

Prescribing Trends of DOACs vs Warfarin between 2014-2024 in England: A Longitudinal Analysis of Routine Outcome Data

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Abstract

Introduction

Oral anticoagulants are essential in the prevention and management of thromboembolic conditions, including venous thromboembolism and atrial fibrillation. Warfarin has historically been the mainstay of treatment due to its efficacy, cost-effectiveness, and suitability in patients with renal impairment and valvular disease. However, its use is limited by the requirement for regular international normalised ratio (INR) monitoring and dietary interactions. Direct oral anticoagulants (DOACs), including apixaban, rivaroxaban, edoxaban, and dabigatran, have increasingly been adopted due to their fixed dosing, rapid onset, and fewer interactions. Understanding prescribing trends within the National Health Service (NHS) is important for informing resource allocation and clinical practice.

Methods

Prescription data were obtained from the NHS Business Services Authority Prescription Cost Analysis dataset. Data for warfarin and DOACs from 2014 to 2024 were extracted and categorised by year, region, and drug type. Key variables included prescription volume, quantity, and net ingredient cost. Descriptive statistical analysis was conducted using STATA.

Results

DOAC prescribing increased by 1313.6% over the study period. Apixaban became the most prescribed DOAC, overtaking rivaroxaban, while edoxaban demonstrated the highest relative growth. Dabigatran use increased until 2018 before plateauing. In contrast, warfarin prescribing declined by up to 80% across England.

Conclusion

There has been a substantial shift in anticoagulant prescribing patterns in England over the past decade, with DOACs replacing warfarin as the dominant therapy. Apixaban is now the most frequently prescribed anticoagulant, reflecting evolving clinical practice and guideline adoption.

Introduction

Oral anticoagulants play a central role in the prevention and treatment of thromboembolic disease, including atrial fibrillation and venous thromboembolism^[1]. The most commonly prescribed oral anticoagulants are vitamin K antagonists, such as warfarin, and direct oral anticoagulants (DOACs), including apixaban and rivaroxaban^[1]. Anticoagulants may be used both therapeutically and prophylactically in a range of clinical settings.

Warfarin has historically been the dominant oral anticoagulant in the United Kingdom due to its established efficacy, suitability in patients with renal impairment or mechanical heart valves, low

acquisition cost, and the availability of a well-established reversal strategy^[2]. However, its use is limited by the need for regular international normalised ratio (INR) monitoring, dietary restrictions related to vitamin K intake, and multiple drug interactions^[2].

The introduction of DOACs has transformed anticoagulation practice. Compared with warfarin, DOACs have more predictable pharmacokinetics, fewer dietary interactions, rapid onset of action, and fixed dosing without routine coagulation monitoring. These advantages have driven increasing uptake in both primary and secondary care^[3]. Nevertheless, DOACs also have limitations, including higher acquisition costs, contraindications in certain patient groups, and variation in dosing frequency and reversal strategies^[3].

Previous studies have described national anticoagulant prescribing trends in England up to 2018–2019^[4]. However, more recent data capturing the impact of the COVID-19 pandemic and national procurement initiatives remain limited. The pandemic disrupted routine INR monitoring, potentially accelerating transitions from warfarin to DOACs. In parallel, NHS England procurement strategies, particularly those favouring edoxaban and subsequently generic factor Xa inhibitors, may have influenced prescribing behaviour.

The aim of this study was therefore to evaluate national and regional prescribing trends for warfarin and DOACs in England between 2014 and 2024, examining changes in prescription volume, quantity dispensed, and cost, and to explore potential drivers of regional variation.

Methods

Study Design and Data Source

This cross-sectional study analysed prescribing data extracted from the Prescription Cost Analysis (PCA) dataset, curated by the NHS Business Services Authority (NHSBSA). The PCA provides comprehensive annual information on all medications dispensed within primary care in England.

Study Drugs

The PCA Annual Statistics (NHSBSA, 2023) offer detailed counts of all prescriptions dispensed across England. Using these data, we calculated the total number of prescriptions for apixaban, dabigatran, edoxaban, rivaroxaban, and warfarin by aggregating prescribing figures from all English regions. NHS Digital also releases monthly prescribing summaries that feed into these annual datasets. The PCA database is independently verified and has been reported to be internally audited with an accuracy rate of at least 99% (NHSBSA, 2023).

Data Extraction:

Data extraction was performed using the NHSBSA Open Data Portal (ODP) via its Application Programming Interface (API). Searches were conducted for each of the five anticoagulants, capturing both the number of prescribed items and the geographical distribution of prescriptions across England. The dataset was then cleaned by cross-checking extracted values against the PCA statistics to identify inconsistencies. Following data cleaning, all variables were imported into STATA for compilation and analysis in line with the predefined statistical plan.

Outcome Variables:

Table 1

describes the variables that were retrieved from the PCA dataset accessed through the NHSBSA Open Data Portal.

Outcome Variable	Variable Name	Description
Year	YEAR_DESC	Calendar year of prescription data (e.g., 2023). Annual data for the past nine years were examined
Region	REGION_NAME	Geographical region as defined by NHS England
Drug Name	BNF_CHEMICAL_SUBSTANCE	Chemical substance name used to identify each of the five anticoagulants
Number of Prescriptions	ITEMS	Total number of prescription items issued for each medication
Total Quantity	TOTAL_QUANTITY	Aggregate quantity of each drug dispensed
Quantity per item	QUANTITY_PER_ITEM	Average quantity per prescription item, calculated using ITEMS and TOTAL_QUANTITY
Net Ingredient Cost	NIC	Total cost in pound sterling (£) of the ingredient component of each medication

Table 1: Variables that were retrieved from the PCA dataset.

