The risk of atrial fibrillation in the general male population: a lifetime follow-up of 50-year-old men

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Aim
This study aimed to estimate the prevalence, incidence rate, and lifetime risk of developing atrial fibrillation (AF) in a population-based study of Swedish men.

Methods and results
The study is a part of ‘The Study of Men Born in 1913’, which is a longitudinal prospective cohort study of 855 men born in 1913 and living in the city of Gothenburg in Sweden. They were followed from the age of 50 years until 98 years with repeated examinations and data from the Swedish National Hospital Discharge Register. A total of 185 (21.6%) men developed AF. The prevalence of AF increased from 0.4% at 50 years old, to 1.9% by 60 years old, to 4.6% by 70 years old, to 12.5% by 80 years old, and to 15.7% by 90 years old. The lifetime risk of developing AF was 22.5%.

Conclusion
Atrial fibrillation is rare at the age of 50 in Swedish men, but it increases exponentially with age, markedly accelerating after 70 years old. In nonagenarians, one of five men has or has had AF.

Keywords
Atrial fibrillation • Epidemiology • Incidence • Prevalence • Population-based studies • Lifetime risk

Introduction
Atrial fibrillation (AF) is the most common form of clinically important cardiac arrhythmia, often associated with other cardiovascular diseases, but may also occur without co-morbidity (lone AF).1 In some cases, AF is asymptomatic and it may be detected incidentally.2 Atrial fibrillation is associated with a significant increase in morbidity and mortality3,4 and may cause various thromboembolic complications, such as ischaemic stroke.5 Furthermore, anti-coagulation therapy is indicated to reduce the risk of ischaemic stroke in patients with AF, thereby exposing the patient to potential bleeding complications.6

Previous population studies have attempted to estimate the prevalence and incidence of AF, but their results are varied.7–9 There are only a few long-term prospective studies using random samples from the general population.3,10–12

The present study aimed to estimate the prevalence of AF at various ages and to investigate the incidence rate and the lifetime risk of developing AF in a random sample of 50-year-old urban men.

Methods

Study population
‘The Study of Men Born in 1913’ is a longitudinal, prospective, population-based study of men born in 1913 and living in the city of Gothenburg in western Sweden. This city has ~50 0000 inhabitants and all of the residents have a unique, national, 10-digit registration number that includes their date of birth and sex. Registration number, names, and addresses are registered by the County Census Bureau, and are required to be kept up-to-date by law. This study complies with the Declaration of Helsinki. The Gothenburg Regional Research Ethics Board approved the present study and informed consent has been obtained from the participants.

From the population register, a sample was drawn in 1963, consisting of all of the men born in 1913 on a day divisible by three (i.e. the third, sixth, and ninth day of each month). These criteria were fulfilled by 973 men (of 2910) men born in 1913 of whom 855 (87.9%) agreed to participate in a health examination and were followed up with repeated examinations in 1967, 1973, 1980, 1988, and 1993
What’s new:
- The cumulative risk of developing AF increases exponentially with age but few studies have an actual near lifetime follow-up.
- In this Swedish sample from the general male population, with a follow-up extending from the age of 50 over a maximum of 48 years, almost one of five men developed AF during his remaining life.

(Table 1). The participants and non-participants have been described in detail elsewhere.13,14

Follow-up and co-morbidity data were collected by the Swedish Hospital Discharge Registry for all participants from 1972 to 2011. Death certificates and autopsy records were obtained and studied for those men who died during follow-up according to the National Bureau of Statistics. A total of 14 men (~1.6%) could not be followed over the entire period, mainly because of emigration.

General measurements and definitions
In each screening examination, medical history was determined and a physical examination was performed. Information on smoking habits was obtained by questionnaire and subjects were classified as current smokers or non-smokers. After a 5-min interview, blood pressure was recorded in the right arm in the sitting position, by a mercury sphygmomanometer with a cuff size of 12 × 23 cm. All blood pressure measurements were recorded to the nearest 2 mmHg in the sitting position. Height was measured to the nearest centimetre. Body mass index was calculated as weight (kg) divided by height squared (m²). Standard 12-lead electrocardiograms (ECGs) were recorded in 1963, 1967, 1973, 1980, 1988, and 1993, with the patients at rest in the supine position. Paper speed was 50 mm/s and calibration was 1 mV: 10 mm. All of the ECG’s were evaluated by a physician, who was blinded to all of the clinical data and classified the ECGs according to whether AF (including atrial flutter) was present. Atrial fibrillation was defined as AF or atrial flutter detected on the ECG recording at any of the screening examinations or by diagnoses from the Swedish Hospital Discharge Register (Swedish International Classification of Diseases 10th Revision [ICD 10] code I48). In 1987 and 1997, new versions (9 and 10) of the ICD were adopted, with diagnoses in the present study re-coded to ICD-10. Medical records from hospitals and outpatient clinics were collected for all of the men.

