European Heart Journal (2013) **34**, 2746–2751
doi:10.1093/eurheartj/eht280

Projections on the number of individuals with atrial fibrillation in the European Union, from 2000 to 2060

Bouwe P. Krijthe[1,2], Anton Kunst[3], Emelia J. Benjamin[4,5,6], Gregory Y.H. Lip[7], Oscar H. Franco[1], Albert Hofman[1], Jacqueline C.M. Witteman[1,2], Bruno H. Stricker[1,2,8]*, and Jan Heeringa[1]

[1]Department of Epidemiology, Erasmus Medical Center, PO Box 2040, 3000 CA Rotterdam, The Netherlands; [2]Netherlands Consortium for Healthy Aging (NCHA), The Netherlands; [3]Department of Public Health, Amsterdam Medical Center, University of Amsterdam, Amsterdam, The Netherlands; [4]National Heart, Lung, and Blood Institute's and Boston University's Framingham Heart Study, Framingham, MA, USA; [5]Department of Epidemiology, School of Public Health, Boston University, Boston, MA, USA; [6]Cardiology and Preventive Medicine Sections, Evans Department of Medicine, Whitaker Cardiovascular Institute, Boston University School of Medicine, Boston, MA, USA; [7]University of Birmingham Centre for Cardiovascular Sciences, City Hospital, Birmingham, UK; and [8]Inspectorate of Health Care, The Hague, The Netherlands

Received 26 February 2013; revised 17 May 2013; accepted 26 June 2013; online publish-ahead-of-print 30 July 2013

Aims Since atrial fibrillation (AF) is associated with increased risks of cardiovascular and cerebrovascular complications, estimations on the number of individuals with AF are relevant to healthcare planning. We aimed to project the number of individuals with AF in the Netherlands and in the European Union from 2000 to 2060.

Methods and results Age- and sex-specific AF prevalence estimates were obtained from the prospective community-based Rotterdam Study. Population projections for the Netherlands and the European Union were obtained from the European Union's statistics office. In the age stratum of 55–59 years, the prevalence of AF was 1.3% in men (95% CI: 0.4–3.6%) and 1.7% in women (95% CI: 0.7–4.0%). The prevalence of AF increased to 24.2% in men (95% CI: 18.5–30.7%), and 16.1% in women (95% CI: 13.1–19.4%), for those >85 years of age. This age- and sex-specific prevalence remained stable during the years of follow-up. Furthermore, we estimate that in the European Union, 8.8 million adults over 55 years had AF in 2010 (95% CI: 6.5–12.3 million). We project that this number will double by 2060 to 17.9 million (95% CI: 13.6–23.7 million) if the age- and sex-specific prevalence remains stable.

Conclusion We estimate that from 2010 to 2060, the number of adults 55 years and over with AF in the European Union will more than double. As AF is associated with significant morbidities and mortality, this increasing number of individuals with AF may have major public health implications.

Keywords Atrial fibrillation • Epidemiology

Introduction

European populations are undergoing a substantial demographic shift in age. The European statistics' office 'Eurostat' estimates that in the European Union, 29.5% of the total population was at least 55 years of age in 2010, and this percentage is expected to rise to 41.0% by 2060.[1] The increased proportion of older adults has several public health consequences, including an increase in the number of older individuals surviving with chronic disease and disability, with a consequent increase in health service utilization.[2,3]

Little is known about the potential rise in the number of individuals with atrial fibrillation (AF) in European populations.[4,5] Atrial fibrillation is the most common sustained arrhythmia in the general population and it has been associated with an increased risk of stroke,[6] dementia,[7] and heart failure.[8] Moreover, AF is associated with an increased risk of cardiac and total mortality,[9,10] as well as substantial costs from diagnostics, interventions, treatments, and inpatient care.[11] Considering the risks of diseases, mortality, and costs associated with AF, it is essential to have valid estimates and projections of the future population prevalence of AF.

* Corresponding author. Tel: + 31 10 7044294, Fax: +31 10 7044657, Email: b.stricker@erasmusmc.nl

The objective of our study was to calculate projections on the number of individuals with AF in the European Union from 2000 to 2060 using information collected in the community-based prospective cohort study: the Rotterdam Study.

