	Outcomes
	educational booklet. WDEP addressed medication issues, answered queries, and promoted adherence and postdischarge follow-up. **Control:** Received usual care **Measurement:** Prevalence of readmission within 90 days and treatment costs associated with hospital readmission.			care group (13.3 %), ($p = 0.006$). The treatment costs associated with hospital readmission in the WDEP group were 19 % lower than those in the usual care group.
(Choumane et al., 2018) (11)	**Anticoagulant type:** Warfarin **Intervention:** Patients counselled about the side effects and the importance of patient's compliance, also received a brochure entitled "Warfarin: Understanding Side Effects and the Importance of Compliance" prepared by the clinical pharmacist. **Control:** No control **Measurement:** Warfarin awareness questionnaire at baseline and after the intervention. Assessing INR level at baseline and after counselling.	2 Months	259	A higher mean knowledge about warfarin score was found after counselling as compared to before counselling (4.82 vs 13.2; $p < 0.001$). The percentage of patients who achieved therapeutic INR levels before counselling was 37.2 % (mean INR 1.69 ± 0.716) which was significantly lower compared with 74.4 % (mean INR 2.11 ± 0.517) after counselling ($p < 0.001$).
(Falamić et al., 2018) (66)	**Anticoagulant type:** Warfarin **Intervention:** Patients educated about warfarin therapy; the indication, action mechanism, meaning of INR value and therapeutic range and importance of adherence. **Control:** Received usual care **Measurement:** TTR monitoring.	6 Months	Intervention group: 65 Control group: 66	The median TTR was significantly higher in the intervention than in the control group (median 93 % vs. 31.2 %, $P < 0.001$).
(Falamić et al., 2019) (67)	**Anticoagulant type:** Warfarin **Intervention:** Patients educated on monthly manner about warfarin therapy, provided with a follow-up plan and a pillbox. **Control:** Received usual care **Measurement:** Incidence of adverse drug reactions.	6 Months	Intervention group: 65 Control group: 66	The cumulative incidence of adverse drug reactions was lower in the intervention group than control group (29 % vs. 85 %, $p < 0.001$).
(Heinrich et al., 2019) (51)	**Anticoagulant type:** Warfarin **Intervention:** A warfarin educational video and warfarin educational booklet was developed by pharmacists. **Control:** No control **Measurement:** Compare pre- and post-video knowledge test and follow-up knowledge test scores.	2 Months	18	The median scores at post-video knowledge test were significantly higher than that of the pre-knowledge test (12 vs. 10, $p < 0.001$). The median score for the follow-up knowledge test was greater than the pre-knowledge test (12 vs. 10, $p = 0.005$).
(Ohgushi et al., 2019) (58)	**Anticoagulant type:** Warfarin **Intervention:** During multidisciplinary ambulatory anticoagulation service (MAAS), Pharmacist assessed warfarin adherence, diet, co medications, lifestyle, adverse reactions with reference to the PT-INR value measured before the interview. **Control:** Received usual care before implementation of (MAAS) **Measurement:** TTR assessment.	830 Days	78	The median TTR increased significantly ($p < 0.05$) from 57 % during the pre-MAAS period to 77 % during the MAAS period.
(Patino et al., 2019)(52)	**Anticoagulant type:** Warfarin **Intervention:** Warfarin education videos include the brand names, mechanism of action, indications, missed doses handling, shapes and colours of warfarin tablets, INR monitoring, dietary interactions, and symptoms of thrombosis and bleeding and when to seek emergency medical attention. **Control:** No control **Measurement:** Mean in clinic visit times.	14 Months	Pre-Intervention: 31 Post-Intervention 1 : 28 Post-Intervention 2:18	Mean in clinic visit times were not significantly decreased from Pre-Intervention to Post-Intervention 1 (53 min vs 47 min, $p = 0.387$). Mean in clinic visit times were significantly reduced from Preintervention to postintervention 2 (53 min vs 39 min, $p = 0.001$).
