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# Warfarin Prescribing in Atrial Fibrillation: The Impact of Physician, Patient, and Hospital Characteristics

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## ABSTRACT

**PURPOSE:** The study investigated the determinants of warfarin use in patients with atrial fibrillation (AF).

**METHODS:** We assembled a retrospective cohort of community-dwelling elderly patients (aged ≥66 years) with AF using linked administrative databases. We identified the physicians responsible for the ambulatory care of these patients using physician service claims and compared patients who did and did not have an identifiable provider. For those patients with an identifiable provider, we assessed the association between patient, physician, and hospital factors and warfarin use.

**RESULTS:** Our cohort consisted of 140,185 patients, of whom 116,200 (83%) had an identifiable cardiac provider. Patients without a provider were significantly more likely to have comorbid conditions that increase their risk of warfarin-associated bleeding. After adjustment for clinical factors, patients without a provider were significantly less likely to receive warfarin (odds ratio 0.37, 95% confidence interval: 0.36-0.38). Of patients with providers, 50,551 patients (43.5%) received warfarin within 180 days after hospital discharge. Warfarin use was positively associated with AF-associated stroke risk factors (eg, prior stroke, congestive heart failure) and negatively associated with warfarin-associated bleeding risk factors (eg, history of intracerebral hemorrhage). After controlling for patient and hospital factors, patients cared for by noncardiologist physicians with cardiology consultation were more likely to receive warfarin then patients treated in noncollaborative environments.

**CONCLUSIONS:** Warfarin continues to be substantially underprescribed to patients who are at high risk for AF-associated cardioembolic stroke. Our findings highlight the need for targeted quality improvement interventions and suggest preferred models of AF care involving routine collaboration between cardiologists and other physicians. 

**KEYWORDS** Anticogulation; Atrial fibrillation; Prescribing; Warfarin; Physician specialty; Quality of care.

Atrial fibrillation (AF), the most common cardiac arrhythmia, has a prevalence of approximately 5% in individuals 65 years or older and approximately 10% in those aged more than 80 years.[1,2] As the population ages, the prevalence of AF and rates of hospitalization for this condition are increasing.[2-5] The risk of thromboembolic stroke in patients with nonvalvular AF ranges from 4% to 15% per year depending on the presence of clinical risk factors[6] and is

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approximately 5 times greater than that seen in patients without AF.[7] Numerous large clinical trials have demonstrated that long-term anticoagulation using warfarin is the most effective way to reduce the risk of stroke,[6,8] but warfarin is received by only 30% to 60% of appropriate patients, even in contemporary studies.[3,9-14] Approximately 15% of all strokes are attributable to AF.[15] Therefore, the clinical and economic consequences of the underuse of warfarin are profound.[16]

Understanding the determinants of warfarin use may help improve the quality of care for patients with AF. Warfarin use seems to be only partially predicted by stroke and bleeding risk factors.[9,12,17,18] However, existing studies evaluated a limited set of potential predictors,[19] relied on surveys to identify warfarin use and comorbidities,[18,19] had small sample sizes,[9,10,14,17,18] assessed warfarin use during hospitalization,[20,21] or were conducted in a managed care environment,[12] and therefore may not be widely generalizable to the majority of patients with AF.

Nonclinical factors, such as physician specialty or volume, which are important predictors of health care quality for other diseases,[22,23] have received limited attention in AF.[17,19,24] The evaluation of physician factors may be particularly relevant for AF because physicians have considerable difficulty accurately evaluating the risks and benefits of anticoagulation[25] and because the monitoring and dosage adjustment required for the safe use of warfarin imposes a substantial burden on physicians.[26] Consequently, certain types of providers and different models of care delivery might be associated with higher rates of warfarin prescribing.

## CLINICAL SIGNIFICANCE

- Warfarin continues to be under-prescribed to patients with non-valvular atrial fibrillation who are at high risk for stroke.
- Patients cared for by non-cardiologist physicians with cardiology consultation were more likely to receive warfarin than patients treated in non-collaborative environments.
- These results support calls for the adoption of interventions to warfarin utilization and suggest preferred models of care.