Methods

Study cohorts

The current investigation was performed within the Rotterdam Study, a community-based prospective cohort study.[12] Our study was designed to examine the onset of, and risk factors for disease in older adults. We used data from two independent cohorts—within the Rotterdam Study—Rotterdam Study 1 (RS1) and Rotterdam Study 2 (RS2).[12]

RS1 started with a baseline visit between 1990 and 1993. All inhabitants age 55 years and over in the Ommoord district of Rotterdam, The Netherlands, were invited to participate ($n = 10\,275$). Of those who were invited 7983 (78%) were enrolled. Between 2000 and 2001, the RS2 started with a baseline visit. All inhabitants of the Ommoord district who had become at least 55 years of age after the start of the Rotterdam Study or who had moved into the study district of Ommoord in the meantime were invited. Of those who were invited (4472 inhabitants) 3011 (67.3%) participated. At baseline, participants were interviewed at home and were examined at the research centre. The examination included a 10 s, 12-lead resting electrocardiogram (ECG). Information on the presence of disease was available by collaboration with the general practitioners in the study area.[13]

The medical ethics committee of Erasmus Medical Center, Rotterdam, approved the study, and all participants gave written informed consent to participate in the study and to obtain medical information from treating physicians separately.

Atrial fibrillation assessment

Prevalent and incident AF were ascertained using three methods.[14] At baseline and during follow-up examinations 10 s, 12-lead ECGs were recorded, stored digitally, and analysed by the Modular ECG Analysis System (MEANS).[15,16] To verify the diagnosis of AF, all ECGs with a diagnosis of AF, atrial flutter, or any other rhythm disorder based on the algorithms of the MEANS software were recoded independently by two research physicians who were blinded to the MEANS diagnosis. The judgment of a cardiologist was sought and taken as decisive in those cases in which disagreement persisted between the coding physicians. Additionally, medical information was obtained from general practitioners, which included their own results as well as results from physicians practicing in hospitals and outpatient clinics. Atrial fibrillation was considered present after diagnosis by a medical specialist or by a general practitioner if it was ascertained by an ECG. Finally, information was obtained from a national registry of all hospital discharge diagnoses. Atrial fibrillation occurring during a serious disease resulting in death, during myocardial infarction, or during cardiac operative procedures in which the individual recovered during the hospital admission was not included. We did not distinguish between AF and atrial flutter when we identified cases because both conditions are very similar with respect to risk factors and consequences.[17,18]

Information on vital status was obtained on a regular basis from the central registry of the Municipality of Rotterdam, from collaborating general practitioners, and by obtaining information during follow-up examinations. For those participants whose information on vital status remained missing, the Central Registry of Genealogy of the Netherlands was consulted. This national institute receives population registry records of all deceased inhabitants in the Netherlands.[13]

European estimates

Population projections were obtained from the statistics office of the European Union, Eurostat.[1] We used 1st January population projections from 2000 to 2060 by sex and 5-year age group, using a 5-year time interval. We used projections for the Netherlands, and the combination of the 27 European Union member states. The methodology of the Eurostat population projections is based on the assumption that socio-economic differences will fade out in the very long run. Values of the demographic indicators: fertility rate, life expectancy at birth, and net international migration, are thus set to converge across the countries in the very long run.[1]

General baseline measurements

Weight and height were obtained at last preceding research centre visit. Data on medications were obtained during the home interview by copying the labels of all medications used and further from a pharmacy database including drug use information from automated medical records. A history of myocardial infarction was defined as self-reported myocardial infarction with hospital admission, the presence of a myocardial infarction on the ECG, or myocardial infarction as judged from the general practitioners records and coded independently by two research physicians.[19] Prevalent heart failure was assessed using a European Society of Cardiology validated score.[20,21] Prevalent diabetes mellitus was defined as the use of hypoglycaemic medication or a pre- or post-load serum glucose level of >11.0 mmol/L.

Statistical analyses

Prevalence of AF was calculated as the proportion of those who had AF in the study population at the index date. For the main analysis, we used information from participants who were alive at 1 January 2002 and for whom information on AF was available. We chose 1 January 2002 as the index date in this analysis as this was the first date that all participants from RS1 and RS2 had a baseline ECG available and thereby the most recent date with accurate AF assessment in all age categories over age 55 years. We calculated prevalence by sex and 5-year age groups. Wilson's score method for a binomial proportion was used to calculate 95% CIs. The estimates of AF prevalence were then used to extrapolate to the population projections from Eurostat to estimate the total number of cases in the Netherlands and in the European Union. These extrapolations were done per sex and 5-year age group, and then combined to estimate the total number of adults over 55 years of age with AF. In the main analyses, we assumed the prevalence to remain stable from 2000 to 2060. We used the estimated age- and sex-specific CI limits (95% CI) to estimate prevalence projections; these 95% CIs do not account for the inadequacy in the population projections or for any temporal changes.