Statistical Analysis

The collected data were analysed using descriptive statistics. The mean and standard deviations were calculated and presented as trends over time. A Prescription Cost Analysis was also conducted to provide data on annual prescribing across England's regions.

Ethics

As this study involved secondary analysis of an existing open-access dataset, no formal ethical approval was required. The work was conducted in accordance with Good Clinical Practice (GCP) in Research. It

also complied with the General Data Protection Regulation (GDPR; 2016) and the Data Protection Act (1998).

Results

The prescription item and quantity trends for anticoagulants were calculated between 2014 and 2024 (Figs. 1a and 1b). The use of DOACs has increased significantly over the last decade, with an average increase in prescription items of 1632% from 2014 to 2024 (Fig. 1a). The most commonly prescribed DOAC in 2024 is apixaban (59.9%), followed by rivaroxaban (27.9%), edoxaban (10.3%) and dabigatran (1.9%). This has changed compared to 2014, where rivaroxaban was the most prescribed DOAC (58.9%), followed by dabigatran (25.7%), apixaban (15.4%) and edoxaban (0%).

The rate of growth among individual DOACs has differed substantially, with some showing exponential increases, while others have remained largely stable. Edoxaban had the largest overall percentage increase in prescription items (704612%), however, it had a sharp decline in 2023 of 63.6%. This is followed by apixaban (5312%) and rivaroxaban (560%). Dabigatran prescriptions have been relatively stable, with only a 1.5% increase since 2014.

Warfarin prescriptions have declined by 72.1% from 2014 to 2024, particularly since 2015. Initially, it was the most prescribed anticoagulant (91.2%). It has since been overtaken by apixaban in 2019 and then rivaroxaban in 2022. It remains the third most prescribed anticoagulant in 2024 (17.3%).

The trends in quantity of each anticoagulant paint a similar picture (Fig. 1b). In this case, warfarin is the second most commonly used anticoagulant, after apixaban, and is closely followed by rivaroxaban.

Anticoagulant costs have changed significantly over the last decade; however, these trends do not fully align with changes in prescribing patterns. Figure 1c shows the aggregated Net Ingredient Costs (NIC) for each anticoagulant. Across 2014–2024, warfarin accounted for the highest total NIC in England, reaching £194,109,106 (39.0%). This is followed by rivaroxaban at £162,932,312 (32.8%), edoxaban at £70,986,208 (14.3%), apixaban at £54,520,247 (11.0%) and dabigatran at £14,755,962 (3.0%). Overall, all anticoagulants had an increase in total NIC from 2014 to 2024, except dabigatran, which decreased by 16.2%. For warfarin, apixaban and rivaroxaban, total NIC increased until 2022, after which it began to decline in 2023, and declined sharply in 2024 for warfarin and apixaban. Edoxaban followed a similar trend, increasing until 2022, with a spike in 2023 and a sharp decrease in 2024.

Figure 1b - Annual Trends in Anticoagulant Units (Quantity) Prescribed in England, 2014–2024.

Figure 3- Annual number of anticoagulant prescriptions (quantity) between 2014–2024 in a) East of England, b) London, c) Midlands, d) North East and Yorkshire, e) North West, f) South East, and g) South West

In the East of England region, the number of DOAC prescriptions increased by 1782%. Apixaban was the most frequently prescribed DOAC followed by rivaroxaban, edoxaban and then dabigatran. Apixaban

prescriptions went up 5953% over the decade, while edoxaban prescriptions increased from 0 to nearly 350,000 in over 10 years. The number of items of dabigatran prescribed initially increased by 70% in the years 2014–2017. From 2018 to 2024, the prescriptions decreased by 48%. In 2024, the number of prescriptions increased by 27%. Overall, dabigatran prescriptions increased by 20% from 2014 to 2024. Rivaroxaban prescriptions increased consistently from 2014 to 2022 by 1169%. In both 2023 and 2024, the number of items decreased by 15%. Nonetheless, the region saw an increase of almost tenfold in rivaroxaban usage. Comparatively, warfarin items issued across the East of England region decreased by 73%. From 2014–2015, the number of warfarin items did increase slightly but then dropped to 1.63 million in 2016. From 2017 onwards, the number of items issued consistently dropped, reaching only 446,394 in 2024. This is in line with the trend across the country, except for dabigatran which saw an overall increase by 20%, whereas nationally it rose 1.5% over the last ten years.

London saw the highest rate of increase in DOAC prescriptions across the country of 2267%. Apixaban prescriptions went up 10687% over the decade, while edoxaban went from 0 in 2014 to 366,464 in 2023. From 2024, this number decreased by 45%. Dabigatran prescriptions initially increased in the years 2014–2019 by 45%. Then from 2019 onwards, its use began to decrease up to 2024 which saw an average yearly decrease of 5%. Overall, London saw a total increase of 1% in dabigatran prescriptions across in 10 years. Rivaroxaban prescription increased consistently from 2014 to 2022 by 1164%. In both 2023 and 2024, the number of items decreased, dropping by 18%. Nonetheless, the region saw an increase of approximately ten times in rivaroxaban usage. Comparatively, warfarin items issued across London decreased by 65.6%. The usage consistently dropped, starting at 1,015,690 in 2014 and reaching 349,383 in 2024.

