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Evaluation of Patients' Knowledge and Practice of Warfarin: A Pre–Post Health Educational Intervention in River Nile State, Sudan (2024–2025)

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Abstract

This quasi-experimental pre–post interventional study evaluated the effect of a structured health education program on patients' knowledge and practice related to warfarin therapy in River Nile State, Sudan, during 2024–2025. Adult outpatients receiving warfarin for at least one month were enrolled using consecutive sampling and assessed before and after the intervention. A total of 150 participants completed both assessments. Data were collected using a structured interviewer-administered questionnaire covering key knowledge domains (indications, adherence, drug and food interactions, adverse effects, missed-dose management, and monitoring requirements) and self-reported practice behaviors. The intervention consisted of standardized face-to-face educational sessions supported by printed materials. Changes in knowledge and practice scores were analyzed using appropriate paired statistical tests. At baseline, most participants demonstrated poor warfarin-related knowledge despite high self- reported adherence. Following the educational intervention, there was a marked improvement across nearly all knowledge domains, with the mean knowledge score more than doubling and the majority of participants transitioning to a good knowledge category. Improvements were particularly notable in awareness of drug and food interactions, recognition of warning signs, and appropriate management of missed doses. Self-reported adherence remained high before and after the intervention, suggesting a ceiling effect. Overall, the study demonstrates that a brief, structured educational intervention is a feasible and effective approach to substantially improving warfarin-related knowledge in a low-resource outpatient setting, highlighting the importance of integrating patient education into routine anticoagulation care to enhance medication safety.

Keywords: Warfarin, Anticoagulation therapy, Patient education, Knowledge and practice, Health education intervention, INR monitoring, Sudan, River Nile State.

INTRODUCTION

Anticoagulation therapy is a major global public-health intervention for preventing avoidable thromboembolic morbidity and mortality, including stroke prevention in atrial fibrillation, treatment and secondary prevention of venous thromboembolism, and thromboprophylaxis in patients with mechanical heart valves, but its population benefit depends on safe long-term use and sustained monitoring systems [Ortel TL *et al*, 2018]. Warfarin remains widely used in many low- and middle-income countries because of affordability and broad indications, yet it has a narrow therapeutic index, clinically important pharmacokinetic and pharmacodynamic variability, and extensive drug–drug and food–drug interactions that make subtherapeutic anticoagulation (risking thrombosis) and supratherapeutic anticoagulation (risking bleeding) persistent hazards without regular INR monitoring and responsive dose adjustment [Holbrook AM *et al*, 2005] [Ortel TL *et al*, 2018]. International guidelines consistently frame warfarin as effective when monitoring infrastructure and patient engagement are adequate, emphasizing individualized risk–benefit assessment, clear patient counseling, and maintenance of INR within indication-specific targets as a core safety requirement [Hindricks G *et al*, 2021] [Lip GYH *et al*, 2018]. The importance of anticoagulation quality has