Several studies suggested that the prevalence of AF is rising over time.[4,22–24] To evaluate the change in prevalence of AF during the follow-up time of the Rotterdam Study, we calculated prevalence figures after the completion of each research centre visit (1 January of 1994, 1996, 2002, and 2006). We used generalized estimating equation methods to test for trends in prevalence of AF.[22,23] This method adjusts for repeated measurements in the same individual. The year of the examination was used to test for trends in prevalence. Age, sex, and calendar year were entered as variables in this model. Data were analysed using the SPSS PASW statistical software, version 20.0 (IBM corporation, Armonk, NY, USA).

Results

Prevalence of atrial fibrillation in the reference population

General characteristics of the reference population are described in *Table 1*. The study sample consisted of 533 individuals with prevalent AF, 242 men and 291 women, at 1 January 2002 (*Table 1*). Those with AF were older [mean age 78.9 years (SD:8.0)] than those without AF [mean age 72.4 years (SD:8.8)]. Moreover, those with AF were more likely to be men, were taller, weigh more, and were more likely to use blood pressure lowering medication, to have heart failure, a history of myocardial infarction, or to have diabetes (*Table 1*).

The prevalence of AF in men was 8.6% and in women 7.1% (*Table 2*). In the age stratum of 55–59 years, the prevalence of AF was 1.3% in men, and 1.7% in women. The prevalence of AF was higher with advancing age; for those >85 years of age, 24.2% of men and 16.1% of women had AF.

During the follow-up of the Rotterdam Study, the age-adjusted risk of AF did not significantly change between 1994 and 2006 (age-adjusted per year of follow-up OR: 1.004, 95% CI: 0.995–1.014) and was similar in men and women [age adjusted OR:1.004 (95% CI: 0.989–1.018) in men, age-adjusted OR: 1.004 (95% CI: 0.992–1.017), in women].

Estimates of atrial fibrillation in The Netherlands

Using the prevalence estimates from the study population, we estimate that ~259 600 (95% CI: 189 300–367 600) adults have AF in the Netherlands in 2010, reflecting 1.6% of the total Dutch population (*Table 3* and *Figure 1*). Approximately half of them were men ($n = 128\,100$). If the prevalence estimates of AF remain stable, the number of individuals with AF will more than double to a peak of about 553 700 (95% CI: 420 900–736 500) in the year 2050 and then decreases slightly to 547 700 (95% CI: 416 000–729 100) in the year 2060. In 2060, the number of adults over 55 with AF would reflect 3.2% of the Dutch population. This increase is similar in men and women. Especially, the number of adults over age 75 with AF will increase from 156 500 in 2010 to 418 100 in 2060, whereas in adults younger than 75 years of age this number would only increase from 103 100 in 2010 to 129 600 in 2060. If we assume no net international migration in the population projections from Eurostat, the total number of AF patients in the Netherlands will similarly rise to a peak of 560 500 in 2050 and to 549 600 in 2060.

Estimates of atrial fibrillation in the European Union

We estimate that there were approximately 8.8 million adults with AF in the European Union (95% CI: 6.5–12.3 million) in 2010 (*Table 3* and *Figure 2*). If the prevalence estimates of AF remain stable, this number will more than double and could reach 17.9 million by the year 2060 (95% CI: 13.6–23.7 million). In 2010, the number of adults age 55 and over with AF would reflect 1.8% of the total population, and this number could rise to 3.5% by 2060. Especially, the number of adults over age 75 with AF will increase from 5.6 million in 2010 to 13.8 million in 2060. If we assume no net international migration in the population projections, the total

Table 1 Characteristics of Study Cohort, at index date ($n = 6934$)

Characteristic	No atrial fibrillation ($n = 6,401$)	Atrial fibrillation (533)	*P*-value*
Age (years)	72.4 (8.8)	78.9 (8.0)	<0.01
Sex (women)	3,818 (59.6)	291 (54.6)	<0.01
Height (cm)	167.0 (8.6)	168.0 (8.2)	<0.01
Weight (kg)	75.4 (12.0)	76.3 (11.0)	<0.01
Use of blood pressure lowering medication	2281 (35.6)	326 (61.2)	<0.01
History of myocardial infarction	565 (8.8)	91 (17.1)	<0.01
Prevalent heart failure	266 (4.2)	153 (28.7)	<0.01
Prevalent diabetes mellitus	888 (13.9)	110 (20.6)	<0.01

Denotes mean ± SD for continuous variables, and *n* (%) for categorical variables.
*From logistic or linear regression, age- and sex-adjusted.