Statistical analysis
All of the analyses were performed using SAS software (version 9.3; SAS Institute, Cary, NC, USA) and R-software (version 2.14; R Foundation for Statistical Computing, Vienna, Austria). The characteristics of participants (Table 2) are presented as the percentage or mean value with standard deviation (SD). The follow-up of the study was from baseline in 1963 to the first detection of AF, death or to 31

<table>
<thead>
<tr>
<th>Year of examination</th>
<th>Age (years)</th>
<th>Participants with ECG available</th>
<th>Participants who died</th>
<th>AF ECG, n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1963</td>
<td>50</td>
<td>855</td>
<td>0</td>
<td>3 (0.4)</td>
</tr>
<tr>
<td>1967</td>
<td>54</td>
<td>792</td>
<td>17</td>
<td>4 (0.5)</td>
</tr>
<tr>
<td>1973</td>
<td>60</td>
<td>718</td>
<td>65</td>
<td>18 (2.5)</td>
</tr>
<tr>
<td>1980</td>
<td>67</td>
<td>580</td>
<td>164</td>
<td>14 (2.4)</td>
</tr>
<tr>
<td>1988</td>
<td>75</td>
<td>397</td>
<td>337</td>
<td>20 (5.0)</td>
</tr>
<tr>
<td>1993</td>
<td>80</td>
<td>232</td>
<td>481</td>
<td>23 (9.9)</td>
</tr>
</tbody>
</table>

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<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Number of participants</td>
<td>n = 855</td>
<td>n = 792</td>
<td>n = 718</td>
<td>n = 580</td>
<td>n = 397</td>
<td>n = 232</td>
</tr>
<tr>
<td>Body mass index (kg/m²)</td>
<td>24.8 (3.2)</td>
<td>25.0 (3.2)</td>
<td>25.5 (3.3)</td>
<td>25.3 (3.3)</td>
<td>25.1 (3.2)</td>
<td>25.7 (3.3)</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>175 (6)</td>
<td>175 (6)</td>
<td>175 (6)</td>
<td>175 (6)</td>
<td>174 (6)</td>
<td>173 (6)</td>
</tr>
<tr>
<td>Systolic blood pressure (mmHg)</td>
<td>138.3 (20.9)</td>
<td>143.8 (21.1)</td>
<td>146.7 (23.8)</td>
<td>155.1 (23.5)</td>
<td>156.6 (23.9)</td>
<td>152.6 (23.0)</td>
</tr>
<tr>
<td>Diastolic blood pressure (mmHg)</td>
<td>91.6 (13.2)</td>
<td>90.6 (12.5)</td>
<td>89.4 (13.3)</td>
<td>84.3 (11.9)</td>
<td>81.2 (11.8)</td>
<td>81.7 (11.6)</td>
</tr>
<tr>
<td>Heart rate (beats/min)</td>
<td>68.5 (12.0)</td>
<td>67.2 (12.3)</td>
<td>69.5 (13.8)</td>
<td>70.1 (13.9)</td>
<td>66.2 (13.5)</td>
<td>72.0 (15.2)</td>
</tr>
<tr>
<td>Prior MI, n (%)</td>
<td>9 (1.1)</td>
<td>23 (2.9)</td>
<td>35 (4.9)</td>
<td>40 (6.9)</td>
<td>35 (8.8)</td>
<td>27 (11.6)</td>
</tr>
<tr>
<td>Diabetes, n (%)</td>
<td>7 (0.8)</td>
<td>14 (1.8)</td>
<td>23 (3.2)</td>
<td>33 (5.7)</td>
<td>34 (8.5)</td>
<td>27 (11.7)</td>
</tr>
</tbody>
</table>

Values are mean (SD) except for the number of participants. MI denotes myocardial infarction.
December, 2011. Men diagnosed with AF at any particular time were no longer regarded as being at risk for AF. The cumulative incidence of AF (Figure 1) was estimated with death as competing risk. If AF was diagnosed at re-examination, earlier ECGs were collected and the date of the first ECG with AF was used to define onset of AF in the analysis.

