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Comprehensive nationwide incidence and prevalence trends of atrial fibrillation in Finland

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ABSTRACT

Objective Atrial fibrillation (AF) is a worldwide healthcare challenge owing to population ageing. In this study, we assessed the current trends in the incidence and prevalence of AF for the first time in an unselected, nationwide population.

Methods In the Finnish Anticoagulation in Atrial Fibrillation study, we gathered comprehensive data including all primary, secondary and tertiary healthcare visits and drug reimbursement from national healthcare registers to identify all patients with incident AF between 2004 and 2018 in Finland. Incident AF was defined as new-onset AF occurring after 2007. Time trends for the incidence and prevalence of AF were calculated and stratified by sex and age.

Results A total of 411 387 patients with AF diagnosis were documented in Finland during 2004–2018. In 2018, the incidence and prevalence of AF in the total Finnish population were 469/100 000 and 4.1%, respectively. The incidence of new-onset AF in the adult population (≥20 years) increased from 471/100 000 in 2007 to 604/100 000 in 2018, but the age-adjusted incidence remained stable. The prevalence of AF increased in the adult population from 2.5% to 5.2%, and was higher in men than in women (5.9% vs 4.6%, p<0.001). The incidence and prevalence of AF increased with age and were 3194/100 000 and 23.4% in patients older than 75 years.

Conclusions Based on comprehensive nationwide data including primary care, we observed an increasing incidence and prevalence of AF over time. This increase was strongly age-dependent with the age-standardised incidence remaining stable during 2007–2018.

Trial registration number NCT04645537.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Atrial fibrillation (AF) is increasing owing to population ageing.

WHAT THIS STUDY ADDS

⇒ Comprehensive nationwide registries, including also primary care, documented that the increase in the incidence and prevalence of AF occurred only in the elderly population, while the incidence of AF is decreasing in the working age population.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Contemporary information on trends in AF burden is valuable for planning future research and healthcare policies.

INTRODUCTION

Atrial fibrillation (AF) is a chronic condition, and most patients require lifelong treatment, including rate or rhythm control for symptom relief and oral anticoagulation to reduce the risk of stroke.[1] Both the incidence and prevalence of AF are strongly age-dependent, and with population ageing, the burden of AF is rapidly increasing worldwide.[2–4]

Due to its major public health implications, it is important to understand the characteristics of these patients and the current trends in the incidence and prevalence of AF. In earlier studies on the incidence and prevalence of AF, the target populations have ranged from regional populations and administrative registers to healthcare claim samples and used diverse methodologies in the capture of AF diagnosis. Most epidemiological studies have included patients from either primary care or hospital registers and have often focused only on certain age groups or regions. This has led to widely differing estimates of the incidence and prevalence of AF.[5–10]