Table 2 Age- and sex-specific atrial fibrillation prevalence

Age	*N*	*n*	% (95% CI)
Men			
55–59	238	3	1.3 (0.4–3.6)
60–64	429	8	1.9 (0.9–3.6)
65–69	567	31	5.5 (4.0–7.8)
70–74	617	45	7.3 (5.7–9.6)
75–80	472	59	12.5 (9.8–15.8)
80–84	316	51	16.1 (12.4–20.4)
>85	186	45	24.2 (18.5–30.7)
Total	2825	242	8.6 (7.6–9.7)
Women			
55–59	286	5	1.7 (0.7–4.0)
60–64	523	7	1.3 (0.6–2.7)
65–69	738	20	2.7 (1.8–4.2)
70–74	778	40	5.1 (3.8–6.9)
75–80	712	68	9.6 (7.6–11.9)
80–84	556	68	12.2 (9.7–15.1)
>85	516	83	16.1 (13.1–19.4)
Total	4109	291	7.1 (6.3–7.9)
All			
Total	6934	533	7.7 (7.0–8.3)

AF, atrial fibrillation; CI, confidence interval; *N*, total number of participants; *n*, number of participants with AF.

Table 3 Projected number of adults with atrial fibrillation in The Netherlands and the European Union between 2000 and 2060

Year	The Netherlands (in thousands)			Age >75	Total	%[a]	European Union (in millions)			Age >75	Total	%[a]
	Men	Women	Age <75				Men	Women	Age <75			
2000	98.2	112.9	83.9	127.3	211.1	1.3	3.4	3.9	2.9	4.3	7.2	1.5
2005	110.2	121.1	92.7	138.6	231.3	1.4	3.7	4.2	3.1	4.9	7.9	1.6
2010	128.1	131.5	103.1	156.5	259.6	1.6	4.2	4.6	3.2	5.6	8.8	1.8
2015	151.2	145.0	119.8	176.3	296.1	1.7	4.8	5.0	3.4	6.3	9.8	1.9
2020	175.9	162.2	135.6	202.5	338.0	2.0	5.3	5.4	3.8	6.9	10.7	2.1
2025	203.9	183.5	139.0	248.4	387.5	2.2	5.9	5.8	4.0	7.7	11.7	2.3
2030	231.3	205.7	145.5	291.5	436.9	2.5	6.6	6.3	4.2	8.6	12.9	2.5
2035	255.8	226.9	147.1	335.7	482.8	2.7	7.2	6.9	4.4	9.7	14.1	2.7
2040	272.9	244.3	140.8	376.3	517.1	2.9	7.9	7.4	4.4	10.9	15.3	2.9
2045	284.1	256.5	129.4	411.3	540.7	3.1	8.4	7.9	4.3	12.0	16.3	3.1
2050	291.0	262.7	122.3	431.4	553.7	3.2	8.9	8.2	4.2	12.9	17.1	3.3
2055	291.7	261.9	125.4	428.1	553.6	3.2	9.2	8.4	4.2	13.4	17.6	3.4
2060	289.7	258.0	129.6	418.1	547.7	3.2	9.4	8.5	4.1	13.8	17.9	3.5

[a]Percentage of total population.