been demonstrated across large trials and registries: analyses show that clinical benefit from oral anticoagulation varies with the quality of INR control at the center and country level (often summarized as time in therapeutic range, TTR), and that between-region variability in TTR is substantial, reinforcing that "effective warfarin therapy" is inseparable from system performance and patient follow- up [Connolly SJ *et al*, 2008] [Wallentin L *et al*, 2010] [Singer DE *et al*, 2013] [Oldgren J *et al*, 2014]. In parallel, rheumatic heart disease remains an important driver of anticoagulation need in many parts of Africa through valve disease and valve surgery, and registry evidence has documented both complications and gaps in evidence-based interventions in rheumatic heart disease populations, highlighting the ongoing relevance of warfarin in contexts where mechanical valves and valvular atrial fibrillation remain common [Zühlke L *et al*, 2015]. Patient knowledge and practice are increasingly recognized as modifiable determinants of safe warfarin use, and validated instruments including the Oral Anticoagulation Knowledge Test (OAK) and other structured knowledge tools have been developed to quantify understanding of indications, dosing, missed-dose responses, interaction risks, and INR monitoring requirements, enabling targeted education and evaluation in clinical research [Zeolla MM *et al*, 2006] [Briggs AL *et al*, 2005]. Across diverse outpatient settings, studies repeatedly document knowledge gaps about warfarin administration, interaction precautions, and recognition of bleeding danger signs, and early evidence linking knowledge deficits to unsafe behaviors (e.g., inappropriate over-the-counter medicine use, inconsistent dietary vitamin K intake, and delayed reporting of symptoms) supports the rationale for structured education as a safety intervention rather than a purely informational activity [Taylor FC *et al*, 1994] [Shrestha S *et al*, 2015] [Yiu AW *et al*, 2018]. Syntheses further suggest that higher patient knowledge is associated with better anticoagulation quality metrics, although the magnitude of effect varies by setting and by whether education is integrated with accessible INR testing and timely dose adjustment, indicating that education is most effective when embedded in functional care pathways [de Oliveira-Filho AD *et al*, 2023]. Interventional evidence nevertheless shows that structured education can meaningfully improve knowledge scores and selected self- management behaviors; for example, randomized and controlled evaluations have reported improvements in warfarin knowledge after one-to-one education supported with written materials, and the TREAT randomized trial demonstrated improved anticoagulation control through a targeted educational and behavioral intervention in atrial fibrillation patients starting warfarin, illustrating that education can translate into clinically relevant INR outcomes under appropriate implementation conditions [Baysal E *et al*, 2018][Clarkesmith DE *et al*, 2013]. In sub-Saharan Africa, achieving stable warfarin therapy is frequently constrained by centralized services, limited access to INR testing, stock-outs, long turnaround times for laboratory results, workforce shortages, and variable availability of structured anticoagulation clinics; a detailed regional review emphasizes that these access barriers interact with low patient and provider anticoagulation knowledge to produce persistently poor control and preventable adverse events, motivating "warfarin care bundle" approaches that combine education with service reorganization and monitoring access [Mouton JP *et al*, 2021]. Empirically, pooled regional estimates underscore the scale of the challenge: a recent systematic review and meta-analysis of studies from sub-Saharan Africa reported low overall quality of anticoagulation, with therapeutic INR achieved in a minority of measurements and a low pooled prevalence of good TTR, indicating that many patients spend substantial time outside therapeutic ranges and are therefore exposed to avoidable bleeding and thromboembolic risks [Demsie DG *et al*, 2025]. Country-level studies echo this pattern while also showing that improvement is possible: pharmacist-managed anticoagulation models in resource-constrained African settings have reported measurable performance outcomes, and observational work from South Africa and Ethiopia highlights that poor anticoagulation control is common in routine services, reinforcing the need for scalable interventions that strengthen both patient knowledge and follow-up systems [Manji I *et al*, 2011] [Ebrahim I *et al*, 2018][Fenta TG *et al*, 2017] [Daba FB *et al*, 2016]. In Sudan, peer-reviewed evidence remains limited and concentrated in selected tertiary facilities rather than state-level health systems, but available studies indicate important vulnerabilities relevant to patient practice and safety, including demonstrated benefit of clinical pharmacist involvement in anticoagulation services and a high burden of warfarin-related drug- interaction risk in cardiac patients, both of which strengthen the case for structured education emphasizing interactions, symptom recognition, and adherence to INR monitoring schedules [Ahmed NO *et al*, 2017] [Hassaballa I *et al*, 2024]. For River Nile State specifically, there is a scarcity of published data describing warfarin users' baseline knowledge and practice, the accessibility and continuity of INR monitoring (including laboratory capacity and travel burden), and the effectiveness of locally delivered educational interventions; in addition, broader health-system disruptions documented in official situation reporting may plausibly exacerbate chronic-care follow-up barriers, making context-adapted education and feasible monitoring pathways particularly salient in Sudanese states outside major tertiary centers [World Health Organization, 2023]. Accordingly, this study was conducted to evaluate patients' knowledge and practice of warfarin and to assess the effect of a structured pre–post health educational intervention among warfarin-treated patients in River Nile State, Sudan, during 2024–2025, generating locally actionable evidence to guide clinicians, public-health planners, and policymakers on whether education measurably strengthens INR-related

