Prevalence of Diagnosed Atrial Fibrillation in Adults: National Implications for Rhythm Management and Stroke Prevention: the AnTicoagulation and Risk Factors In Atrial Fibrillation (ATRIA) Study

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Prevalence of Diagnosed Atrial Fibrillation in Adults

National Implications for Rhythm Management and Stroke Prevention: the AnTicoagulation and Risk Factors In Atrial Fibrillation (ATRIA) Study

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Context Atrial fibrillation is the most common arrhythmia in elderly persons and a potent risk factor for stroke. However, recent prevalence and projected future numbers of persons with atrial fibrillation are not well described.

Objective To estimate prevalence of atrial fibrillation and US national projections of the numbers of persons with atrial fibrillation through the year 2050.

Design, Setting, and Patients Cross-sectional study of adults aged 20 years or older who were enrolled in a large health maintenance organization in California and who had atrial fibrillation diagnosed between July 1, 1996, and December 31, 1997.

Main Outcome Measures Prevalence of atrial fibrillation in the study population of 1.89 million; projected number of persons in the United States with atrial fibrillation between 1995-2050.

Results A total of 17974 adults with diagnosed atrial fibrillation were identified during the study period; 45% were aged 75 years or older. The prevalence of atrial fibrillation was 0.95% (95% confidence interval, 0.94%-0.96%). Atrial fibrillation was more common in men than in women (1.1% vs 0.8%; $P<.001$). Prevalence increased from 0.1% among adults younger than 55 years to 9.0% in persons aged 80 years or older. Among persons aged 50 years or older, prevalence of atrial fibrillation was higher in whites than in blacks (2.2% vs 1.5%; $P<.001$). We estimate approximately 2.3 million US adults currently have atrial fibrillation. We project that this will increase to more than 5.6 million (lower bound, 5.0; upper bound, 6.3) by the year 2050, with more than 50% of affected individuals aged 80 years or older.

Conclusions Our study confirms that atrial fibrillation is common among older adults and provides a contemporary basis for estimates of prevalence in the United States. The number of patients with atrial fibrillation is likely to increase 2.5-fold during the next 50 years, reflecting the growing proportion of elderly individuals. Coordinated efforts are needed to face the increasing challenge of optimal stroke prevention and rhythm management in patients with atrial fibrillation.

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ATRIAL FIBRILLATION IS THE most common clinically significant cardiac arrhythmia. It is also a potent risk factor for ischemic stroke, increasing the risk of stroke 5-fold and accounting for approximately 15% of all strokes nationally.[1] Symptomatic atrial fibrillation may also reduce quality of life, functional status, and cardiac performance.[2] It is associated with higher medical costs as well as an increased risk of death.[3] Specifying the prevalence of atrial fibrillation in the United States has important implications for understanding the population burden of disability and medical costs associated with this arrhythmia.

The prevalence of atrial fibrillation increases substantially with age.[4] Several previous studies have reported varying estimates of the prevalence of atrial fibrillation ranging from 1.2% to 2.8% in persons aged 60 through 69 years to 7.3% to 13.7% in persons aged 80 years or older.[5-8] However, these studies have been limited by relatively small numbers of individuals with atrial fibrillation,[5-8] restricted age ranges,[8] ethnically homogeneous samples,[5-7] and potentially biased ascertainment of atrial fibrillation by reliance on hospitalization data or patient self-report for the detection of atrial fibrillation.[6-8] Overall, these limitations may reduce the generalizability of prior studies' results to current populations.

We assembled a contemporary cohort of patients with atrial fibrillation to provide age-, sex-, and race-specific

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period prevalence estimates of atrial fibrillation among adults and to project the number of persons in the United States who will have atrial fibrillation through the year 2050.