## METHODS

### Setting and Design

We assembled a retrospective cohort of community-dwelling elderly patients (aged ≥66 years) with AF in Ontario, Canada, by linking several large health care databases. Ontario has a population of approximately 12 million people, of whom approximately 1.5 million are aged 65 years or older.[27] All Ontario residents have universal, publicly funded health insurance for hospital care and physician services, and elderly residents also have prescription drug coverage for drugs listed in the provincial formulary. The Canadian Institutes of Health Information database contains a detailed record of all hospital admissions, including demographic characteristics of patients, coexisting illnesses, in-hospital procedures, and mortality. The Ontario Drug Benefit claims database contains information on all outpatient prescription drugs reimbursed for Ontario residents aged 65 years and older. We restricted our analysis to those aged more than 66 years to capture drug use in the year before cohort enrollment. The Ontario Health Insurance Plan database contains information on physician claims for inpatient and outpatient services. The Ontario Registered Persons Database contains basic demographic data and vital status. The Corporate Providers Database of the Ontario Ministry of Health and the Southam Medical Database contain demographic information about physicians in Ontario. These databases were linked anonymously using encrypted individual health card numbers and have been used extensively to study other population-based health outcomes.[28-31] Less than 2% of the basic information on patients is missing in these databases.[32] This study was approved by the ethics review board of Sunnybrook and Women's College Health Sciences Centre, Toronto, Canada. The funders of this study had no role in the design, conduct, or reporting of the study or in the decision to submit the manuscript for publication.

### Cohort Definition

We included all patients with a most-responsible or major comorbid diagnosis of AF (International Classification of Diseases, Ninth Revision [ICD-9] code 427.3) recorded at the time of hospital discharge during the period from January 1, 1994, to March 31, 2002. Validation studies have demonstrated that ICD codes have a specificity of 99% and positive predictive value of 97% for the diagnosis of AF.[33, 34] To identify patients with nonvalvular and nontransient AF, on the basis of Go et al's methods,[12] we excluded patients: for whom AF was listed as a postadmission complication; who had valvular heart disease (defined as having an inpatient diagnosis of mitral stenosis, prosthetic heart valves, or mitral or aortic valve repair or replacement before their admission with AF); who were likely to have perioperative AF (defined as having coronary artery bypass surgery, pericardial surgery, or structural cardiac repair within 30 days before their AF admission); or who had hyperthyroidism or thyrotoxicosis within the preceding 12 months (based on hospital admissions or ≥1 outpatient prescriptions for antithyroid medication). To identify community-dwelling patients who were potentially eligible to receive warfarin as outpatients we excluded patients: who died during admission or within 60 days of discharge; who were residents of chronic care facilities; or who did not have a valid health card number. For patients with more than 1

eligible admission during the period under study, only data from the first admission were included. The hospital discharge date served as the index date for all analyses.

## Assignment of Most-Responsible Cardiac Provider

Physician billing claims data were used to identify the physicians most responsible for the care of the patients in our cohort. The "most-responsible cardiac provider" (MRCP) was identified as the unique physician who submitted the most outpatient service claims for care related to cardiac diagnoses (ie, hypertension [codes 401-403], ischemic heart disease [codes 410-413], pulmonary embolism [code 415], conduction defects and arrhythmias [codes 426-427], congestive heart failure [code 428], valvular heart disease [codes 390-394, 398], arteriosclerosis and aneurysms [codes 440, 441], and other diseases of the heart and circulatory system [codes 429, 459, 785]) in the 6 months after the index date. If 2 physicians submitted an equal number of claims, the physician who submitted the first claim was chosen. The diagnosis code on billing claims is completed by physicians and reflects care for any condition for which the patient was assessed or treated. Only 1 diagnosis code per visit appears in the billing database. Therefore, patients would be identified as not having an MRCP if they did not receive outpatient care reimbursed by the Ontario Health Insurance Plan or if they received outpatient care but their providers did not submit bills for cardiac diagnoses.