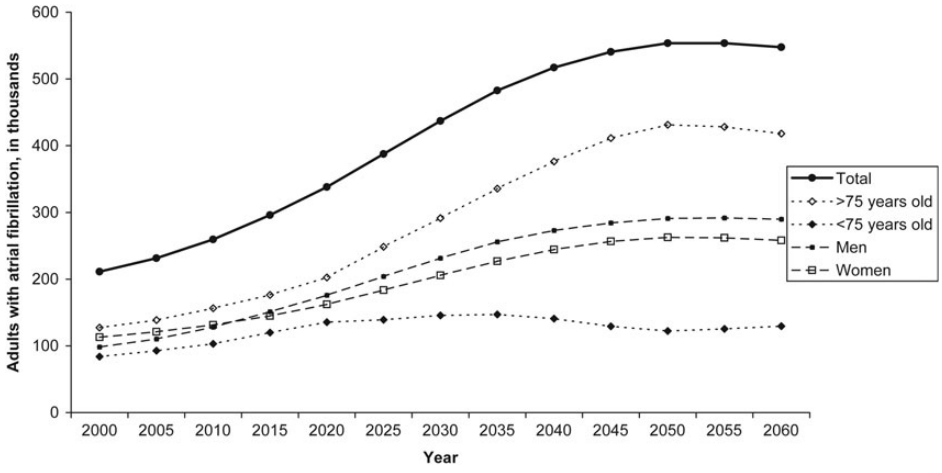

Figure 1 Projected number of adults with atrial fibrillation in the Netherlands between 2000 and 2060.

number of AF patients in the European Union will similarly rise to 16.9 million in 2060.

Discussion

Due to the expected ageing of the European population, the number of individuals with AF is likely to increase. We project that from 2010 to 2060, the number of adults age 55 and over with AF will more than double in the Netherlands and in the European Union. Most of the projected increase will occur in the next few decades. Especially, the number of adults older than 75 years with AF will increase substantively. As AF is associated with significant morbidities and mortality, this increasing number of individuals with AF may have major public health implications.

Several studies estimated the AF prevalence in European populations.[4,5,24–30] Our AF prevalence estimates are broadly similar to estimates from Iceland, Germany, the UK, and Italy,[4,25–27] and our prevalence estimates are higher compared with those from other studies in the UK, Greece, and Sweden.[24,28–30] Several reasons for these differences can be raised. First, differences in AF assessment may play a role. As AF often escapes clinical attention, prevalence estimates are easily underestimated.[31] Furthermore, racial or cultural differences may partly explain the differences as it has been suggested that whites have a higher risk of AF than non-whites.[32–34] Finally, as it

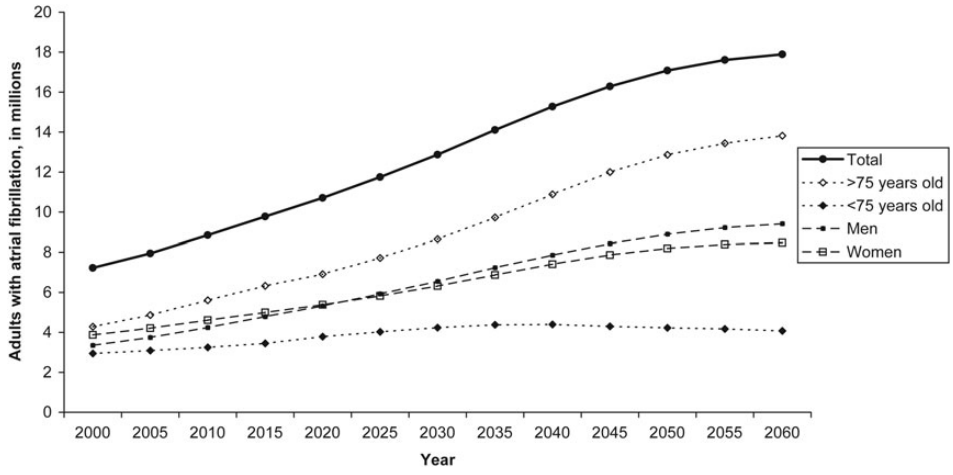

Figure 2 Projected number of adults with atrial fibrillation in the European Union between 2000 and 2060.

was suggested that the prevalence of AF has increased, older studies may present lower prevalence estimates.[4,22–24]

Several studies have projected future numbers of adults with AF in the USA, all of them projecting a doubling of the number of AF patients by the year 2050.[32,35,36] Go *et al.*[32] estimated that the prevalence of adults with AF in the USA will rise from 2.66 million in 2010 to 5.61 million in 2050. Miyasaka *et al.*[35] estimated the USA prevalence of AF to be 6.1 million in 2010 and projected an increase to 12.1 million in 2050. Finally, Naccarelli *et al.*[36] estimated the number of adults in the USA with AF to rise from 3.03 million in 2005 to 7.56 million in 2050. Again, differences between these studies may be explained by differences in study setting, racial variation, and differences in AF assessment. Of note, projections for European populations are limited to Stefansdottir *et al.*[4] who estimated that the number of Icelandic inhabitants with AF will more than double, rising from 4495 (2.0% of total population) in 2008 to 11 088 in 2050 (3.5% of total population), and to Wilke *et al.*[5] who estimated the number of Germans with AF will increase from 1.8 million in 2009 to 2.1 million in 2020.

