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CLINICAL RESEARCH

Trends in the incidence and prevalence of atrial fibrillation in Iceland and future projections

Hrafnhildur Stefansdottir[1,2], Thor Aspelund[3,2], Vilmundur Gudnason[3,2], and David O. Arnar[1,2]*

[1]Department of Medicine, Cardiovascular Research Centre, Landspitali—The National University Hospital of Iceland, Reykjavik, Iceland; [2]School of Health Sciences, University of Iceland, Reykjavik, Iceland; and [3]Icelandic Heart Association, Kopavogur, Iceland

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Aims Data are scarce on the epidemiology of atrial fibrillation (AF) in Europe. The aim of this study was to examine recent trends in the incidence and prevalence of AF and project the prevalence to the year 2050.

Methods and results From 1991 to 2008 a total of 4905 residents of Reykjavik, Iceland were diagnosed with AF at the city's main health care centre. The age-standardized incidence of AF increased in women (0.9% per year, 95% CI 0.1–1.8) but not in men (0.1% per year, 95% CI −0.6 to 0.9). The age-standardized prevalence increased per year by 1.8% (95% CI 1.3–2.3) in men and 2.3% (95% CI 1.7–2.9) in women from 1998 to 2008. The number of adults with AF in Iceland is projected to increase from 4495 (prevalence 2.0%) in 2008 to 11 088 (prevalence 3.5%) in 2050, if the incidence of AF and mortality remain constant beyond 2008. However, if the incidence continues to increase as it has and mortality decreases according to projections for the general population, the projected number will rise to 13 583 (prevalence 4.3%).

Conclusion In this study in a northern European population, the incidence of AF increased in women but not men from 1991 to 2008. The prevalence of AF is currently high and the number of patients with AF is expected to triple in the next four decades. AF is already a serious public health problem and the burden of this disease could reach epidemic proportions in the coming years.

Keywords Atrial fibrillation • Incidence • Prevalence • Trends • Projections

Introduction

Atrial fibrillation (AF) is the most common sustained arrhythmia in clinical practice and is associated with an increased risk of stroke, heart failure, dementia, and death.[1,2] The current economic burden of AF in Europe is substantial and this has widespread implications for the planning of national health care systems.[3] The number of individuals diagnosed with conditions considered risk factors for AF, such as ischaemic heart disease, heart failure, obesity, and diabetes, has been increasing in recent years.[4–6] It has been postulated that the incidence of AF may be increasing as well, although there are currently insufficient data to either support or refute this theory.

Studies on trends in the incidence of AF in Europe have been limited to hospital admissions which may underestimate the burden of this arrhythmia.[7–9] One community-based study from the USA showed an increase in the incidence of AF from 1980 to 2000 but two later studies did not demonstrate this same trend.[10–12] The prevalence of AF has reportedly been increasing over different time periods ranging from the late 1960s to the turn of the twentieth century.[13–16] More recent data, however, have not been published. Lifetime risks for development of AF are 1 in 4 for men and women 40 years of age and older and AF is more common with older age.[17] The age distribution of populations in developed countries is expected to shift in the coming years with older age groups becoming more prominent. Predictions from the USA suggest that the number of persons with AF in that country will increase three-fold from 2000 to 2050.[10,18–19] Such long-term predictions have not been published for European populations.

The aim of this study was to examine recent trends in the incidence and prevalence of AF in the general population and to

* Corresponding author. Tel: +354 5431000; fax: +354 5436467, Email: davidar@landspitali.is

provide prevalence estimates for AF in Iceland through 2050. The characteristics of the Icelandic population, regarding both genetic make-up and risk of cardiovascular disease, are typical for northern Europe.[20–21] Two-thirds of the population reside in the capital Reykjavik, which has only one major health care centre. This was a retrospective open cohort study on adult residents of Reykjavik.

Methods

Study design and population

From 1991 to 2008 the population of Reykjavik aged 20–99 years increased from 99 221 residents to 145 907. The percentage of the population 65 years of age or older was 16% in both 1991 and 2008. The Icelandic health care system has universal access, similar to other countries in Europe. The two largest hospitals in Reykjavik (Reykjavik City Hospital and Landspitalinn) were merged into the Landspitali—The National University Hospital of Iceland in 2002. This hospital is the main health care centre in Iceland and the only hospital in Reykjavik with inpatient, outpatient, and emergency care services. In addition, it is the only facility where elective direct current (DC) cardioversion for AF is performed. A large proportion of patients with AF in the Reykjavik area are therefore likely to have received care at this hospital or one of its predecessors. Since 1 January 1987 a computer-based database has been in use for all patient visits to the hospitals (Reykjavik City Hospital and Landspitalinn, from 1987 to 2001, Landspitali—The National University Hospital of Iceland from 2002 to 2008), with information on diagnosis, coded according to the International Classification of Diseases (ICD), and the dates of patient encounters. All residents of Reykjavik 20–99 years of age with a diagnosis of AF (ICD-9 code 427.9 or ICD-10 code I48) between 1 January 1987 and 31 December 2008 were identified from this database. Patients with only post-operative AF after open heart surgery were not included, but no further attempt was made to subclassify AF. An analysis on the validity of the AF diagnosis was done and hospital charts of random 100 incident AF cases were reviewed. All of them had an ECG confirmed diagnoses of AF. A recent study from Malmo, Sweden also reported a high validity of the diagnosis of AF from a national hospital discharge register.[22] Presence of hypertension, ischaemic heart disease, heart valve disease, heart failure, diabetes mellitus, stroke, and transient ischaemic attack (TIA) was noted if patients had the corresponding diagnoses codes, either preceding or during the same visit as the initial AF diagnosis (see Appendix). Follow-up was performed for the outcome of death up until 31 December 2008. Information on residency and date of death was obtained from Statistics Iceland.