self-care behaviors in a low-resource setting where monitoring access and health literacy may constrain safe anticoagulation [Mouton JP *et al*, 2021] [Demsie DG *et al*, 2025]. The novelty and added value lie in producing state-level, pre–post intervention evidence from River Nile State using structured measurement of warfarin knowledge and practice in a real-world service context where such data are scarce, thereby informing pragmatic anticoagulation safety strategies and supporting scalable patient-centered interventions for Sudan and comparable settings [Ahmed NO *et al*, 2017] [de Oliveira-Filho AD *et al*, 2023]. The primary objective of this study is to determine whether a structured health educational intervention improves warfarin users' knowledge score and INR-related practices (primary outcomes: pre–post change in knowledge score and pre–post change in reported monitoring/safety practices) in River Nile State, Sudan (2024–2025)

1. MATERIALS AND METHODS

1.1 Study Design

A quasi-experimental (pre–post) interventional study was conducted to assess changes in patients' knowledge and practice of warfarin following a structured health education intervention. The same participants were evaluated at two time points: baseline (prior to the intervention) and follow-up (Post the intervention). Participants served as their own controls. No randomization or parallel control group was included.

1.2 Study Setting and Study Period

The study was carried out in outpatient healthcare facilities providing follow-up care for patients receiving oral anticoagulant therapy in River Nile State, Sudan. Data collection was conducted between from October 2024 to November 2025. Individual healthcare facilities were not identified by name.

1.3 Study Population

The study population comprised adult patients receiving warfarin therapy who attended the participating outpatient clinics during the study period. Healthcare professionals and prescribers were not included as study participants.

1.4 Eligibility Criteria

1.4.1 Inclusion Criteria

- Adults aged 18 years or older
- Receiving warfarin therapy for at least one month prior to enrollment
- Able to provide informed consent

1.4.2 Exclusion Criteria

- Cognitive impairment that precluded reliable completion of the questionnaire
- Critical illness at the time of recruitment
- Refusal to participate or withdrawal of consent

Eligibility criteria were applied prior to enrollment and were not modified during the study.

1.5 Sample Size Determination

The sample size was calculated for a before–after (paired) design using the paired means formula appropriate for pre–post comparisons:

$$n = \frac{(Z_{1-\alpha/2} + Z_{1-\beta})^2 \times \sigma^2 d}{\delta^2}$$

where n is the required number of paired observations, $Z_{1-\alpha/2}$ corresponds to the two-sided confidence level, $Z_{1-\beta}$ corresponds to study power, σ_d is the standard deviation of the within- subject differences, and δ is the expected mean change in the primary outcome (knowledge score).

A 95% confidence level (α = 0.05; $Z_{1-\alpha/2}$ = 1.96) power ($Z_{1-\beta}$ = 0.84) were specified. In the absence of prior local estimates for σ_d and δ,a moderate standardized effect size (Cohen's d = 0.5) was assumed for planning purposes. Based on this assumption, the minimum required number of complete paired observations was calculated, and the estimate was inflated to account for anticipated loss to follow-up.

After applying the dropout adjustment, the final target sample size was set at 150 patients, which was achieved during the study period.

1.6 Sampling Technique

A consecutive sampling approach was employed. All eligible patients attending the participating outpatient clinics during the recruitment period were approached sequentially and invited to participate until the predetermined sample size was reached. No probability-based sampling methods were applied.

1.7 Data Collection Instrument

Data were collected using a structured interviewer-administered questionnaire developed specifically for this study. The questionnaire consisted of two main domains:

- **Knowledge domain:** Items assessing understanding of warfarin indication and use, importance of adherence, common food and drug interactions, recognition of bleeding warning signs requiring medical attention, missed-dose management, and the need for regular monitoring.
- **Practice domain:** Items assessing self-reported medication-taking behavior, disclosure of concomitant medications (including over-the-counter and herbal products), and follow-up practices.

The questionnaire was administered to the same participants at baseline (immediately before the educational intervention) and at follow-up (after the intervention). Each correct knowledge response or safer reported practice was scored as 1, while incorrect, unsafe, or "don't know" responses were scored as 0. Domain scores were calculated by summing item scores, with higher scores indicating greater knowledge or safer practice. Formal psychometric validation and reliability testing were not performed; therefore, the instrument was not described as validated.