Results

A total of 855 men participated in the study over the 48-year time period. The clinical characteristics of the study population are shown in Table 2. At baseline, three men had prior AF diagnosis, more than half of the participants were current smokers and 2.5% had survived myocardial infarction.

During 48 years of follow-up, we found that 21.6% (n = 185) of the participants developed AF. Atrial fibrillation was diagnosed in 127 participants through the Swedish Hospital Discharge Registry, 52 during screening examinations, and six had the diagnosis of AF only from a death certificate. By 2011, the last year of follow-up, 97.3% of participants had died.

The prevalence and incidence of AF exponentially increased from 50 to 85 years of age. After 85 years of age, this incidence continued to increase at a lower rate, while the prevalence in surviving men considerably decreased. The prevalence of 0.4% for AF in 50-year-old men increased to 6.8% by 75 years old, to 16.7% by 85 years old, and then decreased to 8% by 98 years old (Figure 2).

The incidence rate of AF was 2.4 per 1000 person-years among 50- to 54-year-old men, 26 per 1000 at 65–69 years, 79.3 per 1000 at 75–79 years, 141.6 per 1000 at 85–89 years, 189.2 per 1000 at 90–94 and 135.6 per 1000 at 95–98 years.

The risk of developing AF also increased with age (Figure 1). The cumulative prevalence of AF adjusted for competing risk of death was 1.6% at 60 years old, 6.0% at 70 years old, 13.6% at 80 years old, 20.9% at 90 years old and 22.5% at 98 years old.

Discussion

In the present study, we estimated the prevalence, incidence rate, and lifetime risk of developing AF. Our results show an essentially exponential increase of AF from 50 to 85 years old and a continuous increase in the incidence rate until 98 years old, with an almost 23% risk of developing AF during over a lifetime.

Recent studies estimated that the potential increase in AF would be three-fold over the next 40 years. However, the prevalence and incidence rate of AF vary in the literature, possibly because of the different population samples being selected. One of the greatest advantages of using a longitudinal cohort study is the possibility to calculate the lifetime risk of AF in our population. Previous studies have described a relatively low prevalence and incidence of AF among male air crew, however, this was a highly selected sample of mostly young and healthy men. A prevalence <5% for AF has been reported from general population samples where a major part of the population was below the age of 60 years. However, prevalence >15% for AF has been reported among men ≥75 years old.

The prevalence of AF in our study corresponds well with other long-term, population-based, cohort studies (Table 3). In the Rotterdam Study, the age-specific prevalence of AF in men increased from 0.7% at 55–59 years old to 17.8% at 85 years old or older. In the Framingham Heart Study, 5209 men and women have been followed prospectively for several decades with a prevalence of AF of 0.2–0.3% at 25–35 years old, 0.3–0.4% at 55–64 years old, and 5–9% at 62–90 years old. In studies of AF from general practice, the prevalence of AF is 0.7% among 10 000 patients and it increases from 0.3% at 50–59 years old to greater than 6.6% for older than 80 years. The highest rate of prevalence of AF is found among the oldest part of the population. In the nursing home setting, the prevalence of AF increases from 5% in persons aged 60–70 to 22% in persons older than 91 years. These figures are similar to those found in our study. The reason why we observed a decline in the prevalence of AF at the oldest age may indicate that freedom from AF is an essential factor for reaching a high age. However, because of the low number of subjects older than 90 years, this result should be interpreted with caution.

One of the few long-term, prospective, population studies reported an incidence rate of 1 per 1000 person-years for AF among men aged 25–65 years with a 22-year follow-up. After the
age of 70 years, the same study reported an incidence of 12 per 1000 person-years for AF. Other studies have shown incidence rates for AF of ~5 per 1000 person-years over the age of 60 years and ~10 per 1000 person-years over the age of 70 years. In the Manitoba follow-up study, 3983 relatively young male air crew recruits were continuously observed for 44 years using incidence rates of AF based on person-years of observation. In that study, 7.5% of the recruits developed AF during follow-up. However, the incidence rate of AF was much higher in the present study than in this previous study, probably because our sample was much less selective and with a high follow-up rate.

A frequent problem with cohort studies is whether the non-participants differ from the participants. In cross-sectional studies, there is always a chance of underestimating the true prevalence because those with concomitant cardiovascular diseases who may have AF are more likely to be non-responders. This may cause selection bias, which produces a higher patient morbidity in the non-participant group than in the participant group. One of the strengths of our study was the high participation rate which reduced the risk of selection bias. Another problem in longitudinal studies is the rate of follow-up. In the present study, <2% of our population was lost to clinical follow-up mainly because the data came from a Swedish registry, which has been highly validated. This also reduces the risk of bias because of a potentially increased morbidity among those being lost to follow-up.