Statistical analysis

Changes in mean age at diagnosis of AF by year were assessed with linear regression. Incidence and prevalence rates were calculated per sex and age group (20–54, 55–64, 65–74, and 85–99 years of age). The mid-year population of Reykjavik for the corresponding category served as the denominator. These rates were then used to directly calculate overall incidence and prevalence, age and sex standardized to the 2008 Reykjavik census population. Trend in incidence was examined with the Poisson regression model and trend in prevalence with the logistic regression model. Calendar year, sex, and age group were entered as variables into the models. There was incomplete data registration on incident cases in 2002 and 2003. We suspect, although unable to confirm, that temporary changes in the cardiology services after the merger of the Reykjavik City Hospital and Landspitalinn in 2002 may have resulted in a registration error of AF cases. Based on this, a decision was made to exclude these 2 years from the regression analysis on incidence. Just over half of the patients had more than one hospital visit with a diagnosis of AF during the study period. The mean time between visits was 500 days, with 90% of them occurring within 4 years of the first diagnosis of AF. Patients with a first diagnosis of AF from 1 January 1987 to 31 December 1990 were therefore excluded from incidence calculations to reduce the risk of counting prevalent cases as incident. Statistical significance was set at $P < 0.05$.

The prevalence of AF was also calculated using a prevalence model previously described by Miyasaka *et al.*[10] In this model the age- and sex-specific prevalence of AF at each year is calculated based on the following measures from the previous year: the prevalence and incidence of AF, yearly mortality in the general population and the relative risk of mortality for AF patients compared with the general population (see further details in Supplementary material online). For example, the prevalence of AF in 65-year-old men in 2009 was calculated based on these measures in 64-year-old men in 2008. The earliest available data on age- and sex-specific mortality in Reykjavik were from 1997, so the model was used from this point on. The modelled prevalence fit well with the earlier described calculated prevalence. The model was then continued through to the year 2050. The projected prevalence rates were calculated in four different ways. First, the incidence of AF was kept constant at the 2008 rate and mortality at the average rate of 2006–2008. Second, the incidence was increased per year according to the trend from 1991 to 2008 and mortality was kept constant. Third, the incidence was kept constant and forecasts of the mortality in the Icelandic population were used and finally with the changes in both incidence and mortality. The relative risk of mortality for AF patients was kept constant. The age- and sex-specific prevalence rates were applied to the corresponding medium variant of the population estimates from Statistics Iceland to project the total number of persons in Iceland expected to have AF in every year from 2009 to 2050. We then determined the contribution of population growth, changes in demographics and changes in prevalence on the difference in the number of people with AF in 2050 compared with 2008 (see Supplementary material online for further details).

All analyses were performed using SAS version 9.2 and R version 2.12.

Ethics

This study complied with the Declaration of Helsinki and was approved by the Icelandic Data Protection Authority and the National Bioethics Committee of Iceland.

Results

Baseline characteristics

A total of 4905 residents of Reykjavik aged 20–99 years were diagnosed with AF at Landspitali—The National University Hospital of Iceland from 1991 to 2008, of which 59.0% were men (*Table 1* and Supplementary material online, *Table S1*). The mean age at diagnosis increased significantly from 69.3 ± 12.3 years in 1991 to 71.9 ± 12.8 years in 2008 for men and from 76.5 ± 10.6 to 78.6 ± 11.1 for women ($P < 0.001$ for both sexes).

Incidence

The age- and sex-standardized incidence of AF per 1000 person-years was 2.1 in 1991 and 2.4 in 2008. The relative increase in

0.5% per year did not reach statistical significance (95% CI −0.1 to 1.0, $P = 0.08$). In men the age-standardized incidence did not change significantly (0.1% per year, 95% CI −0.6 to 0.9, $P = 0.70$) (*Figure 1*). Furthermore, there was no significant change in all age groups in men except in those aged 85–99 years, where the incidence increased by 3.8% per year (95% CI 1.8–5.8) (*Table 2* and Supplementary material online, *Table S2*). In women the age-standardized incidence increased by 0.9% per year (95% CI 0.1–1.8, $P = 0.004$). In women under 65 years of age the change in incidence was not significant but in those 65 years of age or older the incidence increased by 2.1% per year (95% CI 1.1–3.0, $P < 0.001$). The difference in the trend in incidence between these groups was significant ($P = 0.012$).