This study is based on the Finnish Anticoagulation in Atrial Fibrillation (FinACAF) study, which included all Finnish patients with AF over a 15-year period until 2018. To the best of our knowledge, this is the first comprehensive, nationwide AF study based on all levels of health registry data, including primary, secondary and tertiary healthcare. In this study, we assessed the incidence and prevalence of AF and characterised the changes in these trends
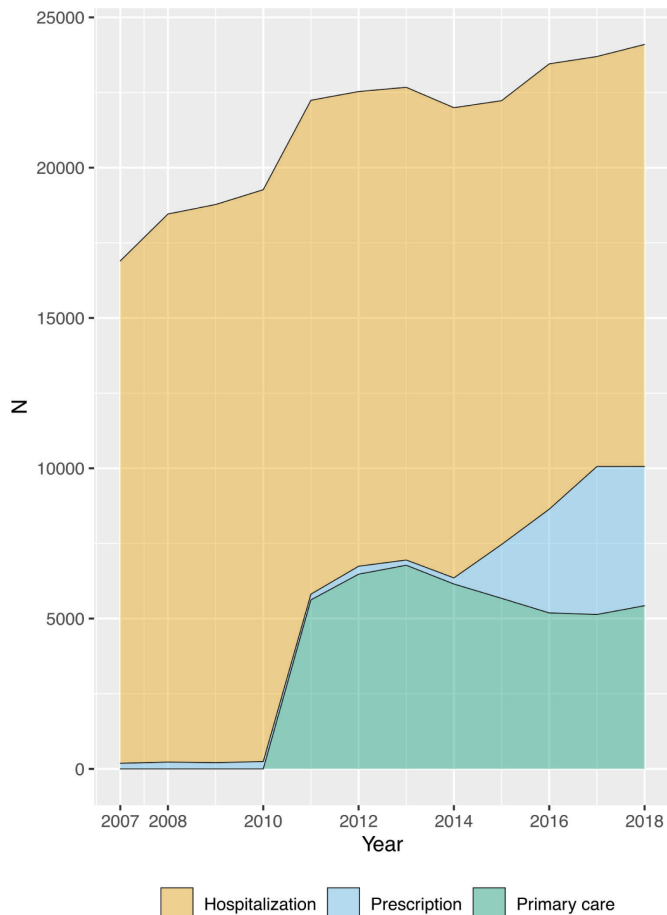
Figure 1 Frequencies of new-onset atrial fibrillation diagnosis by data source by year. Sources: hospitalisation: care register of Healthcare of hospitalisation and hospital outpatient care (HILMO), primary healthcare: (AvoHILMO) and reimbursement: national reimbursement register of prescriptions (Kela).

over time. Moreover, we evaluated sex-specific and age-specific differences in the incidence and prevalence of AF and described the characteristics of the average patient.

METHODS

The FinACAF study was a nationwide, retrospective, register-based cohort study that included all patients diagnosed with AF in Finland between 2004 and 2018.[11] In Finland, all contacts in healthcare are mandatory to be registered in nationwide registers. Patients were identified from three national healthcare registers: hospitalisations and outpatient specialist visits from the Care Register of Healthcare (HILMO), primary healthcare visits from the Care Register of Healthcare (AvoHILMO) and drug prescriptions from the National Reimbursement Register maintained by the Social Insurance Institution (KELA). A list of the registers utilised in the study is presented in online supplemental table 1, and the design and methods have been reported in more detail.[11] Figure 1 shows the frequencies of new-onset AF diagnosis by data source and year. The hospital care register HILMO contains nationwide data on inpatient hospital care since 1969, and the

National Primary Health Care Register was launched in 2011 and completed in 2012. The inclusion criteria were diagnosis code I48 in the International Classification of Diseases, 10th Revision (ICD-10) from 1 January 2004 to 31 December 2018 in any of the above-mentioned registers.

All Finnish residents have a unique national identification code, and the patients' individual data from the Finnish population and healthcare registers were linked together using this identification code. The study was conducted without any direct patient involvement or contact during any phase of the study. Therefore, no patient consent was needed according to the Finnish legislation. The study was registered in the ENCePP e-register (http://www.encepp.eu; EUPAS29845) and ClinicalTrials. gov/ct2/home. This study followed the Strengthening the Reporting of Observational Studies in Epidemiology statement while reporting the results.[12]

To ensure the classification of patients with new-onset AF as incident cases, we considered a patient to have incident AF only if the diagnosis occurred after 1 January 2007 allowing at least a 3-year period without AF diagnosis registration in the Finnish healthcare registers. Patients taking warfarin from 2004 to 2006 were also excluded from the incidence cohort. Population data at the end of each calendar year were obtained from Statistics Finland.

Statistical methods

Both the incidence and population data were aggregated by calendar year and 5-year interval age groups. The raw incidence rates (1/100 000) were calculated by dividing the total number of incident AF cases per year by the total number of the Finnish population free of AF on the first day of that year.

