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Aims Atrial fibrillation is a common and important cause of cardiovascular morbidity and mortality that may become more prevalent due to an ageing population and more prolonged exposure to predisposing cardiovascular disease states. This study examines recent trends in hospitalizations related to atrial fibrillation in Scotland.

Methods and Results Scotland (population 5·1 million) has a well described system for recording hospitalization data. All hospital discharges (and death) can be linked for each individual patient. We examined the period 1986–1996, during which time a total of 103 085 hospitalizations with a principal or secondary diagnosis of atrial fibrillation were recorded. The number of hospitalizations with a principal diagnosis of atrial fibrillation increased threefold from 1869 in 1986 to 5757 in 1996; the number with a secondary diagnosis rose from 3577 to 11 522. Similar increases were seen in the number of patients hospitalized, in those having a ‘first-ever’ hospitalization and in population hospitalization rates overall. The average age of patients rose, in men from 63·8 (SD 13·2) to 65·0 (13·2) years and in women from 72·2 (12·2) to 73·2 (11·4) years. The proportion of those aged >75 years rose from 33% to 35% in men and from 56% to 60% in women. Average length of stay and case fatality fell during this period, but, because of the overall increase in hospitalizations, atrial fibrillation contributed to a growing proportion of cardiovascular-related bed-days utilized (from 18% to 37% with atrial fibrillation coded in any diagnostic position).

Conclusion The number of hospitalizations for atrial fibrillation has increased dramatically (two- to threefold) in recent years. These findings may be due to a real increase in atrial fibrillation prevalence, changing medical practice (e.g. coding or admission thresholds) or both. Consequently, the public health burden of atrial fibrillation is enormous. Moreover, the observed increase in atrial fibrillation-related hospital activity shows no sign of abating.

Introduction Atrial fibrillation is the commonest chronic cardiac arrhythmia[1,2]. It increases in prevalence with increasing age[1,2]. It is frequently associated with underlying cardiovascular and metabolic disorders such as coronary heart disease, hypertension, heart failure, valve disease, hyperthyroidism and diabetes mellitus[1–4]. Atrial fibrillation is itself an important cause of cardiovascular morbidity and mortality, particularly stroke, but also heart failure[5]. The prevalence of atrial fibrillation is believed to be increasing for two reasons. Firstly, the population in many ‘developed’ countries is ageing[6]. In Scotland, the proportion of the population >65 years rose from 14-4% to 15-3% between 1986 and 1996, an increase of approximately 45 000 men and women in a population of approximately five million. Secondly, survival of patients with the underlying diseases associated with atrial fibrillation is improving[7,8]. A rising prevalence of atrial fibrillation may also be leading to an increasing public health burden. Much of this burden will be borne by the hospital sector. Certainly, the number of patients discharged from short stay hospitals
in the U.S.A. between 1982 and 1993 increased 2·1-fold[9]. Similar large increases were noted in Denmark in the period 1980–1993[4]. It is also likely that the publication and dissemination of the evidence from seminal trials in the early 1990s, demonstrating the benefit of anticoagulation in these patients, has raised awareness of atrial fibrillation even more and further increased hospitalization rates. This study examines more recent trends in hospitalizations related to atrial fibrillation in Scotland during the period 1986 to 1996.

Methods

Data source

The Information and Statistics Division of the National Health Service in Scotland collects and collates data on all hospital discharges using the Scottish Morbidity Record Scheme (SMR)[10]. Between 1986 and 1996 data from patient case records were routinely used to code up to six diagnoses at the time of hospital discharge according to the Ninth Revision of the World Health Organisation International Classification of Diseases (ICD9)[11]. The term ‘discharge’ includes both live discharges and deaths. Hospital data are also linked to information held by the General Register Office for Scotland relating to all deaths within the United Kingdom. These data permit analysis of trends in hospitalization on both an ‘episode’ basis and, using each individual’s unique identifier assigned during their first hospital contact, a ‘patient’ basis. A recent audit has found the accuracy of SMR-1 data to be approximately 90% for both primary and secondary diagnoses.