METHODS

Study Population

We assembled a cohort of adults aged 20 years or older with diagnosed atrial fibrillation between July 1, 1996, and December 31, 1997, who received care within Kaiser Permanente of Northern California, a large group-model health maintenance organization. Kaiser Permanente cared for nearly 3 million members during the study period. Health plan members had a demographic, race or ethnic, and socioeconomic profile similar to the overall northern California population, with the exception of a lower proportion of patients aged 65 years or older (15% vs 17%) and only slightly higher median incomes (35% vs 42% with <$35000 annual household income) (N. P. Gordon, ScD, unpublished data, July 2000).

To identify patients with atrial fibrillation, we searched an automated clinical database containing diagnoses from all ambulatory visits for a diagnosis of atrial fibrillation (code 427.31 from the *International Classification of Diseases, Ninth Revision, Clinical Modification* [*ICD-9*]), an electrocardiographic database for physician-confirmed diagnoses of atrial fibrillation, and an automated hospital discharge diagnosis database for principal discharge diagnoses of atrial fibrillation (*ICD-9* code 427.31). Of note, the electrocardiographic database included diagnoses for all inpatient and outpatient electrocardiograms (Model No. XLi; Hewlett Packard; Boise, Idaho), which have been performed in all Kaiser Permanente medical centers since 1994.

We applied several exclusion criteria to identify only adult patients with nontransient atrial fibrillation who were also health plan members to ensure that they were in the source population for prevalence calculations. Thus, exclusion criteria included presumed transient atrial fibrillation identified only by an electrocardiogram performed during a hospitalization without a principal discharge diagnosis of atrial fibrillation, transient atrial fibrillation after recent cardiac surgery, no evidence of health plan membership surrounding the atrial fibrillation diagnosis, age younger than 20 years on the index date, and hyperthyroidism during the 12 months before the index atrial fibrillation diagnosis. We captured diagnoses for exclusion criteria from comprehensive hospital discharge diagnosis and billing claims databases for health plan and out-of-network admissions, respectively, as well as an automated ambulatory database of emergency department and outpatient clinic visits.

Transient, perioperative atrial fibrillation was defined as the presence of a single diagnosis of atrial fibrillation within 30 days after coronary artery bypass graft surgery (*ICD-9* codes 36.10-36.19), pericardial surgery (*ICD-9* 37.10-37.12, 37.24-37.25, 37.31-37.33, 37.35, or 37.40), or structural cardiac repair surgery (*ICD-9* 35.31-35.39, 35.41, 35.42, 35.50-35.54, 35.60-35.63, or 35.70-35.73) and no evidence of atrial fibrillation in our databases subsequently. Concomitant hyperthyroidism was defined as an outpatient or hospital discharge diagnosis of hyperthyroidism or thyrotoxicosis (*ICD-9* 242.0-242.9), a filled prescription for methimazole or propylthiouracil in the outpatient pharmacy database, and/or a low serum thyroid-stimulating hormone level found in a laboratory database (without a concurrent prescription for thyroxine) during the 12 months before the index atrial fibrillation diagnosis.