## Patient, Physician, and Hospital Predictors

We identified patient comorbidities by searching hospital discharge abstracts and physician claims data for the presence of relevant diagnostic codes in any diagnosis field for the 5-year period up to and including the index date (ie, comorbidities that were identified on the index hospitalization were also included). We also searched drug claims for the year before the index event. Using these sources, the following stroke risk factors were included: prior ischemic stroke (hospital abstract ICD-9 codes 434 or 436), congestive heart failure (hospital abstract ICD-9 code 428), hypertension (hospital abstract ICD-9 codes 401-404 or physician claim codes 401-403), diabetes (hospital abstract ICD-9 code 250 or 2 physician claim codes 250), coronary artery disease (hospital abstract ICD-9 code 410-414), and the number of hospital admissions a patient had during the year before the index date. Similarly, the following bleeding risk factors and warfarin contraindications were identified: prior upper gastrointestinal bleeding (hospital abstract ICD-9 codes 531, 532, 534, 578.0, 578.1, 578.9), lower gastrointestinal bleeding (hospital abstract ICD-9 562, 569.3, 569.8), intracerebral hemorrhage (hospital abstract ICD-9 codes 430 or 431 as the most-responsible diagnosis), renal disease (using a combination of hospital admissions, physician claims, and inpatient and outpatient dialysis treatments), liver disease (hospital abstract ICD-9 codes 571.2, 571.4, 571.5, 571.6, 456.0, 456.1, 456.2), dementia or cognitive impairment (hospital abstract ICD-9 codes 290.1 to 290.4, 290.8, 290.9, 294.1, 331.0, 331.1, 331.2 046.1, 046.2), and use of antiplatelet agents or nonsteroidal anti-inflammatory agents. We classified patients into 5 socioeconomic categories based on the median personal income of the neighborhood in which they lived. We defined patients as "prevalent" warfarin users if they had filled a prescription for warfarin any time during the year before the index date.

On the basis of the specialty of the MRCP and whether a cardiologist submitted a service claim in the 6 months after the index date, we classified patients as having received care by 1 of 7 mutually exclusive physician groups: cardiologists, general internists with or without cardiology consultation, family physicians with or without cardiology consultation, and other specialties (eg, pulmonology, nephrology, hematology) with or without cardiology consultation. MRCP specialty was determined from the Corporate Providers Database of the Ontario Ministry of Health and has been validated by the Ontario Physician Human Resources Data Centre. The number of years that a physician had been in practice was calculated as the number of years elapsed between the index date of the patient for whom they were the MRCP and their year of medical school graduation. The average annual volume of patients with AF treated by each physician was estimated by dividing the total number of patients with AF for whom they were the MRCP by the number of years the physician actually treated 1 or more patients with AF. Physicians were categorized into high (>5 AF cases/year), medium (2-5 AF cases/year), or low-volume (<2 AF cases/year) tertiles.

The annual volume of the hospital from which each patient was discharged was determined in a similar manner as for physicians. Hospitals were classified into high (>220 AF cases/year), medium (130-220 AF cases/year), or low-volume (<130 cases) tertiles. Using hospital discharge abstracts, we categorized the specialty of the physicians caring for patients while in hospital into 1 of 4 mutually exclusive groups: cardiology, general internal medicine (if no cardiologist was involved), family physician or general practitioner (if no cardiologist or internist was involved), and other physician (if no cardiologist, internist, or family physician was involved).

## Statistical Analyses

We conducted 2 sets of analyses. First, we compared patients who did and did not have an identifiable MRCP. Second, for those patients with an identifiable MCRP, we evaluated predictors of having received a prescription for warfarin during the 6-month period after hospital discharge. Descriptive analyses were performed using Student *t* and chi-square tests. Odds ratios (ORs) and 95% confidence intervals (CIs) for the association between potential predictors and our outcomes of interest were estimated using generalized estimating equations (with a compound symmetry variance-covariance structure). To confirm our results, we performed a multivariable Cox proportional hazards