(Izzettin et al., 2019) (54)	**Anticoagulant type:** Warfarin **Intervention:** Patients received patient education, consultation on lifestyle and anticoagulant usage issues from a pharmacist. **Control:** No control **Measurement:** The Oral Anticoagulation Knowledge (OAK) Test, Short Form-36 (SF-36) and Duke Anticoagulation Satisfaction Scale (DASS) were applied before and after. Maintenance of INR within the target range and complication rates.	3 Months	25	The positive impact of pharmacist counselling and education on therapeutic results were demonstrated. At baseline, only 48 % of patients achieved target INR value compared with 88 % of patients achieved target INR value post intervention ($p = 0.027$). Pretest and posttest results of the patients revealed statistically significant improvements on the physical and mental score components of the SF-36 ($p = 0.001$; $p = 0.001$), OAK test scores ($p \leq 0.001$) and the (negative) "limitations" and "burdens" and "positive effects" components of the DASS ($p = 0.005$; $p < 0.001$; $p = 0.001$). During the study, 4 % of patients had an emergency room visit due to bleeding.
(Cao et al., 2020)(10)	**Anticoagulant type:** Warfarin **Intervention:** A warfarin teaching booklet followed by face-to-face education for patients. **Control:** No control **Measurement:** Patients were instructed to complete the AKA questionnaire independently; INR values were	3 Months	383	There were significant correlations between patients' educational level and total questionnaire score ($P = 0.001$). There were significant correlations between total questionnaire score and time in therapeutic range ($P < 0.001$), or percentage of international normalized ratio measurements within range ($P < 0.001$).

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References	Anticoagulant type- Intervention- Control- Measurement	Follow up period	Participants	Outcomes
	collected from hospital databases and telephone follow up. TTR values were calculated.			
(Lim et al., 2020) (41)	**Anticoagulant type:** Rivaroxaban **Intervention:** pharmacists provide ample anticoagulant supply and educate on DVT risks through a program offering a "Rivaroxaban after-hours pack" containing a patient information booklet. **Control:** No control **Measurement:** Measured bleeding episodes; clinically significant bleeding and clinically relevant nonmajor bleeding.	33 Months	120	Twelve patients (10.0 %) presented with clinically relevant nonmajor bleeding. There was no clinically significant bleeding.
(Dreijer et al., 2020) (44)	**Anticoagulant type:** OAC **Intervention:** Implementation of a multidisciplinary antithrombotic team including pharmacist who provided information and education to patients about antithrombotic therapy. **Control:** Received usual care before implementation of a multidisciplinary antithrombotic team. **Measurement:** Proportion of bleeding or thrombotic event after hospitalization.	13 Months	Intervention group: 815 Control group: 727	No significant effect on patients treated with VKA in relation to bleeding and thrombotic events between the usual care period (14.8 %) and intervention period (13.4 %) and (odds ratio [OR], (95 % CI) 0.90 (0.64–1.23). No significant effect on patients treated with DOAC in relation to bleeding and thrombotic events between the usual care period (10 %) and intervention period (12.5 %) (odds ratio [OR], (95 % CI) 1.29 (0.57–2.92).
(Liang et al., 2020) (29)	**Anticoagulant type:** Warfarin **Intervention:** Receive pharmacist led education and follow-up service (PEFS). **Control:** Receive usual care **Measurement:** Knowledge level of warfarin therapy was assessed by a 10- item questionnaire at 30 days post discharge. Anticoagulation control was calculated as the proportions of time in the therapeutic range (TTR) and time within the expanded target range (TER).	6 Months	Intervention group: 77 Control group: 75	One month after discharge, the PEFS group had better warfarin knowledge by answering 57.5 % of questions, compared with the UC group (43.0 %), ($P = 0.003$). The PEFS group spent more TER than the UC group, six months after hospital discharge, ($P = 0.024$). TTR was not significantly different between the groups (35.9 % vs 29.5 %, $p = 0.203$).
