The Economic Costs of Atrial Fibrillation in Australia

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PRICEWATERHOUSECOOPERS

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Executive summary

Atrial Fibrillation (AF) is the most common sustained cardiac arrhythmia. AF is a condition that affects the heart, causing an irregular pulse. Symptoms of AF include palpitations, shortness of breath, dizziness, fainting and chest discomfort or pain, which lead to significant discomfort and lower quality of life for people with AF. More critically, AF can lead to significant complications, including:

- a significantly higher risk of stroke – studies indicate that the relative risk of stroke for people with AF varies from 2.5 to 7 times that of the general population.
- more severe strokes and increased risk of death following stroke
- a significantly higher risk of heart failure – up to threefold risk of heart failure according to several studies.
- higher overall mortality – up to 90% higher according to some estimates.

Diagnosis and Treatment

AF is often asymptomatic and can present with vague non-specific symptoms. Often it is only detected when a person presents with serious complications including stroke. Once detected, treatment is available, although side effects can be significant. Most treatment methods focus on rhythm or rate control. Anticoagulant treatments such as warfarin are also typically employed to reduce the risk of the major adverse events, although treatment with warfarin itself can lead to side effects and adverse events, particularly excessive bleeding. In a small number of cases, cardiac surgery is used to treat AF.

Prevalence of Atrial Fibrillation in the Community

AF has been the subject of few studies in Australia compared to other cardio-vascular diseases. As a result, estimating the population prevalence of AF is difficult. We have relied on international evidence to derive prevalence estimates for Australia. Among Australian residents during 2008-09, we estimate that 240,000 people (1.1%) suffer from AF. More than half of these people are over the age of 75. Further, we estimate that an extra 6,300 people suffered a stroke for the first time during the year as a result of AF. A very significant number of hospitalisations occurred as a result of AF – we estimate that there were 45,600 hospital separations for AF – more than for stroke or heart failure.

The estimated cost of AF

We estimate that the annual costs to the Australian economy in 2008-09 resulting from AF are at least **$1.25 billion** per annum through medical costs, costs of long term care for those with a disability, and lost productive output. This equates to **$5,200 per annum** for every person with AF. By way of comparison, this is over double the estimated per person cost of obesity and higher than the per person cost of cardiovascular disease or osteoarthritis. We have been conservative when estimating individual component costs, and have not quantified other costs, including (but not limited to) the reduced quality of life that people with AF experience. The table below summarises our estimate of the costs of AF. Health system costs are by far the most significant cost, reflecting both the significant number of hospitalisations required for AF and the significant costs associated with AF-attributable stroke and heart failure.

In this report, we have not put a dollar value on the reduced quality of life from pain, reduced capacity to participate in physical or social activities, and increased feelings of anxiety and/or depression. We have also not placed a dollar value on the years of life lost due to early death.

Costs to Australian society of Atrial Fibrillation, year ending 30 June 2009 ($A000s)

Direct health system costs	$'000
Atrial Fibrillation	
Admitted hospital services	159,143
Non-admitted hospital services	50,582
General practitioner medical	29,978
Specialist medical	95,923
Other professional services	24,696
Pharmaceutical	74,682
Sub-Total - Identifiable AF health costs	**435,005**
Stroke	
Health system costs excluding pharma	**215,750**
Heart Failure	
Hospital services	170,943
Other services	52,097
Total	**223,040**
Total Health system costs	**873,795**
Other Direct Expenditure	
Disability costs	60,179
Residential Aged Care Costs	126,562
Total	**186,741**
Total Other Direct Expenditure	**186,741**
Non-financial costs (human capital approach)	
Atrial Fibrillation	
Productivity - absenteeism	17,348
Productivity - premature death, paid work	10,560
Productivity - premature death, unpaid work	23,653
Productivity - premature death, search & hiring costs	1,904
Sub-Total - Productivity Costs	**53,466**
Unpaid Carer Costs	**135,083**
Total Non-financial costs	**188,549**
Total	**1,249,085**

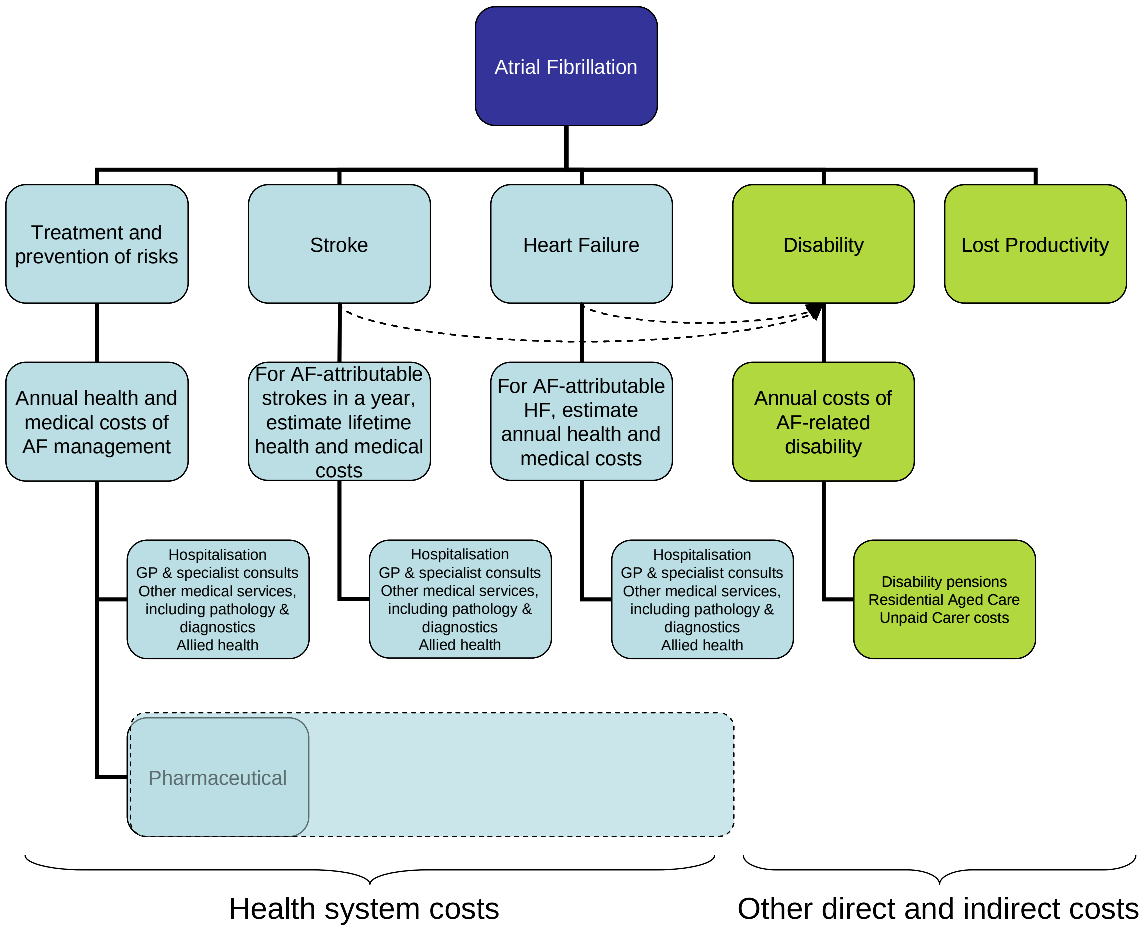
A significant portion of AF's costs arise as a result of major events associated with AF, including stroke and heart failure. In total, **$797 million**, or **64%** of the costs identified above arise as a result of stroke and heart failure, or as a result of premature mortality associated with AF. To the extent to which these events can be avoided or minimised, the burden of the disease can be substantially reduced. A review of the evidence indicates a case for more investment in preventative approaches. In many cases, AF is only detected after the person presents with serious complications, such as a stroke, thromboembolism or heart failure, while studies have estimated that around 30% of AF is diagnosed incidentally when patients are hospitalised for other reasons.

Estimation approach

In arriving at these estimates, we have used the ‘prevalence’ approach to estimate the cost of AF to the Australian economy, as far as data allows. This approach involves estimating the total cost in a given year of the disease for all people with the disease during that year. This requires development of a profile of the prevalence of AF in Australia, estimation of the proportion of people who have been diagnosed and treated for AF (and hence those for whom the AF is undiagnosed) and estimation of the number of health events in the year – hospital admissions, stroke, heart failure – which are a result of AF. Note that throughout our methodology we have taken a conservative approach to costing AF where there is uncertainty in the available evidence.

Our costings have focussed on health system costs, other direct costs and indirect expenditure associated with AF. The figure below provides a high level schematic of our measurement approach. In summary, AF leads to direct health costs (highlighted in blue) in treating and preventing the risks associated with AF, and also leads to stroke and heart failure. It leads to higher levels of disability (which carries both direct and indirect costs) and lost productivity.

Framework for measuring the economic costs of AF



Health system costs

Health system costs include expenditure on hospitals, pharmaceuticals and primary and community health care. Few data sources directly identify health expenditure on AF and there have been no major Australian studies. Our approach therefore involves a blend of direct and indirect measurement approaches to estimate AF’s health system costs. For example, Begg, et al’s 2007 study on the burden of disease provides details on the likely costs associated with stroke, while literature can be used to identify the ‘attributable fraction’ of stroke which is due to AF. We therefore estimate the cost of stroke events associated with AF by estimating the portion of strokes and hence stroke costs which are attributable to AF.

Having reviewed the evidence, we focus on the following three main ‘buckets’ of health system costs associated with AF.

- Costs associated directly with diagnosis and treatment of AF and management of AF-related risks. This includes hospital admissions which are primarily for AF and primary care and treatment which is directly-related to AF.
- Costs of strokes attributable to AF, which have been estimated by considering the average lifetime health costs of a first-ever ischemic stroke, and multiplying this by the estimated number of additional strokes arising as a result of AF.
- Costs of heart failure attributable to AF, which were estimated by considering total per annum heart failure costs for the entire population, and taking the proportion which is attributable to AF.

We estimate that the total health system expenditure on AF was $873.8 million in 2008-09. This estimate is likely to be an underestimate, as it is likely that there are additional costs associated with warfarin adverse events and longer length of stay for hospital admissions where AF is a complicating factor, which we have been unable to cost. Additionally, we have assumed that stroke costs are in line with the average lifetime cost of first-ever strokes, despite evidence indicating that strokes associated with AF are more severe.

Other direct costs

Other direct costs associated with AF are largely a result of the additional disability suffered by those with AF. Disability leads to direct government expenditure on disability pensions, carer payments, and other disability payments for formal care, home modification and so on. It can also lead to early entry into nursing homes, which carries further costs.

There is limited data in Australia to measure the extent to which people with AF experience higher levels of disability than the rest of the population. However, there is clear evidence that stroke and heart failure lead to higher levels of disability, and since these events can be attributable to AF, it is reasonable to conclude that AF leads to higher levels of disability.

We have used an indirect measurement approach to estimate this cost – for stroke, we consider the average lifetime disability costs of a first-ever ischemic stroke, and multiply this by the estimated number of additional strokes arising in the year as a result of AF. For heart failure, we consider the average per person government expenditure on disability and multiply this by the additional number of persons with a disability as a result of AF-attributable heart failure. We estimate the annual disability costs of AF as $60.2 million for the year ending June 2009, and the residential aged care costs as $126.6 million.

Non-financial costs of AF

Non-financial costs include lost wages of those who must take time off work for treatment or can no longer work as a result of their illness, informal carers who cannot work as a result of the need to care for disabled family members, as well as wages lost as a result of premature death. Full details of the costing methodology are provided in Section 16, and in summary

- Productivity costs have been estimated in relation to the length of stay of patients in hospital and the number of work days lost for those dying from AF while of working age.

- Informal care costs have been estimated in a similar way to other disability costs.

We estimate productivity losses to be up to $53.5 million. These costs are small relative to the total cost of AF, because the majority of people with AF are older than working age.

Unpaid care is a significant burden on society. We have estimated the value of unpaid care using data on the carer costs associated with stroke and heart failure. We estimate that the value of unpaid care for AF is some $135.1 million per annum.

Sources of uncertainty

Despite the fact that AF results in very significant health impacts and costs to the Australian economy, the evidence regarding the costs of AF and the number of people with AF is incomplete. In arriving at our estimates, we have had to rely significantly on international literature as well as survey-based estimates of health system utilisation for Australia based on small sample sizes. Given the potentially large costs associated with AF, we encourage greater investment in research and data to better understand this disease.

The most significant areas of uncertainty include:

- The population prevalence of AF
- The health system costs directly related to AF
- The relative risk of specific events such as stroke and heart failure
- The cost of specific events such as stroke, given that evidence indicates that may be more severe, but also associated with higher mortality.

Below, we summarise the results of sensitivity testing around these key assumptions.

Sensitivity Analysis

	Total cost	Difference	%
Baseline	$1,249 m		
Increase prevalence of AF to 1.2%	$1,333 m	$84 m	7%
Increase prevalence of AF to 1.5%	$1,601 m	$352 m	28%
Increase portion of strokes / heart failure caused by AF by 5%	$1,302 m	$53 m	4%
Decrease portion of strokes / heart failure caused by AF by 5%	$1,196 m	-$53 m	-4%
Increase lifetime cost of stroke by 10%	$1,289 m	$40 m	3%
Increase per person AF health costs by 10%	$1,293 m	$44 m	3%
Increase per person AF health costs by 25%	$1,358 m	$109 m	9%

Increasing the assumed portion of the population with AF by 0.1% (from 1.1% to 1.2%) has a significant impact on the results, increasing the overall cost by 7%. Increasing population prevalence further – from 1.1% to 1.5% (as in a recent Swedish study of the economic costs of AF), increases costs substantially, by some 28% or $352 million per annum. Our estimates of population prevalence are at the lower end of the range of observed levels internationally (1% to 2%) although this is part reflects the fact that Australia's population is relatively younger than other countries studied. Nevertheless, an increase of this magnitude is certainly within realistic bounds.

Also very significant is the impact of adjusting the direct health system costs arising as a result of AF. A 25% increase would bring the per person costs of AF into line with the cost identified in the Swedish study and leads to an increase of $109 million or 9%. In estimating the health system costs of AF, we were unable to put a cost on some important elements, including longer length of stay in hospital for those with AF as a complicating factor, and adverse events arising from warfarin medication. Estimates of the costs of specialist medical and allied health care were also uncertain. An increase of this magnitude is certainly within realistic bounds.

If all the impacts identified in the table above were combined, the overall economic cost of AF could be some 45% higher - as high as $1.8 billion per annum.

Despite these areas of uncertainty, it is clear that the burden of AF is very significant in the context of the Australian economy, with high health system costs, disability impacts and significant impact on quality of life.

1 Introduction

Atrial Fibrillation (AF) is the most common sustained cardiac arrhythmia. It is a major health issue in Australia, imposing significant costs on Australian economy and society. Those with AF suffer from increased risk of stoke and heart failure, higher overall mortality and diminished quality of life. Treatment methods focus on rhythm and rate control along with ongoing treatment with anticoagulants such as warfarin.

1.1 What is Atrial Fibrillation?

Atrial Fibrillation (AF) is the most common sustained cardiac arrhythmia, increasing in prevalence with age (Benjamin et al, 2009; Fuster et al, 2006). AF is a supraventricular tachyarrhythmia which is characterised by uncoordinated atrial activation with consequent deterioration of atrial mechanical function (Fuster et al, 2006). In layman's terms, AF is a condition that affects the heart by causing an irregular pulse. It occurs when the electrical impulses controlling the heartbeat become disorganised, so that the heart beats irregularly and too fast. The problem starts in the upper chambers of the heart (the atria), and causes these chambers to quiver (or fibrillate), rather than beat normally. This can mean that the heart is not pumping as efficiently as it should be.

Symptoms

AF can occur in a variety of cardiac and non-cardiac conditions. It is often asymptomatic and can present with vague non-specific symptoms. Too often, AF is only detected after a patient presents with serious complications of AF, such as a stroke, thromboembolism or heart failure (NCCCC, 2006). There is a 25 -30 % reduction in the filling of the main pumping chamber of the heart resulting in lower output causing fatigue and congestion causing breathlessness, dyspnoea (shortness of breath), bloating and swelling of the legs. Other symptoms of AF include palpitations, dizziness, syncope (fainting) and chest discomfort or pain.

Types of Atrial Fibrillation

There are a number of different types of AF which are commonly used in the academic literature and are described below. These categories are not mutually exclusive and an individual may have several episodes of paroxysmal AF and occasional persistent AF, or the reverse. More importantly, AF tends to be progressive, so that a person with paroxysmal AF can later develop more sustained forms of AF.

- Paroxysmal AF involves episodes which terminate spontaneously and last no longer than one week. If the AF becomes sustained, it is considered persistent.
- Persistent AF involves episodes which last longer than one week and in which the disturbance does not resolve spontaneously. Persistent AF requires an intervention such as electrical or pharmacological cardioversion, to be converted back to sinus rhythm.
- Permanent AF usually refers to otherwise healthy people with continuous AF in whom the decision has been made to accept the arrhythmia, or to a person in whom cardioversion is not successful (Fuster et al, 2006).