Strengths and limitations

The strength of our study is that our projections are based on prevalence estimates from a population-based cohort study, the Rotterdam Study, with extensive follow-up with the examination at 3–4 yearly intervals, and a continuous registration of disease and mortality. First, we used screening ECGs at each follow-up examination. Second, we used all information available in the general practitioners' files of all participants. In the Dutch health care system, patients have one general practitioner, who serves a gatekeeper function, including a registration and filing of medical information from their own work as well as the results from other physicians practicing in hospitals and outpatient clinics. When individuals switch to another general practitioner, all medical information is transferred to the new practice. Finally, we used a nation-wide registry of all hospital discharge diagnoses.

However, our study has some limitations. Our projections are based on some assumptions. Most importantly, our projections are based on a Dutch population of mainly north-western European descent. This reference population may not be representative of the entire Dutch population and even less of the European Union. As whites have a higher risk of AF than non-whites,[32–34] our projections for the European Union might be overestimated because of ethnic variation within the European Union. Also other risk factors for AF such as, height, weight, and cardiovascular disease may vary between European countries, and thereby may lead to differences in AF prevalence. The numbers of individuals should therefore be cautiously interpreted and only be regarded as estimations. Second, in the main analyses, we assumed that the AF prevalence remains stable whereas several studies suggested that the prevalence is rising over time.[4,22–24] This rise in prevalence might be explained by more clinician monitoring and awareness of AF, improved survival of AF patients, or from increased prevalence of clinical conditions that are associated with a higher risk of AF.[37] Indeed, it may not be realistic to assume that this increase will continue for future decades. It is possible that increased attention to cardiovascular risk factors and subsequent treatment may reduce the risk of AF.[37] Also some studies suggested that the incidence of cardiovascular diseases such as myocardial infarction and heart failure has decreased in recent years, which could result in a decrease in the prevalence of AF.[38,39] The rise in age-adjusted prevalence during the years of follow-up in the Rotterdam Study did not reach statistical significance. Therefore, we assumed in our main results that the prevalence of AF is stable over time—if at all, this might have led to some underestimation in these results.

Conclusions

In the European Union, the number of adults with AF will substantially increase in the coming decades and may even double in the period from 2010 to 2060. As AF is associated with significant morbidities and mortality, this increasing population burden of AF will have major public health implications. Our results underscore the

importance of preventative strategies aiming to reduce the risk of AF within comprehensive programs aimed to improve the health of the ageing population.

Acknowledgements

The authors thank all the participants and staff of the Rotterdam Study, as well as the general practitioners and pharmacists of the Ommoord district for help with data collection and validation.

Conflict of interest: none declared.

Funding

The Rotterdam Study is supported by the Erasmus Medical Center and Erasmus University Rotterdam; The Netherlands Organization for Scientific Research (NWO); The Netherlands Organization for Health Research and Development (ZonMw); the Research Institute for Diseases in the Elderly (RIDE); The Netherlands Heart Foundation; the Ministry of Education, Culture and Science; the Ministry of Health Welfare and Sports; the European Commission (DG XII); and the Municipality of Rotterdam. E.J.B. was funded by 1R01HL092577, 1R01 HL102214, and 1RC1HL101056.