Table 1 Baseline characteristics of patients at diagnosis of AF in Reykjavik, Iceland 1991–2008

Characteristic	Men, *n* (%)	Women, *n* (%)	All, *n* (%)
Age, years[a]	70.4 ± 13.6	76.6 ± 11.6	73.0 ± 13.1
Age group, years			
20–55	354 (13)	106 (5)	460 (9)
55–64	472 (17)	161 (8)	633 (13)
65–74	785 (28)	468 (22)	1253 (26)
75–84	825 (29)	813 (39)	1638 (33)
85–99	378 (13)	543 (26)	921 (19)
Ischaemic heart disease	1182 (42)	723 (35)*	1905 (39)
Heart failure	661 (23)	563 (27)	1224 (25)
Valvular heart disease	170 (6)	138 (7)	308 (6)
Hypertension	637 (23)	594 (28)*	1231 (25)
Diabetes	255 (9)	164 (8)*	419 (9)
History of stroke or TIA	451 (16)	397 (19)	848 (17)

TIA, transient ischaemic attack.
[a]Mean ± standard deviation.
*$P < 0.05$ for comparison between men and women, after controlling for age.

Prevalence

From 1998 to 2008 the age- and sex-standardized prevalence of AF increased from 1.5 to 1.9%. In 2008 the prevalence was 2.3 and 1.5% in men and women, respectively. The annual percentage change was 2.0% (95% CI 1.6–2.4, $P < 0.0001$) overall, 1.8% (95% CI 1.3–2.3, $P < 0.0001$) in men and 2.3% (95% CI 1.7–2.9, $P < 0.0001$) in women. When examined by age group, there was no significant change in the prevalence of AF in both sexes 20–54 and 54–64 years of age. There was a greater increase in prevalence with increasing age in both men and women and the association was linear ($P < 0.0001$ and $P = 0.0027$ for linear trend, respectively). The prevalence increase was most pronounced in men 85–99 years of age, or 5.1% per year (95% CI, 3.6–6.6) (*Table 3* and Supplementary material online, *Table S3*).

Prevalence projections

Applying the 2008 age- and sex-specific prevalence rates to the Icelandic census population gave an estimate of 4495 individuals 20–99 years of age with a diagnosis of AF in Iceland. This amounts to a prevalence of 2.0%. Using the prevalence model previously described and assuming that the incidence of AF and mortality remains constant beyond 2008, the projected number of adults with AF will be 7612 (prevalence 2.8%, 95% CI 2.7–2.8) in 2030 and 11 088 (prevalence 3.5%, 95% CI 3.4–3.5) in 2050. If the assumption is that incidence will remain constant but that mortality changes according to projections for the general population of Iceland, the total number of patients will be 7948 (prevalence 2.9%, 95% CI 2.8–2.9) in 2030 and 12 076 (prevalence 3.8%,

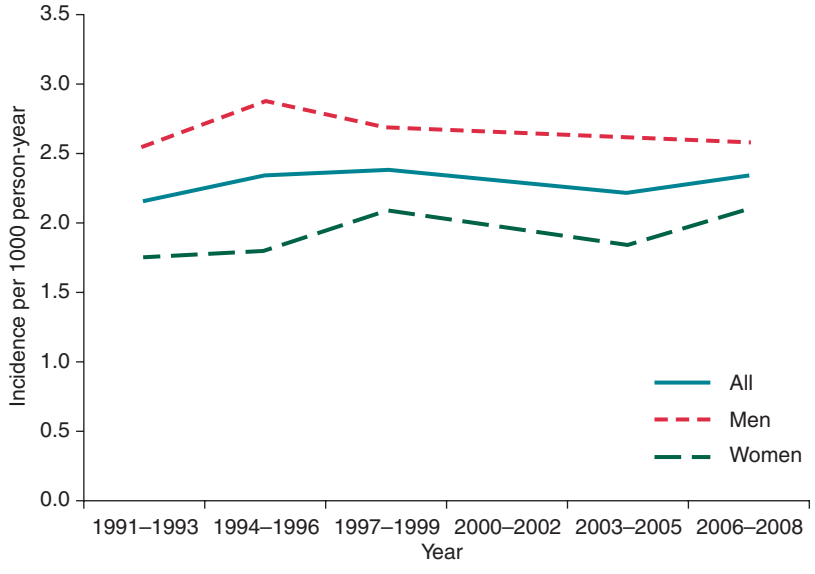

Figure 1 The incidence of AF in Reykjavik, Iceland 1991–2008 overall and by sex. Age standardized to the Reykjavik census population in 2008.