The UK's National Collaborating Centre for Chronic Conditions (NCCCC) (2006) has developed a clinically-relevant categorisation of AF as follows:

- Acute-onset AF is an episode of AF that has started suddenly or has made symptoms get worse. This may be the first time it has happened ('recent-onset AF'), or the person may have had AF before. It can happen in people with persistent or paroxysmal AF, and in those who are already being treated for AF as well as those who aren't being treated. Some people with acute AF that results in potentially dangerous symptoms may need to be treated in hospital.

- Post-operative AF may occur after surgery. It usually stops by itself, but may require treatment.
- Lone AF occurs in the absence of any co-morbid cardiovascular disease or other precipitants of AF.

1.2 Risk factors for developing Atrial Fibrillation

Many risk factors for developing AF have been identified, including other cardiac medical conditions as well non-cardiac conditions like sleep apnoea. Established risk factors for AF are summarised below.

Table 1 Risk factors for AF

Category	Risk Factor	Source
Demographic	Increasing age	Schnabel, et al (2009), and other studies
	Males generally suffer greater incidence and prevalence of AF.	Feinberg, et al (1995); and Stewart, Hart, Hole and McMurray (2001)
	Race may be a risk factor, as recorded prevalence tends to be higher among Caucasians. There are few large studies of non-Caucasian cohorts.	Benjamin et al (2009)
Cardiac conditions	AF is commonly associated with, and complicated by stroke.	Kimura, Minematsu and Yamaguchi (2005)
	Congestive Heart Failure (CHF)	Stewart et al (2002), and other studies
	Valvular disease	Schnabel et al (2009), and other studies
	Myocardial infarction	Kannel, Abbott, Savage and McNamara (1982), and other studies
Cardiovascular risk factors	Hypertension	Schnabel et al (2009), and other studies
	Diabetes mellitus	Schnabel et al (2009), and other studies
	Obesity may increase the risk of AF	Tsang et al (2008)
Dietary and lifestyle factors (may also be cardiovascular risk factors)	Cigarette smoking	Heeringa, Kors, and Hofman (2008)
	Excessive alcohol consumption	Lowenstein et al (1983); Conen et al (2008)
	Excessive caffeine consumption	NCC-CC (2006)
	Emotional or physical stress	NCC-CC (2006)
	Excessive sports practice (emerging evidence)	Schoonderwoerd, et al (2008)
Other factors (emerging evidence)	Sleep apnoea	Schoonderwoerd, et al (2008)
	A wide pulse pressure	Mitchell et al (2008)
	Inflammation - the incidence of AF after cardiac surgery suggests that inflammation is a contributing factor.	Schoonderwoerd, et al (2008)

1.3 Morbidity and mortality impacts of Atrial Fibrillation

Atrial Fibrillation is associated with significant morbidity and mortality, resulting particularly from strong links with both stroke and heart failure.

Increased risk of stroke

There is strong evidence that AF increases the risk for stroke. Between 20% to 30% of all acute stroke patients are found to be in AF (Glader et al, 2004 and Steger et al, 2004) and one in every six strokes occurs in a person with AF (Fuster et al, 2006). Stroke risk persists even in asymptomatic AF (Page, et al, 2003) and continues when the person returns to sinus rhythm, regardless of whether the AF is converted to sinus rhythm via medications or electrical cardioversion.

Peer-reviewed literature estimates that AF increases the risk of stroke by between two and seven fold (Benjamin et al, 2008; Krahn et al, 1995; Wolf, Abbott and Kannel, 1991; Arch Intern Med. 1994). In Australia, the Heart Foundation reports that the risk of stroke in people over the age of 65 with untreated AF is approximately one in 20 per year, which is five to six times higher than those of a similar age without AF. Stroke recurrence is significantly greater after one year in people with AF compared to those without AF (Dulli, Stanko and Levine, 2003).

The attributable risk of stroke increases significantly with age, rising from 1.5% for those aged 50-59 years to 23.5% for those aged 80-89 years. These data suggest that the elderly are particularly vulnerable to stroke when AF is present (Wolf, et al, 1991).

Increased severity of strokes and mortality from strokes

Ischaemic strokes associated with AF are typically more severe than ischaemic stroke without the presence of AF, and this increased severity is independent of advanced age and other stroke risk factors. The frequency of bedridden state, used as an indicator of stroke severity, was 41.2% in stroke patients with AF, compared to 23.7% in patients without AF ($p<0.0005$) (Dulli et al, 2003).

AF also increases the risk of post-stroke mortality. Thirty day and one year mortality rates following stroke are significantly higher in those with AF (Lin, et al, 1996).

In stroke patients, concurrent AF is associated with greater disability, longer in-hospital patient stay and lower rate of discharge to own home (Wolf, et al, 1998).

Increased risk for heart failure

There is strong evidence that AF increases the risk for heart failure. Peer-reviewed literature estimates that AF increases the risk of heart failure by approximately three-fold (Krahn et al, 1995; Stewart et al, 2002; Wang, et al, 2003). It can often be difficult to tell which came first: the AF causing heart failure due to rapid heart rate and increased myocardial oxygen demand or whether the heart failure led to the AF due to increased left ventricular wall stress. Nevertheless, Wang et al (2003) found that 42% of AF subjects had congestive heart failure (CHF) at some point during their lifetime.

This is consistent with findings from the Framingham study showing that AF and CHF occur together frequently in the same individual. Among 931 Framingham Study participants diagnosed with CHF, 24% had prior or concurrent AF. A further 17% were diagnosed with AF subsequently, so that the total proportion of CHF subjects with AF at some time was 41%.

Increased risk for overall mortality

AF leads to a 40% to 90% increased risk for overall mortality (Krahn et al, 1995; Benjamin et al, 1998)

Benjamin et al (1998) used data from the Framingham Heart Study to establish the risk factor-adjusted odds ratio for death in men and women with AF as 1.5 and 1.9 respectively. The study also found that most of the excess of mortality attributed to AF occurs early after diagnosis of AF.

Increased risk for other conditions

The UK NCCC (2006) reports that in addition to the mortality and morbidity impacts described above, AF can result in reduced exercise tolerance and/or impairment of cognitive function.

The Rotterdam study found that dementia and subtypes of Alzheimer's disease and vascular dementia may be related to AF even if no clinical strokes have occurred (Ott, et al, 1997).

1.4 AF and quality of life

AF can be highly symptomatic, with people with AF experiencing palpitations, dizziness, fatigue, chest pain and breathlessness. These symptoms can erode physical independence as people with AF grow to rely on assistance from others for help with daily tasks. People with AF can also experience loss of vitality and energy, a process which can be accelerated by exercise intolerance and restrictions on mobility. They may be forced to effect changes to their diet, hobbies and travelling plans. The result is deterioration in the physical well-being of the individual and diminished satisfaction that a person would otherwise enjoy from the physical aspects of their lifestyle.

In addition to these physical impacts, AF can also affect the mental health of people who have it. Thrall et al (2007) found that approximately one third of people with AF have elevated levels of depression and anxiety, which persist at 6 months. Symptoms of depression were the strongest independent predictor of future quality of life in these people. A 2005 study by Ong et al demonstrated the association between self-reported symptoms of depression and poor physical and mental quality of life in people with AF (Ong, et al, 2005). This study is consistent with research into other medical conditions regarding the link between depression and quality of life (Ruo, et al, 2003, Bush, et al, 2005).

The financial cost of prescription drugs, medical care and therapy, hospital visits and possible surgery can be a cause of worry for people with AF. The anxiety from financial hardship may be exacerbated where people are also forced to downgrade or change job roles to a less stressful role, or retire early. People with AF may be additionally concerned about being unable to fulfil personal or family responsibilities.

There is also the anxiety and stress induced by having to be vigilant about symptoms (which may lead to hyper-sensitivity to symptoms), and from the increased worry about the illness and a possible lifelong need for rate or rhythm control intervention. People with AF may feel apprehension about their future and the impact that AF would have on their pre-existing medical conditions.

As a result of their deterioration in physical health and well-being, functional abilities and physical independence, people with AF may feel less inclined or able to socialise, especially where their mental health has suffered. The social lifestyle of people with AF may be also diminished due to required changes in their diet and hobbies. In the case where individuals need to switch job roles or retire early, they may also experience a change or loss in social stimulation from work. Family life of people with AF can likewise be affected. They may have to cope with a reduced ability or inability to look after young children or grandchildren, and may find it difficult to attend family gatherings and retain family connections. Furthermore, relationships with close family members may suffer from deterioration in the physical and mental health function of people with AF.

Recent studies on quality of life

Quality of Life is defined by the World Health Organisation as "an individual's perception of their position in life in the context of the culture and value systems in which they live and in relation to their goals, expectations, standards and concerns". There have been a number of studies assessing the impact of AF on quality of life. Not unexpectedly, a common finding in these studies is that people with AF have significantly poorer quality of life than the general population (Reiffel, 2008 and Dorian, et al, 2000). A recently published systematic review concluded that people with AF have significantly poorer quality of life compared with healthy controls, the general population, and other people with coronary heart disease (Thrall et al, 2006). Dorian et al (2000) found that subjective health-related quality of life in people with intermittent AF is significantly impaired and commensurate with that in people with significant cardiac disease and much worse than healthy controls. A study by Stewart et al found that heart failure leads to a worse quality of life than AF but the two may co-exist.

The results of the study undertaken by Dorian et al (2000) are summarised in Table 2 below. In the table, lower scores represent lower quality of life. It shows that across all measurements, quality of life was significantly lower in people with AF compared to healthy controls. The magnitude of these differences was approximately a full standard deviation unit in almost all cases. In particular, people with AF had lower general health, physical role, emotional role and vitality than healthy controls compared to other domains. It is notable that the impact of AF on physical role and emotional role appear to be far greater than the impact on physical functioning, mental health and social functioning. These physical and emotional role limitations suggest that AF affects not only the person with AF, but also the people around them.

Table 2 Key results of AF quality of life study by Dorian et al

	Subjects with AF (n = 152)	Healthy Subjects (n = 47)
Demographic Characteristics		
Age (years)	58 (± 12)	54 (± 14)
Gender (% male)	73%	44%
SF-36 Quality of Life Scores[1]		
General health	54 (± 21)	78 (± 17)
Physical functioning	68 (± 27)	88 (± 19)
Physical role	47 (± 42)	89 (± 28)
Mental health	68 (± 18)	81 (± 11)
Emotional role	65 (± 41)	92 (± 25)
Social functioning	71 (± 28)	92 (± 14)
Bodily pain	69 (± 19)	77 (± 15)
Vitality	47 (± 21)	71 (± 14)

Notes:

1 The SF-36 is a widely used generic health scale with standardised scores ranging from 0 to 100. Higher scores represent better quality of life. Figures in brackets show standard deviations. SF-36 is a useful quality of life questionnaire but may not be as sensitive as desired to be able to detect differences in AF vs non AF subjects.

Other studies have found that younger people and women with AF are likely to suffer a greater impact on their quality of life than other people with AF. Reynolds, et al (2006) found that AF reduces quality of life in the younger population to a greater extent than the more elderly population.

Gender differences in quality of life for people with AF have been demonstrated in a number of studies, which indicate that females report worse quality of life relative to males (Dorian, et al, 2002 and Paquette, et al, 2000). Females are found to be more likely than males to report AF-related complaints, such as greater frequency and severity of symptoms (Paquette, et al, 2000 and Rienstra, et al, 2005). Females may also have a greater tendency than males to amplify their physical symptoms, which can lead to heightened health-related distress.

Ong, et al (2005) indicated that AF has a greater impact on self-reported *physical* quality of life in females than in males, despite similarities in age, cardiac history, ejection fraction, type of AF, AF episode frequency and cardiac medications. It was suggested in the study that females may have a style of responding to or perceiving AF that is correlated with poor physical quality of life outcomes. For instance, women may be more likely to receive episodes of fibrillation or symptoms of their arrhythmia as more distressful, burdensome or intrusive than men. In contrast, no gender differences were found with respect to perceived *mental* quality of life

1.5 Detection and prevention

Diagnosis of AF is confirmed through examination, electrocardiogram (ECG), chest X-ray and more recently, the echocardiogram (NCCCC, 2006). Detection of AF can be difficult. AF is frequently asymptomatic and often detected only incidentally by pulse assessment and/or ECG screening (Fitzmaurice et al, 2007; Psaty et al, 1997). Failure to detect AF means that the potential adverse consequences of AF, such as stroke and heart failure, may occur before AF is diagnosed. However active screening (eg through pulse taking and targeted ECG use) for AF has been proven to detect additional cases (see for example Fitzmaurice et al, 2007).

Although AF treatment has been studied extensively, AF prevention has received relatively little attention. Benjamin, et al (2009) note that observational data suggest that some lifestyle habits, dietary variables and medications may be associated with lower AF rates. However there is limited data on the effects of therapeutic interventions or lifestyle modifications on AF primary and secondary prevention. A specialist in the field identified that meticulous blood pressure control may reduce the incidence of new onset AF. Drugs which slow the heart rate (such as beta-blocker, centrally acting calcium blockers, amiodarone, class I anti-arrhythmics agents and possibly digoxin) may also reduce the incidence of new onset AF.

1.6 Treatment

There are no comprehensive Australian-specific treatment guidelines for AF. The National Health and Medical Research Council (NHMRC, 2008) has published a summary of best available evidence and information on current clinical practice regarding AF treatments, comparing rate and rhythm control. The National Stroke Foundation (2007) has also published guidelines for acute stroke management, which specify anticoagulant therapy for people with AF to prevent recurrent ischemic stroke.

More comprehensive guidelines for the treatment of AF have been sourced from the UK National Health Service guidelines for the management of AF, commonly referred to as the “NICE guidelines” (NCCCC, 2006), as well as guidelines developed by the American College of Cardiology, American Heart Association, and European Society of Cardiology (Fuster et al, 2006).

Treatment methods for AF

Overall, treatment is challenging as no really useful (and safe) agents are currently available to reduce the incidence, severity and duration of AF. Treatment of AF aims to relieve symptoms, improve quality of life and reduce the risk of potentially severe complications such as systemic thromboembolism, possible stroke or death. In addition to anticoagulant therapy, there are two main treatment strategies for AF: rhythm control and rate control.

Anticoagulation

Most people with AF should be offered anticoagulant medication (a form of antithrombotic therapy) to thin their blood and reduce the risk of clotting. Common anticoagulants are aspirin and warfarin. All people with AF should have a stroke risk assessment to determine whether they require aspirin (for lone uncomplicated low risk AF) or a stronger anticoagulant for higher risk individuals. If the person with AF agrees to anticoagulation treatment, this should be started as soon as possible after diagnosis and some people are advised to take an anticoagulant on a long-term basis.

The use of anticoagulation as a long-term treatment option should not be underestimated in terms of its impact on the individual and health system costs. Treatment with warfarin, for example, requires blood tests at least once a month and often more regularly, using significant health system resources and inhibiting the individual's ability to travel. There are risks associated with anticoagulants, such as an increased risk of excessive bleeding if injured and in the case of warfarin, a 1.5 % per year risk of major, life threatening bleeding. Other side effects of warfarin include nausea, vomiting, and abdominal bloating and cramps.

Rate control and rhythm control

Rate control and rhythm control aim to control the heart rate (how fast it beats) and the heart rhythm (how regularly it beats), with methods that are tailored to the particular patient.

Rhythm control Therapy for AF is often directed toward the maintenance of sinus rhythm by means of electrical cardioversion and the use of antiarrhythmic drugs, also known as pharmacological cardioversion. This is referred to as the rhythm control approach.