**Table 1** Baseline Characteristics

| | All Patients (n = 140,185) | | | Patients with Identifiable Providers (n = 116,200) | | |
|---|---|---|---|---|---|---|
| | Patients with an Identifiable Cardiac Provider (n = 116,200) | Patients without an Identifiable Cardiac Provider (n = 23,985) | *P* Value | Warfarin Users (n = 50,551) | Warfarin Non-users (n = 65,649) | *P* Value |
| Patient predictors | | | | | | |
| Warfarin use in prior year, % | 36.7 | 23.0 | <.001 | 76.9 | 5.6 | <.001 |
| Age, mean years (SD) | 76.8 (6.9) | 77.9 (7.2) | <.001 | 76.2 (6.5) | 77.2 (7.1) | <.001 |
| Female, % | 48.9 | 50.6 | <.001 | 48.3 | 49.4 | <.001 |
| Admissions in prior year, mean (SD) | 1.5 (1.0) | 1.5 (1.1) | <.001 | 1.4 (0.9) | 1.6 (1.1) | <.001 |
| Income quintile, % | | | <.001 | | | <.001 |
| 1 | 22.4 | 24.9 | | 21.6 | 23.0 | |
| 2 | 23.0 | 22.2 | | 22.7 | 23.3 | |
| 3 | 19.6 | 19.1 | | 19.8 | 19.5 | |
| 4 | 16.8 | 16.0 | | 17.1 | 16.5 | |
| 5 | 18.2 | 16.7 | | 18.8 | 17.7 | |
| Coronary artery disease, % | 40.3 | 20.3 | <.001 | 34.6 | 44.6 | <.001 |
| Stroke risk factors, % | | | | | | |
| Prior stroke | 7.5 | 12.5 | <.001 | 10.4 | 5.3 | <.001 |
| Congestive heart failure | 34.6 | 22.1 | <.001 | 38.6 | 31.6 | <.001 |
| Diabetes | 23.4 | 23.0 | .19 | 24.0 | 22.9 | <.001 |
| Hypertension | 73.6 | 59.7 | <.001 | 73.8 | 73.5 | .32 |
| Bleeding risk factors, % | | | | | | |
| Prior upper GI bleed | 5.8 | 7.8 | <.001 | 4.3 | 6.9 | <.001 |
| Prior lower GI bleed | 8.3 | 9.4 | <.001 | 7.4 | 9.0 | <.001 |
| Prior intracerebral bleed | 0.3 | 0.7 | <.001 | 0.2 | 0.4 | <.001 |
| Renal disease | 12.5 | 13.3 | <.001 | 11.7 | 13.1 | <.001 |
| Liver disease | 0.7 | 1.5 | <.001 | 0.5 | 0.8 | <.001 |
| Dementia | 1.5 | 4.1 | <.001 | 1.1 | 1.8 | <.001 |
| Antiplatelet use | 40.9 | 29.2 | <.001 | 29.9 | 49.3 | <.001 |
| NSAID use | 27.4 | 25.6 | <.001 | 25.4 | 28.8 | <.001 |
| Physician predictors | | | | | | |
| Specialty of physicians involved in care, % | | | | | | <.001 |
| Cardiology | – | – | – | 14.1 | 15.9 | |
| Internal medicine with cardiology consultation | – | – | – | 1.0 | 1.0 | |
| Internal medicine without cardiology consultation | – | – | – | 4.4 | 5.3 | |
| Family medicine with cardiology consultation | – | – | – | 22.5 | 15.3 | |
| Family medicine without cardiology consultation | – | – | – | 51.0 | 53.7 | |
| Other specialty with cardiology consultation | – | – | – | 1.8 | 1.6 | |
| Other specialty without cardiology consultation | – | – | – | 5.3 | 7.2 | |
| Annual volume of MRCP (patients per year), % | | | | | | <.001 |
| <2 | – | – | – | 35.8 | 34.5 | |
| 2-5 | – | – | – | 36.1 | 35.0 | |
| >5 | – | – | – | 28.2 | 30.5 | |
| Clinical experience of MRCP (y), % | | | | | | .05 |
| <15 | – | – | – | 25.4 | 26.0 | |
| 15-21 | – | – | – | 24.3 | 24.1 | |
| 22-30 | – | – | – | 25.0 | 24.5 | |
| >30 | – | – | – | 25.3 | 25.4 | |
| Gender of MRCP (female), % | – | – | – | 13.7 | 12.7 | <.001 |
| Hospital predictors | | | | | | |
| Teaching hospital, % | 25.5 | 30.4 | .002 | 25.0 | 25.9 | .002 |

