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Drivers of hospitalisation trends for non-valvular atrial fibrillation in Western Australia, 2000–2013

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ABSTRACT

Objective: To determine if increasing hospitalisations for non-valvular atrial fibrillation (NVAF) in Western Australia (WA) was due to incident (first-ever) or repeat hospitalisations, an ageing population structure, changing procedural practice or a combination of these factors.
Methods: We conducted a longitudinal retrospective population study on all WA residents aged 25–94 years between 2000 and 2013, with a principal hospital discharge diagnosis of NVAF. Person-linked hospital morbidity and mortality records were used to measure annual rate ratios (RRs) and 95% confidence intervals (CIs) in the total and incident NVAF (25–94 years) hospitalisations, further stratified by sex and by age-specific standardised groups (25–44, 45–64, 65–75, 75–84, 85–94 years).
Results: There were 55,532 total hospitalisations for NVAF between 2000 and 2013, patient mean age 68.3 years, and 58% male. Annual age- and sex- standardised rates for total NVAF hospitalisation increased by 3.0%/year (RR 1.030; 95%CI; 1.028, 1.038), and in both men and women. The largest absolute increase in hospitalisation rate occurred in those aged 85–94 years (Δ613/100,000 men and women combined). Incident NVAF hospitalisations showed a borderline decline of 0.5%/year (RR 0.99; 95%CI; 0.99, 1.0) with a statistically significant trend in women but not men. The rate of AF admissions associated with a catheter ablation increased by 13%/year (95%CI; 13.1%, 15.3%).
Conclusion: The increasing rates of total hospitalisation for NVAF is driven more by repeat than incident admissions, escalating hospitalisations in the very elderly, and more frequent interventional procedures. These drivers have major economic and healthcare planning implications.

1. Introduction

Atrial fibrillation (AF) is a worldwide epidemic, with the reported prevalence and incidence steadily rising over recent decades [1–3]. This common arrhythmia, which includes atrial flutter, causes substantial morbidity and mortality, and can have a significant impact on quality of life [2,4–6]. Therefore, AF constitutes a major public health problem with increasing health care service utilisation and cost burden. Importantly, it has been recognised that AF-related hospitalisations are responsible for the majority of economic costs associated with AF [6]. Studies from Europe and North America have reported dramatic increases in hospitalisations for AF through the 1980's to 2000's [7–9]. In Australia, the total number of hospitalisations for AF as a principal diagnosis increased by over 200% between 1993 and 2007 [10]. However, the latter study was not restricted to non-valvular AF (NVAF) and was unable to define the extent to which incident (first-ever), repeat AF hospitalisations, or an ageing population structure contributed to the increasing hospitalisation rates. Changing procedural practice, particularly AF catheter ablation, may also impact on the contemporary trend of AF hospitalisations, with increasing cost to the health sector [11]. Therefore, our objective was to assess and compare the sex- and age-specific standardised trends in total and incident NVAF hospitalisation in the residential population of Western Australia (WA), aged 25 to 94 years in the most recent era from 2000 to 2013. We also assessed the impact of catheter ablation on NVAF hospitalisation trends.

2. Methods

Routinely collected hospital and death administrative datasets in WA were used to obtain hospital and death records for all WA residents with at least one hospitalisation for AF between 1 January 2000 and 31 December 2013 were obtained. The State Hospital Morbidity Data Collection and the Death Registry are accurately linked by the WA Data Linkage Branch using probabilistic matching [12]. These two core datasets routinely capture all public and private hospitalisations and death records in WA. Every hospital record included age, sex, principal discharge diagnosis and up to 20 additional discharge diagnosis categories using the International Classification of Diseases, version 9 (ICD-9) and 10 (ICD-10). To determine the total number of hospitalisations due to AF, every hospitalisation with a principal discharge diagnosis of AF or atrial flutter from the start of 2000 to the

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end of 2013 was identified (ICD-9 codes 427.3; ICD-10 code I48). Incident cases of AF were defined as patients with a first-ever hospitalisation for AF as a principal diagnosis from 2000 to 2013, with no admission for AF in the 15 years prior the date of admission. Any NVAF cases were identified by excluding the patients with a history of valvular heart disease, defined as the presence of rheumatic mitral valve disease or mechanical heart valve prosthesis (see Supplementary Table 1 for ICD codes) [13].