Hospitalization for atrial fibrillation

For the period 1986–1996, we identified all hospitalizations occurring within Scotland where atrial fibrillation (ICD9 427·3) was coded at discharge as either the principal (first position) or a secondary diagnosis (second to sixth diagnostic positions). This ‘episode-based’ data set was then analysed to determine the number of individual patients who contributed to these hospitalizations on an annual basis. Using a retrospective review of data we also identified the annual number of men and women who had their ‘first ever’ hospitalization with a principal diagnosis of atrial fibrillation by excluding those with a previous hospitalization associated with atrial fibrillation within 5 years.

All data were directly obtained from the Information and Statistics Division of the National Health Service in Scotland. All data analyses were performed using SPSS for Windows version 9.0.

Results

Total episodes of hospitalization

Between 1986 and 1996, a total of 103,085 hospitalizations in Scotland were coded with a principal or secondary diagnosis of atrial fibrillation at discharge. In 1986 women accounted for more hospitalizations (53% overall) than men. By 1996, however, men accounted for slightly more hospitalizations (51% overall).

Figure 1 (principal diagnosis) and Fig. 2 (secondary diagnosis) show the sex-specific trends in the number of atrial fibrillation-related hospitalizations (‘episodes’) recorded per annum, in addition to the number of patients who were hospitalized, during this period. In both men and women, the number of hospitalizations associated with a principal diagnosis of atrial fibrillation increased by 6%–10% per annum until 1990–91 and then increased at almost double this rate thereafter. In 1996 there were an additional 2094 (232%) and 1794 (185%) hospitalizations (principal diagnosis) respectively, compared to 1986. During this same period, a similar trend was
observed in the number of hospitalizations associated with a secondary diagnosis of atrial fibrillation. These increased substantially in both men (253% more than 1986) and women (196% more than 1986). Overall, in 1996 there were an additional 6213 (244%) male and 5580 (192%) female hospitalizations associated with a diagnosis of atrial fibrillation (coded in any position) compared to 1986.

**‘First ever’ hospitalization**

Table 1 shows the number of individual patients who experienced a first ever hospitalization with a principal diagnosis of atrial fibrillation during the period 1986–96 and their relative contribution to the total number of hospitalizations recorded per annum. Some of these data are also presented in Fig. 1. In both men and women, the number of patients with a first-ever hospitalization for atrial fibrillation increased substantially (two- to threefold), but these admissions, as a proportion of all hospitalizations with atrial fibrillation, decreased modestly during this period.

**Recurrent hospitalization**

In 1986, 6.1% of men (n=52) discharged with a principal diagnosis of atrial fibrillation were readmitted within that calendar year with the same diagnosis, by 1996 this figure had risen to 18.7% (n=471). The equivalent figures for those discharged with a secondary diagnosis of atrial fibrillation was 6.1% (n=91) in 1986 and 14.4% (n=642) in 1996. Similarly, in women, 6.6% (n=60) discharged with a principal diagnosis of atrial fibrillation in 1986 were readmitted compared to 15.0% (n=360) in 1996. The equivalent figures for those discharged with a secondary diagnosis of atrial fibrillation were 5.9% (n=103) in 1986 and 13.2% (n=608) in 1996.

**Population rate of hospitalization for atrial fibrillation**

Table 2 shows the population rate of hospitalization associated with either a principal or secondary diagnosis of atrial fibrillation at discharge during 1986–1996. Irrespective, of its diagnostic position, the overall...
Table 2  Annual rate of hospitalization for atrial fibrillation per 1000 population in Scotland (1986–1996) according to its diagnostic position at discharge

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Table 2 Annual rate of hospitalization for atrial fibrillation per 1000 population in Scotland (1986–1996) according to its diagnostic position at discharge

![Figure 3](image)

**Figure 3** Trends in sex and age-specific, rates of hospitalization per 1000 population for atrial fibrillation as the principal diagnosis in those aged >55 years, 1986–1996. Age group: ● =55–64 years; ◆ =65–74 years; ▲ =75–84 years; ■ =85 years and over.

population rate of hospitalization associated with a diagnosis of atrial fibrillation increased by about threefold between 1986–1996. This increase was most marked in men, who in 1986, had a lower, and by 1996 a higher, overall rate of hospitalization compared to women. For example, in men, the hospitalization rate associated with a principal diagnosis of atrial fibrillation increased by a factor of 3·3 during this period compared to 2·8 in women.