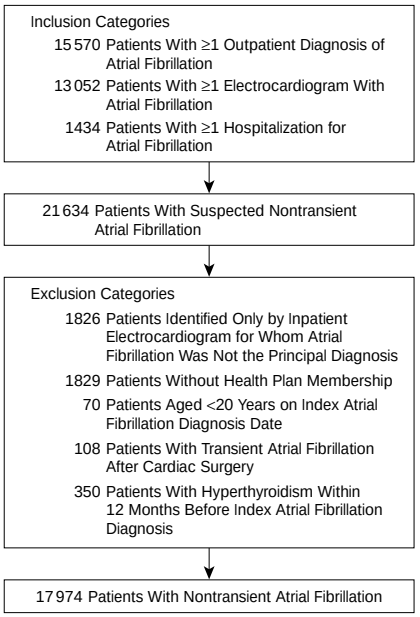
Patient Characteristics

Patient age, sex, and race or ethnicity (white, black, Hispanic, and other or multiple) were ascertained from administrative and hospitalization files. Race or ethnicity status was available on 89% of the cohort. We searched inpatient and outpatient databases during the 5 years before index date to identify diagnosed valvular heart disease, which was defined as mitral stenosis, a prosthetic heart valve, or evidence of mitral and/or aortic valve repair or replacement (*ICD-9* codes 35.01-35.02, 35.11-35.12, 35.21-35.24, 394.0, 394.2, 396.0, 396.1, 396.8, 746.5, V42.2, or V43.3); previous ischemic stroke (*ICD-9* 433-434); previously diagnosed heart failure (*ICD-9* 402.01-402.11, 402.91, 425.1, 425.4, 425.5, 425.7, 425.9, or 428.0-428.9), and known coronary heart disease (*ICD-9* codes 410-414). We relied on an ambulatory visit database to identify diagnosed hypertension (*ICD-9* 401-405). The presence of diabetes mellitus was assessed from a longitudinal health plan diabetes registry[9] that identified patients with diabetes between 1994-1997 using relevant inpatient and outpatient diagnoses (*ICD-9* 250.0-250.8), self-reported diabetes from a patient survey, an abnormal (>6.7%) hemoglobin A_{1C} level, or a filled prescription for oral hypoglycemic agents or insulin.

Prevalence of Atrial Fibrillation

We calculated the period prevalence of atrial fibrillation in the adult population within Kaiser Permanente of Northern California overall and stratified by age and sex.[10] The denominator for the prevalence calculations was the adult (age ≥20 years) population of health plan members during the study period. This was determined by taking the average number of registered adult members from July 1, 1996, through December 31, 1997, based on quarterly membership counts from administrative files. Based on an a priori hypothesis,[11] we attempted to compare the prevalence of atrial fibrillation between white and black patients. The proportion of white and black subjects in each 5-year age-sex subgroup 50 years or older in the source population was estimated using self-reported race or ethnic data from a weighted sample of 11 047 Kaiser Permanente members 50 years and older (N. P. Gordon, ScD, unpublished data, July 2000). Only those whose race or ethnicity were known and were 50 years and older were included in compari-

Figure 1. Cohort Assembly of 17974 Adults With Diagnosed Atrial Fibrillation Within Kaiser Permanente of Northern California, July 1, 1996, Through December 31, 1997



Numbers shown for the inclusion and exclusion criteria are not mutually exclusive.

sons of the prevalence of atrial fibrillation between white and black patient subgroups.

United States Projections of Atrial Fibrillation

We applied the age- and sex-specific prevalence calculations of atrial fibrillation in our study population to 1995 United States census data[12] to estimate the number of US adults with this condition in 1995. Based on the anticipated growth of the population in the United States, we projected the number of adults who will have diagnosed atrial fibrillation by directly applying age- and sex-specific prevalence estimates from our study to US Census projections for each adult age and sex category through the year 2050.[12,13] We also conducted a sensitivity analysis of our projections using different assumptions of the prevalence of atrial fibrillation and US Census projections. Specifically, we used the 95% confidence intervals (CIs) of the age- and sex-specific prevalence of atrial fibrillation from our study to create low and high scenarios for its prevalence in the population. We also used the reasonable low and reasonable high series from US Census projections,[12,13] which correspond to an approximate 10% lower or higher estimate, to reflect the potential error in the census projection. By combining these assumptions, we established a lower and upper bound of our projections of the number of US adults who would have atrial fibrillation.

Statistical Analysis

Continuous variables are presented as mean (SD), and categorical variables are reported as proportions with 95% CIs.[10] Estimates of the period prevalence of atrial fibrillation are presented as proportions with 95% CIs. Prevalence between subgroups was compared using a χ^2 test. As noted above, the projected numbers of adults with atrial fibrillation in the United States are reported per 5-year period between 1995 and 2050 with a sensitivity analysis based on varying assumptions of atrial fibrillation prevalence and US Census estimates.