2.1. Statistical analysis

The overall and sex- and age-specific standardised rates for total NVAF hospitalisations were calculated using the direct method, standardising to the age and sex distributions of the total WA population in the 2011 Census. The rates for incident (first-ever) NVAF hospitalisations were standardised similarly, but using the age and sex distributions of the WA population who were free of a prior AF hospitalisation in 2011. Age-specific rates were divided into the following age groups, for between-study comparability: 25–44 years, 45–64 years, 65–74 years, 75–84 years, 85–94 years, and an overall group of 25–94 years. All age groupings were standardised by 5-year age groups. Age-specific standardised rates were further stratified by sex. Trends in rates of hospitalisation for a principal diagnosis of NVAF were examined using Poisson log-linear regression models. Annual rate ratios (RRs) with 95% confidence intervals (CIs) were obtained from these regression models. An interaction term between age and sex was also tested for both total and incident NVAF hospitalisations.

The number of AF ablations and number of electrical cardioversions were counted and described as the proportion of total AF hospitalisations (/1000) each year which included that procedure during admission (see ICD codes for catheter ablation and cardioversion in Supplementary Table 1).

SAS version 9.4 for Windows and Microsoft Excel were used to conduct the statistical analysis. Ethical approval was obtained through the WA Department of Health, Human Research Ethics committee (ethics number: 2014/55 date: 05/09/2016). This study adhered to the requirements of the Privacy Act 1988 and the National Statement on ethical conduct in Human Research. The study protocol also conforms to the ethical guidelines of the 1975 Declaration of Helsinki as reflected in a priori approval by the institution's human research committee.

3. Results

3.1. Total and age-specific standardised AF hospitalisation rates

A total of 61,040 hospitalisations for AF as a principal diagnosis were identified from 2000 to 2013. Of these, 5508 hospitalisations had a history of valvular AF, leaving 55,532 NVAF hospitalisations for analysis. In this final cohort, 58.9% were male and the mean age was 68.3 years (SD = 13.1).

Table 1 shows the crude frequency and age-standardised total and incident AF hospitalisation rates in men, women and combined between the years 2000 and 2013. An interaction term between age group and sex was tested for total and incident AF hospitalisation with both being significant ($p < 0.001$). Therefore both overall and sex-stratified age-specific group results are presented. The overall age- and sex-standardised rate of total AF hospitalisations increased from 259.3 (95% CI, 249.7, 268.8) to 332.5 per 100,000 population (95% CI, 323.8, 341.2) with annual increase of 3.0% (trend $p < 0.001$). The total hospitalisation rates per calendar year and average annual increases were greater for men than women (annual increase 3.4% vs 2.5% respectively).

Fig. 1 and Supplementary Table 2 shows the temporal trends in age-specific standardised rates of total NVAF hospitalisation for men and women. There was a significant increase in total AF hospitalisation rates in every age-specific group in both sexes, except women aged 25–44 years. At the start, the highest NVAF hospitalisation rates occurred in men aged 75–84 years followed by 65–74 years; in women it was highest in the 75–84 year age group followed by 85–94 years. However, by the end of study period the highest rates were seen in both men and women aged 85–94 years followed closely by the 75–84 year age group. Although the relative annual increases (rate ratios) were similar across all age-specific groups, the absolute magnitude of the increase in total AF hospitalisation rates was by far the largest in men and women aged 84–95 years (Δ613.3 per 100,000). The rate of AF hospitalisations associated with a catheter ablation increased from 9.4 to 119.4 per 1000 AF hospitalisations, representing a 13.3% annual increase over the period (trend $p < 0.001$) (Table 1). The average electrical cardioversion rate was 347.8 per 1000 AF hospitalisations which declined by 0.9% annually (95%CI; 0.6%, 1.3%, $p < 0.001$).