(Metaxas et al., 2020) (16)	**Anticoagulant type:** OAC **Intervention:** Chronic oral anticoagulant patients were invited for a regular medication review (MR) service in Swiss community pharmacies, "Polymedication-Check" (PMC). Semistructured interview of formulated open-ended questions about OAC therapy. **Control:** No control **Measurement:** OAC knowledge was assessed with seven newly generated items asked face-to-face during a PMC and by telephone.	14 Days	81	At baseline, OAC patients ($n = 31$) had more knowledge gaps than VKA patients ($n = 50$; $p < 0.05$). After PMC, patients with one or more knowledge gaps decreased significantly from 66.0 % at baseline to 31.3 % at follow-up ($p < 0.001$). Most patients (98.6 %) were satisfied with the counselling provided by the pharmacists.
(Patel et al., 2020) (38)	**Anticoagulant type:** Rivaroxaban & Warfarin **Intervention:** During the DOAC education class, patients are educated on the importance of adherence and bleeding risk, and are individually evaluated for prescription coverage, appropriateness of therapy, laboratory monitoring. **Control:** Received nurse-led hospital-based warfarin monitoring clinic. **Measurement:** Proportion of patients on either warfarin or rivaroxaban with at least 90-day persistence, defined as a consistent refill for 90 days, 90 - day hospital readmission or emergency department (ED) visits, and 90-day persistence in patients attended the DOAC education class, defined as a consistent refill for 90 days.	90 Days	Intervention group:236 control group: 78	Persistence to anticoagulation for 90 days did not differ significantly among patients on rivaroxaban versus warfarin (45 % vs 53 %, $p = 0.2678$). A 90-day readmission was similar among patients on rivaroxaban and on warfarin (21 % vs 24 %, $p = 0.5574$) No significant differences in patients with ED visits within 90 days between the two groups (34 % vs 23 %, $p = 0.4719$). In intervention group, patients attended the DOAC education class, had increased 90-day persistence to therapy compared to patients who did not participate (73.6 % vs 28.9 %, $p = 0.0001$).
(Roseau et al., 2020) (17)	**Anticoagulant type:** OAC **Intervention:** Two face-to-face interviews during hospitalization on day 0 (D0) to build patient knowledge for optimum treatment through a standardized structured interview guide using open-ended questions. Information leaflets including drug guidelines were used during the interview and at home. and day 1 (D1) targeting weak points identified on D0 and two additional phone interviews one and six months after discharge (M1&M6) was conducted using the same standardized structured interview guide used on D0. The learning process was designed to enhance patient knowledge and understanding based on 10 cognitive or self-management skills, relating to the optimization of oral anticoagulant therapy management. **Control:** No control **Measurement:** The median patient knowledge score was evaluated at each interview of the process.	6 Months	102	Median knowledge scores after pharmaceutical counselling were 8, 8.5 and 9 at D0, M1 and M6, respectively. Improvements were significant between D0 and M1 ($p = 0.0096$) and D0 and M6 ($p = 0.0003$).
(Saw et al., 2020) (37)	**Anticoagulant type:** Warfarin **Intervention:** Patients received warfarin education via telephone call.	6 Months	Intervention group: 76 Control group: 76	The mean TTRs was not statistically significant between face-to-face and telephone consultations (TTR: 65.7 % vs 64.6 %, $P = 0.853$).

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References	Anticoagulant type- Intervention- Control- Measurement	Follow up period	Participants	Outcomes
	Control: Patients received face to face warfarin education. **Measurement:** The mean TTRs			
(Shilbayeh, 2020) (23)	**Anticoagulant type:** Warfarin **Intervention:** Patients watched an educational video containing basic information about warfarin for 10 min and received relevant informative booklets. **Control:** No control **Measurement:** Oral Anticoagulation Knowledge Assessment (AKA) before and after intervention. The Anti-Clot Treatment Scale (ACTS).	52 Days	85	The knowledge score at baseline was 52.6 ± 17.2 (mean ± SD), and 70.3 ± 10.0 (mean ± SD) post intervention, reflecting significant improvement in patient knowledge scores ($p < 0.000$). The patients had significant increases in their ACTS scales scores ($P = 0.004$).