**Table 1** Continued

| | All Patients (n = 140,185) | | | Patients with Identifiable Providers (n = 116,200) | | |
|---|---|---|---|---|---|---|
| | Patients with an Identifiable Cardiac Provider (n = 116,200) | Patients without an Identifiable Cardiac Provider (n = 23,985) | *P* Value | Warfarin Users (n = 50,551) | Warfarin Non-users (n = 65,649) | *P* Value |
| Annual volume (patients per year), % | | | <.001 | | | <.001 |
| <160 | 32.5 | 31.0 | | 31.5 | 33.3 | |
| 130-270 | 32.6 | 33.3 | | 33.9 | 31.5 | |
| >270 | 34.9 | 35.8 | | 34.6 | 35.1 | |
| Specialty of inpatient service, % | | | <.001 | | | <.001 |
| Cardiology | 28.5 | 14.6 | | 28.8 | 28.4 | |
| General internal medicine | 46.7 | 45.1 | | 47.1 | 46.5 | |
| Family medicine/general practice | 13.2 | 19.9 | | 12.8 | 13.5 | |
| Other specialty | 11.5 | 20.5 | | 11.4 | 11.7 | |

SD = standard deviation; GI = gastrointestinal; MRCP = most-responsible cardiac physician; NSAID = nonsteroidal anti-inflammatory drug; . . . = not applicable.

model to identify predictors of time to warfarin receipt. All analyses were adjusted for the year of patient discharge from hospital and were conducted with SAS version 8.2 (SAS Institute, Cary, NC).

## RESULTS

During our study time frame, 168,697 patients were hospitalized with a most-responsible or major comorbid diagnosis of AF. We excluded 28,512 patients who had valvular heart disease, thyroxicosis, or a high probability of transient AF; who lived in a long-term care setting; or who died within 60 days of hospital discharge. Therefore, our cohort consisted of 140,185 patients of whom 116,200 (83%) had an identifiable MRCP.

### Predictors of Having an Identifiable Cardiac Provider

Compared with patients with an identifiable MRCP, patients without an MRCP were significantly more likely to be older, to have several comorbid conditions associated with an increased risk of warfarin-associated bleeding, and to have had a prior stroke (Table 1). In contrast, these patients were less likely to have received prescriptions for an antiplatelet agent (29.2% vs 40.9%) or a nonsteroidal anti-inflammatory drug (25.6% vs 27.4%). They also were less likely to have been cared for by a cardiologist while in hospital (14.6% vs 28.5%). These associations were maintained on multivariable analysis (Table 2). Patients without an MRCP were considerably less likely to receive warfarin (23.9% vs 43.5%). After adjustment for clinical and hospital factors, the odds that patients without an MRCP received warfarin was 63% lower than patients with an MRCP (OR 0.37; 95% CI, 0.36-0.38).

### Predictors of Warfarin Receipt

The baseline characteristics for the 116,200 patients in our cohort who had an MRCP are presented in Table 1. These patients were treated by 10,949 physicians, of whom 71% were general practitioners or family medicine physicians, 6% were general internists, 15% were cardiologists, and 8% were other internal medicine specialists. Patients had a mean of 5.8 (standard deviation 5.1) visits in the 6 months after discharge. By American College of Chest Physician criteria,[35] 106,891 patients (92.0%) had at least 1 major risk factor for AF-related stroke (ie, prior stroke, congestive heart failure, age >75 years, hypertension).

Overall, 50,551 patients (43.5%) received warfarin within 180 days after hospital discharge. The proportion of patients who received warfarin increased over the course of our study from 36.8% in 1994 to 48.4% in 2002 ($P<.001$ for trend). Warfarin users were significantly more likely to have received a prescription for warfarin during the prior year than nonusers and to be in the highest tertile of physician visits in the 6 months after discharge (50.3% of warfarin users were in the highest visit tertile compared with 33.8% of nonusers). Compared with nonrecipients, warfarin recipients were younger, more likely to be male, less likely to have been hospitalized for other reasons in the year before the index date, more likely to have stroke risk factors, and less likely to have risk factors associated with an increased risk of bleeding on warfarin (Table 1). Warfarin use increased with increasing overall AF-associated stroke risk (38% of patients with a $CHADS_2$ score[36] of 0 received warfarin compared with 51% of patients with a score of 6, $P<.0001$ for trend). Of the 34,400 patients in our cohort who had at least 1 major stroke risk factor and no contraindications to anticoagulation, only 55.6% received warfarin.