RESULTS

Cohort Assembly

During the study period, we initially identified 21634 patients with suspected nontransient atrial fibrillation based on 1 or more of the following methods, which were not mutually exclusive: 15570 with 1 or more outpatient diagnoses of atrial fibrillation; 13052 patients with at least 1 electrocardiogram showing atrial fibrillation in the electrocardiographic database; and 1434 with a principal hospital discharge diagnosis of atrial fibrillation (FIGURE 1). We excluded 1826 patients with atrial fibrillation that was detected only by an electrocardiogram during a hospitalization whose principal discharge diagnosis was not atrial fibrillation, 1829 patients without health plan membership, 70 patients who were younger than 20 years on the index date, 108 patients with presumed transient perioperative atrial fibrillation following cardiac surgery, and 350 patients with evidence of recent hyperthyroidism. The final cohort included 17974 adult patients with diagnosed, presumed nontransient atrial fibrillation.

Within this cohort, 25% were identified only by more than 1 outpatient diagnosis of atrial fibrillation during the study period; 18% were identified only by a single outpatient diagnosis of atrial fibrillation during the study period. We validated the approach of including these patients in the cohort by searching the medical records for electrocardiograms in a random sample of patients from each group. In the sample of 50 patients identified by more than 1 outpatient atrial fibrillation diagnosis only, 78% had at least 1 electrocardiogram in their medical record showing atrial fibrillation. Fifty-six percent of the sample of 50 patients identified only by a single outpatient atrial fibrillation diagnosis had a corresponding electrocardiogram with atrial fibrillation in their records. Essentially all of the retrieved electrocardiograms showing atrial fibrillation had been performed before the start of the electrocardiographic database in 1994. Taking these validation results together with the other subjects identified using electrocardiographic and principal discharge diagnoses, we estimate that at least 87% of the entire cohort had electrocardiographically confirmed atrial fibrillation.

Patient Characteristics

The mean (SD) age of the cohort was 71.2 (12.2) years, and 43.4% were women. Ten percent of the cohort were younger than 55 years; 13.6%, 55 through 64 years; 31.9%, 65 through 74 years; 34.1%, 75 through 84 years; and 10.5%, 85 years or older. Other characteristics of the cohort are summarized in TABLE 1. Of note, only 5% had known valvular heart disease.

Prevalence of Atrial Fibrillation

Among the 1.89 million adult health plan members during the study pe-

riod, the overall prevalence of diagnosed atrial fibrillation was 0.95% (95% CI, 0.94%-0.96%). The prevalence of atrial fibrillation increased with older age (FIGURE 2), ranging from 0.1% among persons younger than 55 years to 9.0% among patients 80 years or older; among persons 60 years or older, 3.8% had atrial fibrillation.

The prevalence of atrial fibrillation was greater in men than in women overall (1.1% vs 0.8%, P<.001) and in every age group. In women, the prevalence increased from 0.1% among those younger than 55 years to 9.1% among those 85 years or older (Figure 2). In men, the prevalence of atrial fibrillation ranged from 0.2% in those younger than 55 years to more than 11% among those 85 years or older (Figure 2).

In addition, among patients 50 years or older, atrial fibrillation appeared to be more common in white (2.2%) than in black (1.5%, *P*<.001) patients. We found that the prevalence of atrial fibrillation was similar in white (0.5%) vs black (0.5%) patients aged 50 through 59 years (*P*=.51) but was more common in white vs black patients in the following age groups, respectively: 60 through 69 years, 1.8% vs 1.3% (*P*=.001); 70 through 79 years, 5.2% vs 4.4% (*P*=.003); and 80 years and older, 9.9% vs 7.7% (*P*=.001).