Table 2 Secular trends in the incidence of AF in Reykjavik, Iceland by sex and age group

	1991–1993	1994–1996	1997–1999	2000–2002	2003–2005	2006–2008
All, age and sex standardized	2.2 (640)	2.3 (748)	2.4 (808)	2.3 (839)	2.2 (872)	2.3 (998)
Men, age standardized	2.6 (378)	2.9 (452)	2.7 (449)	2.7 (477)	2.6 (506)	2.6 (552)
Age group (years)						
20–54	0.4 (41)	0.7 (79)	0.5 (62)	0.5 (64)	0.3 (46)	0.4 (62)
55–64	3.6 (63)	4.1 (72)	3.8 (69)	3.7 (77)	3.5 (85)	3.7 (106)
65–74	9.2 (124)	9.5 (139)	9.1 (139)	8.3 (130)	8.1 (126)	8.0 (127)
75–84	17.4 (110)	17.0 (117)	17.3 (133)	16.4 (142)	16.6 (161)	15.5 (162)
85–99	22.3 (40)	24.2 (45)	24.0 (46)	31.6 (64)	38.1 (88)	34.6 (95)*
Women, age standardized	1.8 (262)	1.8 (296)	2.1 (359)	2.0 (362)	1.8 (366)	2.1 (446)*
Age group (years)						
20–54	0.1 (14)	0.2 (23)	0.2 (23)	0.2 (23)	0.1 (11)	0.1 (12)
55–64	1.1 (21)	1.5 (29)	1.2 (24)	1.3 (29)	0.8 (21)	1.3 (37)
65–74	3.8 (60)	4.3 (75)	4.8 (88)	4.5 (82)	4.2 (74)	5.0 (89)*
75–84	10.2 (97)	10.0 (104)	11.9 (135)	11.2 (139)	11.9 (162)	12.3 (176)
85–99	20.0 (70)	17.2 (65)	23.0 (89)	21.3 (89)	20.6 (98)	24.4 (132)

Values are given as incidence rate per 1000 person-years with number of cases observed in parentheses.
*$P < 0.05$ for trends across calendar-year of AF diagnosis by Poisson regression analysis.

Table 3 Secular trends in the prevalence (%) of AF in Reykjavik, Iceland by sex and age group

	1998–1999	2000–2002	2003–2005	2006–2008
All, age and sex standardized	1.6	1.7	1.8	1.9*
Men, age standardized	1.9	2.1	2.2	2.3*
Age group (years)				
20–54	0.3	0.4	0.3	0.3
55–64	2.5	2.8	2.8	2.7
65–74	6.3	6.9	7.0	7.5*
75–84	12.4	13.8	14.3	15.1*
85–99	18.0	21.0	24.6	27.8*
Women, age standardized	1.2	1.3	1.4	1.5*
Age group (years)				
20–54	0.1	0.1	0.1	0.1
55–64	0.8	1.0	0.8	0.8
65–74	2.6	2.9	2.9	3.3*
75–84	6.6	7.2	8.1	9.0*
85–99	15.0	15.1	15.9	17.5*

*$P < 0.05$ for trends across calendar-year by logistic regression analysis.

95% CI 3.7–3.9) in 2050. With constant mortality but a continuing rise in the incidence of AF in women by 0.9% per year, as was evident from 1991 to 2008, the projected number of patients will rise to 7990 (prevalence 2.9%, 95% CI 2.8–3.0) in 2030 and 12 540 (prevalence 3.9, 95% CI 3.9–4.0) in 2050. Finally, assuming the incidence and mortality change in accordance with the trend in incidence and mortality forecasts, the number of persons with AF in Iceland is projected to be 8329 (prevalence 3.0%, 95% CI 3.0–3.1) in 2030 and 13 583 (prevalence 4.3%, 95% CI 4.2–4.3) in 2050 (*Figure 2*). The predicted number of adults with AF therefore exceeds the 2008 estimates by a range of 147–202% in the year 2050. In comparison the adult Icelandic population is expected to increase by 39% in the same time period, from 229 458 persons in 2008 to 318 624 in 2050 (*Figure 3*). In 2008 the proportion of patients with AF who were 80 years of age or older was 40% but is expected to increase in 55% in 2050. The projected increase in case load of AF patients would be driven by population growth (19.1%), shifting of the age distribution (53.4%), and changes in incidence and mortality (27.5%). Supplementary material online, *Table S4* presents projected number of persons with AF for men and women separately.

Discussion

This large community-based study from Reykjavik, Iceland, shows that from 1991 to 2008 the incidence of AF increased in women but not in men. The prevalence of AF increased overall by 2% per year during the last decade of the study. Assuming no further change in incidence and mortality beyond 2008, the prevalence of AF in Iceland is projected to increase from 2.0% in 2008 to 3.5% in 2050. If, on the other hand, recent trends in the incidence of AF continue and mortality changes as expected in the general population, the projected prevalence will be as high as 4.3% in 2050. This corresponds to an increase in the number of adults with AF by >200%. These are the first prevalence projections for AF using trends in incidence and mortality forecasts.