On multivariable analysis, warfarin receipt after discharge was most strongly associated with warfarin use in the year before discharge (OR 54.18; 95% CI, 51.86-56.51) (Table 3). Warfarin use was also associated with comorbid diagnoses of prior stroke (OR 2.66; 95% CI, 2.48-2.85) and congestive heart failure (OR 1.36; 95% CI, 1.31-1.41). Patient age greater than 90 years was associated with significant reductions in the odds of warfarin receipt (OR 0.47; 95% CI, 0.42-0.52), as were diagnoses of coronary artery disease (OR 0.74; 95% CI, 0.71-0.77), intracerebral hemorrhage (OR 0.18; 95% CI, 0.12-0.28), or liver disease (OR 0.52; 95% CI, 0.40-0.68), or the use of an antiplatelet medication (OR 0.73; 95% CI, 0.70-0.76).

Physician specialty was a predictor of warfarin prescribing. Cardiology involvement in the care of patients treated by general internists, family doctors, and other specialists significantly increased rates of warfarin prescribing. For example, 42.3% of patients treated by family physicians received warfarin as opposed to 53.2% of patients treated by family physicians with cardiology consultation. This relationship remained on multivariable analysis (Table 3). However, on univariate and multivariable analysis, the patients of family physicians with and without cardiology consultation were more likely to receive warfarin than patients treated only by cardiologists (OR 1.10; 95% CI: 1.04-1.17).

The multivariable Cox proportional hazard models yielded similar results to those presented above (data not presented).

**Table 2** Predictors of Having an Identifiable Cardiac Provider (n = 140 185)

| Predictors | Adjusted OR of Having a Nonidentifiable Cardiac Provider (95% CI) |
|---|---|
| Patient predictors | |
| Gender (female vs male) | 1.04 (1.01-1.07) |
| Admissions in prior year (per admission) | 1.15 (1.14-1.17) |
| Income quintile | |
| 1 (lowest) | 1.18 (1.13-1.24) |
| 2 | 1.04 (0.99-1.09) |
| 3 | 1.05 (1.00-1.11) |
| 4 | 1.02 (0.97-1.07) |
| 5 (highest) | 1.00 (referent) |
| Coronary artery disease | 0.46 (0.45-0.48) |
| Stroke risk factors | |
| Age (y) | |
| <70 | 1.00 (referent) |
| 70-74 | 1.08 (1.03-1.14) |
| 75-79 | 1.19 (1.13-1.25) |
| 80-84 | 1.37(1.30-1.44) |
| 85-89 | 1.58 (1.49-1.67) |
| ≥90 | 1.97 (1.83-2.13) |
| Prior stroke | 1.65 (1.57-1.73) |
| Congestive heart failure | 0.57 (0.54-0.59) |
| Diabetes | 1.23 (1.19-1.28) |
| Hypertension | 0.53 (0.93-0.99) |
| Bleeding risk factors | |
| Prior upper GI bleed | 1.29 (1.21-1.37) |
| Prior lower GI bleed | 1.08 (1.02-1.13) |
| Prior intracerebral bleed | 1.99 (1.62-2.43) |
| Renal disease | 1.21 (1.15-1.26) |
| Liver disease | 2.05 (1.79-2.36) |
| Dementia | 2.32 (2.13-2.53) |
| Antiplatelet use | 0.70 (0.68-0.72) |
| NSAID use | 0.98 (0.94-1.01) |
| Hospital predictors | |
| Teaching hospital | 1.47 (1.41-1.54) |
| Hospital average annual volume (patients per year) | |
| <160 | 0.87 (0.83-0.91) |
| 160-270 | 1.04 (1.00-1.09) |
| >270 | 1.00 (referent) |
| Specialty of inpatient service | |
| Cardiology | 1.00 (referent) |
| Internal medicine | 1.80 (1.72-1.88) |
| Family medicine/general practice | 2.79 (2.64-2.95) |
| Other specialty | 2.65 (2.52-2.79) |

OR = odds ratio; CI = confidence interval; GI = gastrointestinal; NSAID = nonsteroidal anti-inflammatory drug.