The annual prevalence on 31 December of each year from 2007 to 2018 was calculated as the cumulative number of patients alive with AF divided by the total Finnish population on the last day of that year. Both the prevalence and incidence were presented for populations aged ≥20 years and ≥75 years, with the entire population as the background population.

To render the raw incidence rates comparable between years and with other populations, we calculated age-standardised rates using the European population as the standard. The incidence of AF was analysed using Poisson regression models with population size as the offset variable and year, age group and hospital district as covariates. To compare the relative incidence rates between the groups, results were presented as incidence rate ratios (IRR) with 95% CI. The R Project for Statistical computing and popEpi package (R Foundation for Statistical Computing, Vienna, Austria. URL http://www. R-project.org/) were used for data analyses.

RESULTS

A total of 411 387 patients with the diagnosis of AF between 2004 and 2018 were documented. Table 1

Table 1 Baseline characteristics of the individuals with new atrial fibrillation (AF) between 2012 and 2018, and characteristics of the cohort of AF patients alive on 31 December 2018

	Incident patients 2012–2018 (n=168 233)	Prevalent patients at the end of 2018 (n=226 847)
Age mean (SD), median	73.4 (12.6), 74.8	74.7 (12.1), 75.5
Age group		
20–64 years	37 169 (22.1)	41 791 (18.5)
65–74 years	47 972 (28.5)	64 868 (28.6)
≥75 years	83 092 (49.4)	120 008 (52.9)
Female sex	82 716 (49.2)	103 138 (45.5)
Hypertension	131 392 (78.1)	193 438 (85.3)
Diabetes	40 922 (24.3)	66 289 (29.2)
Ischaemic stroke or TIA	28 608 (17.0)	48 495 (21.4)
Congestive heart failure	29 822 (17.7)	64 083 (28.2)
Coronary heart disease	47 415 (28.2)	82 911 (36.5)
Hypercholesterolaemia	89 967 (53.5)	146 228 (64.5)
CHA_2DS_2-VASc score	3.59 (1.87)	4.01 (1.98)

Data are presented as n (%) or mean (SD).

CHA_2DS_2-VASc, congestive heart failure, hypertension, age≥75 years, age 65–74 years, diabetes mellitus, stroke, sex category (female), vascular disease; TIA, transient ischaemic attack.

provides the baseline characteristics of incident AF cases and the entire AF population at the end of 2018. Of the patients with new-onset AF, 49.2% were female, the median age was 74.8 years, and the most frequent comorbidity was hypertension (78%). The mean CHA_2DS_2-VASc score was 3.6±1.9.

Incidence of AF
In 2018, the incidence of AF was 604/100 000 among adults aged ≥20 years and 469/100 000 in the entire Finnish population. There was a steep increase in the incidence of AF after the age of 60 years in both men and women (figure 2, online supplemental figure 1). The incidence of AF in the adult population was higher in men than in women (640/100 000 vs 571/100 000, p<0.001 in 2018), and this difference was present in all age groups (figure 2, table 2). Among those aged ≥75 years, the incidence was 3194/100 000 in 2018.

Time trends in AF incidence
The raw incidence of new-onset AF increased from 471/100 000 in 2007 to 604/100 000 in 2018 in the adult population; however, the age-standardised incidence remained stable (figure 3, table 2). Inclusion of the primary care register increased the capture of AF cases, and this increase occurred predominantly in the patients aged ≥75 years. Before 2012, 99% of the new AF cases were captured from the hospital records, but in 2018, only 58% of the new-onset AF cases were derived from the hospital records (figure 1).