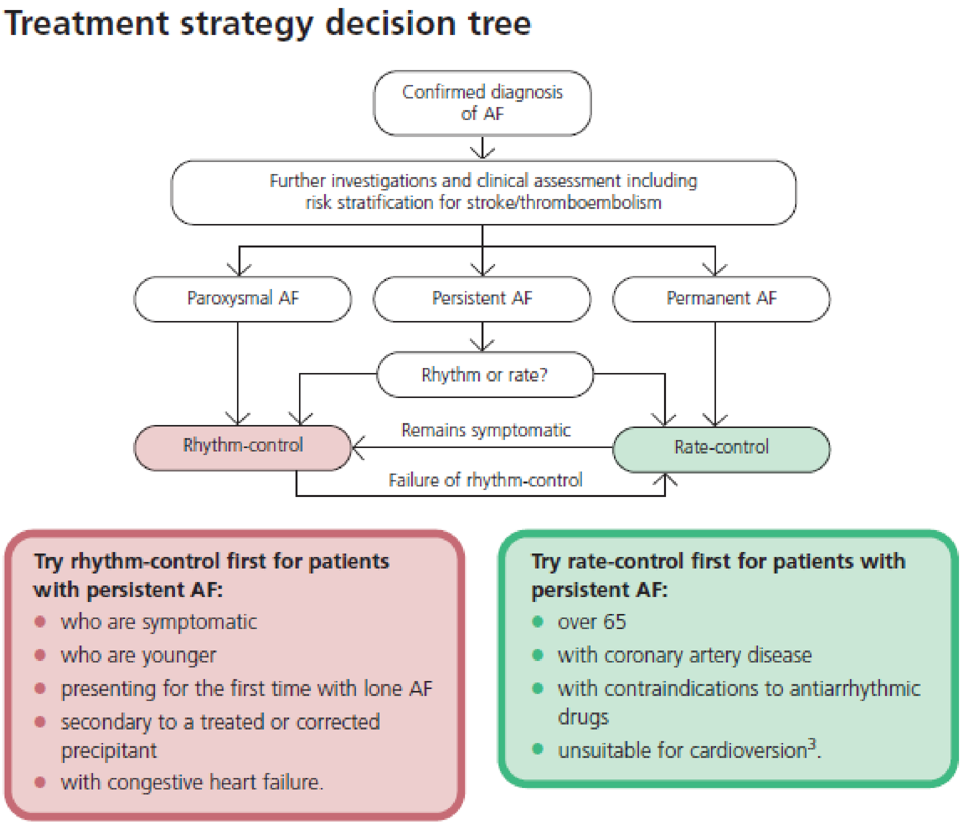
Rate control To control the ventricular rate, the use of atrioventricular nodal blocking agents, such as beta-blockers, calcium channel blockers and digoxin..

Figure 1 provides a treatment strategy decision tree, mapping out treatment approaches.

Both rhythm and rate control strategies have limitations. Rate control medications carry some risk of excessive slowing of heart rate. Not all attempts at attaining rhythm control are successful, and drugs to control rhythm may cause new or more frequent arrhythmias (Fuster et al, 2006). Although rhythm control had been considered superior to rate control in managing AF, recent randomised studies have shown neither strategy to be superior (see for example Iqbal et al, 2005; Wyse et al, 2002; Carlsson et al, 2003; Van Gelder et al, 2002). In addition, a Cochrane systematic review of the trials which compare pharmacological rhythm control and rate control concluded that there was no difference in mortality or quality of life (Cordina and Mead, 2005).

Even with treatment, both strategies still carry significant risks of stroke and heart failure despite anticoagulation and very good rate control. The risk of stroke is unchanged regardless of whether the AF is converted to sinus rhythm via medications or electrical cardioversion. Anti-coagulation needs to be continued for many months once sinus rhythm has been achieved and maintained.

Figure 1 Treatment strategy decision tree, National Collaborating Centre for Chronic Conditions, 2006



Pharmacological treatment

Pharmacological treatments are used in both the rate and rhythm control methods. In rhythm control, pharmacological cardioversion uses antiarrhythmic drugs to help the heart return to its normal rhythm. Pharmacological cardioversion is most likely to be used within the first 48 hours of AF starting. Sometimes antiarrhythmic drugs are used together with electrical cardioversion to help maintain a regular heartbeat after the procedure. This may be needed if electrical cardioversion alone has not worked previously or if AF has come back after previous treatment.

Other treatments for AF are commonly classified in one of four classes according to their primary pharmacologic and electrophysiological properties using the Vaughn Williams scheme. Classes I and III are generally more effective at maintaining SR (rhythm-control), while Classes II and IV are used for their AV nodal blocking and hence rate-control effects. A summary of drugs commonly used around the world in these classes is provided in the table below.

Most of these medications are quite potent and have significant side effects; in fact some may increase the chance of dying compared to no treatment at all.

Table 3 Common AF drugs (Vaughn Williams Classification)

Rhythm-Control	Rate-Control
Class I *Block sodium channels* disopyramide (1a) flecainide (1c) propafenone (1c) quinidine (1a)	Class II *Block beta-receptors* Many beta-blockers such as isoprolol metoprolol propanolol bisoprolol
Class III *Block potassium ion channels* amiodarone sotalol	Class IV *Block calcium ion channels* diltiazem verapimil

Not all AF drugs fit within this scheme. Digoxin, the earliest AF drug, falls outside of this classification altogether. Other drugs have effects outside their primary class. In particular, amiodarone has many other effects, including significant beta-blocking effects, and is sometimes referred to as a multi-channel drug.

Other treatment options

Other treatment options include electrical cardioversion, and cardiac surgery. Treatment with electric shock is called ‘electrical cardioversion’. If an AF episode has lasted longer than 48 hours, then electrical cardioversion may be used, if pharmacological cardioversion has been unsuccessful. Under sedation or a light general anaesthetic, a brief, controlled electric shock is given to the heart, usually through two pads placed on the wall of the chest.

Non-pharmacological management options such as cardiac ablation and pacemaker implantation are also possible for a select group of people for whom other treatments are ineffective or inappropriate. Voeller et al (2008) note that the Cox-Maze procedure, which is cardiac surgery intended to eliminate AF, is recognised as the ‘gold standard’ for surgically curing AF. Virtually all patients with AF who undergo elective cardiac surgery (ie coronary artery bypass grafting or valve repair or replacement) should be strongly considered for a concomitant Cox-Maze procedure. Recent studies have shown that adding a Maze procedure can decrease the late risk of cardiac- and stroke-related deaths in these patients (Voeller et al, 2008). However, the procedure adds to the time spent on cardiopulmonary bypass and may increase the risk of post-bypass brain damage due to low blood pressure, reduced oxygen supply or micro-clots.

1.7 Implications for cost estimates contained in this report

The range of health services which are used to treat Atrial Fibrillation is quite broad. Data on the numbers of people with AF receiving the different treatment options and pathways has not been available to support the analysis for this report. Rather than costing a ‘typical patient pathway’, we have therefore relied on a range of data to build up cost estimates of the health system costs of diagnosis, treatment and prevention of AF. These data include:

- survey data which asks GPs to identify the primary reason or diagnosis for a patient consultation and to identify the medications which are being used to treat those with AF

- survey data which asks the population – including people with AF – to identify treatment received, such as consultations with medical specialists and allied health professionals
- hospital data which identifies patient separations related specifically to AF treatment.

Our approach is set out in detail in the next Section. This approach is the best available based on the current data sources, and we would encourage further research and data collection to better understand the treatment pathways for this important disease.

2 Methodology overview

We have taken a 'prevalence' approach to estimate the cost of AF to the Australian economy. Costing has encompassed health system costs, other direct expenditures and indirect costs such as productivity losses. The directly measurable costs of AF, as well as the attributable portion of events such as stroke and heart failure have also been considered.

Summary of this Section

As far as data has allowed, we have used the 'prevalence' approach to estimate the cost of AF to the Australian economy. This approach involves estimating the total cost in a given year of the disease for all people with the disease during that year.[1] This requires development of a profile of the prevalence of AF in Australia, estimation of the proportion of people who have been diagnosed and treated for AF (and hence those for whom the AF is undiagnosed) and estimation of the number of health events in the year – hospital admissions, stroke, heart failure – which are a result of AF. Costing AF in Australia has proved challenging, as data on those with AF, AF-related events and treatment is often quite poor. Where necessary, we have had to adapt our methodology to make a 'best estimate' of the likely impacts and costs associated with AF. Throughout our methodology we have taken a conservative approach to costing AF where there is uncertainty in the available evidence.

2.1 A framework for measuring costs

In developing a framework for measuring the economic costs of AF, we have considered three sub-categories of costs typically addressed in economic studies of this type. These are health system costs, other direct expenditures and non-financial expenditures. Each of these is discussed in turn.

Health system costs

Health system costs include expenditure on hospitals, pharmaceuticals and primary and community health care. Few data sources directly identify health expenditure on AF and there have been no major Australian studies. Our approach therefore involves a blend of direct and indirect measurement approaches to estimate AF's health system costs. For example, Begg, et al's 2007 study on the burden of disease provides details on the likely costs associated with stroke, while literature can be used to identify the 'attributable fraction' of stroke which is due to AF. We can therefore to estimate the cost of stroke events associated with AF by estimating the portion of strokes and hence stroke costs which are attributable to AF.

Having reviewed the evidence, we focus on the following three main 'buckets' of health system costs associated with AF.

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[1] In contrast, the 'incidence' approach is used for some diseases, measuring the present value of all future costs associated with a disease in respect of all those who contract a disease in a given year. In our view, the data available for this approach does not lend itself well to analysis.

- Costs associated directly with diagnosis and treatment of AF and management of AF-related risks. This includes hospital admissions which are primarily for AF and primary care and other out-of-hospital treatment which is directly-related to AF.
- Costs of strokes attributable to AF, which have been estimated by considering the average lifetime health costs of a first-ever ischemic stroke, and multiplying this by the estimated number of additional strokes arising as a result of AF. Literature also indicates that people with AF tend to have more severe strokes than those without AF. Due to data limitations we have not adjusted for this, as the higher first-year costs for a more severe stroke may be offset in the long-term by lower long-term costs arising from higher mortality.
- Costs of heart failure attributable to AF, which were estimated by considering total per annum heart failure costs for the entire population, and taking the proportion which is attributable to AF.

We note that there is a range of weaker evidence linking AF with other specific diseases – for example, depression and dementia. The strength of this evidence is not sufficient in our view to include in our full costing, but we note it in our discussion on quality of life and other societal impacts in Section 1.

Other direct costs

Other direct costs associated with AF are largely a result of the additional disability suffered by those with AF. Disability leads to direct government expenditure on disability pensions, carer payments, and other disability payments for formal care, home modification and so on. It can also lead to early entry into nursing homes, which carries further costs. There is limited data in Australia to measure the extent to which people with AF experience higher levels of disability than the rest of the population. However, there is clear evidence that heart failure and stroke lead to higher levels of disability, and since these events can be attributable to AF, it is reasonable to conclude that AF leads to higher levels of disability. We have used an indirect measurement approach to estimate this cost. For AF-attributable stroke, we consider the average lifetime disability-related costs of a first-ever ischemic stroke, and multiply this by the estimated number of additional strokes arising in the year as a result of AF. For AF-attributable heart failure, we consider the average disability expenditure in Australia per person with a disability, and multiply this by the estimated number of persons experiencing a disability as a result of AF-attributable heart failure.

Non-financial costs

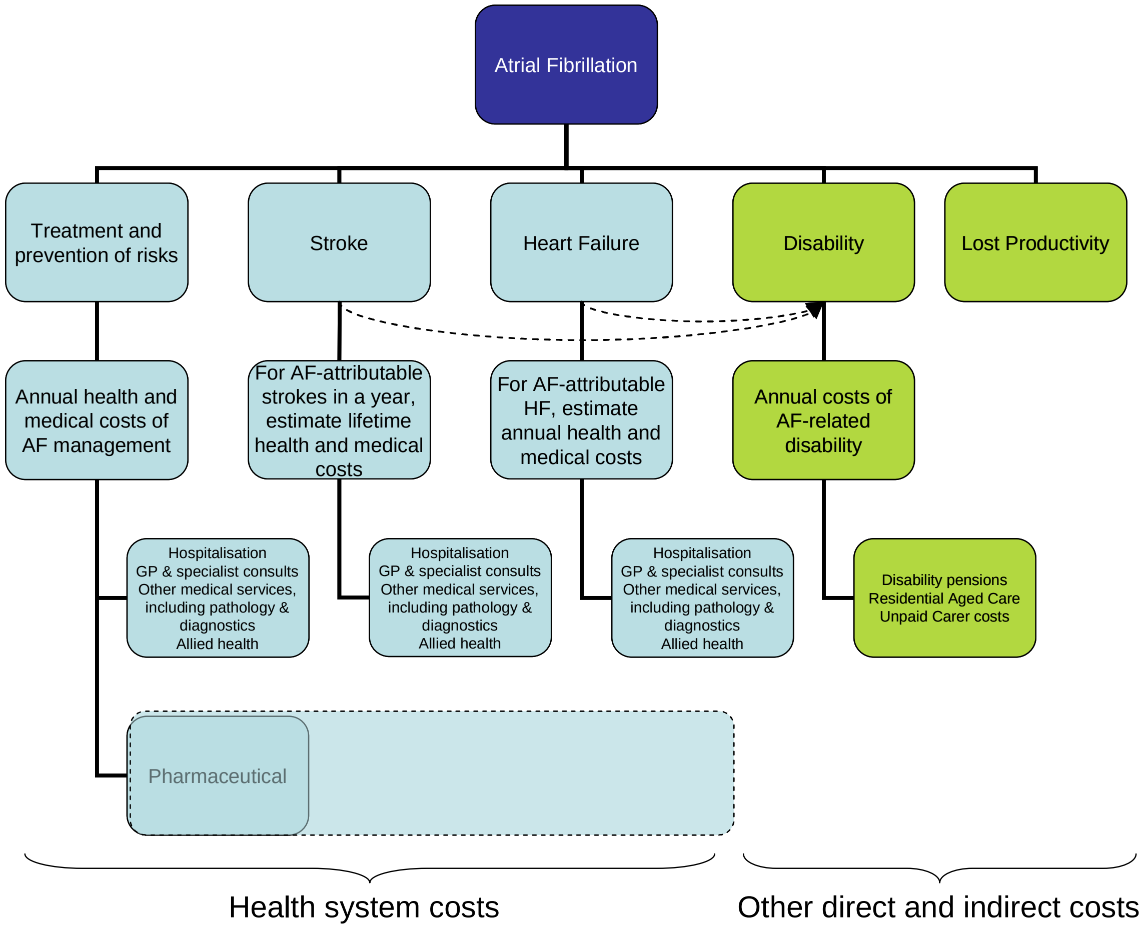
Non-financial costs include lost wages of those who must take time off work for treatment or can no longer work as a result of their illness, informal carers who cannot work as a result of the need to care for disabled family members, as well as wages lost as a result of premature death. Full details of the costing methodology are provided in Section 6, and in summary

- Productivity costs have been estimated in relation to the length of stay of patients in hospital and the number of work days lost for those dying from AF while of working age.
- Informal care costs have been estimated in a similar way to other disability costs.

We have not costed the economic costs of reduction in quality of life and higher mortality associated with AF. In Section 1 we discussed the significant literature about the quality of life and mortality impacts of AF. We have highlighted and quantified these aspects, but without assigning a dollar value to them.

Figure 2 provides a high level schematic of our measurement approach. In summary, AF leads to direct health costs (highlighted in blue) in treating and preventing the risks associated with AF, as well as stroke, heart failure. It leads to higher levels of disability (which carries both direct and indirect costs) and lost productivity.

Figure 2 Framework for measuring the economic costs of AF



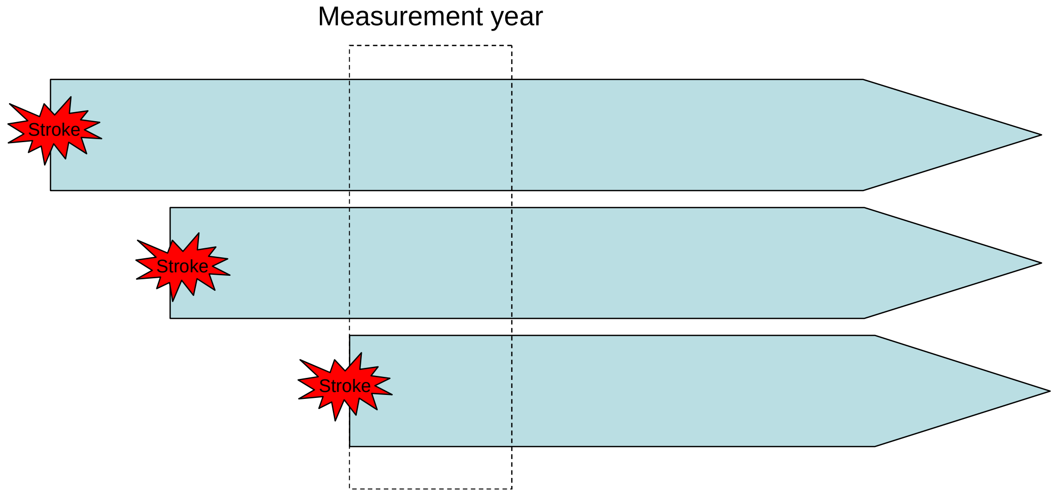
Lifetime costs versus annual costs

As far as data has allowed, we have used the 'prevalence' approach to estimate the cost of AF to the Australian economy. This approach involves estimating the total cost in a given year of the disease for all people with the disease during that year.

Where there are significant consequences of a major 'event' which has been caused by AF then our approach is to take the full cost occurring during the year which is associated with those events. So, for heart failure, we have estimated the attributable portion of heart failure costs which occur during the measurement year.