References

1. Eurostat. The Europop2010 (Eurostat Population Projections 2010-based) convergence scenario contains statistical information on population projections at national level.
2. Brinks R, Tamayo T, Kowall B, Rathmann W. Prevalence of type 2 diabetes in Germany in 2040: estimates from an epidemiological model. *Eur J Epidemiol* 2012; **27**:791–797.
3. Mura T, Dartigues JF, Berr C. How many dementia cases in France and Europe? Alternative projections and scenarios 2010–2050. *Eur J Neurol* 2010;**17**:252–259.
4. Stefansdottir H, Aspelund T, Gudnason V, Arnar DO. Trends in the incidence and prevalence of atrial fibrillation in Iceland and future projections. *Europace* 2011;**13**: 1110–1117.
5. Wilke T, Groth A, Mueller S, Pfannkuche M, Verheyen F, Linder R, Maywald U, Bauersachs R, Breithardt G. Incidence and prevalence of atrial fibrillation: an analysis based on 8.3 million patients. *Europace* 2013;**15**:486–493.
6. Marini C, De Santis F, Sacco S, Russo T, Olivieri L, Totaro R, Carolei A. Contribution of atrial fibrillation to incidence and outcome of ischemic stroke: results from a population-based study. *Stroke* 2005;**36**:1115–1119.
7. Ott A, Breteler MM, de Bruyne MC, van Harskamp F, Grobbee DE, Hofman A. Atrial fibrillation and dementia in a population-based study. The Rotterdam Study. *Stroke* 1997;**28**:316–321.
8. Wang TJ, Larson MG, Levy D, Vasan RS, Leip EP, Wolf PA, D'Agostino RB, Murabito JM, Kannel WB, Benjamin EJ. Temporal relations of atrial fibrillation and congestive heart failure and their joint influence on mortality: the Framingham Heart Study. *Circulation* 2003;**107**:2920–2925.
9. Stewart S, Hart CL, Hole DJ, McMurray JJ. 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**:359–364.
10. Miyasaka Y, Barnes ME, Bailey KR, Cha SS, Gersh BJ, Seward JB, Tsang TS. Mortality trends in patients diagnosed with first atrial fibrillation: a 21-year community-based study. *J Am Coll Cardiol* 2007;**49**:986–992.
11. Ringborg A, Nieuwlaat R, Lindgren P, Jonsson B, Fidan D, Maggioni AP, Lopez-Sendon J, Stepinska J, Cokkinos DV, Crijns HJ. Costs of atrial fibrillation in five European countries: results from the Euro Heart Survey on atrial fibrillation. *Europace* 2008;**10**:403–411.
12. Hofman A, van Duijn CM, Franco OH, Ikram MA, Janssen HL, Klaver CC, Kuipers EJ, Nijsten TE, Stricker BH, Tiemeier H, Uitterlinden AG, Vernooij MW, Witteman JC. The Rotterdam Study: 2012 objectives and design update. *Eur J Epidemiol* 2011;**26**: 657–686.
13. Leening MJ, Kavousi M, Heeringa J, van Rooij FJ, Verkroost-van Heemst J, Deckers JW, Mattace-Raso FU, Ziere G, Hofman A, Stricker BH, Witteman JC. Methods of data collection and definitions of cardiac outcomes in the Rotterdam Study. *Eur J Epidemiol* 2012;**27**:173–185.
14. Heeringa J, van der Kuip DA, Hofman A, Kors JA, van Herpen G, Stricker BH, Stijnen T, Lip GY, Witteman JC. Prevalence, incidence and lifetime risk of atrial fibrillation: the Rotterdam study. *Eur Heart J* 2006;**27**:949–953.
15. Kors JA, van Herpen G, Wu J, Zhang Z, Prineas RJ, van Bemmel JH. Validation of a new computer program for Minnesota coding. *J Electrocardiol* 1996;**29** (suppl):83–88.
16. van Bemmel JH, Kors JA, van Herpen G. Methodology of the modular ECG analysis system MEANS. *Methods Inf Med* 1990;**29**:346–353.
17. Halligan SC, Gersh BJ, Brown RD Jr, Rosales AG, Munger TM, Shen WK, Hammill SC, Friedman PA. The natural history of lone atrial flutter. *Ann Intern Med* 2004;**140**: 265–268.
18. Lelorier P, Humphries KH, Krahn A, Connolly SJ, Talajic M, Green M, Sheldon R, Dorian P, Newman D, Kerr CR, Yee R, Klein GJ. Prognostic differences between atrial fibrillation and atrial flutter. *Am J Cardiol* 2004;**93**:647–649.
19. de Torbal A, Boersma E, Kors JA, van Herpen G, Deckers JW, van der Kuip DA, Stricker BH, Hofman A, Witteman JC. Incidence of recognized and unrecognized myocardial infarction in men and women aged 55 and older: the Rotterdam Study. *Eur Heart J* 2006;**27**:729–736.