(Li et al., 2020) (24)	**Anticoagulant type:** Rivaroxaban **Intervention:** Pharmacist led education and follow-up service (PEFS) group: consisted of observation of drug interactions with rivaroxaban, embolic complications management. medication education materials were distributed to patients. **Control:** Received usual care **Measurement:** Incidences of bleeding complications.	90 Days	Intervention group: 179 Control group: 202	The cumulative incidences of bleeding complications, such as gastrointestinal tract and skin ecchymosis, were significantly higher in the UC group (12.4 % vs. 6.1 %, $P = 0.038$; 4.5 % vs. 0.6 %, $P = 0.018$).
(Alhmoud et al., 2021) (36)	**Anticoagulant type:** Warfarin **Intervention:** Teleconsultation by pharmacist to patients on dosing regimen and next follow-up appointment, and reinforced patient education about warfarin. **Control:** No control **Measurement:** TTR before and after service transition**.** The percentage of visits with INR values within therapeutic range.	12 Months	108	There was no statistically significant difference in mean TTR before and after service transition (82.3 ± 19.4 before vs 83.4 ± 18.4 after; $P = 0.67$). The percentage of visits with INR values within therapeutic range was comparable between the traditional and new service (68.4 % ± 16.9 vs 64.3 % ± 16.8, $P = 0.06$).
(Falamić et al., 2021) (28)	**Anticoagulant type:** Warfarin **Intervention:** Patients educated about warfarin therapy and provided with a follow-up plan and pillbox. **Control:** Received standard care **Measurement:** Use of Croatian-adapted DASS questionnaire (Cro-DASS) to measure the health-related quality of life (HRQoL).	6 Months	Intervention group: 65 Control group: 66	Participants in the intervention group scored significantly lower (median being 66.0 vs 86.5 in the control groups, $p < 0{,}001$), indicating higher HRQoL.
(Jiang et al., 2021) (25)	**Anticoagulant type:** Warfarin **Intervention:** Remote warfarin management model using Yixing app. Patients offered continuous medication education about warfarin therapy. **Control:** Traditional pharmacy services. **Measurements:** Patients' awareness on warfarin therapy score obtained from questionnaire. medication Adherence: the percentage of days that correct warfarin dose was taken in the monitored period**.** Fraction of time in therapeutic range (FTTR).	6 Months	Intervention group: 66 Control group: 64	The median score of the patient awareness in the intervention group was 8.00, which was significantly higher than that in the control group, 6.50, ($p = 0.001$). No significant difference in the percentage of the correct-warfarin-taken days between the two groups (72 % intervention vs 78 % control group, $p = 0.520$). FTTR was (80.3 % in intervention group vs 72.1 % in control group, $p = 0.033$).
(Karaoui et al., 2021) (18)	**Anticoagulant type:** OAC **Intervention:** Patients received standard nursing counselling and pharmacist counselling. **Control:** patients received only standard nursing counselling. **Measurement:** Readmission rate and bleeding events. Mortality rate at 30 days post discharge.	30 Days	Intervention group:100 Control group: 100	There was no significant difference in readmission rates between intervention and control group on day 30 (15 versus 12, $p = 802$). No significance difference between intervention and control group in bleeding events within 30 days postdischarge (14 versus 17; $p = 0.700$), respectively. No significant difference in mortality rate at 30 days postdischarge (2 patients in the intervention versus 4 patients in the control group; $p = 0.724$).
(Kanafileskookalayeh & Bhojan, 2021) (26)	**Anticoagulant type:** Warfarin & Acenocumarol **Intervention:** Pharmacist provided effective counselling regarding therapy and dietary modifications. **Control:** Patients received usual care by physicians. **Measurement:** Monitor of INR.	6 Months	70	In the preintervention group 45.78 % of INRs were within the therapeutic range, while in the postintervention group it was 64.25 % ($p < 0.0001$).