Our approach to estimate stroke costs have been modified slightly to reflect available data. We have estimated the number of strokes which occur during the measurement year and the portion which are attributable to AF, and multiplied this by the lifetime cost of those stroke events. This is a commonly used adaptation of the 'prevalence' approach which reflects ease of measurement – the most up-to-date literature on stroke events reflects lifetime costs, rather than annual prevalence costs. If we did not take the lifetime costs, then we would need to estimate the extra costs this year of stroke events which occurred in previous years and which were attributable to AF, as Figure 3 demonstrates. If the population is stable, then the lifetime costs approach will be approximately equivalent to the alternative approach of adding up the costs occurring this year for all strokes attributable to AF in this and prior years.

Figure 3 Lifetime versus prevalence approach for estimating the cost of stroke events.



Adaptations to avoid double-counting

To avoid the potential for double counting of health system costs associated with AF, stroke and heart failure, we have made a number of adjustments to our estimates:

- A narrow definition has been used to identify hospitalisations directly related to AF, using ICD-10-AM principal diagnosis codes. These events will be different to those which underpin the heart failure and stroke cost estimates, which are largely related to the initial heart failure and stroke events which lead to hospitalisation and would be recorded under different ICD codes. Thus, there is limited likelihood of double counting of hospital costs.

- Pharmaceutical costs have been excluded from the stroke and heart failure estimates, as the approach we have used to estimate the pharmaceutical costs for AF is broad and hence likely to encompass the medications used in the stroke and heart failure costings. Many of the medications which are used to treat people with AF are the same as those used following stroke and heart failure, and there would be a very real risk of double counting if we were to include pharmaceutical estimates from all the studies. This may be a source of conservatism in our estimates, as a number of medications for stroke survivors and people with heart failure will be additional to the medications provided for AF, however it is not possible from the studies to separately identify the costs of these.

- The costs of GP visits identified for AF, over and above those included in costings for attributable heart failure and stroke, were identified based on a narrow definition of only those visits which involved management of the AF.

Health inflation and population trends

All costing and other data has been presented as at 30 June 2009. Refer to Appendix D for health inflation rates and Appendix E for population trends which have been used to standardise data to this valuation date.

In the remainder of this report we outline the prevalence and profile of AF in Australia, as well as the number of AF-related stroke and heart failure events occurring each year (Section 3). We then present a more detailed outline of both the estimated costs for each of the elements outlined above and a more detailed methodology used to derive these estimates (Sections 4 to 6).

2.2 Data Sources

A range of primary data sources and literature have been used to estimate the economic costs of Atrial Fibrillation. The table below summarises.

Table 4 Key data sources

Item	Main data sources
Population Prevalence	Various published literature – See Section 3
Health system costs	
Admitted hospital services	Australian National Hospital Morbidity database
Non-admitted hospital services	AIHW Health Expenditure in Australia 2006-07
GP services, Specialist medical services outside hospital, Other health professional services	AIHW General Practice Activity in Australia (BEACH) data used to estimate volume of activity for people with AF. Medicare Statistics to identify per consultation costs. AIHW Health Expenditure in Australia 2006-07 to identify aggregate cost of non-hospital medical services
Pharmaceutical	Pattern of medications usage from BEACH study (unpublished data) Cost of medications estimated from PBS data.
Stroke events	Lifetime health system costs of stroke derived from Cadilhac et al (2009) AF -attributable strokes derived from various sources. See App C
Heart Failure prevalence	Annual cost derived from Clark et al (2004) AF-attributable heart failure derived from various sources. See App C
Other direct Costs	
Disability Costs Residential Aged Care Costs	Lifetime disability and aged care costs of stroke derived from Cadilhac et al (2009). Annual disability costs per disabled person derived from Report on Government Services and ABS Survey of Disability, Ageing and Care. Disability due to heart failure from Gure et al (2008) AF -attributable strokes and AF-attributable heart failure derived from various sources. See App C
Indirect Costs	
Productivity costs	National Hospital Morbidity database and Dewey (2001) for estimates of days off work due to hospitalisation ABS Deaths Australia ABS Cat 6302.0 Average Weekly Earnings
Unpaid Carer costs	As for Disability Costs.

2.3 Sources of Uncertainty

Despite the fact that AF results in very significant health impacts and costs to the Australian economy, the evidence regarding the costs of AF and the number of people with AF is incomplete. In arriving at our estimates, we have relied significantly on international literature as well as survey-based estimates of health system utilisation for Australia based on small sample sizes. Given the potentially large costs associated with AF, we encourage greater investment in research and data to better understand this disease.

The most significant areas of uncertainty include:

- The population prevalence of AF
- The health system costs directly related to AF
- The relative risk of specific events such as stroke and heart failure
- The cost of specific events such as stroke, given that evidence indicates that may be more severe, but also associated with higher mortality.

Sensitivity analysis regarding these key factors is presented in Section 7.

3 Profiling the Population with AF

Over 240,000 (1% to 2%) people in Australia have AF, 70% of whom have their AF diagnosed and are receiving some treatment. AF is predominantly a disease of older persons with more than 10% of people over the age of 85 suffering from AF.

In 2008-09, there were 47,000 hospital separations for AF and Flutter. Separation counts have been growing at 7% per annum and are now more than either heart failure or stroke.

There were 6,300 additional first-ever strokes occurring during the year as a result of AF.

Summary of this Section

Understanding the profile of AF in Australia is a challenge as, unlike diabetes and a range of cardiovascular risk factors, no major population-based studies of AF have been undertaken in Australia. In this section we present a picture of the profile of AF in Australia, including

- The prevalence of AF in the general population
- The number of first-ever stroke events which are attributable to AF
- The number of hospitalisations which are due to AF

3.1 Prevalence of AF in the population

Understanding the profile of AF in Australia is a challenge as, unlike diabetes and a range of cardiovascular risk factors, no major population-based studies of AF have been undertaken in Australia. Therefore, our approach has been to use a range of international studies of AF to estimate the likely prevalence of AF in Australia. Most studies we have reviewed estimate an overall population prevalence of between 1% and 2%, with several studies providing more detailed age-specific prevalence rates, particularly for the population over age 45.

International research papers also detail the attributable risk and relative risk of stroke and heart failure events with respect to AF.

International research

Prevalence and incidence research on AF is predominately based on studies of populations in Western Europe and the United States (US). See for example:

- The Scottish Renfrew/Paisley Study (Stewart, Hart, Hole and McMurray, 2001)
- The Spanish PREV-ICTUS Study (Cea-Calvo et al, 2007)
- The UK West Birmingham Atrial Fibrillation Project (Lip et al, 1997)
- Analysis of general practice data in England and Wales (Majeed, Moser and Carroll, 2001)
- The Dutch Rotterdam Study (Heeringa et al, 2006)
- The US Framingham Heart Study (Wolf, Abbott and Kannel, 1991)
- The US California- based Kaiser study: AnTicoagulation and Risk Factors In Atrial Fibrillation (ATRIA) (Go et al, 2001)
- The US Cardiovascular Health Study (Furberg et al, 1994)

- The US Minnesota-based study (Miyasaka et al, 2008)

The target populations in these studies are generally over 45 years of age as AF is very uncommon in infants and children.

Other more recent studies focus on the prevalence of AF in mainland China (Zhou and Hu, 2008) and Korea (Jeong, 2005). In general, prevalence rates from these studies are lower than those from Western countries.

Findings from these international prevalence studies indicate that AF roughly doubles with each advancing decade of age, from below 1% at age 50–59 years to 10% or more at age 80–89 years. Prevalence rates by age are generally higher for men than women. Refer to 7Appendix A for Australian and international prevalence rates from the studies reviewed as part of this project.

We note that the method for counting AF varies by study – self-reported, doctor-reported, or diagnosis by electrocardiogram (ECG), the latter being the most common and definitive method.

We did not use estimates from hospital practice data, since it is estimated that only one-third of people with AF may actually have been admitted to hospital (Lip, et al, 1997).

Australian research

There is limited data on the prevalence of AF in the Australian population. To our knowledge, the only publicly available population-based survey was conducted by Lake, Cullen, deKlerk, et al in 1989. Their study provides Australian prevalence rates for the population over 60 years of age, based on a Western Australian cohort of 1,770 people.

Estimating Prevalence of AF in Australia

To estimate the prevalence of AF in Australia we have selected gender- and age-specific prevalence rates based primarily on the US Cardiovascular Health Study (Furberg, et al, 1994), the California-based Kaiser AnTicoagulation and Risk Factors In Atrial Fibrillation (ATRIA) Study (Go, et al, 2001), the Framingham Heart Study (Wolf, Abbott and Kannel, 1991), Miyasaka's modeling of Minnesota US prevalence between 1993-and 1995 and the US Minnesota study (Miyasaka, et al, 2008). These studies were selected based on their sample size, relative similarity to the Australian population, age range and rigorous method for AF diagnosis (predominately ECG-confirmed). We have also included the Western Australia AF study in our core sample due to its applicability to the Australian population. We have selected Australian AF prevalence rates based on the above studies and we have applied these prevalence rates to Australian population data to determine the size of the domestic population afflicted with AF.

Table 5 displays our estimate of the Australian AF population. We have estimated that approximately 240,000 people in Australia have AF as at 30 June 2009. This is a conservative estimate as the overall prevalence is 1.1% of the total Australian population, which is at the lower end of the 1-2% range estimated in other studies. Similar to the population-based studies, our prevalence rates are higher for men than women.

Table 5 AF prevalence and population in Australia

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Australian Population (30 June 2009)			Selected Prevalence			AF Population		
Age	Male	Female	Total	Male	Female	Total	Male	Female	Total
0-64	9,476,481	9,335,195	18,811,675	0.24%	0.25%	0.24%	22,487	23,415	45,902
65–69	412,188	420,288	832,475	4.38%	2.57%	3.46%	18,047	10,790	28,836
70–74	320,838	345,399	666,237	6.31%	4.41%	5.33%	20,255	15,247	35,501
75–79	261,577	307,684	569,261	10.21%	7.37%	8.68%	26,700	22,690	49,390
80–84	177,608	250,075	427,683	12.06%	8.46%	9.96%	21,427	21,164	42,591
85+	117,389	237,372	354,761	12.93%	9.32%	10.52%	15,181	22,128	37,309
Total	**10,766,081**	**10,896,012**	**21,662,093**	**1.15%**	**1.06%**	**1.11%**	**124,097**	**115,433**	**239,530**

(1) - (3) From Appendix E - Population trends
(4) - (5) From Apendix A - Prevalence of AF
(6) = (9) / (3)
(7) = (1) * (4)
(8) = (2) * (5)
(9) = (7) + (8)

Diagnosed versus undiagnosed AF

Of the 240,000 estimated people with AF above, only a portion of these would be diagnosed with AF. This feeds into our later estimates of health service utilisation, particularly preventative pharmaceutical treatments.

We have assumed that of the 240,000 people in Australia with AF, 30% of the cases are undiagnosed. This estimate is based on a study undertaken by the St. George's AF Clinic which found that of 131 patients with AF, 29.8% had been diagnosed incidentally (Savelieva and Camm, 2000). While this is a small study, other studies have shown that, of patients presenting to hospital for non-cardiovascular reasons and for stroke, AF is often incidentally diagnosed (Molaschi, et al, 1995; Savelieva and Camm, 2000).

3.2 New incidents of stroke which are attributable to AF

Because stroke is strongly associated with AF, we have included key assumptions about these conditions in our methodology:

- The incidence of stroke in the population
- The relative risk of stroke in those with AF compared to those without AF.

These assumptions enable us to estimate the number of stroke events in a year which are attributable to AF.

Incidence of Stroke in the population

In identifying the incidence of stroke in Australia, we have focused on first-ever stroke (rather than all stroke) because, later in our report when we estimate the cost of AF-attributable stroke, this is also based on the lifetime cost of first-ever stroke. Thrift (2000) provides estimates of stroke incidence for

Australia, derived from the NEMESIS[2] study. Results from this study have been referenced widely in Australia and form the basis for estimates of stroke incidence and prevalence used by the AIHW.

Table 6 displays the estimated incidence of first-ever strokes and number of people who are estimated to have had first-ever strokes in Australia during 2008-09. Like AF, stroke is far more common at older ages than at younger ages. Overall, around 42,000 first-ever strokes are assumed to have occurred during 2008-09.

Table 6 Stroke incidence and number of first-ever strokes in Australia, 2009

Age	Incidence of new stroke per 100,000 population Males	Incidence of new stroke per 100,000 population Females	Incidence of new stroke per 100,000 population Total	Estimated new strokes, 2009 Males	Estimated new strokes, 2009 Females	Estimated new strokes, 2009 Total
0-34	6	15	10	306	733	1,038
35–39	61	29	45	489	235	724
40–44	61	29	45	475	229	704
45–49	135	77	106	1048	610	1,658
50–54	135	77	106	959	554	1,513
55–59	260	168	214	1696	1,102	2,798
60–64	260	168	214	1429	920	2,349
65–69	566	507	536	2333	2,131	4,464
70–74	566	507	535	1816	1,751	3,567
75–79	1,468	1,178	1,311	3840	3,625	7,464
80–84	1,468	1,178	1,298	2607	2,946	5,553
85+	3,344	2,715	2,923	3926	6,445	10,370
Total	194	195	195	20,923	21,280	42,203
0-64	68	47	57	6,401	4,383	10,784
65+	1,126	1,083	1,102	14,522	16,897	31,419

(1) Thrift et al (2000)

Relative risk (RR) of Stroke due to AF

In statistics and mathematical epidemiology, relative risk (RR) is the risk of an event (or of developing a disease) relative to exposure. In this context, relative risk is a ratio of the probability of the event occurring in the exposed group versus a non-exposed group.

In Table 7 below we summarise Wolf, Abbott and Kannel's estimates of relative risk of stroke due to AF as described in their 1991 study, and based on the Framingham study. Given the difficulties in distinguishing between various types of stroke, their study included all strokes and hence calculated a relative risk for all strokes, despite the fact that AF is, in clinical terms, linked only to ischemic stroke.

The relative risks presented below are high - at ages 80 to 89, a person with AF is 4.5 times more likely to have a stroke than a person who does not have AF. Additionally, the relative risk of stroke for a person with AF increases with age. Thus, the relative risk is highest at the ages at which AF prevalence is highest, and at which the majority of strokes occur.

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[2] North East Melbourne Stroke Incidence Study

Table 7 Relative risk of stroke due to AF

Age	Relative Risk of stroke for AF patients
50-59	4.0
60-69	2.6
70-79	3.3
80-89	4.5

Source: Wolf, Abbott and Kannel (1991)

Stroke incidence attributable to AF

Using the relative risk of stroke due to AF and estimates of first-ever stroke incidence, we have estimated the number of people with AF who have a first-ever stroke in Table 8. Of the 42,000 first-ever strokes in Australia in 2008-09, we estimate that 8,460 occur in people with AF. Comparing this to the number of strokes we would have expected for this group, we estimate that 6,300 additional first-ever strokes occurred in 2008-09 as a result of AF.