**Age and sex-specific rates of hospitalization**

Figures 3 and 4 show the age and sex-specific rates of hospitalization on the basis of either a principal or secondary diagnosis of atrial fibrillation for men and women aged ≥55 years, respectively, during this period. In all age groups the overall rate of hospitalization associated with atrial fibrillation (coded in any position) increased appreciably. The greatest rate increases occurred in men and the elderly, these trends being most evident from 1990–91 onwards. On average women were older than men, those discharged with a principal diagnosis were younger than those with a secondary diagnosis of atrial fibrillation and the average age of both sexes and diagnostic groups increased by about 1 year during this period. The average age of males discharged with a principal diagnosis of atrial fibrillation was 63·8 (SD 13) years in 1986 and 64·9 (13) years in 1996. The equivalent figures for women were 72·0 (12) years and 73·2 (11) years, respectively. The age profile of the subset of individuals who were hospitalized for the first time with a principal diagnosis of atrial fibrillation was similar to the remainder of the cohort. The average age of males discharged with a secondary diagnosis of atrial fibrillation was 70·5 (SD 11) years in 1986 and 71·5 (11) years in 1996. The equivalent figures for women were 75·5 (11) years and 77·2 (10) years, respectively. Overall, the proportion of individuals discharged with a diagnosis of atrial fibrillation (coded in any position) and aged >75 years rose from 33% to 35% in men and from 56% to 60% in women during this period.

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In 1986 length of stay varied widely according to patient age, co-morbidity and the diagnostic position of atrial fibrillation at hospital discharge. On average, women and the elderly had the longest length of stay. However, for both sexes and regardless of the diagnostic position of atrial fibrillation, median length of stay progressively decreased between 1986 and 1996. In 1986 the median length of stay for men with a principal diagnosis of atrial fibrillation fell from 6 (IQR 3–9) days to 3 (1–7) days in 1996. For women the equivalent figures were 8 (4–14) days in 1986 compared to 5 (2–11) days in 1996. Similarly, the median length of stay for male and female hospitalizations with a secondary diagnosis of atrial fibrillation fell from 10 (6–18) and 13 (7–28) days to 8 (3–15) and 11 (5–22) days respectively, between 1986 and 1996. The proportion of all hospitalizations for atrial fibrillation lasting only 1–2 days rose from 13·2% to 30·1% in men and 7·6% to 18·7% in women, between 1986 and 1996.

### Length of stay

In 1986 length of stay varied widely according to patient age, co-morbidity and the diagnostic position of atrial fibrillation at hospital discharge. On average, women and the elderly had the longest length of stay. However, for both sexes and regardless of the diagnostic position of atrial fibrillation, median length of stay progressively decreased between 1986 and 1996. In 1986 the median length of stay for men with a principal diagnosis of atrial fibrillation fell from 6 (IQR 3–9) days to 3 (1–7) days in 1996. For women the equivalent figures were 8 (4–14) days in 1986 compared to 5 (2–11) days in 1996. Similarly, the median length of stay for male and female hospitalizations with a secondary diagnosis of atrial fibrillation fell from 10 (6–18) and 13 (7–28) days to 8 (3–15) and 11 (5–22) days respectively, between 1986 and 1996. The proportion of all hospitalizations for atrial fibrillation lasting only 1–2 days rose from 13·2% to 30·1% in men and 7·6% to 18·7% in women, between 1986 and 1996.