(Marcatto et al., 2021) (43)	**Anticoagulant type:** Warfarin **Intervention:** Patients received comprehensive pharmaceutical care for 12 weeks, covering correct medication administration, education and comorbidities, INR assessment, warfarin dose adjustments, and monitoring for interactions and adherence. **Control:** Receive usual medical care before pharmaceutical care. **Measurement:** Pharmacist assessed the adherence by counting pills. Compared TTR values at different times within the adherence groups (baseline, 12 weeks and 1 year).	12 Months	262	160 patients were high adherent; 71 patients were medium adherent and 31 patients were low adherent. High adherent group have higher TTR than other groups (0.614 ± 0.215 versus 0.490 ± 0.235 versus 0.359 ± 0.199, $p < 0.001$; high, medium and low adherence, respectively). There was a statistically significant difference between the three TTR means within the adherence group (High adherence: 0.137 ± 0.158 versus 0.614 ± 0.215 versus 0.608 ± 0.226, $p < 0.001$; Medium adherence: 0.117 ± 0.159 versus 0.490 ± 0.235 versus 0.517 ± 0.209, $p < 0.001$; Low adherence: 0.158 ± 0.174 versus 0.359 ± 0.199 versus 0.467 ± 0.208, $p < 0.001$, basal versus 12 weeks versus 1 year after, respectively.

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References	Anticoagulant type- Intervention- Control- Measurement	Follow up period	Participants	Outcomes
(Lin et al., 2021) (27)	**Anticoagulant type:** Warfarin **Intervention:** At baseline, the anticoagulant clinics (ACC) pharmacist provided extensive warfarin counselling with an education kit, including a booklet about warfarin use, a pillbox, and a warfarin dosage instruction sheet to facilitate patients' understanding of warfarin use and to reinforce medication adherence. **Control:** No control **Measurement:** Patients completed a self-administered questionnaire before and after the ACC service to assess changes in warfarin knowledge.	60 Days	148	A significant improvement in the knowledge of warfarin use was observed (baseline: 6.3 ± 3.2, follow-up 9.2 ± 1.8, $p < 0.001$).
(Young et al., 2021) (42)	**Anticoagulant type:** Warfarin **Intervention:** Randomized adult participants received e-learning mode of education by pharmacist **Control:** Randomized adult participants to whom warfarin had been prescribed received face to face education. **Measurement:** Validated Oral Anticoagulation Knowledge (OAK) test.	17 Days	Intervention group: 27 Control group: 27	E-learning group had median correct OAK test scores of 85 % compared to 80 % for standard education group ($p = 0.14$). The results of education delivered via pharmacist-facilitated e-learning was noninferior compared to standard pharmacist-delivered education. All of participants were satisfied with the received information.
(Bakey & Nguyen, 2022) (35)	**Anticoagulant type:** DOAC **Intervention:** Pharmacist provided a comprehensive counselling session included information on indication, dosing, administration, and adverse reactions. Patients provided written discharge instructions. **Control:** Received usual care **Measurement:** Rate of medication errors including incorrect dose, no anticoagulation on discharge, medication not covered by funding source, duplicate anticoagulation and drug disease interaction. Hospital admission for VTE or bleeding within 30 days.	10 Months	Intervention group:14 control group: 44	Rate of medication errors were lower in the intervention group (7.1 % vs 36.4 %, $p = 0.046$) Readmission for a VTE or bleeding within 30 days was lower in intervention group (7.1 % vs 20.5 %, $p = 0.424$).
(Jiang et al., 2022) (34)	**Anticoagulant type:** Warfarin **Intervention:** Pharmacist educate patients through Alfalfa application about the basic knowledge of warfarin therapy, including the individualized INR therapeutic range, how to adjust the dose, detection of abnormal bleeding. **Control:** Offline patient received basic knowledge of warfarin therapy and obtained INR results from clinics and adjusted the dosage by local physicians. **Measurement:** Assessed by the TTR, minor and major bleeding and thrombotic events. Warfarin related hospital visits and Warfarin-related hospital admissions.	3 Months	Intervention group:57 Control group: 60	The TTR was significantly lower in the offline group than in the online group (39.6 % vs. 61.0 %, $P < 0.01$). Minor bleeding events and warfarin-related emergency hospital visits were higher in offline group (28.3 % vs. 5.3 %, $P < 0.01$) & (23.3 % vs. 1.8 %, $P = 0.02$), respectively. Major bleeding and thrombotic events, and warfarin-related hospital admissions were not significantly different between the two groups ($P > 0.99$).