3.2. Total and age-specific standardised incident AF hospitalisation rates

Out of all hospitalisations with NVAF as a principal diagnosis over the study period, 40% of cases were incident (first-ever) cases. Of the incident cases, their mean age was 68.0 years (SD = 13.81), 57.5% were male, and 32.2% of admissions were elective. Among the incident cases, the prevalence of most comorbidities, including coronary heart disease, other vascular diseases, heart failure, hypertension, chronic kidney disease, and chronic obstructive pulmonary disease declined over the study period with the exception of cancer and diabetes (Supplementary Table 3). Accordingly, the proportion of incident AF cases with a high predicted stroke risk score also declined over the period.

The incident NVAF admission rates were greater for men than women for every calendar year. The overall age- and sex-standardised rate of incident NVAF hospitalisations decreased from 146.9 (95% CI 139.9, 154.0) in 2000 to 113.1 per 100,000 population (95% CI 108.0, 118.3) in 2013 representing an annual 0.5% decline (trend $p < 0.001$) (Table 1). However, when stratified by gender the observed 0.4% annual

Table 1
Frequency and sex and age-standardised rates of total and incident hospitalisation for non-valvular atrial fibrillation as a principal diagnosis from year 2000 to 2013.

	AF hospitalisation crude frequency			Age-standardised total AF hospitalisation rate per 100,000 person-year*			Age-standardised incident AF hospitalisation rate per 100,000 person-year*			Catheter ablations in (total) AF hospitalisations	
	Men	Women	Overall	Men	Women	Overall	Men	Women	Overall	N	Rate/1000
2000	1679	1208	2887	318.7	198.9	259.3	177.3	115.9	146.9	28	9.7
2001	1671	1265	2936	310.4	200.6	256.0	157.0	100.8	128.8	44	15.0
2002	1736	1284	3020	311.4	199.1	255.6	150.7	97.1	123.8	45	14.9
2003	1653	1264	2917	287.6	189.2	240.2	133.4	82.8	108.2	46	15.8
2004	1857	1309	3166	311.1	193.2	252.7	133.0	82.5	107.6	162	51.2
2005	1893	1359	3252	305.3	194.4	251.2	124.7	80.0	102.1	205	63.0
2006	2045	1463	3508	317.9	205.4	263.4	129.2	82.7	106.2	247	70.4
2007	2248	1598	3846	338.0	216.3	279.1	130.1	84.5	107.6	288	74.9
2008	2232	1669	3901	326.2	219.4	274.6	125.0	84.9	105.0	220	56.4
2009	2670	1764	4434	377.5	225.5	302.3	142.1	86.6	113.9	386	87.1
2010	2902	2022	4924	400.3	249.4	325.6	143.7	98.6	121.2	455	92.4
2011	3199	2169	5368	427.3	259.1	342.8	154.2	92.7	123.0	500	93.1
2011	3516	2269	5785	450.3	261.5	356.5	155.0	94.9	124.5	577	99.7
2013	3414	2174	5588	423.2	242.0	332.5	141.2	85.7	113.1	671	120.1
Annual rate ratio and 95% CIs¶	–	–	–	1.03 (1.03,1.04)	1.02 (1.02,1.03)	1.03 (1.03,1.03)	1.0 (0.99,1.0)	0.99 (0.99, 1.0)	0.99 (0.99,1.0)	–	1.13 (1.13, 1.15)

AF = Atrial Fibrillation; CI = Confidence Interval; N = count.

* The overall and sex-specific rates of total and incident NVAF hospitalisations were standardised to the age and sex distributions of the WA population in 2011 census.

¶ The annual rate ratios (and 95% confidence intervals) were calculated using Poisson log-linear regression models.