20. Remme WJ, Swedberg K, Task Force for the Diagnosis and Treatment of Chronic Heart Failure, European Society of Cardiology. Guidelines for the diagnosis and treatment of chronic heart failure. *Eur Heart J* 2001;**22**:1527–1560.
21. Mosterd A, Hoes AW, de Bruyne MC, Deckers JW, Linker DT, Hofman A, Grobbee DE. Prevalence of heart failure and left ventricular dysfunction in the general population; The Rotterdam Study. *Eur Heart J* 1999;**20**:447–455.
22. 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**:790–795.
23. Friberg J, Scharling H, Gadsboll N, Jensen GB. Sex-specific increase in the prevalence of atrial fibrillation (The Copenhagen City Heart Study). *Am J Cardiol* 2003;**92**: 1419–1423.
24. 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**:1064–1070.
25. Schnabel RB, Wilde S, Wild PS, Munzel T, Blankenberg S. Atrial fibrillation: its prevalence and risk factor profile in the German general population. *Dtsch Arztebl Int* 2012; **109**:293–299.
26. Bilato C, Corti MC, Baggio G, Rampazzo D, Cutolo A, Iliceto S, Crepaldi G. Prevalence, functional impact, and mortality of atrial fibrillation in an older Italian population (from the Pro.V.A. study). *Am J Cardiol* 2009;**104**:1092–1097.
27. Hobbs FD, Fitzmaurice DA, Mant J, Murray E, Jowett S, Bryan S, Raftery J, Davies M, Lip G. A randomised controlled trial and cost-effectiveness study of systematic screening (targeted and total population screening) versus routine practice for the detection of atrial fibrillation in people aged 65 and over. The SAFE study. *Health Technol Assess* 2005;**9**:1–74.
28. Smith JG, Platonov PG, Hedblad B, Engstrom G, Melander O. Atrial fibrillation in the Malmo Diet and Cancer study: a study of occurrence, risk factors and diagnostic validity. *Eur J Epidemiol* 2010;**25**:95–102.
29. Ntaios G, Manios E, Synetou M, Savvari P, Vemmou A, Koromboki E, Saliaris M, Blanas K, Vemmos K. Prevalence of atrial fibrillation in Greece: the Arcadia Rural Study on Atrial Fibrillation. *Acta Cardiol* 2012;**67**:65–69.
30. 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**:284–288.
31. Engdahl J, Andersson L, Mirskaya M, Rosenqvist M. Stepwise screening of atrial fibrillation in a 75-year-old population: implications for stroke prevention. *Circulation* 2013;**127**:930–937.
32. Go AS, Hylek EM, Phillips KA, Chang Y, Henault LE, Selby JV, Singer DE. 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. *JAMA* 2001;**285**:2370–2375.
33. Gill PS, Calvert M, Davis R, Davies MK, Freemantle N, Lip GY. Prevalence of heart failure and atrial fibrillation in minority ethnic subjects: the Ethnic-Echocardiographic Heart of England Screening Study (E-ECHOES). *PLoS ONE* 2011;**6**:e26710.
34. Marcus GM, Alonso A, Peralta CA, Lettre G, Vittinghoff E, Lubitz SA, Fox ER, Levitzky YS, Mehra R, Kerr KF, Deo R, Sotoodehnia N, Akylbekova M, Ellinor PT, Paltoo DN, Soliman EZ, Benjamin EJ, Heckbert SR, Candidate-Gene Association Resource Study. European ancestry as a risk factor for atrial fibrillation in African Americans. *Circulation* 2010;**122**:2009–2015.
35. Miyasaka Y, Barnes ME, Gersh BJ, Cha SS, Bailey KR, Abhayaratna WP, Seward JB, Tsang TS. Secular trends in incidence of atrial fibrillation in Olmsted County, Minnesota, 1980 to 2000, and implications on the projections for future prevalence (vol 114, pg 119, 2006). *Circulation* 2006;**114**:E498–E498.
36. Naccarelli GV, Varker H, Lin J, Schulman KL. Increasing prevalence of atrial fibrillation and flutter in the United States. *Am J Cardiol* 2009;**104**:1534–1539.
37. Heeringa J. Atrial fibrillation: is the prevalence rising? *Europace* 2010;**12**:451–452.
38. Yeh RW, Sidney S, Chandra M, Sorel M, Selby JV, Go AS. Population trends in the incidence and outcomes of acute myocardial infarction. *N Engl J Med* 2013;**362**: 2155–2165.
39. Blecker S, Paul M, Taksler G, Ogedegbe G, Katz S. Heart failure associated hospitalizations in the United States. *J Am Coll Cardiol* 2013;**61**:1259–1267.