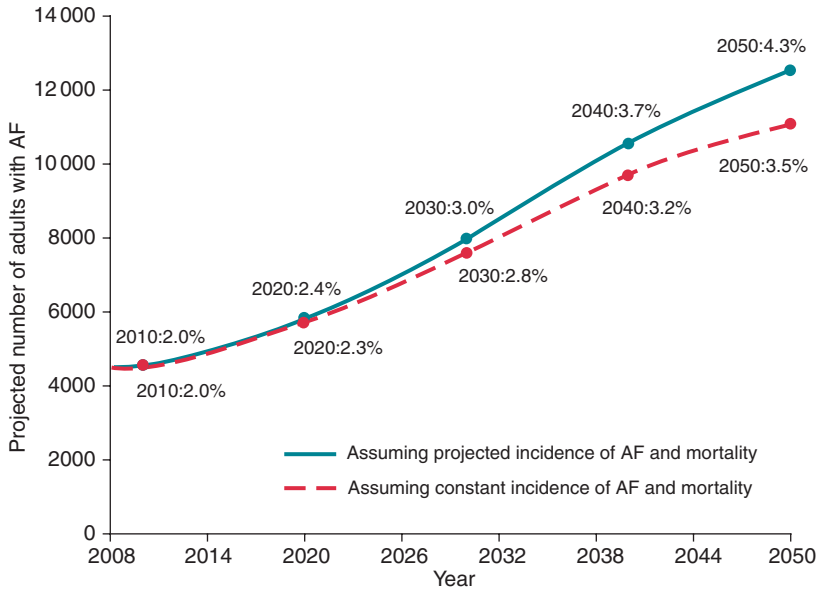

Figure 2 Projected burden of diagnosed AF in 20–99 year olds in Iceland 2008–2050 assuming no change in the incidence of AF and mortality beyond 2008 and assuming a continued increase in incidence as evident in 1991–2008 and mortality according to projections for Iceland. Data labels present prevalence figures in selected years.

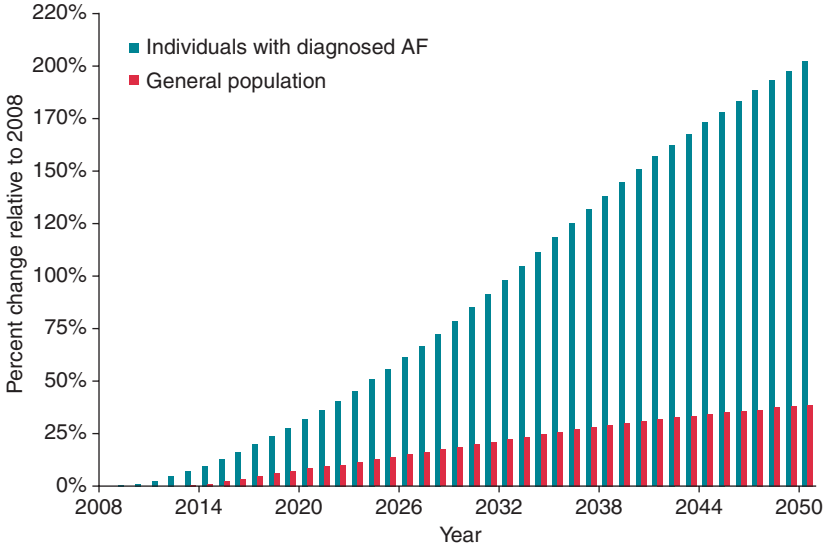

Figure 3 Estimated percentage changes in the number of individuals 20–99 years of age with AF in Iceland assuming a continued increase in incidence as evident in 1991–2008 and mortality according to projections for Iceland, and the Icelandic population 20–99 years of age relative to 2008 values.

Trends in the incidence of AF

The trend in the incidence of AF from 1991 to 2008 showed distinct patterns by sex and age groups. There was no significant change in men except in the oldest age group, 85–99 years of age where the increase was almost 4% per year. In women, however, the overall incidence increased by 0.9% per year. There was a slight but steady incidence in those younger than 65 years of age but a 2.1% increase per year in those 65 years of age or older. The reason for the different trends by sex is not clear. In the last decades the prevalence of ischaemic heart disease increased to a similar degree in men and women in the general population of Reykjavik.[5] Furthermore in a population-based study on a large cohort of citizens of Reykjavik, the prevalence of diabetes and obesity increased and blood pressure

decreased at a comparable rate in both sexes from 1981 to 2006.[23] The observed trends in the incidence of AF might concievably reflect trends in the prevalence of some newer risk factors for AF not accounted for in population attributed risk models. At present much of the population risk for AF remains unexplained.[21,24] Studies have shown that the risk of AF is lower in patients with hypertension or heart failure if the disease severity is less and if drugs that suppress the renin–angiotensin system are used for treatment.[25–28] In addition, the risk of AF after myocardial infarction has decreased with the introduction of acute reperfusion therapy.[29] If treatment of men and women with these disorders has differed this might in part help explain the different trends in incidence of AF.