In the present study, approximately half of the men with a diagnosis of AF had at least two ECGs with AF during screening examinations. The other half of the population may have had paroxysmal AF. This proportion is in accordance with the findings in the Framingham Study where ~60% of AF was considered to be chronic AF. In other studies of AF, 10-s resting ECGs were detected in 74% of all subjects with AF who had a 24-h ambulatory ECG.

Only one longitudinal cohort study has reported the lifetime risk for development of AF with a follow-up of >30 years. This previous study showed that men aged 40 years had a 26% risk of developing AF during 31 years of follow-up. In our study, the risk of developing AF at the age of 50 years during 48 years of follow-up was 22.5%.

It can be debated whether atrial flutter should be included in the description of AF or not. We chose to follow the same criteria as in the Framingham study in which atrial flutter was included.

One of the limitations in this study is that it only included men because baseline screening was only performed in men. Therefore, we could not estimate the incidence and prevalence of AF in women. Previous studies have found a higher prevalence of AF among men than in women. Another limitation is that data from the Swedish primary care register were not available for further detection of AF. Our study, as well as others, may have underestimated the true incidence of AF because patients with asymptomatic or paroxysmal AF remain undiagnosed. Finally, participants in the present study were exclusively Caucasians and confirmatory data from other populations are needed, particularly with respect to younger and non-Caucasian people.

In conclusion, we found a steady increase in the proportion of AF, as well as the incidence rate for AF, with increasing age in men. After the age of 50 years, one of five men has the probability of developing AF during his lifetime. Because AF is an independent risk factor for stroke, with as much as a five-fold increased risk, preventive measures, even in subclinical AF, may be beneficial. Therefore, further studies should focus on elucidating the risk factor profile for AF and on identifying important predictors for developing cardiovascular complications from AF.

### Conclusion

Atrial fibrillation is a common finding in the general population. The cumulative risk of developing AF increases exponentially with age. In this Swedish sample from the general population, one of five men developed AF during his life.

## Acknowledgements

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## Conflict of interest

None declared.

## References


### Table 3 Prevalence of AF in different studies

<table>
<thead>
<tr>
<th>Study</th>
<th>Sex</th>
<th>% (age, years)</th>
<th>% (age, years)</th>
<th>% (age, years)</th>
<th>% (age, years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>'Men Born in 1913’, Sweden, n = 855</td>
<td>M</td>
<td>0.6 (54)</td>
<td>3.4 (67)</td>
<td>6.8 (75)</td>
<td>15.3 (91)</td>
</tr>
<tr>
<td>Framingham Heart Study, USA, n = 5191</td>
<td>M + F</td>
<td>0.5 (50–59)</td>
<td>1.8 (60–69)</td>
<td>4.8 (70–79)</td>
<td>8.8 (80–89)</td>
</tr>
<tr>
<td>Rotterdam Heart Study, Holland, n = 6808</td>
<td>M</td>
<td>0.8 (55–59)</td>
<td>5.2 (65–69)</td>
<td>13.0 (75–79)</td>
<td>17.9 (≥ 85)</td>
</tr>
<tr>
<td>F</td>
<td>0.6 (55–59)</td>
<td>2.9 (65–69)</td>
<td>6.5 (75–79)</td>
<td>17.5 (≥ 85)</td>
<td></td>
</tr>
<tr>
<td>Cardiovascular Heart Study, USA, n = 5201</td>
<td>M</td>
<td>–</td>
<td>5.9 (65–69)</td>
<td>5.8 (70–79)</td>
<td>8.0 (≥ 80)</td>
</tr>
<tr>
<td>F</td>
<td>–</td>
<td>2.8 (65–69)</td>
<td>5.9 (70–79)</td>
<td>6.7 (≥ 80)</td>
<td></td>
</tr>
<tr>
<td>Rochester Study, USA, n = 2122</td>
<td>M</td>
<td>0.5 (45–54)</td>
<td>1.0 (55–64)</td>
<td>6.0 (65–74)</td>
<td>16.1 (≥ 75)</td>
</tr>
<tr>
<td>F</td>
<td>0.5 (45–54)</td>
<td>1.5 (55–64)</td>
<td>3.0 (65–74)</td>
<td>12.2 (≥ 75)</td>
<td></td>
</tr>
</tbody>
</table>

M, male; F, female; –, no data available.