In the Midlands region, DOAC prescriptions increased by 1963% from 2014 to 2024. Apixaban prescriptions went up 7815% over the decade. Edoxaban saw a consistent rise from 2014–2023 as the usage went up from 0 to 811,915 items. But in 2024 there was a sharp decline to 300,227 items. Dabigatran prescriptions initially increased in the years 2014–2018 by 169%. Then from 2019 onwards, its use began to decrease up to 2024 by 43%. Overall, across 10 years dabigatran prescriptions increased by 54%. Rivaroxaban prescriptions increased consistently from 2014 to 2020 by 706% but then had a slight decrease of 1.5% from 2020 to 2023. Interestingly, rivaroxaban prescriptions increased to its highest amount in 2024, reaching 1.25 million. Overall, rivaroxaban prescriptions increased by 1100%. Comparatively, warfarin items issued across the Midlands decreased by 72.6%. From 2014–2015, the number of warfarin items did increase slightly from 2.02 million to 2.04 million but then dropped back 1.91 million in 2016. From 2017 onwards, the number of items issued consistently dropped, reaching approximately 550,000 in 2024. Compared to the nation, the Midlands had a much higher number of dabigatran items issued.

In the North East and Yorkshire region, DOAC prescription items increased from 2014 to 2024 by 1337%. Apixaban prescriptions went up 5380% over the decade. Edoxaban saw a consistent rise from 2014–2023 as the number of items went up from 0 to 628,355 units. But in 2024 there was a sharp decline to 212,288 units. Dabigatran usage initially increased in the years 2014–2018, by 49%. Then from 2018

onwards, the number of prescriptions began to decrease up to 2024 which saw only 39%. Overall, dabigatran prescriptions decreased by 8.6%. Rivaroxaban prescriptions increased consistently from 2014 to 2022 by 624%. From 2023, the number of items decreased by 16%. Comparatively, warfarin items issued across North East and Yorkshire decreased by 69.3%. From 2014–2015, the number of warfarin items did increase slightly from 2.05 million to 2.04 million but then dropped back 1.92 million in 2016. From 2017 onwards, the number of items issued consistently dropped, reaching only 627,903 in 2024.

In the North West region, the number of DOAC prescriptions increased by 1423% from 2014 to 2024. Apixaban prescriptions went up 4343% over the decade. Edoxaban saw a consistent rise from 2014–2023 as the usage went up from 0 to 541,602 units. But in 2024 there was a sharp decline to 231,253 units. Dabigatran items initially increased in the years 2014–2019 by 120%. Then from 2019 onwards, the number of prescriptions began to decrease up to 2024 by 30%. Over the ten-year period, dabigatran item prescription increased by 42%, the highest in the country. Rivaroxaban usage increased from 2014 to 2021 by 904%. From 2021 onwards the number of items decreased by 22%. Rivaroxaban prescriptions increased by 681%. Comparatively, warfarin items issued across the North West decreased by 67.7%. From 2014–2015, the number of warfarin items did increase slightly from 1.54 million to 1.56 million but then dropped back 1.46 million in 2016. From 2017 onwards, the number of items issued consistently dropped, reaching only 497,341 in 2024. Compared to the national trend, the North West saw a significant and persistent increase in dabigatran usage.

In the South East region, DOAC prescriptions increased from 2014 to 2024 by 949.69%. Apixaban prescriptions went up 5003% over the decade. Edoxaban saw a consistent rise from 2014–2023 as the usage went up from 0 to 541,602 items. But in 2024 there was a decline to 231,253 prescriptions. Dabigatran prescriptions initially increased in the years 2014–2018 by 48%. Then from 2018 onwards, the number of items began to decrease up to 2024 by 41%. Across 10 years, dabigatran prescription by 13%. Rivaroxaban prescriptions increased consistently from 2014 to 2020 by 460%. From 2021 onwards the number of items decreased by 2024 Comparatively, warfarin items issued across the South East decreased by 68%. From 2014–2015, the number of warfarin items did increase slightly from 1.54 million to 1.56 million but then dropped back 1.46 million in 2016. From 2017 onwards, the number of items issued consistently dropped, reaching only 497,341 in 2024. As a whole, the number of prescriptions issued for warfarin decreased by 75%.

In the South West region, DOAC usage increased by 570% from 2014–2024, which represents the smallest increase in DOAC use across the country. Apixaban prescriptions went up 4093% over the decade. Edoxaban saw a consistent rise from 2014–2023 as the usage went up from 0 to 579,069 items. But in 2024 there was a sharp decline to 208,133 items. Dabigatran prescriptions initially increased in the years 2014–2019 by 25%. Then from 2019 onwards, its use began to decrease up to 2024 by 53%. Rivaroxaban prescription increased consistently from 2014 to 2020 by 335%, before decreasing 35% from 2020–2024. Comparatively, warfarin items issued across the South West

decreased by 80%. From 2014 onwards, the number of items issued consistently dropped, reaching only 288,681 in 2024.

Discussion

Rivaroxaban was the most used DOAC in the UK until 2016, when it was overtaken by apixaban. This initial lead reflects rivaroxaban receiving EU marketing authorisation in 2008, earlier than apixaban in 2011^[5, 6]. This shift could be attributed to apixaban's more favourable safety profile. A meta-analysis demonstrated that rates of stroke, systemic embolism, and major and gastrointestinal bleeding were all significantly lower with apixaban than rivaroxaban, with similar efficacy^[7]. Therefore, this transition to apixaban is likely in response to emerging evidence supporting apixaban's superior safety profile.

Cost is another important factor underpinning this shift. The net ingredient cost (NIC) per prescription item and per quantity was analysed for both drugs, where quantity represents the total number of tablets dispensed (Figs. 4a and 4b). While NIC per prescription item has been similar since 2016, NIC per quantity is consistently lower for apixaban from 2014 onwards. In addition, apixaban's improved safety profile may reduce indirect long-term costs associated with complications such as bleeding and thromboembolism. A cost-effectiveness model comparing DOACs with warfarin over 30 years found that apixaban generated greater overall savings. Its incremental net benefit (£7533) exceeded that of rivaroxaban (£5,279) at a willingness-to-pay threshold of £20,000 per QALY, alongside a marginally higher QALY (5.488 vs 5.451)^[8]. Together, these findings suggest that apixaban offers both clinical and economic advantages.