Table 8 Incidence of first-ever stroke in the AF population

	(1)	(2)	(3)	(4)	(4)	(5)	(6)	(7)	(8)	(9)
	Population - Males			Incidence of new stroke per 100,000 persons	umber of new strok	Relative Risk of stroke with AF	Incidence of new stroke per 100,000 Non-AF Persons	Incidence of new stroke per 100,000 AF Persons	Estimated new strokes, 2009 AF Persons	Number of additional strokes due to AF
Age	AF Persons 2009	Non-AF 2009	Total 2009							
0-44	0	6,787,998	6,787,998	19	1,270		19	162	-	0
45–49	3,883	772,777	776,660	135	1,048	1	135	135	5	-
50–54	4,362	705,671	710,032	135	959	4	133	530	23	17
55–59	6,243	645,981	652,224	260	1,696	4	253	1,011	63	47
60–64	7,999	541,567	549,566	260	1,429	2.6	254	661	53	33
65–69	18,047	394,141	412,188	566	2,333	2.6	529	1,375	248	153
70–74	20,255	300,583	320,838	566	1,816	3.3	494	1,631	330	230
75–79	26,700	234,878	261,577	1,468	3,840	3.3	1,189	3,923	1,048	730
80–84	21,427	156,181	177,608	1,468	2,607	4.5	1,032	4,645	995	774
85+	15,181	102,208	117,389	3,344	3,926	4.5	2,302	10,359	1,573	1,223
Total	124,097	10,641,984	10,766,081	194	20,923		156	3,496	4,338	3,208
0-64	22,487	9,453,994	9,476,481	68	6,401		66	642	144	97
65+	101,610	1,187,990	1,289,600	1,126	14,522		869	4,128	4,194	3,110
	Population - Females			Incidence of new stroke per 100,000 persons	Number of new st	Relative Risk of stroke with AF	Incidence of new stroke per 100,000 Non-AF Persons	Incidence of new stroke per 100,000 AF Persons	Estimated new strokes, 2009 AF Persons	Number of additional strokes due to AF
Age	AF Persons 2009	Non-AF 2009	Total 2099							
0-44	0	6,619,836	6,619,836	18	1,197	1	18	-	-	0
45–49	3,734	788,342	792,076	77	610	1	77	607	3	-
50–54	4,216	715,575	719,791	77	554	4	76	541	13	10
55–59	6,278	649,618	655,896	168	1,102	4	163	1,061	41	31
60–64	9,187	538,408	547,595	168	920	2.6	164	881	39	24
65–69	10,790	409,498	420,288	507	2,131	2.6	487	1,994	137	84
70–74	15,247	330,153	345,399	507	1,751	3.3	460	1,520	232	161
75–79	22,690	284,993	307,684	1,178	3,625	3.3	1,007	2,870	754	526
80–84	21,164	228,912	250,075	1,178	2,946	4.5	909	2,080	866	673
85+	22,128	215,244	237,372	2,715	6,445	4.5	2,047	4,406	2,038	1,585
Total	115,433	10,780,579	10,896,012	195	21,280		159	3,571	4,122	3,094
0-64	23,415	9,311,780	9,335,195	47	4,383		46	409	96	64
65+	92,018	1,468,799	1,560,817	1,083	16,897		876	4,376	4,026	3,030
TOTAL	**239,530**	**21,422,563**	**21,662,093**		**42,203**				**8,460**	**6,302**

Notes:

(4) Table 6

(5) Table 7

(6) (4) / {(5)*(1) + (2)} * (3)

(7) (5) * (6)

(8) (1) * (7)

(9) (8) - (1) * (6)

3.3 Hospital presentations for AF

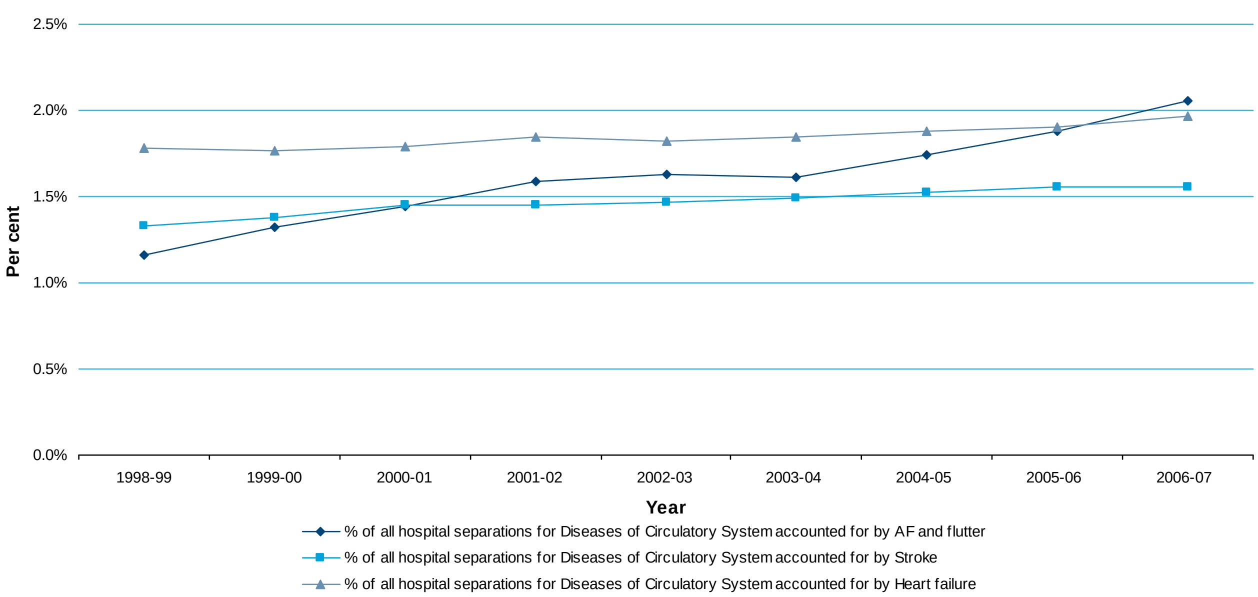
In this section we present a summary of the identified hospital separations and patient days for Atrial Fibrillation (AF) and Atrial Flutter, as well as AF-attributable stroke and heart failure as reported in AIHW's National Hospital Morbidity Dataset. Please refer to Appendix F for a list of the ICD-10-AM principal diagnosis codes used to extract this data. AF and atrial flutter are grouped in hospital statistics, so we are unable to separately identify AF alone.

Hospital separations

In total, there were 45,600 hospital separations with a principal diagnosis of AF and flutter in 2006-07. This is very significant in the context of cardio-vascular diseases. By way of comparison, there were 34,500 separations for stroke and 43,700 separations for heart failure in the same year.

Hospital separations due to AF have been growing rapidly. Since 1998-99 there has been a 10% increase in the total number of hospital separations for all cardiovascular diseases, while over this same time period the total number of hospital separations due to heart failure have increased by 4%, for stroke by 11% and for AF and flutter by a very significant 67%. Atrial fibrillation and flutter separations now represent a larger share of circulatory system related separations than stroke or heart failure.

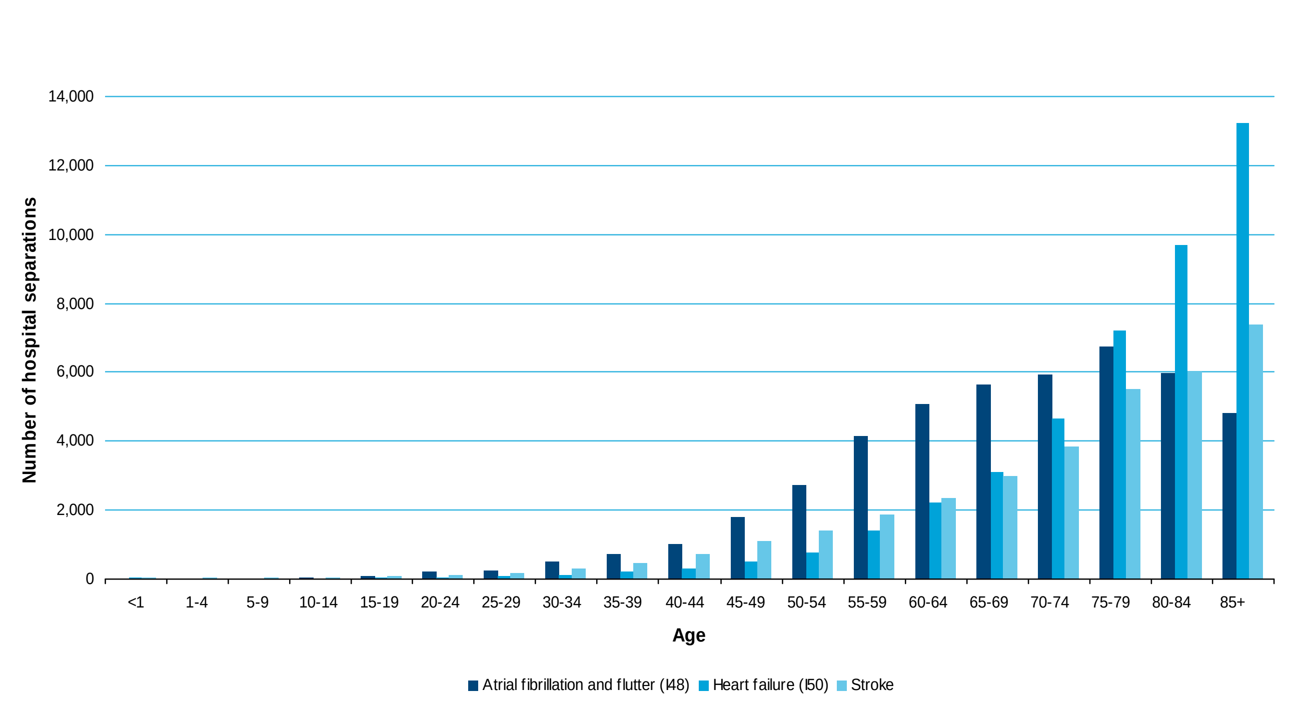
Figure 4 Hospital separations for heart failure, stroke and AF and flutter as a per cent of total separations for Diseases of the Circulatory System from 1998-99 to 2006-07



Source: National Hospital Morbidity Dataset

Figure 5 illustrates that the number of hospital separations increases with age. The number of hospital separations for atrial fibrillation and flutter are greatest for those aged 75-79, with the number of separations beginning to decrease at 80 years and over, in line with smaller population at those ages.

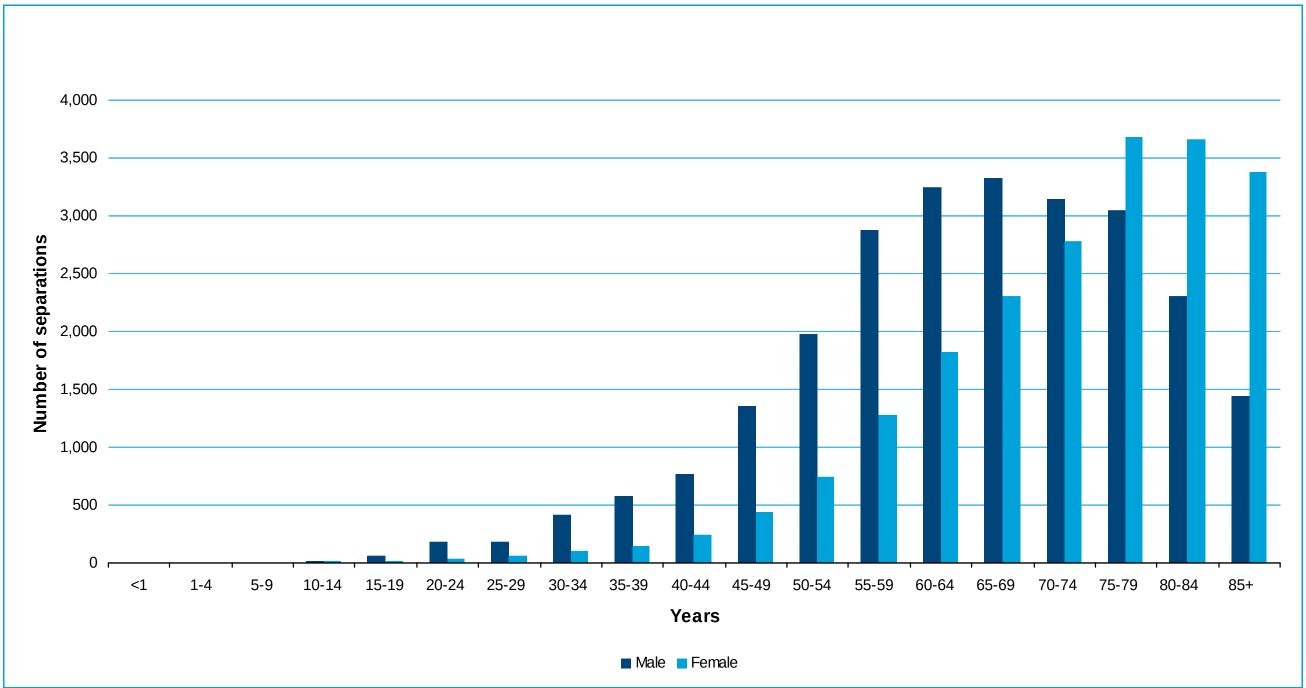
Figure 5 Hospital separation, by age for AF and flutter as the principal diagnosis in ICD-10-AM, Australia 2006-07



Source: National Hospital Morbidity Dataset

Figure 6 illustrates that the age distribution of separations for atrial fibrillation and flutter varies by gender, with females generally admitted for AF and flutter at older ages compared to males.

Figure 6 Hospital separation, by age and gender for AF and flutter as the principal diagnosis in ICD-10-AM, Australia, 2006-07



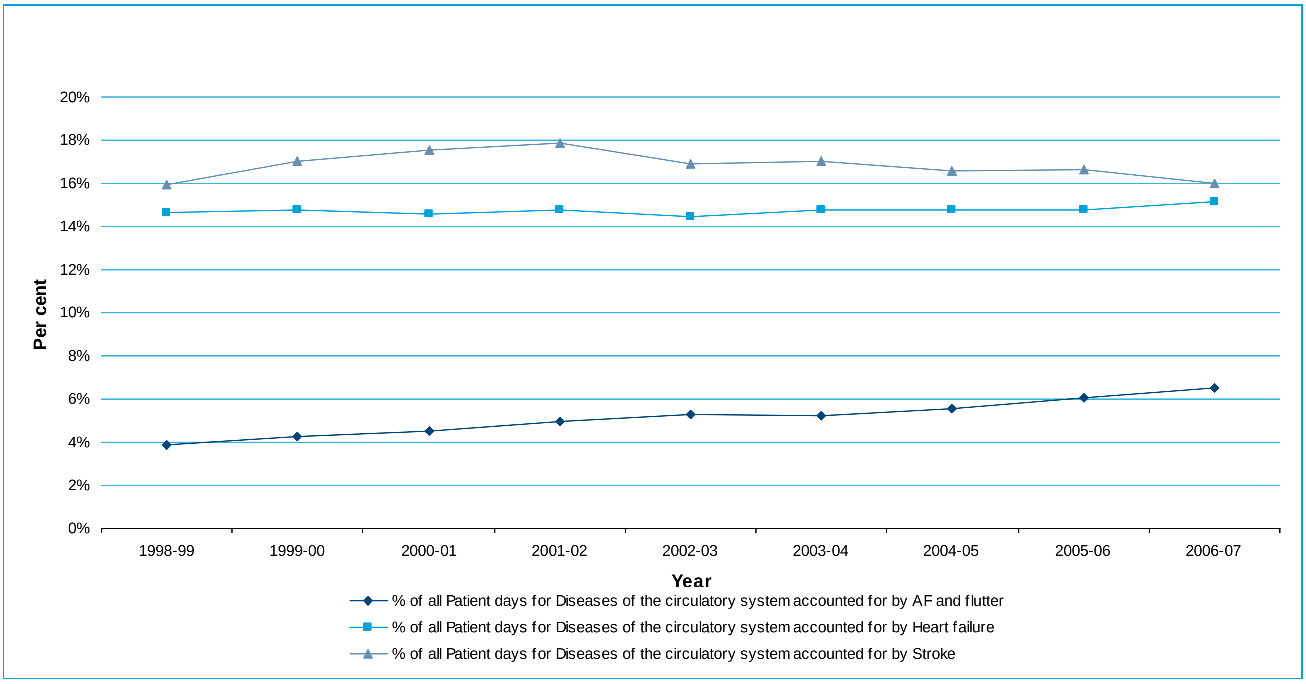
Average length of stay

The average length of stay for atrial fibrillation and flutter in 2006-07 was 3.2 days; this has remained relatively stable since 1998-99 and is significantly lower than the average length of stay for heart failure (7.7) and stroke (10.8). On average males spend around one day less per hospital separation than females for the treatment of atrial fibrillation and flutter.

Patient days

There has been a steady rise in the total patient days for atrial fibrillation and flutter since 1998-99. Similarly the percentage of total patient days for Diseases of the Circulatory System accounted for by atrial fibrillation and flutter has increased from 4% in 1998-99 to 7% in 2006-07 (Figure 7). In 2006-07 Stroke and Heart Failure accounted for 16% and 15% respectively of the total patient days for Disease of the Circulatory System (Figure 7).

Figure 7 Patient days for heart failure, stroke, and AF and flutter, as a per cent of total patient days for Diseases of the Circulatory System from 1998-99 to 2006-07



Source: National Hospital Morbidity Dataset

4 Health System Costs

Health system costs include expenditure on hospitals, pharmaceuticals, and primary and other care associated with AF and the costs of treating specific health events such as stroke and heart failure. We estimate that health system expenditure due to AF was $874 million in 2008-09.

Summary of this Section

Our approach to estimating the health system costs, summarised in Table 9, has been to:

- Estimate the identifiable health system costs of hospitalisations which are solely related to AF, as well as the treatment of AF by health professional outside hospitals and through pharmacological methods.
- Estimate the AF-attributable portion of stroke events which occur during the year, and estimate the AF-attributable stroke cost based on published studies estimating the long term health system expenditure in Australia associated with stroke events.
- Estimate the AF-attributable portion of heart failure costs, based on published studies estimating the annual health system expenditure in Australia associated with heart failure.

Table 9 Health system expenditure, summary of approach

Item	Approach
Identifiable AF-related costs	
Admitted hospital services	Identified separations costed at relevant casemix cost weight
Non-admitted hospital services	Scale up admitted hospital costs using ratio of admitted hospital expenditure to non-admitted hospital expenditure for total population.
GP services	Estimate percentage of all GP visits which are for AF, multiplied by cost per visit
Specialist medical services (incl pathology) outside hospital	Estimate portion of total Australian expenditure on these services, using same proportion as for GP services
Other professional services	Estimate portion of total Australian expenditure on these services, using same proportion as for GP services
Pharmaceutical	Patterns of drug usage for people with AF from survey results, multiplied by average cost of pharmaceutical treatments.
AF-attributable stroke costs	
All health system costs excluding pharmaceuticals	Lifetime per person health system expenditure on first-ever stroke (identified from literature), excluding pharmaceutical, multiplied by AF-attributable strokes. Pharmaceutical costs have been excluded due to potential for double-counting.
AF-attributable heart failure costs	
Hospital expenditure	Attributable fraction of total hospital expenditure on heart failure p.a., from literature
All other health system costs, excl pharmaceutical	Estimated by scaling up of hospital expenditure above. Pharmaceutical costs have been excluded due to potential for double-counting.