(Merks et al., 2022) (30)	**Anticoagulant type:** Dabigatran **Intervention:** Patients experienced standard practice plus education delivered by pharmacist. **Control:** Patients experienced standard practice in the delivery of medication information **Measurement:** Medication adherence assessed on day 7, day 21, and day 90 after initiation of Dabigatran, measured by missed doses/days and the number of doses/days, which were combined to assess full adherence.	3 Months	Intervention group:153 Control group: 172	Patients in the Intervention group were more adherent (mean days on Dabigatran/week) than Control Group: - At 7 days (6.0 ± 0.9 vs 5.4 ± 1.1, $p < 0.0001$). - At 21 days (5.6 ± 1.0 vs 4.9 ± 1.3, $p < 0.0001$). - At 90 days (5.5 ± 1.3 vs 4.4 ± 2.0, $p < 0.0001$).
(Navin et al., 2022) (39)	**Anticoagulant type:** Rivaroxaban and Apixaban **Intervention:** Pharmacists educate patients about DOAC renal adjustment, drugs and alcohol interactions, adherence and bridging education. **Control:** No control **Measurement:** Medication adherence was measured using a medication possession ratio (MPR); sum of the total day supply of medication during a defined period of time divided by the number of days elapsed during that period of time.	6 Months	50	Patients followed up by anticoagulation management services (AMS) had an average MPR of 91 %.
(Shiga et al., 2022) (31)	**Anticoagulant type:** Edoxaban and Apixaban **Intervention:** patients received an educational program include motivational interviewing about adherence to DOAC based partnership, acceptance, compassion, and evocation. **Control:** Received standard counselling. **Measurement:** Medication adherence rate.	6 Months	Intervention group: 134 Control group: 134	Both groups had high adherence rates, (mean [SD], 92.9 % [12.3 %] and 94.5 % [11.0 %], $p = 0.259$).
(Pham et al., 2022) (40)	**Anticoagulant type:** DOAC **Intervention:** The pharmacist met patients at first tele-visit, 31–60 and 61–90 days from randomization, provided education about adverse effects, drug interactions alarm symptoms to report.	7 Months	Intervention group: 233 Control group: 203	Knowledge scores were similar for the intervention patient's vs control patients (63.7 % vs 62.2 %).

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References	Anticoagulant type- Intervention- Control- Measurement	Follow up period	Participants	Outcomes
	Control: Patients did not receive pharmacist education **Measurement:** Assessed patients' DOAC related knowledge using 15 items adapted from a questionnaire of AC knowledge.			
(Wilson et al., 2023) (32)	**Anticoagulant type:** DOAC **Intervention:** An adapted DOAC checklist was developed to confirm the appropriate use and dose of DOAC medications, ensure medication access and education for the patient, and establish sufficient protocols for the transition of care from the ambulatory setting to the patient's home. Pharmacist consultation and educational materials were provided to patients. **Control:** Didn't receive pharmacist consultation. **Measurement:** Medication possession ratio (MPR) at 90 days, included MPR and proportion of days covered (PDC) at 180 and 365 days.	365 Days	Intervention group: 211 Control group: 216	Intervention group had approximately the same distribution of MPR (9.3 % vs 10 %) less than 80 % at 90 days. Neither MPR nor PDC at 180 and 365 days showed a statistically significant difference between intervention and control subjects.
(Bonsu et al., 2023) (33)	**Anticoagulant type:** OAC **Intervention:** Patients attended an Adult Outpatient Thrombosis Service (TS) may receive education on their anticoagulants, including printed and verbal information. **Control:** No control. **Measurement:** Adherence to oral anticoagulant therapy was assessed using the 12-item validated Adherence to Refills and Medications Scale (ARMS) score.	19 Months	399	Self-reported adherence to anticoagulation therapy using the 12-item ARMS was 3.6 % higher for patients on DOACs than warfarin (90.9 % versus 87.3 %, $p = 0.385$).