Figure 4b - Net Ingredient Cost per Unit of Anticoagulants Prescribed (Quantity) in England, 2014–2024

However, apixaban is not without limitations. Cost-effectiveness analyses assume that costs are limited to drug acquisition, overlooking hidden costs in administration and monitoring. Apixaban requires twice-daily dosing, compared to once-daily dosing for rivaroxaban. Simpler regimens are associated with improved adherence and reduced costs related to missed doses^[9]. Additionally, apixaban requires more frequent dose adjustments based on age, weight, and renal function^[10]. These factors will require input from clinicians, pharmacists, and nurses, increasing staffing costs. This explains why rivaroxaban remains the second most used DOAC in the UK.

Together, these factors contribute to the regional variation seen in the adoption of apixaban and rivaroxaban across England. In the North West, apixaban overtook rivaroxaban earlier than the national average - first in quantity in 2014 and later in prescription items in 2016. In contrast, the South West lagged behind, with apixaban only surpassing rivaroxaban in 2017 for quantity and as late as 2020 for prescription items (Figs. 2 and 3).

One explanation for this variation is regional procurement. Each NHS region operates a Regional Pharmacy Purchasing Group responsible for negotiating drug prices^[11]. This can lead to differences in

NIC per item or quantity, making certain DOACs more cost-effective locally. However, NHSBSA data from 2016 show the NIC per quantity for Rivaroxaban was 1.7 and for Apixaban was 0.98 in both regions, suggesting that pricing alone does not fully explain this variation.

Local prescribing guidelines also contribute to regional variation in DOAC use. A study by Ho et al. suggests that local policies play a key role in determining DOAC choice^[11]. In the North West, several trusts favour apixaban: it is first-line for non-valvular atrial fibrillation (NVAf) in Cheshire and Merseyside and in Greater Manchester, with rivaroxaban as an alternative^[12, 13]. In Lancashire and South Cumbria, both drugs are first-line options^[14]. For deep vein thrombosis (DVT) and pulmonary embolism (PE), both apixaban and rivaroxaban remain first-line across all North West trusts.

In contrast, most South East trusts list both apixaban and rivaroxaban as first-line treatments for NVAf and acute VTE/PE^[12–16]. Some formularies, such as Bristol, North Somerset, and South Gloucestershire, provide additional prescribing considerations when choosing a DOAC, such as food requirements, weight, and renal function^[17]. For example, rivaroxaban must be taken with food, unlike apixaban, which influences patient suitability. Overall, DOAC selection depends on local policy and clinician-patient shared decision-making.

Edoxaban, introduced in 2015, is the newest DOAC and has shown the largest percentage increase in use between 2014 and 2024. A major driver was the NHS England ‘edoxaban switch programme’ launched in 2022^[18]. Through a negotiated pricing agreement, edoxaban became the most cost-effective DOAC at the time, generating an estimated £100 million in savings^[18]. While NICE endorses all four DOACs for use within the NHS, NHS England provided incentives for the adoption of edoxaban as a first-line DOAC, rewarding GP practices with up to £14.8 million^[19]. Other advantages include once-daily dosing, administration without food, and suitability for patients with lactose intolerance, unlike other DOACs.

Despite this, edoxaban remains the third most used DOAC. Uptake has been limited by several factors. Notably, there is no licensed antidote, complicating overdose management^[17]. Edoxaban also cannot be used for the immediate treatment of VTE or PE, requiring at least five days of parenteral anticoagulation. Edoxaban also requires dose adjustments based on weight and renal function, as well as when patients are taking potent P-glycoprotein inhibitors^[17]. These drawbacks, combined with its restricted use cases, have limited edoxaban’s uptake in spite of the national incentives.

In terms of safety, edoxaban is broadly comparable to other DOACs. A meta-analysis found no significant differences in ischaemic stroke, systemic embolism, intracranial haemorrhage, or all-cause mortality between DOACs. However, edoxaban, dabigatran, and rivaroxaban were associated with higher rates of gastrointestinal bleeding compared to apixaban^[20].

Edoxaban’s growth was largely driven by its initial price advantage. However, this advantage is waning. Edoxaban remains under patent until 2027, whereas generic apixaban became available in 2022 and rivaroxaban in 2024. Consequently, NHS England updated its guidance in 2024 to recommend generic

apixaban and rivaroxaban as the most cost-effective twice-daily and once-daily DOACs, respectively^[21]. This accounts for the nearly two-thirds decline in edoxaban items and quantity in 2024 compared to its 2023 peak. This poses challenges for clinicians managing patients who have already transitioned from apixaban to edoxaban, only to face yet another switch, potentially eroding trust in the NHS. Ensuring that cost-saving measures can be implemented while optimising clinical outcomes and upholding patient confidence is key.

Dabigatran, the first DOAC introduced, is now the least prescribed. It differs as a direct thrombin inhibitor instead of factor Xa, and requires twice-daily dosing. Its use has declined across multiple regions, including the South East, South West, East, and North East & Yorkshire. This could be attributed to newer DOACs having better efficacy and safety than dabigatran. Meta-analyses show dabigatran carries a higher risk of myocardial infarction, although overall efficacy and safety are broadly comparable^[22].