Our approach is similar to that adopted by the AIHW in its 2000-01 study into Health Expenditure by Disease, identifying and costing directly attributable costs where possible, and then allocating a reasonable portion of other health system expenditure.

We conservatively estimate the Australian health system costs due to AF at **$874 million** in 2008-09, or **$3,640 per person with AF**. Table 10 provides a summary of health system costs for identifiable AF treatment and for the treatment of attributable stroke and heart failure events. AF treatment is the largest cost contributor to health system costs, followed by heart failure and then stroke. Within each disease state, admitted and non-admitted hospital services make up the single largest portion of health system costs.

Table 10 Summary: Health system costs (A$000s), 2008-09

Direct health system costs	$'000
Atrial Fibrillation	
Admitted hospital services	159,143
Non-admitted hospital services	50,582
General practitioner medical	29,978
Specialist medical	95,923
Other professional services	24,696
Pharmaceutical	74,682
Sub-Total - Identifiable AF health costs	**435,005**
Stroke	
Health system costs excluding pharma	**215,750**
Heart Failure	
Hospital services	170,943
Other services	52,097
Total	**223,040**
Total Health system costs	**873,795**

4.1 Health system costs of AF

Health System costs directly arising from AF are estimated as far as possible from the various health system expenditure databases, such as Medicare, Pharmaceutical Benefits Scheme (PBS), the National Hospital Morbidity Dataset, the National Hospital Cost Data Collection (NHCDC), the National Admitted Patient Care Collection (NAPCC) and the AIHW Health Expenditure report.

The following costs are identified:

- Hospital expenditure on admitted and non-admitted services
- General Practitioner (GP) visits
- Other expenditure on specialist medical services, including pathology and diagnostic imaging.
- Other health professionals
- Pharmaceutical expenditure

Our methodology, key assumptions and results in estimating these costs for each of these items is set out below.

4.1.1 *Hospital Expenditure*

Admitted hospital services

Hospital expenditure is the single biggest health system cost for AF, as it is for most other diseases. The National Hospital Morbidity Database provides data on the total number of separations for both public and private hospitals for people with a principle diagnosis for atrial fibrillation or atrial flutter, identified using the diagnosis code ICD-10-AM code I48. In 2006-07 there were a total of 45,619 such separations. If we identify AF/flutter separations using DRG codes, a total of 40,798 were identified in that same year. We have use the higher estimate, based on diagnosis code, but used the 'pattern' of DRGs identified to help with our costing. Approximately 70% of these separations occurred in a public hospital and 30% occurred in a private hospital.

To estimate the cost of each separation, we used Australian Refined Diagnosis Related Groups (AR-DRG) cost weights for public hospitals. ICD-10-AM diagnosis codes were mapped to the AR-DRG to which they relate, and a weighted-average of the cost weights for public hospitals was calculated. The public hospital cost weights were used as these are more complete estimates of the cost of the hospital stay.[3]

The average cost per AF or flutter separation is estimated at $3,384 as at 30 June 2009. In Table 11 we display the total admitted hospital services expenditure directly due to AF for the year ending 30 June 2009. These figures were obtained by multiplying the total number of AF/AFL separations for all hospitals times the average cost per separation. The total cost in 2008/09 was $159.1 million, with $112.3 million (70.6%) spent in public hospitals and $46.9 million (29.4%) spent in private hospitals.

Table 11 Admitted hospital services expenditure directly due to AF, 2008-09

(1)	Separations with principal diagnosis I48 Atrial fibrillation and flutter, year ending June 2007	45,619
(2)	Population Trend	1.031
(3)	Separations with principal diagnosis I48 Atrial fibrillation and flutter, year ending June 2009	47,029
(4)	Cost per public hospital separation	$3,384
		Total
(5)	**Total costs ($m)**	**$159.1 m**

(1) AIHW National Hospital Morbidity Dataset 2006-07
(2) From Apendix E Population trends
(3) = (1) * (2)
(4) Derived using DoHA data from NAPCC report "Clinical profiles for public hospitals, AR-DRG v5.2 Australia, 2004-05" and
(5) = (3) * (4).

[3] Cost weights were developed using the National Hospital Cost Data Collection (NHCDC) Cost Report Round 11 (2006-07) and the National Admitted Patient Care Collection (NAPCC) report "Clinical profiles for public hospitals, AR-DRG v5.2 Australia, 2004-05."

A number of AF hospital costs were not able to be costed, due to lack of suitable data for the Australian environment. A recent study (Ericson 2009) of the economic costs of AF in Sweden was able to identify hospital presentations where AF was a complicating factor, and costed the longer length of stay for those presentations. Further, as we will see later in this section, almost two-fifths of those on medication for AF are prescribed warfarin. Adverse events have been noted – particularly serious bleeding events which can lead to hospitalisation. The US Anti-coagulation Guidelines taskforce (Ansell et al 1997) summarised several studies which indicated that between 3% and 11% of warfarin patients would have a major haemorrhage each year. These studies overestimate adverse events as many were undertaken before improvements to anti-coagulation management, including standardised reporting of anticoagulation activity using the INR (international normalised ratio).

Non-admitted hospital services

Non-admitted hospital services include emergency, outpatient and other outreach services. Data on non-admitted hospital services is limited. The AIHW report on Health Expenditure in Australia 2006-07 provides an estimate of the aggregate cost of non-admitted hospital expenditure. Based on the ratio of admitted to non-admitted hospital expenditure for all conditions in public and private hospitals, we have estimated that the non-admitted hospital expenditure directly due to AF is $50.6 million for 2008-09.

Table 12 Non-admitted hospital services expenditure directly due to AF, 2008-09

			Public	Private	Total
(1)	June 2009	Admitted hospital costs due to AF	$112.3 m	$46.9 m	$159.1 m
	June 2006	Hospital costs on all conditions			
(2)		Admitted services	$17,109.0 m	$6,349.0 m	
(3)		Nonadmitted services	$7,332.0 m	$334.0 m	
(4)		Nonadmitted / Admitted services	42.9%	5.3%	
(5)	June 2009	Nonadmitted hospital costs due to AF	$48.1 m	$2.5 m	$50.6 m

(1) From Table 10
(2) - (3) AIHW: "Health Expenditure Australia 2006-07," Table C1
(4) = (3) / (2)
(5) = (1) * (4)

4.1.2 General Practice services

General practitioners are the first port of call for most people in the Australian health care system. We have estimated the cost of AF-related GP services by identifying the number of GP visits which include management of AF, and multiplying by the average fee for a GP consultation.

The AIHW's report on General Practice Activity in Australia (Britt et al, 2008) analyses Bettering the Evaluation and Care of Health (BEACH) data for the period April 2007 to March 2008 based on 95,300 encounters between GPs and patients from a random sample of 953 practising GPs across the country. Atrial Fibrillation was reported as a problem managed on 984 occasions, which represents 0.7% of total problems managed. This equates to approximately 690,000 items billed through Medicare. We assume an average Medicare rebate for GP services of $38.32, and an average patient contribution of $22.91 for those services which are not bulk billed.

In Table 13 we display the General Practice (GP) services and costs directly due to AF. We have estimated that the total costs are $30.0 million, with $26.5 million spent by the government through Medicare and $3.5 million spent in individual patient contributions towards their GP services.

Table 13 General Practice services and costs directly due to AF

		June 2007	March 2009	April 2009	June 2009
(1)	General practice Medicare items claimed			101,508,068	101,764,705
(2)	Total Medicare rebate for general practitioner items			$3,865.7 m	$3,899.9 m
	Average cost per item				
(3)	Medicare rebate				$38.32
(4)	Patient out of pocket costs (if not bulk billed)		$22.70		$22.91
(5)	Percent of visits bulk billed		77.7%		
(6)	Average out of pocket costs per visit				$5.11
	AIHW June 2007 survey problems managed relating to:				
(7)	AF or flutter	984			
(8)	All Conditions	145,078			
(9)	Percent of problems managed related to AF or flutter	0.7%			
(10)	General Practice Items related to AF or flutter				690,225
	General practice costs related to AF or flutter				
(11)	Medicare rebate				$26.5 m
(12)	Patient out of pocket costs (if not bulk billed)				$3.5 m
(13)	**Total**				**$30.0 m**
	Index factors to 30 June 2009		March 2009	April 2009	
(14)	Medical inflation factor		1.009	1.006	
(15)	Population trend factor			1.003	

(1) - (2) April 2009 data from Medicare Benefits Schedule items A1, A11 and A22
(3) = (2) / (1)
(4) March 2009 Medicare statistics Table B5 & B6
(5) March 2009 Medicare statistics Table C3
(6) = (4) * [1 - (5)]
(7) - (8) AIHW "General Practice Activity in Australia 2007-08," Table 7.2
(9) = (7) / (8)
(10) = (1) * (9)
(11) = (3) * (10)
(12) = (6) * (10)
(13) = (11) + (12)
(14) From Apendix D Health inflation
(15) From Apendix E Population trends

4.1.3 Specialist medical services and other health practitioners

Specialist medical services include those services provided by specialists such as cardiologists as well as therapeutic and diagnostic procedures, diagnostic imaging, pathology and other miscellaneous services. Most medical services in Australia outside hospitals are provided on a fee-for-service basis and attract benefits from the Australian Government under Medicare.

Other health practitioners (other than doctors or dentists) include chiropractors, optometrists, physiotherapists, speech therapists, audiologists, dieticians, podiatrists, homeopaths, naturopaths, practitioners of Chinese medicine and other forms of traditional medicine, etc.

There is no data to describe the specialist medical and other health professional costs of people with AF in Australia. In the costings, we have assumed that people with AF will use the same relative proportion of specialist medical services and other health professional services as they use of GP services (approximately 0.7%). On this basis, we estimate that total expenditure on specialist medical services (including pathology and imaging) due to AF is $95.9 million and total expenditure on other health professionals is $24.7 million.

Table 14 Specialist and other health professional costs due to AF

		Medical services	Other health practitioners
(1)	Total expenditure, 2006-07	$16,701.0 m	$3,276.0
(2)	Medical inflation factor	1.078	1.078
(3)	Population trend factor	1.031	1.031
(4)	Estimated Total expenditure, 2008-09	$18,562.5 m	$3,641.1 m
(5)	General practitioner expenditure	$4,419.9 m	-
(6)	Total expenditure, 2006-07 (excluding general practicioner)	$14,142.6 m	$3,641.1 m
(7)	Proportion in respect of AF patients	0.68%	0.68%
(8)	Estimated expenditure for AF patients	$95.9 m	$24.7 m

Notes

(1) AIHW: "Health expenditure Australia 2006-07", Table A3

(2) Based on inflation index table of this report

(3) Based on "Australian Population Growth" table of this report

(4) = (1) * (2) * (3)

(5) From **Error! Reference source not found.**

(6) = (4) - (5)

(7) From **Error! Reference source not found.**

(8) = (2) * (3) * (4)

There is considerable uncertainty around this estimate – using unpublished data from the ABS National Health Survey (NHS) those who self-identified as having AF were up to 8.4 times as likely to go to a specialist and up to 7.5 times as likely to visit other health professionals as compared to the remainder of the population aged over-65 non-AF population, so this would suggest that the actual cost for people with AF may be far higher than we estimate. However, the NHS estimates are based on a very small sample of people who self-identified with AF - in part because the NHS did not include AF in the 'tick list' of conditions which people could identify they had – and so are somewhat unreliable.

4.1.4 Pharmaceutical treatments

Pharmaceuticals form a key part of the treatment pathway for AF, including pharmacological cardioversion to help the heart return to normal rhythm, the use of antiarrhythmic drugs to help maintain a regular heartbeat and anticoagulant (also known as antithrombotic) drugs to thin the blood and reduce the risk of clotting.

To determine pharmaceutical usage patterns in Australia we have utilised unpublished BEACH data from the period 20 January 2009 to 23 February 2009. The sample contained 2,963 patients from 102 GP visits. Of the sample of 2,963 patients, 127 (4.3%; 95% CI: 3.4–5.1) had atrial fibrillation and seven patients (0.2%) had flutter making a total of 134 patients (4.5%) with atrial fibrillation or flutter. No patient had both conditions recorded. Some key findings include:

- Of the 134 atrial fibrillation or atrial flutter patients, 128 answered the question on current medications. Of these 128 respondents, 123 (96.1%) indicated that they were currently taking medication for atrial fibrillation or atrial flutter.
- Fifty-seven of the 128 patients (44.5%) were currently taking one medication, and 32.0% were taking two medications, 13.3% were taking three medications and 6.3% were taking four medications for atrial fibrillation or atrial flutter.

- A total of 222 medications were recorded for atrial fibrillation or flutter, of which 72.0% were initiated by a specialist and 28.0% by a GP (excluding 11 missing responses). The duration of medication use was most commonly over 12 months, accounting for 86.7% of the medications taken (excluding 19 missing responses).
- Anticoagulant and antithrombotic agents were the most common medications for AF (39.2%). warfarin made up 87 of the 95 antithrombotics recorded, and clopidogrel accounted for the other eight.

In Table 15 we detail the AF pharmaceutical usage patterns and the resulting costs for AF. We start by taking the number of Australians with AF, based on our estimated prevalence and assume that 29.8% of AF cases are undiagnosed (based on Savelieva and Camm, 2000), and hence not taking medication for AF. The average number of medications per person with AF is 1.80 (based on percentage of patients taking 1, 2, 3 or 4 medications for AF from BEACH). In the BEACH study, 96.9% of diagnosed AF patients were taking medication for AF. Based on this assumption, the annual number of prescribed medication for AF is 292,000.

To estimate the cost of these drugs, we have used BEACH data on prescription patterns, and cost per item data from the Pharmaceutical Benefits Scheme (PBS) to estimate the weighted average cost to government of prescriptions. Patient co-payment estimates are assumed to be $5.30 per script, in line with payments made by concession card holders. On average, most medications were used throughout the year, although a small number of medications were used for less than the full year, giving a weighted average prescription duration of 11 months in a year for all drug types combined.

In determining an annual cost of prescriptions, we have multiplied the average cost per prescription times the number of prescriptions times the average length of time on the prescription per annum. The total cost for AF pharmaceuticals is $74.7 million, including $57.5 million of government costs through PBS and $17.2 million in out-of-pocket expenses for the patient. A key consideration in our costing methodology is that medications used to treat AF may also be used to treat comorbidities. For example a person may be taking an anticoagulant because they have AF and/or because they have had a stroke. Therefore to avoid overstating total AF pharmaceutical costs, later in this report we have excluded the pharmaceutical costs for Stroke and Heart Failure survivors, which are significant co-morbidities associated with AF. We note that the BEACH-SAND survey inquired regarding medications used to treat AF, and not all medications taken, so overall we are confident that our approach avoids over-estimation.