United States Projections of Atrial Fibrillation

We next applied the age- and sex-specific prevalence data from our study population to census information on the US population[12,13] to estimate the number of adults with atrial fibrillation through the year 2050 (FIGURE 3). We estimate that approximately 2.1 million Americans had atrial fibrillation during the period of cohort assembly and that there are nearly 2.3 million US adults with atrial fibrillation currently (lower bound, 2.0 million; upper bound, 2.5 million). Furthermore, we project that this number will increase approximately 2.5-fold to more than 5.6 million by the year 2050 (lower bound, 5.0 million; upper bound, 6.3 million) (Figure 3). As the overall number of persons affected by atrial fibrillation increases, the proportion of the most elderly will similarly increase. We estimate that currently 1.85 million (82%) of US adults with atrial fibrillation are 65 years or older and nearly 830 000 (37%) are 80 years or older (TABLE 2). By the year 2050, we project that 4.97 million (88%) of US adults with atrial fibrillation will be 65 years or older and 2.95 million (53%) will be 80 years or older. Of note, despite the higher prevalence among men, we estimate that about half of adults with atrial fibrillation will be women, reflecting the greater number of older women in the United States. Furthermore, given the decline in the incidence of rheumatic fever within the United States and the relatively low prevalence of known valvular heart disease observed in our cohort (4.9%), the overwhelming majority of these patients will have nonvalvular atrial fibrillation.

COMMENT

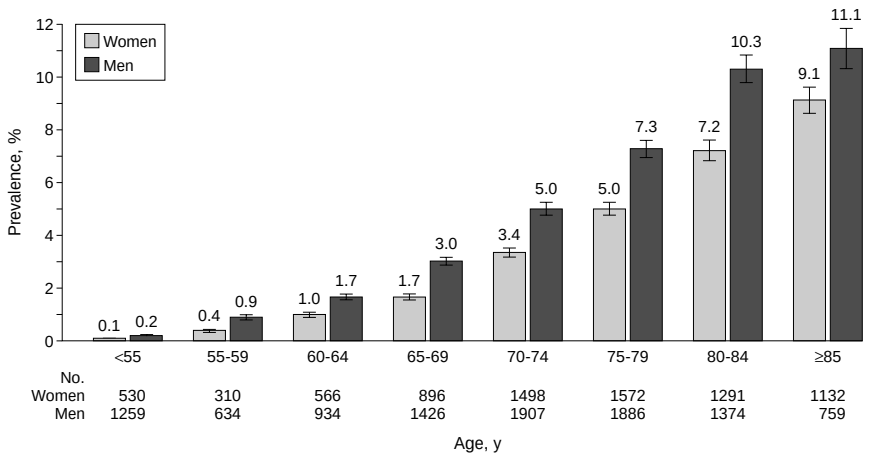
Within a large, ethnically diverse population, we found that 1% of all adults were diagnosed with atrial fibrillation. The prevalence of atrial fibrillation was strongly associated with increasing age, with nearly 4% of persons 60 years and older and 9% of persons 80 years and older having been diagnosed with atrial fibrillation. Women had a lower prevalence of atrial fibrillation at every age compared with men, but the overall number of affected women was similar. Black patients appeared to be less likely than white patients to have atrial fibrillation. The national impact of this arrhythmia is substantial, because we estimate that 2.3 million US adults currently have atrial fibrillation. This burden will likely increase in the coming decades since we

Table 1. Baseline Characteristics of 17 974 Adults With Diagnosed Atrial Fibrillation, July 1, 1996-December 31, 1997*

Characteristic	ATRIA Cohort (n = 17 974)
Age, mean (SD), y	71.2 (12.2)
≥80 y	25.4
Women	43.4
Race†	
White	84.7
Black	3.6
Hispanic or Latino	2.5
Other or multiple	9.1
Known valvular heart disease	4.9
Previous ischemic stroke	8.9
Diagnosed heart failure	29.2
Hypertension	49.3
Diabetes mellitus	17.1
Previous coronary heart disease	34.6
Angina	21.8
Myocardial infarction	9.4