Furthermore, unlike other DOACs, close monitoring for bleeding and anaemia is also required for patients who have gastritis, gastro-oesophageal reflux or oesophagitis^[22]. In addition, it uses a different reversal agent (idarucizumab) compared to factor Xa inhibitors (andexanet alfa), which complicates hospital protocols. Although idarucizumab (£2,400) is substantially cheaper than andexanet alfa (£14,000–£25,000), maintaining separate reversal pathways may reduce its appeal^[23, 24]. Therefore, its safety profile, unique monitoring needs, and the need for a separate reversal agent may be limiting factors in the use of dabigatran.

Finally, dabigatran presents dispensing challenges. Unlike other DOACs, it cannot be repackaged into compliance aids or blister packs. They are sensitive to moisture, so they must remain in their original packaging^[25]. This makes it difficult for the most vulnerable patient groups, including the elderly and those requiring polypharmacy. These hurdles explain why NHS England ranks dabigatran as a fourth-line DOAC and why its use in hospitals across England is declining despite price reductions^[21].

From 2014 to 2024, there has been a consistent decline in warfarin prescriptions across all regions of England, while prescriptions of DOACs have increased substantially, averaging an 87% annual rise relative to total anticoagulant prescriptions. Warfarin usage saw an average decline of 65%, with associated costs reducing by 66.4% for the NHS^[26]. However, the Southwest showed the most pronounced decrease in warfarin prescriptions, while London's decline was minimal. The slight reduction in warfarin prescriptions in London could be attributed to variations in patient demographics. London has certain areas that may have a higher elderly population or individuals with a multitude of comorbidities, making them less able to adapt to frequent medication changes. This is supported by a systematic review by Davies et al. (2022), which stated that cautious prescribing should be undertaken in these populations as medication transitions can decrease adherence by 10% due to the body's reduced capacity for adjustment. As a result, fewer patients may have been switched to DOACs from their original warfarin. Further, London may see higher warfarin prescriptions due to patient comorbidities. Additionally, these areas may have an increased number of patients with medical conditions like prosthetic heart valves, severe renal impairment, and antiphospholipid syndrome who are not eligible to

switch to DOACS (Medlinskiene et al., 2021)^[27]. Similarly, multi-comorbid patients, like those in London, are more susceptible to adverse drug events^[27], making switching riskier.

Finally, warfarin is still favoured in some populations due to patient apprehension and reluctance to transition from warfarin to DOACs. This perspective is reflected in a study by Medlinskiene et al. (2021)^[27], where patients emphasised their resistance to change. This highlights how confidence with long-term warfarin use, due to familiarity, despite regular INR monitoring and dietary changes, creates hesitation to change to a DOAC due to uncertainty of the unknown, regardless of overall convenience. Therefore, the slower transition observed in London may not only indicate clinical caution but also a higher burden of complex and patient perspectives, highlighting the importance of shared decision making.

The COVID-19 pandemic played a vital role in accelerating the progression from warfarin to DOACs. With the restrictions on healthcare, such as minimizing in-person visits^[28], rendering INR monitoring for warfarin an increased challenge. Due to the safety profile of warfarin, it necessitates the need for regular therapeutic monitoring of INR to ensure patient safety and efficacy, requiring frequent patient visits^[28]. In comparison, DOACs offer an efficient alternative and a more predictable pharmacokinetic profile, as monitoring is not a requirement, whilst also providing the same overall benefit^[29]. Consequently, regions including the North West, Yorkshire, and South West have shown the largest increases in the use of DOACs. This may have been due to proactive implementation during the pandemic, which was encouraged by the NHS^[30]. Moreover, COVID-19 caused the introduction of telephone consultations, which facilitated this shift by enabling clinicians to initiate and follow up DOAC prescriptions remotely without hospital attendance^[30]. However, this approach posed some challenges, specifically for individuals hard of hearing and the elderly, where communication barriers during remote consultations may have hindered uptake and adherence, demonstrating the need for tailored communication strategies^[30].

The cost differences between warfarin and DOACs play a vital role in prescribing trends across different regions of England^[4]. For the NHS, the cost of warfarin is 85p per month, and the cost of DOACs is over £50, which strongly influences regional prescribing patterns as areas with higher budgets can invest in newer anticoagulants in contrast to regions with financial constraints^[4]. These findings align with the regional findings in this dataset, where increased DOAC uptake was noted in higher-funded areas. Although DOACs have a higher upfront cost, they are considered cost-effective at a willingness to pay threshold of £20,000 per QALY, with all DOACs yielding a positive net benefit over warfarin^[4, 26]. The cost-effectiveness is largely due to the lower risk of severe complications requiring hospitalisation and the lack of INR monitoring^[26, 31, 32]. Notably, while the number of fatal or severe adverse drug reactions (ADR) for DOACs declined by 6% per million annually, the incidence for warfarin doubled in 2019 compared to the decade earlier, highlighting safety concerns for individuals with multiple comorbidities and within the elderly population^[4, 33]. The persistent use of warfarin in London indicates that regional variation can be driven by patient complexity and unique clinical profiles. Overall, at a national level, the

data highlights that DOACs are the more cost-effective option in comparison to warfarin, yielding long-term cost savings, lower complication rates, and improved patient outcomes, therefore supporting their wider uptake throughout the NHS.

Conclusion

This longitudinal analysis revealed a significant shift in anticoagulant prescribing patterns across England between 2014 and 2024. Warfarin was widely used in the early years of the study period, however, its prescriptions have steadily declined, with a marked drop from 2018 onwards. This reflected evolving clinical preferences, patient conveniences and changes prompted by the COVID-19 pandemic. In contrast, DOAC prescriptions increased rapidly, due to their ease of use, reduced monitoring and better safety profiles. Apixaban is the most prescribed DOAC, replacing Rivaroxaban as the first-line choice in most regions. Edoxaban had the highest percentage increase in use due to NHS financial incentives; however, uptake remains limited due to clinical factors, such as the lack of a reversal agent. Dabigatran, the first DOAC introduced, remains the least prescribed due to its high risk of adverse events and limitations in its dispensing. These findings show that changing clinical environments, cost-effectiveness and evidence-based guidelines shape the anticoagulation management across NHS England.