Table 15 Pharmaceutical use and costs for AF

(1)	Number of Australians with AF				239,530
(2)	% Diagnosed incidentally				29.8%
(3)	% Diagnosed GP patients currently taking medication for AF				96.1%
(4)	Average number of medications per patient				1.80
(5)	Annual Australian prescriptions for AF				291,635
(6)	Medication distribution of groups receiving over 5% of Rx				Prescription Count (7)
	Warfarin	39.2%			114,290
	Digoxin	13.5%			39,410
	Amiodarone	5.4%			15,764
	Sotalol	6.3%			18,391
	Metoprolol	5.9%			17,078
	Acetylsalicylic acid	5.0%			14,450
	All Other	24.8%			72,252
	Total	**100.0%**			**291,635**
	Cost Per Rx (per Month)	(8) PBS Subsidy	(9) Patient Contribution	(10) Total	
	Warfarin	12.56	5.30	17.86	
	Digoxin	11.25	5.30	16.55	
	Amiodarone	14.59	5.30	19.89	
	Sotalol	27.11	5.30	32.41	
	Metoprolol	11.51	5.30	16.81	
	Acetylsalicylic acid	7.70	5.30	13.00	
	All Other*	30.10	5.30	35.40	
(11)	Duration of Rx	< 6 Months	6-12 Months	>12 Months	Average Duration (13)
	Warfarin	7.3%	7.3%	85.4%	11.1
	Digoxin	12.0%	0.0%	88.0%	10.9
	Amiodarone	30.0%	10.0%	60.0%	9.0
	Sotalol	0.0%	16.7%	83.3%	11.5
	Metoprolol	16.7%	8.3%	75.0%	10.2
	Acetylsalicylic acid	9.1%	0.0%	90.9%	11.2
	All Other**	1.8%	1.8%	96.4%	11.8
(12)	Assumed average durati	3.0	9.0	12.0	11.1
(14)	Annual Cost of Rx	PBS Subsidy $'000	Patient Contribution $'000	Total $'000	
	Warfarin	15,971.7	6,738.2	22,709.9	
	Digoxin	4,840.0	2,280.9	7,120.9	
	Amiodarone	2,070.0	751.9	2,821.9	
	Sotalol	5,733.3	1,120.9	6,854.2	
	Metoprolol	2,014.1	927.6	2,941.7	
	Acetylsalicylic acid	1,244.1	856.3	2,100.4	
	All Other**	25,621.4	4,511.7	30,133.2	
	Total	**57,494.6**	**17,187.5**	**74,682.2**	

Notes

(1) From Table 4, "AF prevalence and population in Australia"
(2) Savelieva and Camm "Clinical relevance of silent atrial fibrillation: prevalence, prognosis, quality of life, and management," 2000
(3) Australian GP Statistics and Classification Centre Family Medicine Research Centre, BEACH-SAND AF report; Table 5.1
(4) Derived from BEACH-SAND AF report, Table 5.2
(5) = (1) * (2) * (3) * (4)
(6) Derived from BEACH-SAND AF report; Table 5.4
(7) = (5) * (6)
(8) Estimated from Pharmaceutical Benefits Scheme (PBS) data; "All Other" taken as weighted average of treatments provided.
(9) = (9 Patient) * (10)
(10) = (10) + (11)
(11) BEACH-SAND AF report; Table 5.3
(12) Average of period start and end points
(13) Sumproduct of rows in (13) by (14)
(14) = (10 or 11) * (15)

Over-the counter drugs

In addition to PBS-based treatments, a number of non-prescription treatments are provided to people with AF which may not be captured above. Although the BEACH-SAND data does not explicitly state if medications are doctor-prescribed, the majority of the medications described above are prescription-only. The exception is acetylsalicylic acid (e.g. aspirin) which is available over the counter but can also be prescribed by a doctor. Due to the lack of information on over-the-counter drugs use amongst people with AF, we have assumed that the rates of acetylsalicylic acid use from BEACH-SAND are doctor-prescribed and therefore we have not costed non-prescription drugs.

4.2 Health system costs of stroke which are attributable to AF

As detailed in Section 1 and Section 3 of this report, there are significant mortality and morbidity impacts due to AF's linkage with stroke, including increased risk for stroke and increased severity and mortality from stroke. Using our prevalence approach to costing AF, the most appropriate method is to estimate the full lifetime costs of each AF-related stroke event occurring in a year and add that to our estimates of other health system costs for the year.

A recent paper published by Cadilhac et al (2009) provides estimates of the lifetime average cost of ischemic stroke, and we have used this to estimate the costs of AF-attributable stroke events occurring in a year. We have focussed on the costs for ischemic stroke, rather than all strokes, as it is ischemic stroke to which AF is clinically linked.

Table 16 below summarises the average health system costs payable in the first year and then in all subsequent years following stroke, from Cadilhac et al (2009).

Table 16 Breakdown of lifetime costs for ischemic strokes, Australia, 2004

	Average first-year costs per case.	Average annual subsequent-year costs per case.
Health system costs		
Pre-admission (GP or ambulance)	440	
Ambulance transfers	116	
Emergency department presentations	33	
Acute hospitalisation	8,644	
Subsequent hospitalisations	2,243	173
Inpatient rehabilitation	7,087	646
Outpatient rehabilitation	672	29
GP care	168	75
Specialist medical care	175	25
Investigations	221	143
Private Allied Health	107	172
Out-of-pocket costs	545	61
Medication Costs	441	753
Other		124
Sub-total	20,892	2,201
Disability-related costs		
Caregiver costs	1,126	1,094
Community Services	20	835
Respite care	307	11
Sub-total	1,453	1,940
Aged Care Costs		
Aged Care facilities & assessment teams	2,373	1,783
Total	**$24,718**	**$5,924**

Cadilhac et al (2009) estimate that the present value of the lifetime costs of first-time ischemic stroke, using a discount rate of 3% was $57,106 in 2004. Below, we estimate the health system expenditure related to AF-attributable stroke. Note that to avoid double-counting and to be conservative, we have excluded pharmaceutical expenses from the stroke cost estimates, because many of the prescriptions used to treat AF may also be used in stroke survivors. For consistency, we have also removed Residential Aged Care (RAC) costs and Disability costs from our estimates here, and included these costs in Section 5 Other Direct Costs. This is in line with OECD guidelines on the definition of health system expenditure.

Table 17 Estimated health expenditure AF-attributable stroke, 2008-09

	First year costs	
(1)	First year cost per stroke	$24,718
(2)	Health system costs	$20,892
(3)	Exclude Medication costs	$441
(4)	Relevant first-year health system costs	$20,451
	Subsequent year costs	
(5)	PV Lifetime cost per stroke	$57,106
(6)	PV subsequent year costs	$32,388
(7)	Portion which is health system expenditure	37%
(8)	Exclude Medication Costs	13%
(9)	Relevant first-year health system costs, portion	24%
(10)	Relevant first-year health system costs, $	$7,917
	Relevant stroke lifetime costs	
(11)	Relevant per-stroke lifetime health system cost	$28,368
(12)	Inflation factor	1.21
(13)	Relevant per-stroke lifetime health system cost (200	**$34,237**
	Number of AF-attributable strokes	
(14)	Total number of first-ever strokes in 2008-09	42,203
(15)	Additional strokes due to AF, 2008-09	6,302
(16)	Cost of AF attributable strokes occurring in 2008-9	**$215.7 m**

Notes
(1) (5) From Cadhilac et al (2009)
(2) (3) (7) (8) From Table 16
(4) (2) - (3)
(6) (5) - (1)
(9) (7) - (8)
(10) (9) * (6)
(11) (4) + (11)
(13) (11) * (12)
(14) (15) From Table 8
(16) (13) * (15)

The total health system costs of stroke attributable to AF are therefore estimated to be $215.7 million.

4.3 Health system costs of heart failure which are attributable to AF

According to the AIHW, Australian data on the incidence and prevalence of heart failure in Australia is very limited. Based on findings from the National Health Survey 2004-05, the AIHW estimated that around 263,000 Australians have chronic heart failure (or about 4% of the population aged 45 or more). Because of the lack of incidence data for Australia, our estimates for heart failure have had to rely on a prevalence approach to estimating the cost of AF-attributable heart failure. That is, our estimate is based on the attributable fraction of heart failure *prevalence* which can be attributed to AF, multiplied by the current estimated health system costs of all heart failure in 2008-09.

Like stroke, there is strong evidence that AF increases the risk for heart failure. However there is no definitive research on the cost of heart failure alone. The 2005 AIHW report on health system expenditure by disease type in Australia includes estimates of the cost of many conditions which lead to heart failure, such as ischemic heart disease, high blood pressure and diabetes. Taking these costs in total would result in an overestimate of the current burden of Heart Failure itself. Clark, McLennan, Dawson, et al undertook a study “Uncovering a hidden epidemic: a study of the current burden of heart failure in Australia" which estimates the total health system expenditure on heart failure in Australia. They estimated a total of $1,260 million in health system expenditure for heart failure in 2000, including $840 million in hospital expenditure.

Table 18 displays the heart failure health system costs due to AF. Clark, et al's method was to determine the hospitalisation costs due to HF based on the number of separations and the daily cost of the relevant AR-DRGs (similar to our methodology for costing direct AF hospital expenditure). To be conservative, the study used the lowest average cost per day of hospitalisation for such patients which was $600 in 2000. Incorporating health inflation and population growth, we estimate that the heart failure hospitalisation costs for 2008-09 are $1,284.1 million.

To estimate health system costs outside the hospital, Clark, et al rely on a number of studies which estimate that hospital costs for the management of heart failure in a range of other developed countries typically comprise around two thirds of total heart failure-related expenditure. Based on this we estimate that the total other direct health system costs related to heart failure are $642.1 million (or 50% of the hospitalisation costs). To avoid double-counting, we have deducted an estimate of pharmaceutical costs from the total heart failure health system costs based on the ratio of pharmaceutical costs to hospitalisation costs for ischemic heart disease (item 7).

Based on our calculation that 13.3% of Australian heart failure is attributable to AF (See Appendix C), we estimate that heart failure costs due to AF are $223.0 million, with $170.9 million due to hospital expenditure and $52.1 million due to other direct health costs.

Table 18 Heart failure health system costs due to AF

	Year ending	December 2000	June 2009
(1)	Heart Failure hospital service costs	$840.0 m	$1,284.1 m
(2)	Other direct costs	$420.0 m	$642.1 m
(3)	Total direct costs	$1,260.0 m	$1,926.2 m
(4)	Inflation factor		1.361
(5)	Population trend factor		1.124
(6)	Ischemic heart disease costs, year ending	30-June-2001	
	Hospital costs	$1,050.0 m	
	Pharmaceutical costs	$205.0 m	
(7)	Ratio of pharmaceutical to hospital costs	19.5%	
(8)	Heart Failure hospital service costs		$1,284.1 m
	Other direct costs (X-Pharma)		$391.4 m
	Total direct costs (X-Pharma)		$1,675.5 m
(9)	% Heart Failures due to AF		13.3%
(10)	**Heart Failure Costs due to AF**		
	Hospital service costs		$170.9 m
	Other direct costs		$52.1 m
	Total		**$223.0 m**

(1) - (3) 2000 costs are from "Uncovering a hidden epidemic: a study of the current burden of heart failure in Australia."
Other direct costs are estimated as 50% of hospital costs.

(4) Based on Apendix D Health inflation

(5) Based on Apendix E Population trends

(6) From "Health System Expenditure on disease and injury in Australia, 2000-01" by the Australian Institute of Health and Wellfare; Table 5

(7) = (6 Pharma) / (6 Hospital)

(8) Heart Failure Costs = (1)
Other Direct Costs (X-Parma) = (2) - [(1) * (7)]

(9) Based on Apendix C Attributable risk calculations

(10) = (8) * (9)

5 Other Direct Costs

Other direct costs are those expenditures which are not health expenditures, but are direct payments made to manage the disease and deal with its symptoms. These include costs for managing disability, such as the cost of formal care, early entry to nursing homes and home modifications. We estimate the other direct costs of AF were $186.7 million in 2008-09.

Summary of this Section

Our approach to estimating the other direct costs of AF has been to focus on the additional disability associated with AF, and the costs associated with this disability. Because there is no strong evidence to quantify the extent to which AF directly causes greater levels of disability than the general population, we have instead used an indirect method of estimation, by considering the disability costs associated with stroke and heart failure. We use estimates of the present value of the disability-related costs of stroke events which occur during the year which are attributable to AF, based on published studies estimating the long term expenditure in Australia associated with stroke events. For disability arising due to heart failure, we use estimates of the per person expenditure on disability, and the number of additional persons in 2008-09 with a disability as a result of AF attributable heart failure.

Our approach is summarised below.

Item	Approach
Stroke-related Disability, care etc	Lifetime cost of community services, paid care and residential aged care for a first-ever stroke (identified from literature), multiplied by estimated number of additional strokes per annum arising from AF.
Heart-failure related care costs	Annual per person cost of community services & paid care and residential aged care, multiplied by estimated additional number of persons with a disability, as a result of AF-attributable heart failure. ..

We estimate that disability and residential aged care costs due to AF cost the Australian society is at least **$186.7 million** annually or **$778** per person with AF.

Table 19 Summary: Other direct costs due to AF, 2008-09

	AF-attributable Stroke	AF-attributable Heart Failure	Total
Disability Costs	$45.4 m	$14.8 m	$60.2 m
Residential Aged Care Costs	$92.2 m	$34.4 m	$126.6 m
Total Other Direct Costs - AF	**$137.6 m**	**$49.2 m**	**$186.7 m**

5.1 Estimating Disability Costs associated with AF

It has not been possible to directly identify the extent to which AF leads to additional disability in the community, because of the lack of good population studies of AF in Australia. Instead, we have had to rely on an indirect method to cost the additional disability costs associated with AF. A range of data and literature identifies that stroke and heart failure leads to substantially higher levels of disability and hence because some strokes and heart failure is attributable to AF, it is reasonable to assume that AF leads to higher levels of disability. The ABS Survey of Disability, Ageing and Carers (SDAC) contains data on the prevalence of severe and profound disability in the general population as well as in people with stroke. According to SDAC, people disabled by stroke are 2.5 to 3.2 times more likely to be severely or profoundly disabled as compared to the general disabled population. Meanwhile, a US study, (Gure et al. 2008), identified that people with congestive heart failure were 51% more likely to require assistance with activities of daily living than those without the disease.

5.2 Disability and RAC costs for AF attributable stroke

In Section 4.2, we discussed our approach for identifying the health system costs associated with AF-attributable strokes which occur each year. We have used a similar approach to identify the AF-attributable costs of stroke, for both disability and aged care. Table 20 summarises data from Cadilhac et al (2009), which estimates the lifetime costs of first-time ischemic stroke. Overall, Cadilhac estimates that disability and aged care costs for those suffering first-time ischemic were on average $2,861 per person in the first year and $2,785 in subsequent years. Only a portion (one-seventh) of Carer costs have been included in these estimates. We understand that the carer costs estimated by Cadilhac are time-based costs and include both formal and informal care. Analysis by PwC of the ABS Survey of Disability, Ageing and Care indicates that hours of informal care provided to people who are severely and profoundly disabled are around six times that provided through paid care. As a result, we have included one-sixth of Cadilhac's estimated costs here as paid care, and six-sevenths of the costs to our 'indirect costs' estimate later in Section 6.2, as an estimate of the value of unpaid care.

Table 20 Estimated non-health costs of first-ever ischemic stroke, 2004

	Average first-year costs per case.	Average annual subsequent-year costs per case.
Disability-related costs		
Carer costs (paid)	161	156
Community Services	20	835
Respite care	307	11
Sub-total	488	1,002
Aged Care Costs		
Aged Care facilities & assessment teams	2,373	1,783
Total	**$2,861**	**$2,785**

Source: Cadilhac (2009)

Using these results, and allowing for the fact that around 6,300 first-ever strokes per annum are a result of AF, Table 21 summarises the AF-attributable costs for stroke. We estimate that disability arising from AF-attributable stroke leads to some $45 million in disability costs and $92 million in aged care costs each year.

Table 21 Estimated AF-attributable non-health costs of first-ever ischemic stroke

		Disability	Aged Care
	First year costs		
(1)	Relevant first-year health system costs	$488	$2,373
	Subsequent year costs		
(2)	PV Lifetime cost per stroke	$57,106	
(3)	PV subsequent year costs	$32,388	
(4)	Portion which is unpaid care costs	17%	30%
(5)	Relevant subsequent-year costs, $	$5,480	$9,748
	Relevant stroke lifetime costs		
(6)	Relevant per-stroke lifetime cost	$5,968	$12,121
(7)	Inflation factor	1.21	
(8)	Relevant per-stroke lifetime cost (2008-09)	**$7,202**	**$14,629**
	Number of AF-attributable strokes		
(9)	Total number of first-ever strokes in 2008-09	42,203	
(10)	Additional strokes due to AF, 2008-09	6,302	
(11)	Cost of AF attributable strokes occurring in 2008-9	**$45.4 m**	**$92.2 m**

Notes

(1) (2)	From Cadilhac et al (2009)
(3)	From Table 17
(4)	From Table 20
(5)	(3) * (4)
(6)	(1) + (5)
(7)	Appendix E
(8)	(6) * (7)
(9) (10)	From Table 8
(11)	(8) * (10)

5.3 Disability and RAC costs for AF attributable heart failure

Estimates by Gure et al. (2008) in a study conducted in the US indicated that people with congestive heart failure were 30% more likely to receive informal care, three times as likely to be in residential aged care, but equally likely as the general population to receive paid care. Because the US and Australian systems differ in how and to whom care is provided, we have focussed on the estimates of disability drawn from the US study, rather than the various care levels. The study indicated that, after adjusting for other factors, those with congestive heart failure were 51% more likely to require assistance with activities of daily living than those without..

Using the prevalence patterns of disability in the Australian population as identified through the SDAC, we estimate that there are 1.38 million people in Australia requiring assistance with activities of daily living (ADLs). Using the prevalence estimates of heart failure and atrial fibrillation shown in Appendix C and the relative level of disability of those with heart failure, we have estimated the number of people with heart failure who require assistance with ADLs (70,530). Further, using the age specific rates of relative risk for heart failure for those with AF from Appendix C, we have estimated that some 4,020 of those cases are attributable to heart failure.

Government expenditure on disability is very substantial. Estimates from the Report on Government Services indicate that around $12 billion a year is spent by the government on disability and care services. This equates to over $12,000 per disabled person over age 65, and $7,000 per disabled person under age 65 each year.