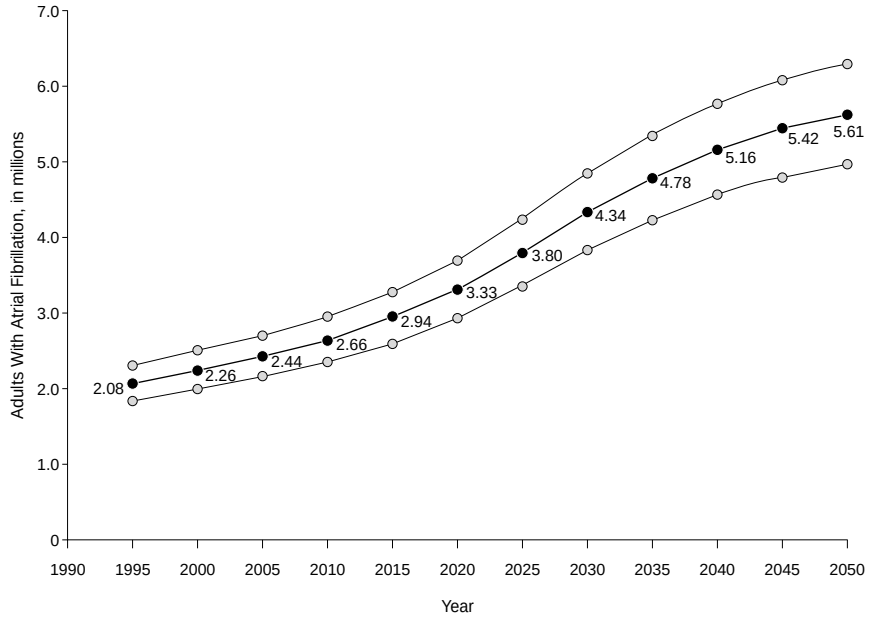
*Data are presented as percentage unless otherwise indicated. ATRIA indicates AnTicoagulation and Risk Factors in Atrial Fibrillation Study.
†Race distribution was based on 15 941 patients (89% of ATRIA cohort) with assigned race.

Figure 2. Prevalence of Diagnosed Atrial Fibrillation Stratified by Age and Sex



Errors bars represent 95% confidence intervals. Numbers represent the number of men and women with atrial fibrillation in each age category.

Figure 3. Projected Number of Adults With Atrial Fibrillation in the United States Between 1995 and 2050



Upper and lower curves represent the upper and lower scenarios based on sensitivity analyses.

Table 2. Projected Age and Sex Distribution of Adults With Atrial Fibrillation in the United States Between 2000 and 2050*

	Year		
	2000	2025	2050
Women	48.6	46.3	47.4
Age group, y			
<65	18.0	15.5	11.5
65-79	45.3	48.7	35.9
≥80	36.7	35.8	52.6

*Data are presented as percentage.

project that 5.6 million US adults will have atrial fibrillation by the year 2050. This nearly 2.5-fold estimated increase reflects the projected increase in the number of elderly persons, mostly resulting from the higher birth rate during the immediate post-World War II era. Indeed, we estimate that there will likely be nearly 3 million individuals 80 years or older with atrial fibrillation by the year 2050.

Our study had several strengths. We assembled the largest cohort of adults with atrial fibrillation reported to date—many times the size of prior studies of atrial fibrillation prevalence[4]—which allowed a relatively precise estimation of recent age-, sex-, and race-specific prevalence of diagnosed atrial fibrillation within an unselected, usual care population. We estimate that at least 87% of this cohort had electrocardiographically confirmed atrial fibrillation. Our cohort was highly representative of the California state population and had greater representation of older patients, particularly those 80 years and older, as well as women compared with earlier randomized trial populations.[1] Our cohort also had greater race or ethnic diversity than randomized trial populations and most observational studies.[1,5-8] Finally, our estimates of atrial fibrillation prevalence are the most current assessments to date.