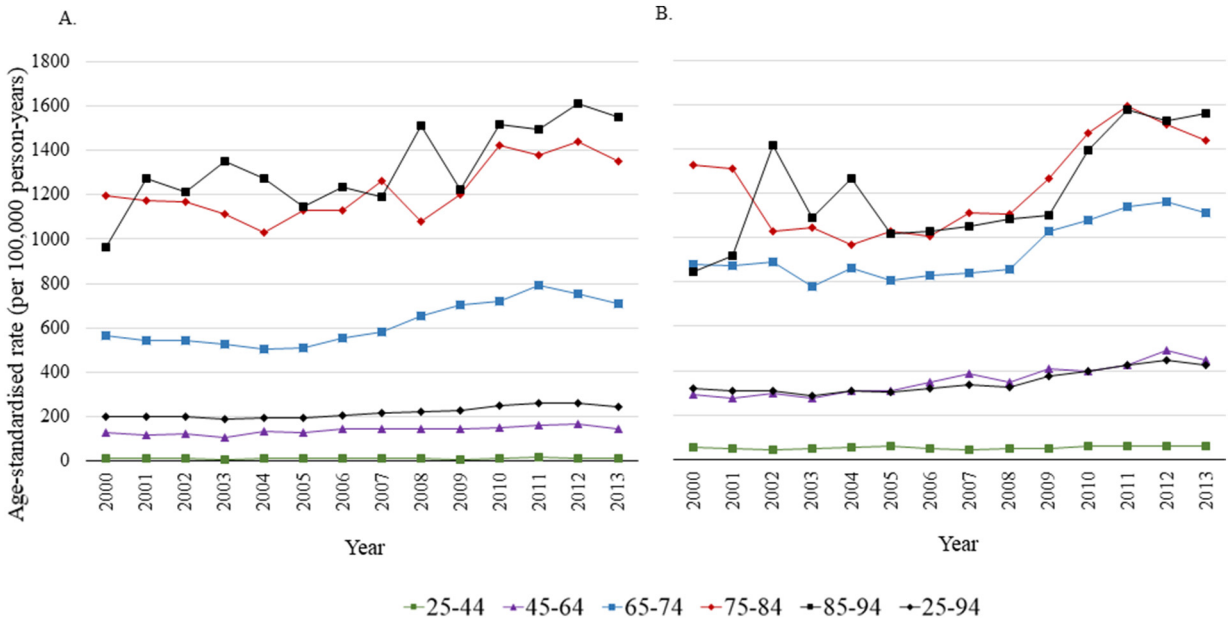

Fig. 1. Age-standardised rates of hospitalisations for atrial fibrillation as a principal diagnosis aged between 25 and 94 years, in WA from 2000 to 2013. A. Women, B. Men.

decrease in men was not statistically significant, whereas a significant annual decrease of 0.7% was observed for females (Table 1). Fig. 2 and Supplementary Table 4 show the temporal trends in age-specific standardised incidence of NVAF hospitalisation stratified by gender. There was no significant change in age-specific rates for either men or women, except for small declines in annual rate seen in men aged 65–74 years, and women aged 75–84 years.

4. Discussion

Our findings highlight that repeat, not incident, NVAF admissions are the predominant reason for increasing hospitalisation rates from 2000 to 2013. Further, the increasing AF admission rates are particularly evident in very elderly patients, demonstrating the impact of an ageing population. Finally, annual increases in AF catheter ablations indicate a significant change in interventional practice.

The healthcare and cost burden of NVAF has grown considerably driven by increases in numbers and hospitalisation costs [11,14,15]. Hence, a clear understanding of current NVAF hospitalisation trends and the underlying drivers is critical for appropriate healthcare planning and for reducing healthcare demands. We found a 3% annual increase in the age and sex-standardised rate of NVAF admissions in WA from 2000. Our data extends previous reported trends, which demonstrated a 203% relative increase in unlinked AF hospitalisations as a principal diagnosis in Australia between 1993 and 2007 [10]. This trend also mirrors that reported by Patel et al. [14] from their National Inpatient Sample of the adult US population between 2000 and 2010.