This study provides the most current analysis on the trends in incidence of AF in a general population. Other studies from Europe on trends in incidence of AF were based on hospital admissions alone and showed an increase in hospitalized patients with AF during the 1980s through 1990s.[7–9]. It is not clear whether this was due to a true increase in the incidence of AF or due to changes in hospital admissions criteria. While this current study is based on hospital records, it includes, in addition to admissions, elective DC cardioversions, outpatient clinic, and emergency room visits. A comprehensive community-based study from Olmsted County in MN in the USA showed that the age- and sex-adjusted incidence of AF increased by 0.6% per year in the period of 1980–2000.[10] In contrast to our study the trend reached significance in men but not women, but the rate of increase was not different between the sexes. The Olmsted County study and this current one only partially overlap in time so it is possible that the trend in incidence is truly changing. It would, in this regard, be of interest to know if there was any difference in the trend in the first vs. second half of the study from Olmsted County. In the ARIC study there was no change in the age-specific incidence of AF from 1987 to 2004.[11] There are some possible explanations for the difference between this study and the current one. The study sample was considerably smaller in the ARIC study, with 680 patients with AF 65 years of age or older compared with 3812 in the current one. In addition, the trends were compared in smaller age groups than in this study. It is therefore possible that the sample sizes were not large enough to detect significant trends. Finally, in a study from 1992 to 2002 on a 5% sample of Medicare patients (age $\geq$65 years) in the USA, there was a steady overall incidence.[12] Data on trends by sex were not published, making comparison with our study difficult.

Trends in the prevalence of AF

The prevalence of AF increased from 1998 to 2008 by 2% per year. An increase in prevalence could be the result of increasing incidence and/or improved survival. The trend in prevalence by age groups in women reflected the change in incidence, with the prevalence increasing in those 65 years of age or older. Similarly in the oldest age group for men, who had an increase in incidence, the prevalence increased although to a slightly greater degree. However, the prevalence also increased in men 65–74 and 75–84 years of age, where the incidence was stable. There are limited data on temporal changes in the mortality of AF patients compared with the general population and specifically if there has been any difference in the trend by sex.

Few previous studies have reported age- and sex-specific trends in the prevalence of AF and none with as recent data as this current one. In the Framingham Study and the Copenhagen City Heart Study the prevalence of AF in middle-aged and elderly men but not women increased significantly from the 1970 to 1990s.[13–14] It was postulated that this sex-specific trend may in part result from improvement in survival after myocardial infarction, which had been greater in men than women. Even so, the same trends were evident in men and women with no history of this disease. Two more recent studies from the UK, from a primary care setting, reported an increase in the prevalence of AF in both sexes of all ages at the turn of the century.[15–16] The annual percentage change in prevalence was more than double of what we found and the change per year was even higher in the earliest studies. Even though these studies have been conducted in different settings, this might possibly be an indication that the rise in the prevalence of AF is slowing.

Future projections

The prevalence of AF in both Europe and the USA was reported to be ~1% in the 1990s.[18,28] In this study, the 2008 prevalence of AF in Iceland was 2%. Even with no change in incidence and mortality beyond 2008, it is estimated that the number of adults with AF in Iceland will almost triple over the next four decades. This can be attributed to the expected growth and ageing of the population. If we also factor in the recent trend in the incidence of AF and the projected decrease in mortality in the general population the number goes up from 4495 in 2008 to 13 583 in 2050, an increase in 202%. These are the first long-term prevalence projections for AF in Europe, although there have been three published prevalence projections for AF from the USA, with the initial point ranging from 1995 to 2005.[10,18–19] All of them projected a similar relative increase in the number of people with AF as in our study, assuming no change in incidence of AF or mortality. Only one of these studies assumed an increase in incidence and none incorporated mortality projections into the prevalence model as done in this current study. The projected absolute number of people with AF differed between the studies. In the previously mentioned study from Olmsted County the projected number was in the range of 12–16 million people in 2050, depending on the trends in incidence. The other two studies, from a health maintenance organization in California and a national health insurance database, projected lower numbers (around 6 and 8 million, respectively). As is postulated in these studies, the difference could be related to different study settings, race composition, or case ascertainment. Our results most closely compared with the study from Olmsted County. The Icelandic population is ~1000 times smaller than the US population so the projected case load in relative terms is similar between these studies.

If we apply our prevalence rates to Europe we roughly estimate that there are currently ~10 million Europeans diagnosed with AF and that by 2050 this number could rise to a staggering 25–30 million.[30] An increasing proportion of the AF population will be over 80 years old. This has serious implications for the planning of health and welfare systems in Europe. In addition to treating

AF, efforts will need to focus on developing effective upstream therapies to prevent the disease and a more aggressive approach to decrease the risk of serious complications such as stroke. In this regard, a stricter adherence to practice guidelines for AF is imperative as current data indicate that the use of anticoagulation therapy to prevent stroke is significantly underutilized.[31]

Study limitations and strengths

There are clear limitations to this analysis. We did not exclude those with secondary causes of AF other than recent cardiac surgery. The diagnosis of AF was only acquired through hospital records, which likely underestimates the incidence of AF in the population. However, the diagnosis was not only obtained from hospital admissions, but also from emergency room and outpatient clinic visits. We do not have information on how many cases were missed as the only published study from Iceland on the prevalence of AF reported rates from over 40 years ago.[32] As previously mentioned, based on the structure of the health facilities in Reykjavik, we believe that the majority of patients with AF receive care at the city's only hospital. In support of that, our incidence and prevalence rates were higher than in other studies based only on hospital admissions and compared more closely to studies that additionally had information from non-hospital-based physicians.[7–9,33] Patients with asymptomatic AF are likely to be underrepresented in a study such as this. An increase in hospital coding for AF diagnosis and awareness of AF leading to an increase in ECG use could confound the observed trend in incidence of AF. However, if this was a major factor we would have expected to see an increase in incidence in both men and women.