### Overall days of hospitalization

Despite the reduction in average length of stay, the dramatic increase in all atrial fibrillation hospitalizations between 1986 and 1996, resulted in an approximate 80% increase in the total number of days of hospitalization per annum for both sexes (refer to Table 3). In 1996, atrial fibrillation, as the principal diagnosis at discharge, accounted for 7·0% (3·1% in 1986) of bed-days used for cardiovascular reasons in men. Coded in any position, atrial fibrillation was associated with a remarkable 37% (17·8% in 1986) of cardiovascular bed-days. These
The respective proportions for women were 9.3% (4.3%) and 44.5% (21.2%).

Atrial fibrillation hospitalizations as a proportion of all hospital activity in Scotland

As a principal diagnosis, atrial fibrillation accounted for 0.2% of all hospital discharges in 1986 and 0.75% in 1996. As a secondary diagnosis, it was associated with an additional 0.43% of discharges in 1986, increasing to 1.2% in 1996. Overall, therefore, the contribution of all hospitalizations for atrial fibrillation (in any diagnostic position) to total hospital activity in Scotland, rose appreciably during this period from 0.65% to 1.95%.

As a principal diagnosis, atrial fibrillation accounted for 2.7% of all discharges for a cardiovascular reason in men in 1986 and 6.3% in 1996. The proportions as a secondary diagnosis and in any coding position were 5.1% and 7.8% in 1986 and 12.2% and 18.5% in 1996. The respective figures for women as a principal, secondary or any diagnosis were 3.8%, 7.5% and 11% in 1986 rising to 7.4%, 15.3% and 22.7% in 1996.

In men, those recording a ‘first ever’ hospitalization (principal diagnosis) represented 3.7% of all male patients hospitalized for any cardiovascular condition in 1986 and 8.1% in 1996. In women, the equivalent figures were 4.7% in 1986 and 9.7% in 1996.

Concomitant diagnoses

The commomest consultant diagnoses in 1986 in men with a secondary diagnosis of atrial fibrillation were acute myocardial infarction (14%), other coronary heart disease (43%), stroke (9%), chronic heart failure (17%) and respiratory disease (3%). These proportions were 7%, 42%, 8%, 16% and 4% in 1996. The respective figures for women were 7%, 38%, 13%, 16% and 2% in 1986 and 6%, 33%, 11%, 14% and 6% in 1996.

Conversely, the commomest other diagnoses in men with a principal diagnosis of atrial fibrillation in 1986 were myocardial infarction (17%), other coronary heart disease (54%), stroke (2.2%) and chronic heart failure (13%). These proportions were 1.1%, 42%, 1.4% and 7% in 1996. The respective figures for women were 1.4%, 52%, 4.1% and 13.1% in 1986 and 1.0%, 56%, 3.4% and 13% in 1996.

In-hospital case fatality

In men, the in-patient case fatality rate associated with a principal diagnosis of atrial fibrillation fell from 2.9% in 1986 to 1.8% in 1996 and from 13.0% to 7.8% in those where atrial fibrillation was a secondary diagnosis. In women the case fatality rate associated with a principal diagnosis of atrial fibrillation fell from 5.2% in 1986 to 3.4% in 1996. Case fatality fell from 19.2% to 11.8% in women for a hospitalization associated with a secondary diagnosis of atrial fibrillation. In 1996 the total number of male case fatalities associated with a principal diagnosis of atrial fibrillation had risen to 208% of the number recorded in 1986 (from 26 to 54). In women the equivalent figure was 186% (from 50 to 93). For atrial fibrillation as a secondary diagnosis the increase was 210% in men (214 to 450 deaths) and 182% in women (370 to 672 deaths). The ratio of deaths associated with a secondary vs a principal diagnosis of atrial fibrillation (7–8:1) did not change between 1986 and 1996.

1-year case fatality

The 1-year case fatality rate in men hospitalized for atrial fibrillation (principal diagnosis) was 16.1% in 1986 and 11.9% in 1996. These rates were 32.8% and 23.7% for atrial fibrillation as a secondary diagnosis. In women these rates were 17.6% and 16.2% for a principal and 36.4% and 32.9% for a secondary diagnosis of atrial fibrillation.