Declarations

The authors of this article declare that they have no conflicts of interests or financial contributions.

Ethics approval and consent to participate

This study analysed publicly available, anonymised aggregate prescribing data obtained from the NHS Business Services Authority (NHSBSA) Prescription Cost Analysis (PCA) dataset. The dataset contains no identifiable patient information.

Ethical approval

and informed consent were not required in accordance with UK Health Research Authority guidance for research using publicly available anonymised data.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Author Contribution

HN and EJ are joint first authors. HN, EJ, AAS, ZA, and JJ made substantial contributions to the conception and design of the work, as well as the acquisition, analysis, and interpretation of data. HN and EJ drafted the manuscript, and all authors critically revised the work for important intellectual content. All authors approved the final version of the manuscript and agree to be accountable for all aspects of the work, ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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Not applicable.

Data Availability

The datasets analysed during the current study are publicly available from the NHS Business Services Authority (NHSBSA) Prescription Cost Analysis (PCA) repository. Dataset: Prescription Cost Analysis (PCA) - England Repository: NHSBSA Open Data Portal Available at: [<https://opendata.nhsbsa.net/dataset/prescription-cost-analysis-pca-annual-statistics>] All data used in this study are publicly accessible anonymised aggregate prescribing data. No additional datasets were generated during the current study.

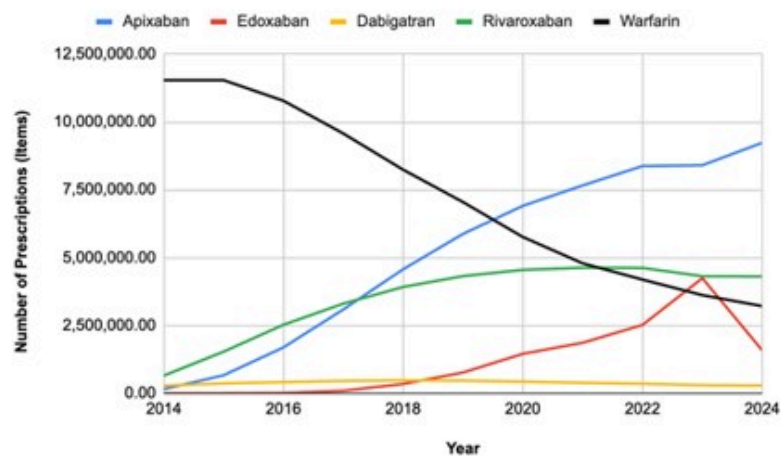
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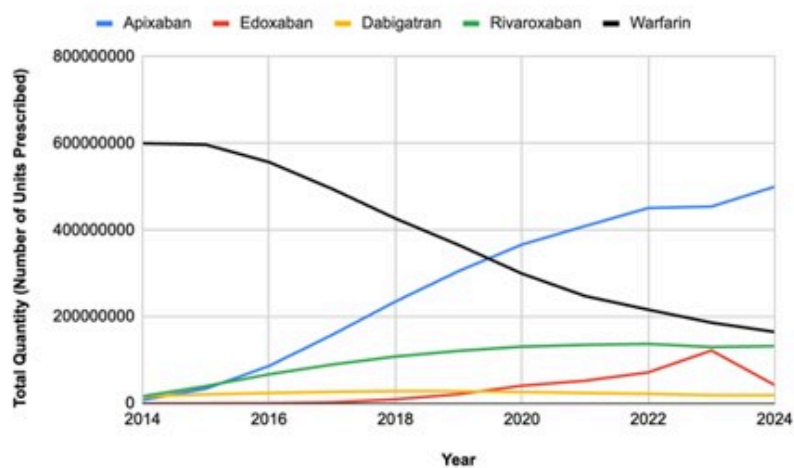
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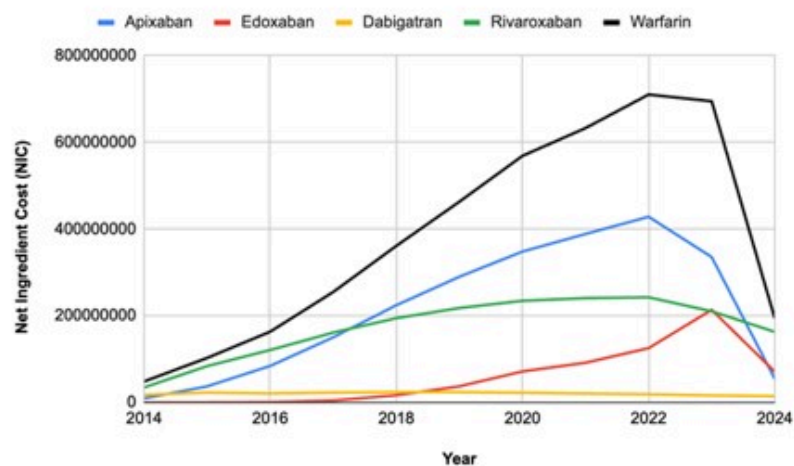
Figures