The IRR of new-onset AF showed a decrease from 2007 to 2018 in patients aged <65 years, but increased in those aged 65–74 and ≥75 years (Poisson regression

model with calendar year, age groups, sex and hospital district as covariates) (figure 4). There were significant interactions between year and sex (p<0.001) and year and age (p<0.001), and when applying this in the model, the incidence of AF decreased by around 10% in both sexes in the age group <65 years. In the age group 65–74 years, AF incidence increased in women by 20%, but not in men. A marked increase of 30%–40% was detected in the age group ≥75 years in both sexes (figure 4). The corresponding information given as raw incidence rates of new-onset AF during 2007–2018 is provided in online supplemental figure 2.
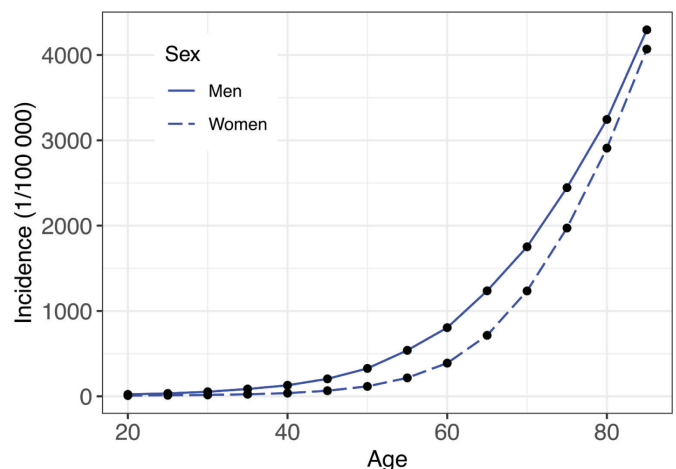

Figure 2 The incidence of atrial fibrillation in men and women in relation to age in 2018.

Table 2 Incidence of atrial fibrillation in the adult population (≥20 years) in Finland for men and women

	Men				Women				All		
Year	N	Population (100 000)	Rate	Age standardised rate	N	Population (100 000)	Rate	Age standardised rate	N	Population (100 000)	Rate
2007	9527	19.21	496.0	323.4	9206	20.57	447.4	199.6	18733	39.78	470.9
2008	10378	19.28	538.4	346.6	9814	20.62	476.0	211.6	20192	39.90	506.1
2009	10361	19.33	535.9	341.7	9990	20.67	483.2	213.5	20351	40.01	508.7
2010	10576	19.41	544.9	341.9	10302	20.73	496.9	219.2	20878	40.14	520.1
2011	12184	19.49	625.2	386.2	11817	20.81	567.9	243.1	24001	40.30	595.6
2012	12173	19.57	622.1	382.2	11786	20.87	564.6	241.2	23959	40.44	592.4
2013	12193	19.64	620.7	377.8	11860	20.94	566.3	242.4	24053	40.59	592.6
2014	11679	19.72	592.2	356.0	11590	21.01	551.6	234.5	23269	40.73	571.3
2015	11745	19.79	593.5	351.0	11505	21.06	546.3	227.6	23250	40.85	569.1
2016	12495	19.86	629.0	366.4	11911	21.10	564.5	231.4	24406	40.96	595.8
2017	12478	19.91	626.7	360.7	12001	21.12	568.1	230.5	24479	41.04	596.5
2018	12754	19.94	639.5	362.3	12063	21.14	570.7	228.4	24817	41.08	604.1

Both raw and age-standardised rates. Age standardisation for European population.