Fatal and non-fatal stroke

Stroke (in any diagnostic position) was coded in 6.6% of male hospitalizations with atrial fibrillation (all positions) in 1986 and 3.0% in 1996. The proportions for women were 10.4% and 8.4% in 1986 and 1996, respectively. The total number of strokes (fatal and non-fatal) associated with atrial fibrillation (any coding position) in men increased from 177 (6.9% of all atrial fibrillation hospitalizations) in 1986 to 292 (3.3%) in 1996. These numbers were 314 (10.8%) and 728 (8.6%) in women. Fatal strokes contributed to 4.1% of case fatalities related to atrial fibrillation in men in the calendar year 1986. The equivalent proportion in 1996 was 12%. In women these figures were 6.2% and 6.8% in 1986 and 1996, respectively.

In the presence of stroke atrial fibrillation was also associated with a particularly long length of stay in hospital. For example, mean length of stay in men with stroke was 23 days (median 11, IQR 5–24) and in those without stroke 11 days (6, 2–11) in 1996.

Discussion

We have revealed a striking increase in hospital activity, morbidity and mortality related to atrial fibrillation in recent years. Between 1986 and 1996, the number of hospitalizations with atrial fibrillation coded as either as the principal or a secondary diagnosis (and in population rates for both these types of hospitalization) almost tripled in men and women. As a consequence, atrial fibrillation, as the principal diagnosis coded at discharge, grew to account for 7% of all cardiovascular...
hospitalizations and 8% of all days of hospitalization for cardiovascular reasons by 1996. In 1996, atrial fibrillation coded in any position contributed to a remarkable 20% of cardiovascular hospitalizations and 41% of cardiovascular bed days. These increases were more marked in males and the very elderly.

Very similar trends were observed when we examined the number of patients hospitalized (as opposed to episodes of hospitalization) and the number of patients having a ‘first ever’ hospitalization. Though most patients had one admission within a calendar year, the proportion of patients having a further hospitalization within that period also increased two- to threefold (e.g. from 6-1% to 18-6% between 1986 and 1996 in men). The average age of patients discharged increased approximately 1 year in both sexes over the period of study.

These general observations contain additional points worthy of further comment. Though women accounted for around half of all hospitalizations overall, their population rate of hospitalization was much lower than in men below the age of 75 years. In keeping with this, women were about 8 years older than men and, by 1996, 60% of women with atrial fibrillation were aged over 75 years compared to 35% of men. This difference accounts for the very much larger bed usage by women compared to men (i.e. elderly patients had a longer length of stay than younger ones). Indeed, atrial fibrillation, coded in any diagnostic position, by 1996 contributed to an extraordinary 45% of bed-days used for cardiovascular reasons by women. There were other important differences between men and women, discussed further below. It is also of interest to note that the increase in hospitalizations related to atrial fibrillation increased most clearly after 1990/91, coinciding with the publication of several trials demonstrating the efficacy of anti-thrombotic therapy in preventing stroke in atrial fibrillation[12–14]. These trials may have led to changes in the threshold for hospital admission and coding practice, especially secondary coding — see below. Such ‘threshold’ changes, presumably coinciding with better treatment, may have accounted for at least some of the reduction in case fatality over the period studied.

Despite the modest fall in case fatality observed, the absolute number of deaths approximately doubled between 1986 and 1996 (76 in 1986 and 147 in 1996 associated with a principal diagnosis of atrial fibrillation and those randomized in the clinical trials of antiplatelet and anticoagulant therapy). The majority of these large trials enrolled patients with an average age of approximately 67 years in 1996, stroke was the principal diagnosis. This proportion is consistent with other smaller series[18,19]. Conversely, where atrial fibrillation was the principal diagnosis, stroke was coded in 1%-3% of cases in a secondary position, though these may have been previous strokes rather than acute events. Stroke was more commonly coded as the principal diagnosis for women than men. The total number of strokes (fatal and non-fatal) associated with atrial fibrillation increased from 491 in 1986 to 1020 in 1996. Stroke was also associated with a greater proportion of in-hospital case fatalities related to atrial fibrillation in 1996 than in 1986.