A



B



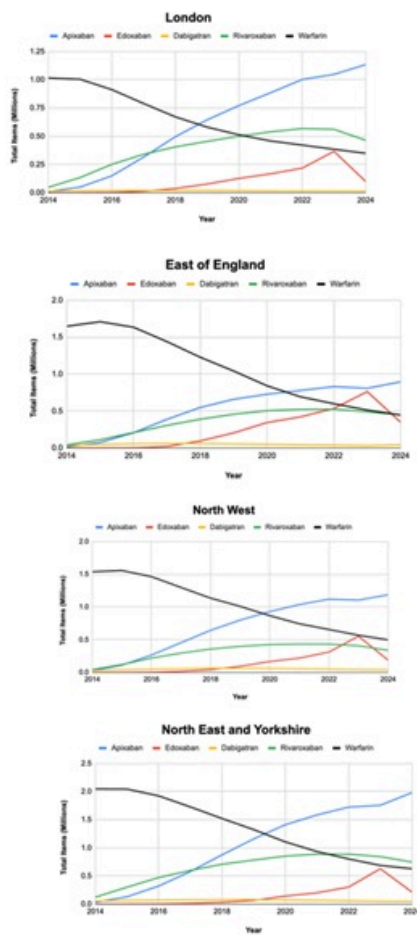
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Figure 1

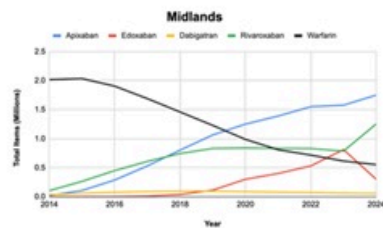
a - Annual Number of Anticoagulant Prescriptions (Items) in England, 2014-2024

b - Annual Trends in Anticoagulant Units (Quantity) Prescribed in England, 2014–2024.

c - Annual Net Ingredient Cost (NIC) of Anticoagulants Prescribed in England, 2014–2024

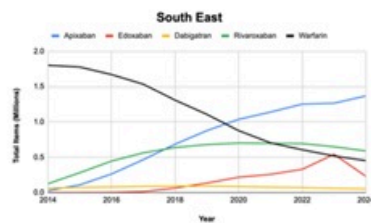


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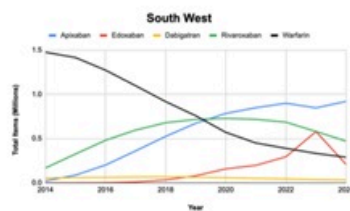
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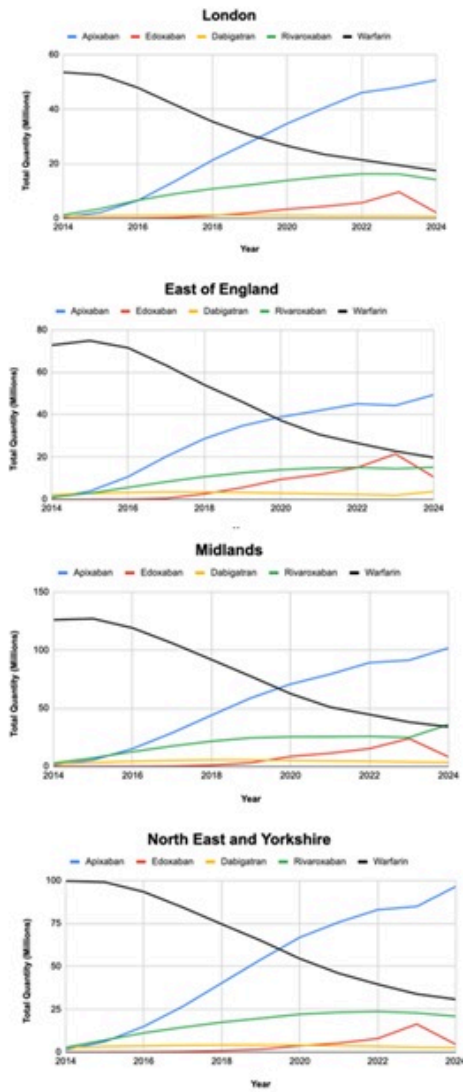


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Figure 2

Annual number of anticoagulant prescriptions (items) between 2014-2024 in a) East of England, b) London, c) Midlands, d) North East and Yorkshire, e) North West, f) South East, and g) South West