## DISCUSSION

The findings of this very large population-based study of patients with nonvalvular AF support existing evidence that warfarin is substantially underprescribed to patients who are at high risk of AF-associated cardioembolic stroke. Because the factors conventionally considered to be associated with higher rates of anticoagulation-related bleeding (eg, a history of gastrointestinal or intracerebral hemorrhage or advanced age) may not substantially increase bleeding risk,[37] our results suggest that both patients with relative contraindications and those without any identifiable contraindications are receiving suboptimal treatment. Because AF-associated stroke is common and burdensome to both patients and the health care system, our results reinforce calls for the more widespread adoption of effective quality improvement interventions aimed at increasing warfarin use.[38]

Our study expands the existing AF literature by demonstrating that patients without identifiable cardiac providers are significantly less likely to receive warfarin and that the nature of interspecialty collaboration for patients with providers significantly affects warfarin use. Patients whose primary provider was not a cardiologist but who were seen in consultation by a cardiologist were more likely to receive warfarin than patients cared for by cardiologists or other physicians alone. Of interest, patients whose primary provider was a cardiologist were less likely to receive warfarin than patients of family physicians, even in the absence of cardiology consultation.

It is possible that primary care providers are better equipped to facilitate the frequent monitoring and dosage adjustments necessary for the safe use of warfarin and therefore are more willing than specialists to prescribe anticoagulation. In contrast, cardiologists may be more knowledgeable about appropriate AF care[39] and may be more

**Table 3** Predictors of Warfarin Use for Patients with Identifiable Providers (n = 116,200)

| | Adjusted OR (95% CI)* |
|---|---|
| Patient Predictors | |
| Warfarin use in prior year | 54.18 (51.86-56.61) |
| Gender (female vs male) | 1.05 (1.01-1.09) |
| Admissions in prior year (per admission) | 0.82 (0.80-0.83) |
| Income quintile | |
| 1 (lowest) | 0.95 (0.90-1.00) |
| 2 | 0.93 (0.88-0.98) |
| 3 | 0.94 (0.89-1.00) |
| 4 | 0.95 (0.89-1.00) |
| 5 (highest) | 1.00 (referent) |
| Coronary artery disease | 0.74 (0.71-0.77) |
| Stroke risk factors | |
| Age (y) | |
| <70 | 1.00 (referent) |
| 70-74 | 1.07 (1.01-1.13) |
| 75-79 | 1.04 (0.99-1.10) |
| 80-84 | 0.94 (0.88-1.00) |
| 85-89 | 0.80 (0.74-0.85) |
| ≥90 | 0.47 (0.42-0.52) |
| Prior stroke | 2.66 (2.48-2.85) |
| Congestive heart failure | 1.36 (1.31-1.41) |
| Diabetes | 1.01 (0.97-1.06) |
| Hypertension | 0.97 (0.93-1.01) |
| Bleeding risk factors | |
| Prior upper GI bleed | 0.53 (0.48-0.58) |
| Prior lower GI bleed | 0.85 (0.79-0.91) |
| Prior intracerebral bleed | 0.18 (0.12-0.28) |
| Renal disease | 0.86 (0.81-0.91) |
| Liver disease | 0.52 (0.40-0.68) |
| Dementia | 0.57 (0.48-0.67) |
| Antiplatelet use | 0.73 (0.70-0.76) |
| NSAID use | 0.86 (0.81-0.76) |
| Physician predictors | |
| Type of physicians involved in care | |
| Cardiology | 1.00 (referent) |
| Internal medicine with cardiology consultation | 1.49 (1.21-1.84) |
| Internal medicine without cardiology consultation | 0.94 (0.83-1.06) |
| Family medicine with cardiology consultation | 1.86 (1.72-2.02) |
| Family medicine without cardiology consultation | 1.08 (1.01-1.16) |
| Other specialty with cardiology consultation | 1.61 (1.36-1.90) |
| Other specialty without cardiology consultation | 0.90 (0.81-0.99) |
| Average annual volume of MRCP (patients per year) | |
| <2 | 0.97 (0.91-1.02) |
| 2-5 | 1.01 (0.95-1.06) |
| >5 | 1.00 (referent) |
| Clinical experience of MRCP (y) | |
| <14 | 1.12 (1.06-1.19) |
| 15-21 | 1.03 (0.98-1.09) |
| 22-30 | 1.04 (0.99-1.10) |
| >30 | 1.00 (referent) |
| Gender of MRCP (female vs male) | 1.05 (0.99-1.11) |
| Hospital predictors | |
| Teaching hospital (yes vs no) | 1.07 (1.01-1.13) |
| Average annual volume (patients per year) | |
| <160 | 1.03 (0.97-1.09) |
| 160-270 | 1.05 (1.00-1.15) |
| >270 | 1.00 (referent) |
| Specialty of inpatient service | |
| Cardiology | 1.00 (referent) |
| Internal medicine | 1.04 (0.99-1.09) |
| Family medicine/general practice | 0.92 (0.86-0.99) |
| Other specialty | 0.86 (0.81-0.92) |