Five previous studies have provided age-specific prevalence estimates based on at least 75 cases of atrial fibrillation.[5-8,14] Our finding that the prevalence of atrial fibrillation increases substantially with age, especially after age 50 years, is consistent with these studies, but the point estimates varied markedly among these studies. For example, among patients aged 75 through 79 years, we found a prevalence of 6.0% compared with a range of 4.8% to 13.7% in other studies[5-8,14] although the CIs from these latter studies' estimates were wide. In addition to random variation, these differences may be explained, in part, by variation in the populations studied and the methods used to detect atrial fibrillation. The approaches used to identify atrial fibrillation varied substantially across studies and included medical record review only[7]; triennial patient surveys[6]; a single screening electrocardiogram and physical examination among potential trial participants[14]; a single-screening electrocardiogram and/or self-reported atrial fibrillation from recruited subjects[8]; and biennial screening electrocardiograms, surveys, physical examinations, and medical records review from recruited subjects.[5] Interestingly, despite using automated clinical and electrocardiographic databases to identify atrial fibrillation within the context of usual clinical care in our population, our prevalence estimates are most consistent with those of the Framingham Heart Study,[5] which used the most systematic screening methods (ie, biennial surveys, physical examinations, electrocardiograms, and medical records review of hospitalizations and outside physician visits) to detect atrial fibrillation among a recruited prospective cohort. However, our study demonstrates a broader range of age-specific prevalences in a more ethnically diverse and contemporary population.

Our preliminary finding that atrial fibrillation was less prevalent among older black patients than white patients is consistent with a previous report from a cohort of older adults.[11] However, our estimates are limited because race or ethnicity status was missing in 11% of patients with atrial fibrillation and was determined for the source population from survey results in a sample of health plan members. Additional research in other populations is needed to confirm this finding and if confirmed to explore underlying mechanisms.

Our study also had several limitations. It is likely that we missed some

patients with atrial fibrillation. In patients with asymptomatic atrial fibrillation, which occurs more frequently than what has been previously estimated,[15,16] or paroxysmal atrial fibrillation, the only way to detect the arrhythmia would be through frequent repeated electrocardiograms (which would depend on atrial fibrillation being present at the time of the test) or continuous 24-hour ambulatory electrocardiographic monitoring. Neither of these options is feasible for such a large population. However, the similarities between our prevalence estimates and those from previous studies suggest that we are not missing a large number of cases. We may have misclassified some patients whose atrial fibrillation was based solely on outpatient physician diagnoses; however, our validation studies suggest that at least 87% of the cohort had atrial fibrillation confirmed electrocardiographically. We were also unable to delineate the prevalence of chronic permanent vs paroxysmal atrial fibrillation. Our US projections were necessarily limited to the assumptions of the underlying census projections[17] and do not adjust for potential future changes in associated conditions such as hypertension and heart failure. Given these caveats, our estimates of the numbers of patients with atrial fibrillation in the future may prove conservative.

In conclusion, atrial fibrillation affects 1 in 25 adults 60 years or older and nearly 1 in 10 adults 80 years or older. Atrial fibrillation confers a large burden from symptoms and ischemic stroke on elderly patients presently, and its impact will be amplified as the number of individuals with atrial fibrillation increases nearly 2.5-fold over the next 50 years. Coordinated efforts by cardiologists, primary care providers, and neurologists will be needed to meet the increasing challenge of stroke prevention and rhythm management in the growing elderly population with atrial fibrillation.

Author Contributions: *Study concept and design:* Go, Selby, and Singer.
Acquisition of data: Go, Phillips, Henault, and Singer.
Analysis and interpretation of data: Go, Hylek, Phillips, Chang, Selby, and Singer.
Drafting of the manuscript: Go, Phillips, and Singer.
Critical revision of the manuscript for important intellectual content: Go, Hylek, Phillips, Chang, Henault, Selby, and Singer.
Statistical expertise: Go, Chang, and Singer.
Obtained funding: Go and Singer.
Administrative, technical, or material support: Go, Hylek, Phillips, Henault, and Singer.
Study supervision: Selby and Singer.
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