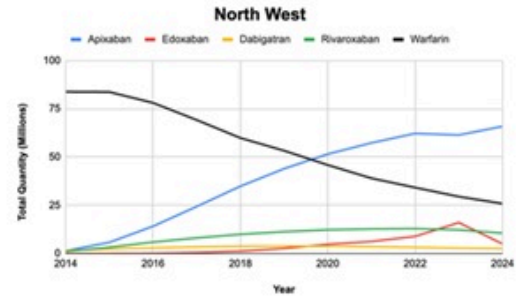


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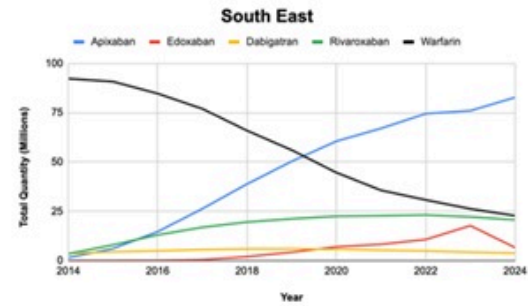
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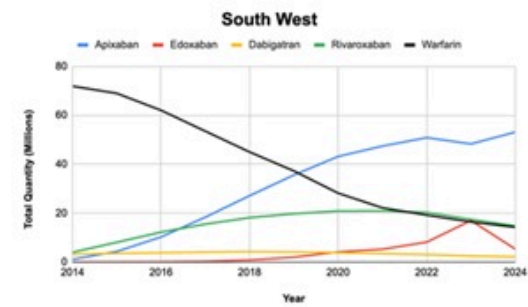
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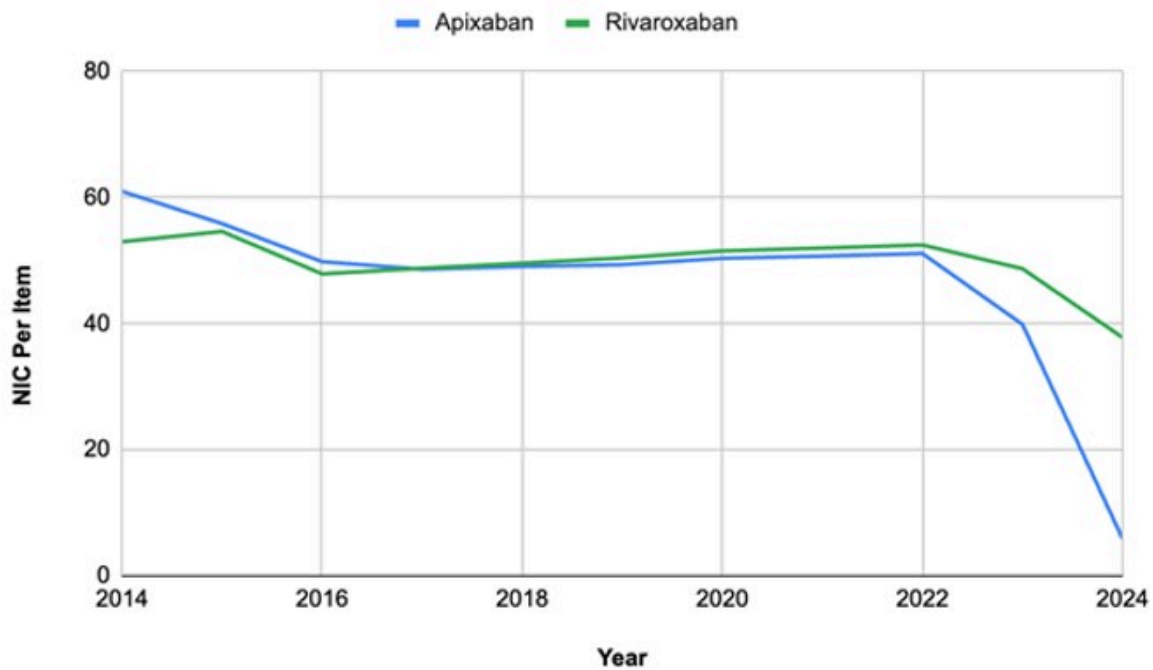
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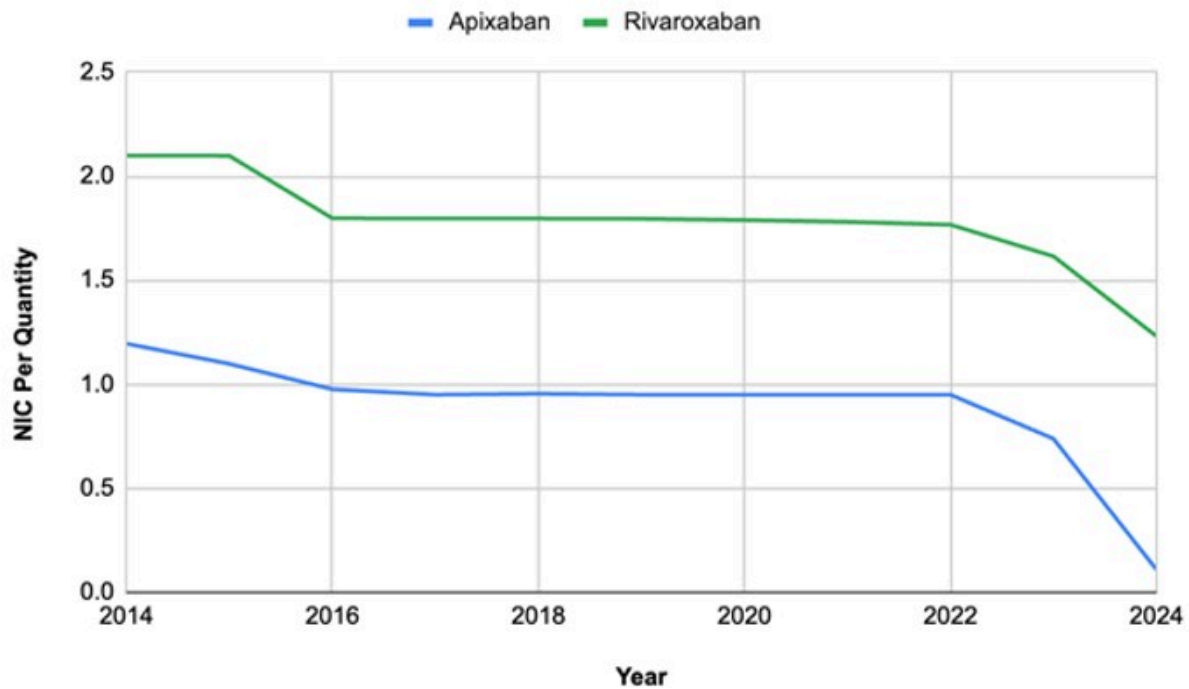
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Figure 3

Annual number of anticoagulant prescriptions (quantity) between 2014-2024 in a) East of England, b) London, c) Midlands, d) North East and Yorkshire, e) North West, f) South East, and g) South West



A



B

Figure 4

a - Net Ingredient Cost per Anticoagulant Prescription (Item) in England, 2014–2024

b - Net Ingredient Cost per Unit of Anticoagulants Prescribed (Quantity) in England, 2014–2024