This was an open cohort study which also has some limitations. If the immigration or emigration rates are high, then changes observed in the incidence or prevalence of AF could be because the composition of study population was changing by year. However, during our study period the net migration rate in Reykjavik was $<1\%$. Finally, the population of Iceland is largely Caucasian so these results might not be directly applicable to other ethnic groups in Europe.

This analysis also has important strengths. The study population consisted of two-thirds of the Icelandic population and is therefore a good representative of the nation as a whole. All the data from the hospital database and from Statistics Iceland have been gathered and registered prospectively. As all inhabitants of Iceland have personal identification numbers the databases could be easily linked and there was no loss to follow-up. The length of the study period and the number of cases in the study are important when trying to determine trends by subgroups.

Conclusion

The age-standardized incidence of AF in Reykjavik, Iceland, increased in women but not men from 1991 to 2008. In the last decade the prevalence of AF increased by a fifth in both sexes. The number of adults with AF in Iceland is projected to triple in the next four decades and an increasing proportion of this population will be of very old age. AF is already a serious public health problem and the burden of this disease could reach epidemic proportions in the coming years.

Supplementary material

Supplementary material is available at *Europace* online.

Conflict of interest: none declared.

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Appendix

Hypertension: ICD-9 401-405. ICD-10 I10-15.
Ischaemic heart disease: ICD-9 410-414. ICD-10 I20-25.
Mitral and aortic valvular heart disease: ICD-9 394-369, 424.0, 424.1. ICD-10 I05, I06, I34, I35.
Heart failure: ICD-9 428. ICD-10 I50.
Diabetes mellitus: ICD-9 249, 250. ICD-10 E10-14.
Stroke and transient ischaemic attack: ICD-9 430-434, 435, 436. ICD-10 G45, I60-64.

References

1. Stewart S, Hart CL, Hole DJ, McMurray JVJ. A population-based study of the long-term risks associated with atrial fibrillation: 20-year follow-up of the Renfrew/Paisley Study. *Am J Med* 2002;**113**:359–64.
2. Bunch TJB, May HT, Bair TL, Osborn JS, Anderson JL, Muhlestein JB *et al.* Atrial fibrillation is independently associated with senile, vascular and Alzheimer's dementia. *Heart Rhythm* 2010;**7**:433–7.
3. Ringborg A, Nieuwlaat R, Lindgren P, Jönsson B, Fidan D, Maggioni AP *et al.* Costs of atrial fibrillation in five European countries: results from the Euro Heart Survey on atrial fibrillation. *Europace* 2008;**10**:403–11.
4. Harmsen P, Wilhelmsen L, Jacobsson A. Stroke incidence and mortality rates 1987–2006 related to secular trends of cardiovascular risk factors in Gothenburg, Sweden. *Stroke* 2009;**40**:2691–7.
5. Sigfusson N, Sigurdsson G, Agnarsson U, Gudmundsdottir II, Stefansdottir I, Sigvaldason H *et al.* Declining coronary heart disease mortality in Iceland: contribution by incidence, recurrence and case fatality rate. *Scand Cardiovasc J* 2002;**36**:337–41.
6. Curtis LH, Whellan D, Hammill BG, Hernandez AF, Anstrom KJ, Shea AM *et al.* Incidence and prevalence of heart failure in elderly persons, 1994–2003. *Arch Intern Med* 2008;**168**:418–24.
7. Frost L, Vestergaard P, Mosekilde L, Mortensen LS. Trends in incidence and mortality in the hospital diagnosis of atrial fibrillation or flutter in Denmark, 1980–1999. *Int J Cardiol* 2005;**103**:78–84.
8. Stewart S, MacIntyre K, Chalmers JWT, Boyd J, Finlayson A, Redpath A *et al.* Trends in case-fatality in 22968 patients admitted for the first time with atrial fibrillation in Scotland, 1986–1995. *Int J Cardiol* 2002;**82**:229–36.
9. Friberg J, Buch P, Scharling H, Gadsboll N, Jensson GB. Rising rates of hospital admissions for atrial fibrillation. *Epidemiology* 2003;**14**:666–72.
10. Miyasaka Y, Barnes ME, Gersh BJ, Cha SS, Bailey KR, Abhayaratna WP *et al.* Secular trends in incidence of atrial fibrillation in Olmsted County, Minnesota, 1980 to 2000, and implications on the projections for future prevalence. *Circulation* 2006;**114**:119–25.
11. Alonso A, Agarwal SK, Soliman EZ, Ambrose M, Chamberlain AM, Prinseas RJ *et al.* Incidence of atrial fibrillation in Whites and African-Americans: The Atherosclerosis Risk in Communities (ARIC) study. *Am Heart J* 2009;**158**:111–7.
12. Lakshminarayan K, Solid CA, Collins AJ, Anderson DC, Herzog CA. Atrial fibrillation and stroke in the general medicare population. *Stroke* 2006;**37**:1969–74.
13. Wolf PA, Benjamin EJ, Belanger AJ, Kannel WB, Levy D, D'Agostino RB. Secular trends in the prevalence of atrial fibrillation: the Framingham Study. *Am Heart J* 1996;**131**:790–5.
14. Friberg J, Scharling H, Gadsböll N, Jensen GB. Sex-specific increase in the prevalence of atrial fibrillation (The Copenhagen City Heart Study). *Am J Cardiol* 2003;**92**:1419–23.
15. DeWilde S, Carey IM, Emmas C, Richards N, Cook DG. Trends in the prevalence of diagnosed atrial fibrillation, its treatment with anticoagulation and predictors of such treatment in UK primary care. *Heart* 2006;**92**:1064–70.