1.8 Health Education Intervention

A standardized health education intervention was provided to all enrolled participants. The intervention comprised face-to-face educational sessions conducted either individually or in small groups within the clinical setting. Each session lasted approximately 30–45 minutes and was delivered by trained educators, including general practitioners and pharmacists, who received study-specific training to ensure consistency and standardization in content delivery. The educational content included:

- Purpose and safe use of warfarin
- Importance of medication adherence
- Common food and drug interactions
- Recognition of bleeding symptoms and indications for seeking medical care
- Management of missed doses
- Importance of regular follow-up and communication with healthcare providers Printed educational materials summarizing key messages were provided to participants. No changes were made to prescribed warfarin therapy as part of the intervention.

1.9 Outcome Measures

1.9.1 Primary Outcomes

- Change in warfarin-related knowledge score between baseline and follow-up
- Change in reported warfarin practice score between baseline and follow-up

1.9.2 Secondary Outcomes

- Self-reported monitoring and follow-up behaviors

No laboratory parameters or clinical efficacy outcomes were predefined as primary endpoints.

1.10 Data Management and Statistical Analysis

Data were entered into a secure electronic database and checked for completeness and consistency. Statistical analyses were performed using SPSS version 26. Descriptive statistics were used to summarize participant characteristics, with categorical variables presented as frequencies and percentages and continuous variables as means and standard deviations or medians and interquartile ranges, as appropriate.

Normality of paired differences was assessed prior to inferential analysis. Paired *t*-tests were applied for approximately normally distributed paired scores, while Wilcoxon signed-rank tests were used for non-normally distributed paired data. McNemar's test was used for paired categorical variables. All statistical tests were two-sided, and a p-value of <0.05 was considered statistically significant. No interpretation of statistical findings was included in this section.

1.11 Ethical Considerations

Ethical approval was obtained from the relevant institutional ethics committee prior to study initiation. Written informed consent was obtained from all participants. Participation was voluntary, and confidentiality was maintained through anonymized data handling and secure data storage. The study was conducted in accordance with the principles of the Declaration of Helsinki. No animals were involved in this study.

2. RESULTS AND DISCUSSION

This quasi-experimental pre–post study evaluated changes in patients' knowledge and practice of warfarin following a structured health education intervention among 150 adult outpatients in River Nile State, Sudan.

1.12 Results

1.12.1 Participant Characteristics

As shown in Table 1, a total of 150 patients receiving warfarin therapy were included in the study. Females constituted the majority of participants (74.0%), while males represented 26.0%. The most common age group was 56–75 years (46.7%), followed by 38–55 years (26.7%). Participants aged 18–37 years and those older than 76 years each accounted for 13.3% of the sample. Regarding education level, 42.7% had primary or secondary education, and 34.7% had no formal education. Artificial heart valve replacement was the most frequent indication for warfarin therapy (33.3%). Baseline medication adherence was high, with 93.3% of participants classified as adherent.

Table 1: Socio-Demographic and Clinical Characteristics of Participants (N = 150)

Variable	*Category*	*n*	*%*
Gender	Female	111	74.0
	Male	39	26.0
Age group (years)	18–37	20	13.3
	38–55	40	26.7

Variable	*Category*	*n*	*%*
	56–75	70	46.7
	>76	20	13.3
Education level	No formal education	52	34.7
	Primary/Secondary	64	42.7
	University	29	19.3
	Postgraduate	5	3.3
Primary diagnosis	Artificial heart valve	50	33.3
	DVT / Pulmonary embolism	47	31.3
	Atrial fibrillation	42	28.0
	Stroke	8	5.3
Smoking status	Non-smoker	133	88.7
	Smoker	17	11.3
Medication adherence (baseline)	Adherent	140	93.3
	Non-adherent	10	6.7

1.12.2 Baseline Knowledge and Reported Practice (Pre-Intervention)

As shown in Table 2, baseline assessment revealed substantial gaps in warfarin-related knowledge and reported practice. Incorrect selection of ibuprofen or aspirin for headache management was reported by 65.3% of participants, while only 34.7% correctly identified paracetamol as the safe option. Awareness of drug–drug and herb–drug interactions was limited, with only 40.7% demonstrating correct knowledge in each domain. Knowledge of warfarin side effects was low, as 72.0% of participants were unaware of potential adverse effects. Misconceptions regarding warfarin safety during pregnancy were common, with 54.7% incorrectly identifying warfarin as safe. In contrast, awareness of the importance of medication adherence was high (93.3%).