(Dhande P et al., 2024)	**Anticoagulant type:** Warfarin **Intervention:** Education on drug-drug and food-drug interactions through patient education leaflets. Education of patients on warfarin about importance of monitoring of INR **Control:** No control **Measurement:** knowledge on warfarin interactions	12 Months	84	-Patient's awareness about warfarin interactions was found to be significantly increased from 61.5 % to 100 % ($p < 0.01$).
(Thomas et al., 2024)	**Anticoagulant type:** Warfarin & acenocoumarol **Intervention:** Patient Information Leaflets (PILs) designed for education, patients received pharmaceutical counselling on VKAs therapy from the clinical pharmacist including, discussions about its adverse effects and explanations regarding its influence on INR. **Control:** Receive usual care **Measurement:** Evaluate the pre-intervention knowledge scores of patients in both the control and intervention groups. -Comparison of total pre-test and post-test AKA scores percentage changes in control and intervention. - Comparison of mean INR range between both control and intervention group.	3 Months	Intervention group: 51 Control group: 51	-In baseline, there were no substantial difference between the control and intervention groups, (p-value = 0.0587). After the intervention, a significant distinction in knowledge scores was observed between the control and intervention groups, (p-value = 0.0001). -The intervention group pre-test and post-test AKA scores ($p = 0.0001$), the control group pre-test and post-test AKA scores (p-value = 0.1406). - There was significant difference in INR (2.28 ± 0.25 vs 2.52 ± 0.21, p-value = 0.0001) between the intervention and control group respectively.
(Wongkornrat et al., 2024)	**Anticoagulant type:** Warfarin **Intervention:** Use of a smartphone drug reminder application to assist patients in maintaining therapeutic INR levels **Control:** Received usual care **Measurement:** Time in Therapeutic Range (TTR)	6 Month	Intervention group: 13 Control group: 16	- The mean TTR was (67.65 ± 1.32 vs 65.77 ± 1.32, p-value = 0.323) for the intervention group and for the control group respectively.
(W. Xu et al., 2024)	**Anticoagulant type: OACs** **Intervention:** Pharmacist-led intensive, targeted education focusing on knowledge deficits identified by the Jessa Atrial Fibrillation Knowledge Questionnaire (JAKQ). The education was limited to 30 min. **Control:** Received usual care **Measurement:** **-** Knowledge levels assessed using the JAKQ. - Medication adherence was assessed by Morisky Drug Adherence Scale-8 (MMAS-8). **-**Medication satisfaction was assessed by Medication Satisfaction Questionnaire II (TSQM-II). - Risk of bleeding	12 Months	Intervention group: 181 Control group: 180	-Baseline scores for knowledge levels were similar between the intervention (mean ± SD: 31.0 ± 20.9 %), and control groups (mean ± SD: 31.3 ± 21.3 %; $P = 0.911$). - Compared with the standard care group, the knowledge level of the education group was significantly increased in 1 month (68.8 % vs. 37.5 %; $P < 0.001$) and 3 months (81.3 % vs. 37.5 %; $P < 0.001$). - After 3 months, the education group had a significantly higher level of adherence than the standard care group [7.75 (6.75–8.00) vs. 6.50 (5.50–6.75); $P < 0.001$]. - The four dimensions of the TSQM-II questionnaire differed significantly between the two study groups at 3 months. Compared with the standard care group, the education group had higher satisfaction scores in treatment effect [66.7 (52.1–83.3) vs. 50.0 (50.0–66.7); $P < 0.001$], side effect [100 (83.3–100) vs. 91.0 (83.3–100); $P = 0.002$], treatment convenience [66.7 (55.6–72.2) vs. 55.6 (44.4–66.7); $P < 0.001$], and overall satisfaction [66.7

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References	Anticoagulant type- Intervention- Control- Measurement	Follow up period	Participants	Outcomes
				(58.3–75.0) vs. 58.3 (50.0–66.7); P < 0.001] - Compared with standard care, pharmacist education is associated with a significantly reduced risk of bleeding (adjusted odd ratio (AOR) = 1.625 95 % CI: 1.037–2.548, P = 0.034)

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