There were substantially more strokes (fatal and non-fatal) associated with atrial fibrillation in women (314 in 1986 and 728 in 1996), in keeping with other evidence suggesting that women with atrial fibrillation may be more likely to have a stroke than men[9,21]. We cannot tell from the database available to us whether there were really more strokes being caused by atrial fibrillation over the period of the study or whether changes in coding practice accounted for the increases observed. The latter is, we believe, likely though it is important to comment that such a change still reveals the burden of strokes related to atrial fibrillation was probably under-recognized in the past due to under-coding.

There are few existing data on the public health burden of atrial fibrillation with which to compare our findings. The number of patients discharged from short stay hospitals in the U.S.A. between 1982 and 1993 increased 2.1-fold[9]. This increase was seen in both the elderly (from 30-6/10 000 to 59-5/10 000 in those ≥65 years) and younger patients (from 7-9/10 000 to 11-5/10 000 in those aged 45–64 years). Our rate for men aged ≥65 years was 16-6/10 000 in 1986 and 54-9/10 000 in 1996; in men aged 45–64 years these rates were 7-3/10 000 and 16-6/10 000, respectively. Our population rates in 1996 are similar to those in the U.S.A. in 1993 for both age groups, though the rates in 1986 were lower than the U.S.A. rates in 1982. Consequently, the increase in hospitalization rates in Scotland has been much steeper. The only other studies we can find relate to single institutions and small numbers of patients[22–26]. Their findings are, however, generally in keeping with our data (average age 72–76 years, ≥ half were female and accounting for between 3%-10% of all emergency medical hospitalizations). These studies and our own do, however, highlight differences between ‘typical’ patients hospitalized with atrial fibrillation and those randomized in the clinical trials of antiplatelet and anticoagulant therapy.

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of age and generally included only 25%–30% of females[12]. These two features (younger age and fewer women) are connected, as pointed out earlier. A higher proportion of women will result in a greater average age, as seen in AFASAK[13] and SPAF II[14].

It is always useful to have some perspective on figures relating to one condition. We have conducted a similar analysis for heart failure, another chronic cardiovascular problem associated with ageing and a large rise in hospitalization for heart failure, another chronic cardiovascular problem (e.g. a change in the threshold for admission or changes in treatment). Some important information is not routinely collected (e.g. pharmacological treatment). Though there was no change in the coding system used in the period of study, physicians may have become more prone to code atrial fibrillation in a secondary position due to increased awareness of this arrhythmia as an important cardiovascular problem. Even atrial fibrillation as the principal diagnosis could have been influenced by changes in practice (e.g. a change in the threshold for admission and changes in other practices related to atrial fibrillation, such as electrical cardioversion) rather than in prevalence[29–32]. The rise in overall discharges is also exaggerated by the increase in repeat hospitalizations. However, even if some, or indeed much, of the apparent increase in hospital activity, morbidity and mortality related to atrial fibrillation is explained by these changes, it is important to point out that this shows that the true burden of atrial fibrillation may have been substantially underestimated in the past.

In summary, there has been a striking, two- to three-fold increase in hospitalizations and patients hospitalized with atrial fibrillation in Scotland between 1986 and 1996. As a consequence, the total number and the proportion of overall hospital bed-days (and cardiovascular bed-days) used in relation to atrial fibrillation has grown enormously, despite a fall in average length of stay. Though the in-patient case fatality rate has fallen in the period of the study, the absolute number of deaths associated with atrial fibrillation has doubled. A similarly large increase in the number of strokes associated with atrial fibrillation was observed. These findings probably reflect both changes in clinical practice (coding behaviour and changes in admission threshold) and population prevalence. The burden of atrial fibrillation on acute hospital services has increased dramatically in recent years either because of greater recognition of the problem, a true increase in the problem, or, most likely, both. Health and hospital services need to adapt and plan to deal with this increase that shows no sign of abating.

References