Table 2. Baseline Knowledge and Reported Practice Related to Warfarin

Item	*Response*	*n*	*%*
Headache medication	Ibuprofen/Aspirin (incorrect)	98	65.3
	Paracetamol (correct)	52	34.7
Importance of adherence	Correct	140	93.3
	Incorrect	10	6.7
Drug interaction knowledge	Aware	61	40.7
	Not aware	89	59.3
Herbal interaction knowledge	Aware	61	40.7
	Not aware	89	59.3
Warfarin side effects	Aware	42	28.0
	Not aware	108	72.0
Warfarin safety in pregnancy	Unsafe (correct)	68	45.3
	Safe (incorrect)	82	54.7

1.12.3 Baseline Knowledge Classification

As shown in Table 3, most participants were classified as having poor knowledge (66.0%), while 34.0% were classified as having moderate knowledge. No participant achieved good knowledge status at baseline. The overall mean knowledge score was 4.22 ± 1.28, with a median score of 4.50.

Table 3: Baseline Knowledge Score Classification

Knowledge level	*n*	*%*	*Mean ± SD*	*Median*
Poor knowledge	99	66.0	2.95 ± 0.81	3.0
Moderate knowledge	51	34.0	5.27 ± 0.44	5.0
Good knowledge	0	0.0		
Total	150	100	4.22 ± 1.28	4.5

1.12.4 Post-Intervention Knowledge and Reported Practice

As shown in Table 4, post-intervention assessment demonstrated marked improvements across all assessed domains. Correct identification of paracetamol as a safe analgesic increased to 97.3%. Knowledge of food interactions, emergency warning signs, missed-dose management, and appropriate communication with healthcare providers each exceeded 97%. Awareness of drug and herbal interactions increased to 83.3% and 82.7%, respectively. Knowledge regarding warfarin safety during pregnancy and breastfeeding reached 96.0%.

Table 4: Post-Intervention Knowledge and Reported Practice Assessment

Item	*Correct response*	*n*	*%*
Safe headache medication	Paracetamol	146	97.3
Food interaction knowledge	Green leafy vegetables	146	97.3
Emergency warning signs	Correct	146	97.3
Missed dose management	Correct	146	97.3
Alcohol interaction	Correct	108	72.0
Multivitamin use	Ask before use	145	96.7
Cold medication	Consult healthcare provider	146	97.3
Dental procedures	Inform dentist	146	97.3
Antibiotic use	Inform physician	146	97.3
Warfarin mechanism	Correct	146	97.3
Drug interactions	Aware of specific types	125	83.3
Herbal interactions	Aware of specific types	124	82.7
Pregnancy/breastfeeding safety	Unsafe	144	96.0

1.12.5 Post-Intervention Knowledge Classification

As shown in Table 5, a total of 114 participants (76.0%) achieved good knowledge status after the intervention, while 36 participants (24.0%) remained in the poor knowledge category. The moderate knowledge category was completely eliminated. The overall mean knowledge score increased to 9.57 ± 4.08, with a median score of 11.50.

Table 5: Post-Intervention Knowledge Score Classification

Knowledge level	*n*	*%*	*Mean ± SD*	*Median*
Good knowledge	114	76.0	11.24 ± 1.02	11.5
Poor knowledge	36	24.0	5.83 ± 1.41	6.0
Moderate knowledge	0	0.0		
Total	150	100	9.57 ± 4.08	11.5