Prevalence of AF

The prevalence of AF in the age group ≥20 years increased from 2.5% in 2007 to 5.2% in 2018 (p<0.001) (figure 5, online supplemental figure 2 and online supplemental table 2). At the end of the study period, the number of AF patients in Finland was 226 847, and the AF prevalence in the total Finnish population was 4.1%. The prevalence increased steeply in the elderly population, and was higher in men compared with women (5.9% vs 4.6%, p<0.001) (figure 6, online supplemental figure 3). Among the elderly ≥75 years, the prevalence of AF was 23.4% in 2018.
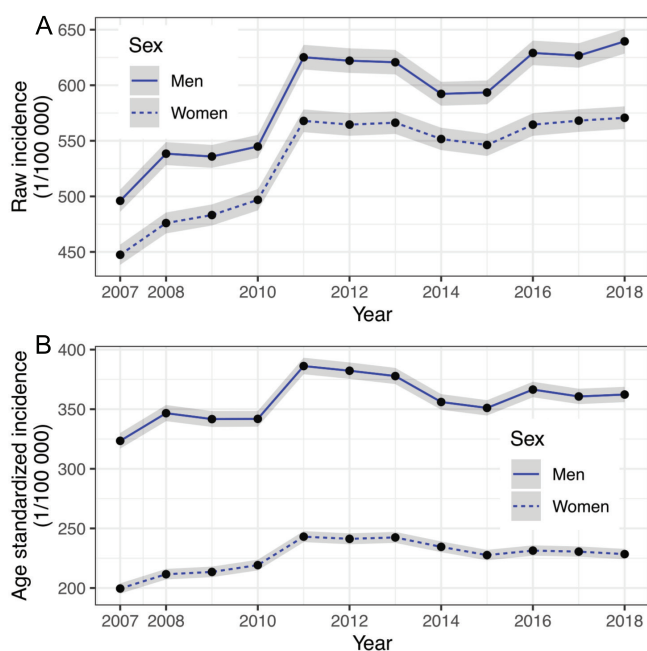

Figure 3 Raw (A) and age-standardised (B) incidence of atrial fibrillation in the adult population (≥20 years) during 2007–2018. Temporary increase in AF incidence in 2011–2013 occurred predominantly in the age group ≥75 years, likely caused by the introduction of the primary care register (AvoHILMO) uncovering older patients with AF treated only in primary care. Grey zone=95% CI.
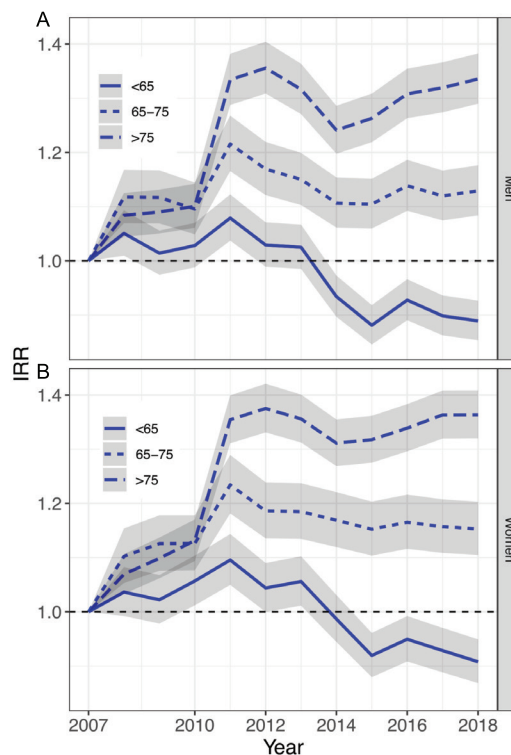

Figure 4 Incidence rate ratios (IRR) of new-onset atrial fibrillation during 2007–2018 comparing the relative changes within the selected age groups in the adult population (≥20 years) in men (upper panel) and women (lower panel). The analysis is based on Poisson regression model with age, sex, calendar year, hospital district, together with interaction term between year and sex and year and age. Grey zone=95% CI. The horizontal long-dashed line=reference line, that is, 1.0.
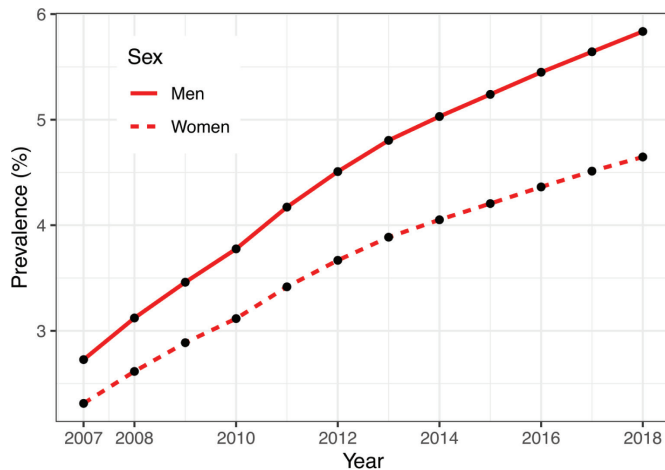
Figure 5 Time trends in the prevalence of atrial fibrillation in men and women in the adult population (≥20 years) of Finland.