For the first time we show that NVAF incident hospitalisation rates have remained relatively stable, even in the older age-specific groups, with the overall incident rate declining marginally. Incident hospitalisations for AF may not be increasing because of a declining prevalence of risk factors (like hypertension) and antecedent conditions

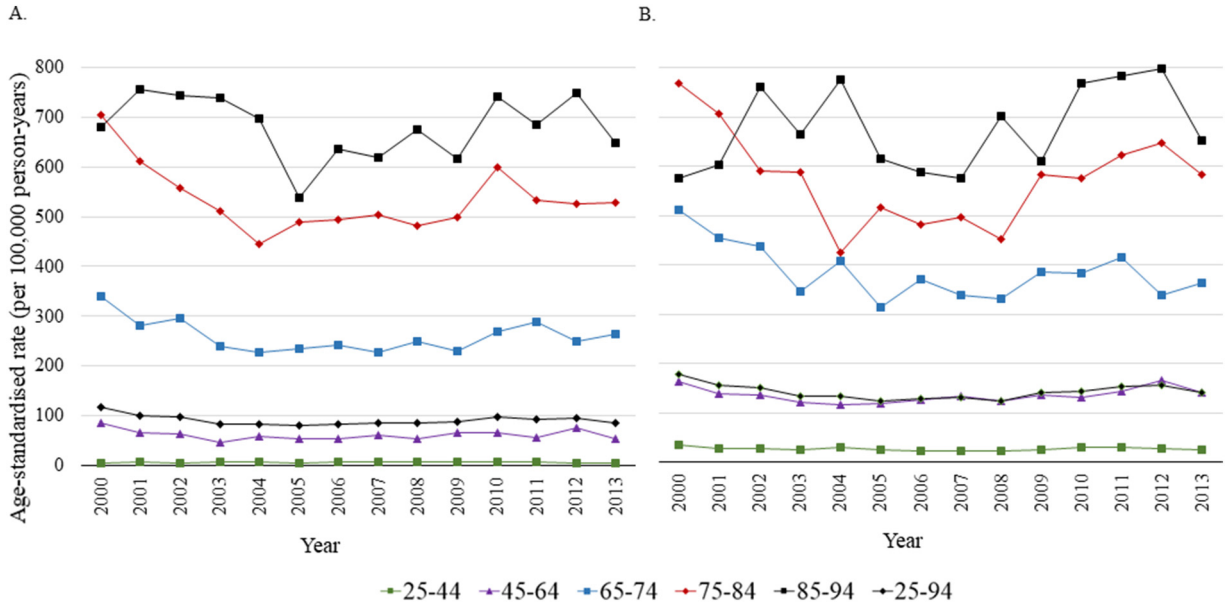

Fig. 2. Age-standardised rates of hospitalisations for incident atrial fibrillation as a principal diagnosis aged between 25 and 94 years, in WA from 2000 to 2013. A. Women, B. Men.

(like heart failure and ischaemic heart disease) in this population [5]. However, hospitalisation data may not capture all new AF cases because they may be asymptomatic or insufficiently symptomatic to warrant hospital admission. Implementation of AF screening tools may capture cases which if managed in the community may possibly prevent incident hospitalisation [16,17].

The observed positive NVAF hospitalisation trends are driven mostly by repeat hospitalisations. The exact causes this cannot be determined, although the increasing proportion of hospitalisations associated with an AF ablation procedure suggests that clinicians increasingly prefer a rhythm control strategy. Previously, Miysaka et al. [18] also suggested that a marked increase in hospitalisation after first diagnosis of AF between 1980 and 2000 in Olmstead County was largely driven by changes in AF management. More detailed studies outlining reasons for repeat hospitalisations could provide insights for effective prevention strategies including more integrated AF care models [19].