1.13 Discussion

This quasi-experimental pre–post study assessed the impact of a brief, structured health-education intervention on warfarin-related knowledge and self-reported practices among outpatients in River Nile State, Sudan. The findings demonstrate a substantial and statistically significant improvement in patients' overall knowledge following the intervention, with the majority transitioning from poor to good knowledge levels. In contrast, self-reported medication adherence remained consistently high before and after the intervention, suggesting that the primary effect of the program was cognitive rather than behavioral in the short term. The marked improvement observed across most knowledge domains including recognition of drug and food interactions, management of missed doses, identification of warning signs, and the importance of informing healthcare providers about warfarin use highlights the effectiveness of focused, face-to-face educational delivery. The use of simple language, direct interaction, and printed reinforcement materials likely enhanced comprehension, particularly in a population with variable educational backgrounds. Nonetheless, certain high-risk areas, such as alcohol interactions and complex medication combinations, showed comparatively smaller gains, indicating the need for repeated reinforcement and targeted messaging.

The magnitude and direction of knowledge improvement observed in this study are consistent with findings reported in previous educational interventions among warfarin users. Prior randomized and quasi-experimental studies have shown that structured patient education significantly enhances anticoagulation-related knowledge and, in some settings, contributes to improved anticoagulation control and safer medication use [Clarkesmith *et al*., 2013; Baysal *et al*., 2018]. Systematic reviews further support the association between higher patient knowledge and improved quality of anticoagulation, while emphasizing that knowledge gains alone may not consistently translate into better clinical outcomes without adequate monitoring and healthcare system support [de Oliveira-Filho *et al*., 2023]. Studies from sub-Saharan Africa similarly report that educational benefits are often constrained by limited access to INR testing and specialized anticoagulation services [Mouton *et al*., 2021].

The lack of observable change in self-reported adherence in the present study contrasts with some previous reports but can be reasonably explained by the already high baseline adherence rate, suggesting a ceiling effect. Similar observations have been noted in studies where adherence was self-reported and baseline compliance was high, limiting the sensitivity of this outcome to detect post-intervention change [Clarkesmith *et al*., 2013].

Beyond comparison, the findings can be interpreted through several contextual and methodological considerations. Face-to-face education allows immediate clarification of

misconceptions and tailoring of information to local dietary habits and commonly used medications or herbal remedies. However, the immediate post-intervention assessment may have inflated knowledge scores due to short-term recall, and reported practice improvements may reflect intention rather than sustained behavioral change.

Several limitations should be acknowledged. The absence of a control group limits causal inference, and reliance on self-reported data introduces the possibility of social desirability and recall bias. Additionally, the study did not evaluate objective clinical outcomes such as INR values, time in therapeutic range, or bleeding and thromboembolic events, which restricts conclusions regarding the clinical impact of the intervention. The short follow-up period further limits assessment of long-term knowledge retention and behavior change.

Despite these limitations, the study provides important practical implications. The intervention was brief, low-cost, and feasible within routine outpatient care, making it suitable for similar low-resource settings. Incorporating standardized warfarin education into routine clinical practice could represent a meaningful step toward improving medication safety. However, education alone is unlikely to be sufficient; it should be integrated with system-level improvements such as accessible INR monitoring, clear dose-adjustment protocols, and periodic reinforcement sessions.

Future research should focus on controlled study designs with longer follow-up periods and inclusion of objective clinical outcomes to determine whether improved knowledge translates into sustained behavioral change and better anticoagulation control. Evaluating combined educational and service-delivery interventions would be particularly valuable in resource-limited contexts.

CONCLUSION

This study provides clear evidence that a brief, structured educational intervention can substantially improve warfarin-related knowledge among patients in River Nile State, Sudan. Following the intervention, the mean knowledge score more than doubled (from 4.22 ± 1.28 to 9.57 ± 4.08), and the proportion of patients with good knowledge increased from 0% at baseline to 76.0%, demonstrating a strong educational effect within a short time frame. Improvements were observed across key safety domains, including drug and food interactions, missed-dose management, and recognition of warning signs, while self-reported adherence remained consistently high (93.3%) before and after the intervention, indicating a ceiling effect for this outcome. Collectively, these findings show that targeted patient education is a powerful and feasible tool for addressing critical knowledge gaps in warfarin therapy and represents an essential foundation for safer anticoagulation care when integrated with appropriate monitoring and follow-up systems.

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