DISCUSSION

In this comprehensive, nationwide study including data from hospitalisations, primary, secondary and tertiary outpatient visits, and drug reimbursements, the prevalence of AF more than doubled from 2007 to 2018 and reached 5.2% in the adult population. The incidence of new-onset AF also increased during the 12-year period, but when adjusted for the ageing population, the incidence of AF remained stable and the incidence of AF decreased in the working age population age. In all age groups, men were more likely to present with AF than women. With advancing age, AF increased exponentially, and among those aged ≥75 years, AF incidence was 3194/100 000 and prevalence was as high as 23.4%.

The reported incidence and prevalence of AF have varied owing to the diverse study populations and methods used to identify patients with AF.[2–10 13 14] This study differs from previous reports in that we used hospital registers and comprehensive outpatient registers complemented by data from the drug
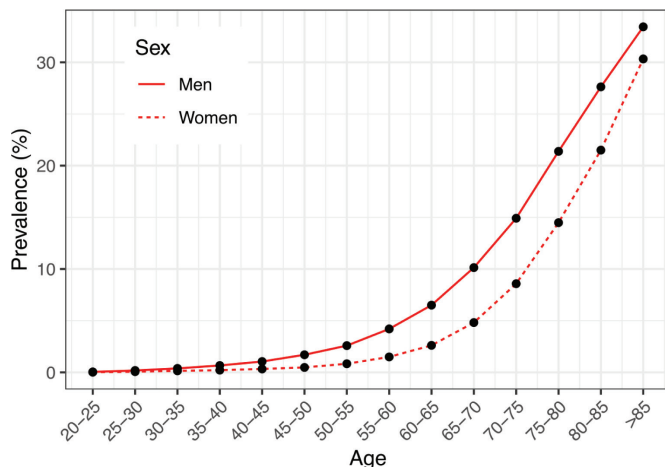
Figure 6 The prevalence of atrial fibrillation in relation to age in 2018 in men and women.

reimbursement register to identify all patients with AF in Finland. However, since the diagnosis of AF depends on recording the arrhythmia with an ECG, many patients with paroxysmal AF or minimal symptoms may have remained undiagnosed.[15]

Only a few previous studies have investigated the AF incidence in the entire population of certain regions. Miyasaka *et al* reported an age-adjusted and sex-adjusted AF incidence of 3.68 per 1000 person-years in Olmsted County, USA, during the year 2000 in the adult population based on integrated medical records, including inpatient and outpatient contacts.[6] In a more recent study from Sweden, based on a regional analysis of 75 800 inhabitants including primary care data, the incidence of AF was 4.0 per 1000 person-years in the entire population.[13] Wilke *et al* observed an AF incidence of 4.4/1000 person-years in men and 3.9/1000 person-years in women, with an AF prevalence of 2.1% based on German health maintenance registers.[14] In 2018, the incidence was slightly higher (4.69 per 1000 person-years) than in these reports in the entire Finnish population. When the analysis was restricted to the adult population (age ≥20 years), AF incidence was 6.40 in men and 5.71 in women per 1000 person-years in 2018 in our study.