OR = odds ratio; CI = confidence interval; GI = gastrointestinal; MRCP = most-responsible cardiac physician; NSAID = nonsteroidal anti-inflammatory drug.

*These results are obtained from a multivariable analysis adjusted for all other predictors and the year of enrollment in cohort.

likely to recommend warfarin use if another physician is able to supervise therapy. Alternatively, the involvement of more physicians, regardless of specialty, may result in higher quality care, or patients who agree to see a cardiologist may be more likely to accept warfarin. Nevertheless, our results are consistent with survey data showing higher rates of warfarin prescribing for patients cared for by general practitioners who also had a cardiology consultant involved in their care.[17] Our results also confirm studies demonstrating that the consultations between generalists and specialists may improve the quality of care for patients with acute myocardial infarction and congestive heart failure.[40-42]

There are several limitations to our analysis. First, we relied on hospitalization records to identify patients with AF. Some patients with AF would not have been hospitalized during the study period. However, given the prevalence of AF and the likelihood that many elderly patients would have been hospitalized at some point during the study period, we believe that our results are generalizable to the majority of community-dwelling elderly patients with nonvalvular AF. Also, the use of hospital records provides high-quality data about patient comorbidity.

Second, some patients may not have received warfarin because of their preferences or other comorbidities, such as severe gait instability, that are not included in administrative data. Alternatively, warfarin may have been purposely withheld from some patients for whom an invasive surgical procedure was subsequently being planned. Although these factors are important,[43] they are unlikely to explain the degree of underprescription that we observed.

Third, rates of warfarin use increased over time during our study time-frame, and patients in the earlier portion of this window may not have received warfarin because several large clinical trials that confirmed the value of anticoagulation for patients with AF were not yet published.[6] However, 8 of the 12 large clinical trials of warfarin use in AF and a widely cited pooled analysis of 5 of the most major trials were all published in 1994 or before,[6,44] and thus the value of anticoagulation should have been recognized by most physicians by the start of our analysis.

Fourth, our analysis was conducted using a cohort derived from Canada, and the nature of clinical practice, including generalist-specialist interaction, physician availability, and universal access to prescription drug coverage, may be different than that in other health care systems and may limit the generalizability of our results.

Finally, because the identity of the physician responsible for supervising a patient's warfarin use is not explicitly contained within administrative data, we relied on an algorithm to assign physicians to patients. As a result, it is possible that patients with cardiac providers may have been labeled as not having one. For example, the providers of patients with AF and diabetes may submit claims for diabetes-related diagnoses rather than AF, thereby making them unidentifiable by our cardiac criteria. As a result, our results are only generalizable to patients with readily identifiable providers, which constituted the majority (83%) of patients in our population-based sample.

It also is possible that physicians were misassigned to patients and that the physicians we identified may not have actually been responsible for deciding whether to prescribe warfarin. This would lead to incorrect inferences about physician-level factors. However, this misclassification would generally bias our results toward the null, and therefore our results might actually be conservative estimates of true effects. Repeating our analysis using more strict criteria for labeling a physician as a patient's most responsible provider (ie, on the basis of the physician who submitted the most cardiac claims and the physician who prescribed the largest number of cardiac drugs), for those 37,969 patients (32.7%) whose physicians could be so identified, did not change our findings.

In summary, warfarin continues to be underused in AF, and patterns of use are not consistent with an accurate assessment of the risks and benefits associated with this therapy. In particular, elderly patients and those with relative contraindications are most likely to be undertreated. These findings highlight the need for in-depth research on the factors responsible for warfarin underuse and targeted quality improvement interventions. Our results also suggest preferred models of care involving routine collaboration between cardiologists and primary care providers in the care of patients with AF.

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