16. Majeed A, Moser K, Carroll K. Trends in the prevalence and management of atrial fibrillation in general practice in England and Wales, 1994–1998: analysis of data from the general practice research database. *Heart* 2001;**86**:284–8.
17. Lloyd-Jones DM, Wang TJ, Leip EP, Larson MG, Levy D, Vasan RS *et al.* Lifetime risk for development of atrial fibrillation: the Framingham Heart Study. *Circulation* 2004;**110**:1042–6.
18. Go AS, Hylek EM, Phillips KA, Chang Y, Henault LE, Selby JV *et al.* Prevalence of diagnosed atrial fibrillation in adults: national implications for rhythm management and stroke prevention: the ATRIA study. *JAMA* 2001;**285**:2370–5.
19. Naccarelli GV, Varker H, Lin J, Schulman KL. Increasing prevalence of atrial fibrillation and flutter in the United States. *Am J Cardiol* 2009;**104**:1534–9.
20. Helgason A, Sigurdardottir S, Gulcher JR, Ward R, Stefansson K. mtDNA and the origin of the Icelanders: deciphering signals of recent population history. *Am J Human Genet* 2000;**66**:999–1016.
21. Aspelund T, Thorgeirsson G, Sigurdsson G, Gudnason V. Estimation of 10-year risk of fatal cardiovascular disease and coronary heart disease in Iceland with results comparable with those of the Systematic Coronary Risk Evaluation project. *Eur J Cardiovasc Prev Rehabil* 2007;**14**:761–8.
22. Smith JG, Platonov PG, Hedblad B, Engström G, Melander O. Atrial fibrillation in the Malmö diet and cancer study: a study of occurence, risk factors and diagnostic validity. *Eur J Epidemiol* 2010;**25**:95–102.
23. Aspelund T, Gudnason V, Magnusdottir BT, Andersen K, Sigurdsson G, Thorsson B *et al.* Analysing the large decline in coronary heart disease mortality in the icelandic population aged 25–74 between the years 1981 and 2006. *PLoS ONE* 2010;**5**:e13957.
24. Benjamin EJ, Levy D, Vaziri SM, D'Agostino RB, Belanger AJ, Wolf PA. Independent risk factors for atrial fibrillation in a population-based cohort: The Framingham Heart Study. *JAMA* 1994;**271**:840–4.
25. Maisel WH, Stevenson LW. Atrial fibrillation in heart failure: epidemiology, pathophysiology, and rationale for therapy. *Am J Cardiol* 2003;**91**:2D–8D.
26. Thomas MC, Dublin S, Kaplan RC, Glazer NL, Lumley T, Longstreth WT Jr *et al.* Blood pressure control and risk of incident atrial fibrillation. *Am J Hypertens* 2008;**21**:1111–6.
27. Jibrini MB, Molnar J, Arora RR. Prevention of atrial fibrillation by way of abrogation of the renin–angiotensin system: a systematic review and meta-analysis. *Am J Ther* 2008;**15**:36–43.
28. Schneider MP, Hua TA, Bohm M, Wachtell K, Kjeldsen SE, Schmieder RE. Prevention of atrial fibrillation by renin–angiotensin system inhibition a meta-analysis. *J Am Coll Cardiol* 2010;**55**:2299–307.
29. Schmitt J, Duray G, Gersh BJ, Hohnloser SH. Atrial fibrillation in acute myocardial infarction: a systematic review of the incidence, clinical features and prognostic implications. *Eur Heart J* 2009;**30**:1038–45.
30. United Nations, Department of Economic and Social Affairs, Population Division. *World Population Prospects: The 2008 Revision: Volume I: Comprehensive Tables*. United Nations publication; 2009.
31. Camm AJ, Kirchhof P, Lip GY, Schotten U, Savelieva I, Ernst S *et al.* Guidelines for the management of atrial fibrillation: the Task Force for the Management of Atrial Fibrillation of the European Society of Cardiology. *Europace* 2010;**12**:1360–420.
32. Onundarson PT, Thorgeirsson G, Jonmundsson E, Sigfusson N, Hardarson T. Chronic atrial fibrillation—epidemiologic features and 14 year follow-up: a case control study. *Eur Heart J* 1987;**8**:521–7.
33. Heeringa J, van der Kuip DAM, Hofman A, Kors JA, van Herpen G, Stricker BH *et al.* Prevalence, incidence and lifetime risk of atrial fibrillation: the Rotterdam study. *Eur Heart J* 2006;**27**:949–53.