The prevalence of AF has varied widely in previous studies depending on the age and population studied. The Dutch Rotterdam Study, a community-based prospective cohort study of adults aged >55 years, reported a prevalence of 6.0% in men and 5.1% in women.[5] In our study, the figures were 12.6% and 9.5%, respectively. Another study from Italy focused on subjects aged ≥65 years in the participating regions using systematic and opportunistic AF screening, followed by clinical and ECG confirmation, found an AF prevalence of 7.3%.[9] In our study, the corresponding prevalence of AF in this age group was 15.3%. Friberg and Bergfeldt reported an AF prevalence of 2.9% in the adult (≥20 years) population in Sweden from 2005 to 2010.[15] In a more recent study from Norway, the prevalence of AF was 3.4% in the adult population (≥18 years).[10] However, both these Nordic studies were based only on hospital registers, which underestimates the true prevalence of AF diagnoses especially in older age groups. In the present FinACAF study, the prevalence of AF in the adult Finnish population was 5.2% in 2018.

Nevertheless, a direct comparison of these epidemiological studies is challenging and, to some extent, not useful. In line with previous studies, a continuous increase in the number of patients with AF was observed in this study.[3 6 9 10] Importantly, this increase may be attributed to the ageing of population and longer life expectancy of AF patients. Half of the new AF patients were aged >75 years and had a mean CHA_2DS_2-VASc score of 3.6. The annual cohorts of new patients have increased slowly, but the total number of AF patients alive has increased

more steeply owing to an ageing population, also in Finland (figures 1 and 5 and online supplemental table 2).

Improved general treatment of AF patients with an increased oral anticoagulant use, probably improves survival, especially in elderly patients.[16] In recent years, blood pressure and other cardiovascular risk factor control have improved, and the overweight adult population has not increased in Finland, which may have also contributed to the unchanged age-standardised incidence of AF.[17 18] Moreover, the increasing interest in AF screening and use of anticoagulation may have contributed to the growing number of patients. During the AF epidemic, our finding of unchanged age-standardised incidence and a decreasing incidence in the younger (<65 years) population is encouraging. However, silent AF is probably being increasingly discovered owing to an increased focus on screening.

The strength of this study was the comprehensive capture of diagnosed AF cases from all levels of healthcare delivery using reliable national registers directed by the Finnish law. As noted, all visits in healthcare are mandatory to be registered in nationwide registers in Finland. These registers have been found to be highly consistent, particularly in the detection of cardiovascular diseases.[19] Elderly AF patients were included mostly from the primary care register; therefore, if only the hospital register data were available, significant erroneous decreases in both the raw and age-standardised incidences would have been observed. Furthermore, because AF is a chronic disease, its prevalence was established as a cumulative cohort of known cases in the population. This approach increases the reliability when the follow-up period of the study population is sufficiently long.[8] In addition, reliable assessment of AF incidence requires a sufficiently long look back period with no previous history of AF. These elements, as well as the sufficient duration of the data collection period, are important for providing reliable and up-to-date information on AF epidemiology.

Our study had some limitations. Since the ICD-10 diagnostic code for AF at the time of the study did not differentiate between the subtypes of atrial arrhythmias, there was no distinction between AF and atrial flutter, or the type of AF (paroxysmal, persistent or permanent). Naturally, registers cannot catch asymptomatic and undiagnosed AF patients, but screening procedures to cover the whole population are not realistic. Furthermore, without ECG verification, there is always a possibility that the clinician has misclassified another arrhythmia as AF. Nevertheless, in Denmark and Sweden, in relatively comparable research environments, register studies have been shown to be highly reliable and accurate in identifying patients with AF when compared with ECG information.[20 21]

CONCLUSIONS

In this nationwide study, using all available national register resources and having all Finnish residents as the background population, we found that both the incidence and prevalence of AF increased from 2007 to 2018. Importantly, this increase appears to be driven mostly by population ageing, and the age-standardised incidence of AF did not increase during this period. In 2018, the incidence of AF in the adult population was 604/100 000 and the prevalence of AF was 5.2%.

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