Since AF prevalence increases with age, an ageing population structure in high-income countries will continue to drive increasing AF hospitalisation rates [5,10,14,15,20]. Our study confirmed that very elderly people aged 84–95 years had the highest NVAF hospitalisation rate by 2013, and over the period experienced the largest absolute increase in hospitalisation rates. Recent studies from the UK [20] and U.S. [14,15] have also reported marked increases in AF hospitalisation rates in the elderly aged ≥80 years. Importantly, we also demonstrated that sex- and age-standardised rates of NVAF incident hospitalisation did not increase over the study period even in the elderly. This suggests that clinicians have generally not lowered their threshold for hospitalisation of patients for NVAF, but once initial hospitalisation has occurred the patient is likely to be re-admitted for inpatient AF care. We are unable to ascertain if increasing hospitalisations of elderly patients principally for their arrhythmia care is an appropriate use of very costly healthcare resources. Nevertheless, many AF-affected patients, particularly when elderly, have multiple comorbidities which drive high rates of all hospitalisations [21,22]. Hence multidisciplinary and integrated models of care to prevent hospitalisations in older AF patients are greatly needed [23].

Recently, major advances in interventional treatments for AF, most notably AF catheter ablation, have undoubtedly contributed to rising inpatient AF care costs [11,14,15]. In the local context, we observed a substantial increase in the proportion of all NVAF hospitalisation involving an AF catheter ablation procedure from 2000 to 2013. This mirrors U.S. trends, where usage of rhythm control therapies initially declined after publication of the AFFIRM and RACE trials, but after 2005 a rapid growth in AF catheter ablations occurred [24]. Ablation is expensive and has a significant inpatient complication rate [25], yet has also been associated with improved symptom burden and quality of life. Some observational studies have suggested outcome improvements [26] although the recently presented CABANA trial found that ablation was not superior to anti-arrhythmic drug therapy for cardiovascular outcomes like death and stroke [27]. However, some studies suggest that AF ablation may be cost-effective in selected patients, particularly for improved quality of life and avoidance of future healthcare costs [28].

5. Strengths and limitations

Administrative datasets have a number of limitations. There is lack of detailed clinical information and the precise reason(s) for hospital admission cannot be ascertained. However, it is likely that AF was the primary cause for hospitalisation when it's coded in the principal position. The diagnosis of AF may be inaccurate although it was previously validated in a randomly selected sample of medical records [5]. Treatment information except for procedures (like ablation) is unavailable and the lack of oral anticoagulation data is a limitation.

This study did not examine whether the outcomes of NVAF cases have changed over the study period. However, we confirmed that the prevalence of most cardiovascular comorbidities have declined, and in an earlier study we also showed that risk-adjusted mortality rates declined in incident hospitalized AF cases up to year 2010 [5]. Hospitalisations rates for NVAF may not be representative for all of Australia, however WA hospitalisation rates for AF as a principal diagnosis in 2014–15 were similar to the average Australian rate for adults aged over 34 years [29]. Our observed rising AF ablation rates are also concordant with national trends [30]. Major strengths of our study include the population-based design in a nationally representative state [31], and the high-quality person-based linkage, allowing for a 15-year look-back period to discern incident from prevalent hospitalisations [12].

6. Conclusion

We demonstrated that age- and sex-standardised rates of hospitalisations for NVAF as a principal diagnosis have increased steadily between 2000 and 2013, and that these were driven primarily by repeat hospitalisations particularly in the elderly. Also, patients were more frequently treated with costly inpatient therapies like AF catheter ablation. Our findings have important economic and healthcare planning implications. Further studies are required to provide insights into developing strategies to prevent costly hospitalisations and determining patients in whom AF ablation are likely to be most cost-effective.

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijcard.2018.09.047.

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Authorship statement

All authors take responsibility for all aspects of the reliability and freedom from bias of the data presented and their discussed interpretation.

Conflicts of interest

None declared.

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