Table 22 Government expenditure on disability and care

	(1)	(2)	(3)	(4)
	Government Disability Expenditure		Disabled Population	Expenditure Per Person
	June 2008	June 2009		2009
0-64 years	$m	$m		$
CSTDA	$4,345.2	$4,580.5		$6,072
HACC on 0-64 population	$650.0	$685.2		$908
Total	**$4,995.2**	**$5,265.7**	**754,405**	**$6,980**
65 + years				
HACC on 65+ population	$1,001.9	$1,056.2		$1,686
Residential aged care (RAC)	$5,080.6	$5,355.7		$8,552
CACP	$447.8	$472.0		$754
EACH	$198.8	$209.6		$335
National Respite for Carers	$173.5	$182.9		$292
Veterans home care	$198.5	$209.2		$334
Multi-purpose service program	$78.3	$82.5		$132
Transition care program	$52.8	$55.7		$89
Day therapy centres	$34.6	$36.5		$58
Total	**$7,266.8**	**$7,660.3**	**626,277**	**$12,232**
Total	**$12,262.1**	**$12,926.1**	**1,380,682**	
(5) Medical inflation factor	1.038	1.038		
(6) Population growth factor	1.015			

Notes
(1) Report on Government Services 2009
(2) = (1) * (5) * (6)
(3) Prevalence rates from ABS Survey of Disability, Ageing and Care, 2003; applied to 2009 pop
(4) = (3) / (2)
(5) From Apendix D Health inflation
(6) From Apendix E Population trends

Based on an average per annum cost of $12,232, we estimate that the additional disability-related costs of AF-attributable heart failure are $49.2 million per annum.

Table 23 Estimated AF-attributable non-health costs of heart failure

		Disability	Residential Aged Care	Total
(1)	Disability expenditure p.a., over 65's	**$3,680**	**$8,552**	**$12,232**
(2)	Disability due to AF-attributable heart failure	4,020	4,020	4,020
(3)	Cost of AF attributable heart failure ($m)	**$14.8 m**	**$34.4 m**	**$49.2 m**

Notes
(1) From Table 18
(2) From Appendix B
(3) (1) * (2)

6 Non Financial Costs

Non financial costs are those which arise as a result of the disease, but which are generally 'opportunity' costs as a result of revenues which cannot be earned or produced as a result of the disease. These include lost wages of those who must take time off work for treatment or can no longer work as a result of their illness, informal carers who cannot work as a result of the need to care for disabled family members, as well as wages lost as a result of premature death. We estimate non-financial costs to be $189 million annually.

Summary of this Section

Non financial costs include impacts on productivity through lost employment, workplace absenteeism, transfer of employment into less demanding and productive jobs, and reductions in work intensity. They also include the dead weight loss (or welfare loss) associated with the tax implications of these losses and transfers, as well as the costs associated with carers.

The work and transfer patterns associated with AF in Australia are estimated to cost **$189 million** annually, or **$786** per person with AF. The components of these costs are summarised in the table below and explained in detail in following sections.

Table 24 Summary: Non Financial Costs 2008-09 ($A000s)

	$'000
Productivity – absenteeism	17,348
Productivity - premature death, paid work	10,560
Productivity - premature death, unpaid work	23,153
Productivity - Premature death, Search and hiring costs	1,900
Unpaid care	135,083
Total ('000)	**188,549**
Dollars per person with AF	**$787**

6.1 Productivity costs

There are a number of ways in which AF may impact on productivity. In the first instance it may have an impact on a person's capacity to work. For those who suffer moderate or severe conditions they may have to take additional leave from work to recover from symptoms. In severe cases people with AF may have to retire early or pursue less intensive career paths in order to manage their condition. In the most extreme cases where the condition becomes terminal, the resulting loss of life generates a real economic cost in terms of reduced labour and the denial of the economic benefits of the person's productive capacity.

These costs can be estimated using a 'human capital' approach, which allows for the opportunity cost associated with the condition to be considered. The human capital approach measures indirect costs in terms of the value of foregone productive activity attributable to premature mortality and morbidity. Productive activity can be either ‘market’ or ‘nonmarket’. Market activity refers to all productive activities (such as work) that are remunerated. Nonmarket production includes such activities as child rearing, housekeeping, home maintenance, volunteer work, and other productive activities for which no payment is received. Valuing nonmarket activities poses methodological and empirical challenges. Failure to estimate the value of nonmarket production understates the value of production by all groups. This bias is particularly severe for women and the elderly, who have lower labour-force participation rates than nonelderly males.

Estimates of the value of lost nonmarket production are based on a ‘replacement cost approach’. This approach values productive activity according to the cost of substituting unpaid activity with a paid worker. Domestic activity such as child care, housework, and home maintenance has been valued according to the average hourly rate for cleaners as set by the state awards for NSW and WA in 2006 — $15.59 (NSW Cleaning and Building Services Contractors (state) Award, Daytime Rate), $14.71 Cleaners and Caretakers Award 1969 WA. The average across both of these awards expressed in 2008-09 terms is $17.06 per hour.

An alternative to the human capital would be to adopt a frictional approach. Almost all studies estimating indirect costs use the human capital approach and hence we have adopted this approach in or core results; one of the criticisms of human capital is that it may overestimate the actual production losses for society. A frictional approach allows for estimates to reference pre-existing levels of unemployment or increased productivity. For short-term absenteeism, work may be taken over by others; non-urgent work may be cancelled or made up for by the sick employee on his return to work. For long-term absences, work can be taken over by someone drawn from the ranks of the unemployed or by reallocating remaining employees over the required work effort.

The frictional approach requires assumptions to be made regarding when the friction period occurs, its frequency and for how long it will last. The length of the friction period adopted is based on average vacancy durations which depend on the level of unemployment and the efficiency of the labour market in matching labour market supply and demand. Koopmanschap (1992) derived a friction period of 2.5 months based on data of the average period necessary to fill vacancies in the Netherlands. This assumption has been included in the model such that it provides a range of estimates of total indirect costs rather than a single point estimate. At the bottom of the range is the estimate based on a frictional approach and the top of the range is the estimate based on a human capital approach assuming full employment.

As with any similar analysis there are a series of assumptions upon which the estimates are based. One of the principle assumptions is that the number of people with AF is too low for any changes in their employment status or their retirement to have a material impact on the overall labour market. Hence any productivity losses will not influence average weekly earning statistics. The approach we have adopted focuses on the days of employment lost and as a result does not consider extended breaks, slower working pace, or more intermittant work patterns. The data upon which the analysis is based was sourced from various ABS catalogues including 6302.0 Average Weekly Earnings and 3235.0 Population by Age and Sex, the Australian Institutes of Health and Welfare’s National Hospital Morbidity Database and a number of prominent journal articles.

Lost productivity - Absenteeism

People with AF, depending on the degree of severity, are expected to be absent from work more often than those without AF. Absenteesim may be related to hospitalisation, and therefore reflected in the data regarding separations (adjusted for employment). Alternatively it may result in a higher incidence of general sick days in which no hospitalisation occurred. Days away from work for those people that were hospitalised are based on the average length of stay for the individual. Consistent with the literature, we have also assumed that each separation is accompanied by an average of 2 at home days to facilitate recovery (Dewey 2001). Dewey 2001 also assumed an additional 0.37 days per incident to account for a further loss in productivity; this assumption has been integrated into the model.

Lost work days not related to inpatients were estimated based on the assumption that for employed patients treated in an outpatient setting, the quantity of work lost was equal to half that of inpatients. This assumption is based on the approach adopted by Ringborg et al (2008) which looked at the costs of AF across five European countries.

Based of the prevalence of AF, the productivity loss associated with AF totals $17.4 million. The majority of this cost is attributable to people with AF in between the ages of 60 to 69 and is driven primarily by a relative large incidence of separations for this age bracket. Females with AF account for approximately a half of the cost ($7.8 million) of males with AF, due primarily to differentials in average weekly earnings in the later age brackets. The bulk of these costs are assumed to be borne by employers as sick leave entitlements. The methodology underlying these estimates is provided in Table 25. The calculations assume that each separation results in a total 8.17 days of reduced work output.

Table 25 Calculation of costs associated with absenteeism, males in 2008-09

Age	(1) AF population	(2) AF separations	(3) Employment adjusted separations	(4) Average weekly earnings	(5) Total annual loss
			Males		
45–49	3,883	762	731	1,410	1,684,799
50–54	4,362	856	821	1,410	1,892,326
55–59	6,243	1,226	1,190	1,302	2,531,445
60–64	7,999	1,571	1,500	1,414	3,466,079
65–69	18,047	3,543	0	0	0
70–74	20,255	3,977	0	0	0
75–79	26,700	5,242	0	0	0
80–84	21,427	4,207	0	0	0
85+	15,181	2,981	0	0	0
Total – Males	124,097	24,365	4,242	**Total**	**9,574,648**
			Females		
45–49	3,734	733	705	1,086	1,250,393
50–54	4,216	828	796	1,086	1,411,744
55–59	6,278	1,233	1,200	1,092	2,141,709
60–64	9,187	1,804	1,749	1,039	2,969,637
65–69	10,790	2,118	0	0	0
70–74	15,247	2,993	0	0	0
75–79	22,690	4,455	0	0	0
80–84	21,164	4,155	0	0	0
85+	22,128	4,345	0	0	0
Total - Females	115,434	22,664	4,450		**7,773,483**
Total – All	239,531	47,029	8,692		**17,348,131**

Notes

(1) From Table 5

(2) From Figure 4

(3) = (2) adjusted for age/gender related unemployment rates, from ABS Cat 6291.0.55.001 Labour Force, Australia,

(4) From ABS Cat 6302.0 Average Weekly Earnings

(5) = 8.17 / 5 * (4) * (3) 8.17 days is based on assumed average length of hospital stay of 3.2 days, an assumed length of home stay of 2.0 days, 2.6 non-hospital work days lost, and an additional 0.37 days of lost productivity (Dewey 2001).

Therefore, we estimate that the annual cost of lost productivity arising from absenteeism due to AF is $17.3 million per annum.

Lost productivity - Premature mortality

In addition to absenteeism, people with AF will have an effect on the productive capacity of the economy where their condition is terminal and results in premature mortality. The death of a person with AF results in the removal from the labour market of their skills and productive capacity. This loss of current and future productivity increases the younger the individual.

We have estimated three costs associated with the premature mortality impact of AF:

- Forgone paid work
- Forgone unpaid work
- Search and hiring costs

Our estimate of these costs are based on both the age and gender profile of instances of mortality and average weekly earnings. An individual's foregone lifetime earnings are estimated as the net present value of the amount of productive time lost between death and retirement and the average weekly earnings foregone (at 65 years of age). Mortality data was sourced from the ABS's Causes of Death series (33.3.0). The mortality rates were attributed to age based on the prevalance of the disease and the expected remaining lifetime earnings were derived from ABS 6310.0.

On the basis of a human capital approach, the premature mortality impact of AF is estimated to cost $10.6 million annually. Costs are attributable to the loss of workers between the ages of 45 and 64. In the younger age bands, there are fewer deaths, but the per person cost is higher refecting the longer time lost until retirement age. Costs between age bands are approximately equal below age 64. There does not appear to be a significant gender based difference. The impact based on a frictional approach is $260,000.

Table 26 Calculation of costs associated with premature death, paid work (human capital approach)

Age group	(1) AF as cause of death	(2) Dead who would otherwise be working	(3) Net present value of lost earnings per person
Male			
45–49	1	1	739,866
50–54	1	1	977,850
55–59	3	2	1,579,617
60–64	5	5	1,906,540
65–69	19	0	-
70–74	35	0	-
75–79	84	0	-
80–84	117	0	-
85+	170	0	-
Female			-
45–49	1	1	679,143
50–54	1	1	978,530
55–59	3	3	1,571,220
60–64	7	7	2,127,714
65–69	14	0	-
70–74	33	0	-
75–79	89	0	-
80–84	159	0	-
85+	448	0	-
TOTAL	1,190	21	**10,560,480**

Notes:

(1) Mortality rates based on age-specific death rates from ABS Cat 3302.0 Cause of Death, and scaled up for estimated number of deaths due to AF, 2007

(2) = (1) adjusted for unemployment rates

(3) = Based on ABS Cat. 6310.Employee Earnings, Benefits and Trade Union Membership, August 2008.

Table 27 Calculation of costs associated with premature death, paid work (frictional approach)

Age	(1) Dead who would otherwise be working	(2) AWE	(3) Lost AWE by mortality adjusted for frictional period
Male			
45–49	1	1,410	9,444
50–54	1	1,410	15,468
55–59	2	1,302	31,926
60–64	5	1,414	69,618
65–69	0	0	0
70–74	0	0	0
75–79	0	0	0
80–84	0	0	0
85+	0	0	0
Female			
45–49	1	1,086	8,540
50–54	1	1,086	15,153
55–59	3	1,092	33,436
60–64	7	1,039	75,338
65–69	0	0	0
70–74	0	0	0
75–79	0	0	0
80–84	0	0	0
85+	0	0	0
TOTAL	21		258,923

Notes:

(1) Based on previous table.

(2) ABS Cat. 6310.Employee Earnings, Benefits and Trade Union Membership, August 2008, adjusted for inflation

(3) = (1) * (2) * 10 . See Koopmanschap (1992).

In addition to paid work we also estimated lost productivity associated with unpaid work. The inclusion of these costs is often seen as essential in that it addresses gender imbalances in labour market participation and while the value of the product of such activity is not observable in a market sense it is still productive and should be considered. Our analysis is based on discounting the foregone productivity associated with premature death and the average hours per week of unpaid work by age and gender (ABS Cat No 2068.0). We estimated this cost to be $23.7 million based on a human capital approach. On a frictional approach, this cost is significantly lower at $2.5 million.

Another cost related to mortality is that associated with employers replacing lost capacity.These costs refer to the search and hiring costs for replacement labour. These can be estimated based on the present value of bringing forward by three years the average cost of staff turnover (26 weeks at AWE). The search and hiring costs associated with mortality due to atrial fibrillation amount to $1.9 million.

To sumarise, we estimate that the annual cost due to lost productivity arising from premature mortality from AF is in the range $4.7 to $35.9 million per annum.

Table 28 Summary : Costs due to lost productivity arising from premature mortality from AF

	(1) Human Capital Method	(2) Frictional Method
Premature death – Paid work	$10.3m	$0.3m
Premature death – Unpaid work	$23.7m	$2.5m
Premature death – Search and hiring costs	$1.9m	$1.9m
TOTAL	$35.9m	$4.7m

Lost productivity - Employment

There is no available data on the employment and unemployment patterns of persons with AF in Australia or overseas. One of the reason for this lack of data could be that people with AF may be able to manage their condition such that they can participate in the workforce, albiet at a diminished capacity.

However, despite the lack of available data and the fact that only 19% of people with AF are of working age (age 45 to 65), it is important to consider these costs. It is during this 20 year period that average annual earnings for an individual are at their highest as would be their productivity (and any productivity losses if they are unable to participate in the labour market, in whole or in part).

It is reasonable to expect that AF is a driver of early retirement, underemployment, or even unemployment for this age group. A more subtle form of productivity loss without absense from work is sick people who continue to work but at a suboptimal level.

Given the lack of Australian data and the subsequent inability to provide good estimates of the standardised difference in employment between persons with AF and the general population at the agregate level, let alone age and gender standardised differences, we have not included costs from employment in the final estimate. As a result the estimate of total nondirect costs should be viewed as conservative and at the lower bound of what the actual cost would be.

6.2 Unpaid Carers

Some people with AF receive care at home, some may be transferred to residential care depending on the disability caused by the condition, other co-morbidities and the availability of carers. As with persons with AF there are real economic losses associated with the carers labour not being available for productive purposes. The most typical way to quantify carer costs to society is in terms of opportunity costs; in other words, this is the value of lost wages foregone by the carer. Ideally the estimate would reference the number of carers by gender and broad age group and the average hours of care across a range of differing severity of condition.

This data is not publicly available for AF in Australia, so instead we have had to adopt an approach which is similar to that used previously in this report to estimate disability-related costs. We use estimates of the present value of the unpaid care-related costs of stroke events which occur during the year which are attributable to AF, based on published studies estimating the long term expenditure in Australia associated with stroke events (Cadilhac 2009). In our view, this approach is likely to be an underestimate of the unpaid carer costs associated with AF, as it does not include care related to AF episodes or heart failure.

Cadhilac's study estimates the costs of both paid and unpaid carer costs of stroke, and uses this opportunity cost method to measure the value of unpaid care. The NEMESIS interview data obtained at years 3, 4 and 5 comprised the average amount of time caregivers spent providing informal care for stroke survivors. Only the additional care provided because of the stroke was included, because in some cases informal care had been provided prior to the stroke. Carer time costs were calculated using one third of the average of seasonally adjusted weekly earnings (February and May 2004).

Table 29 Estimate costs of unpaid care, AF-attributable first-ever strokes

	First year costs	**Unpaid Care**
(1)	Relevant first-year health system costs	$965
	Subsequent year costs	
(2)	PV Lifetime cost per stroke	$57,106
(3)	PV subsequent year costs	$32,388
(4)	Portion which is unpaid care costs	16%
(5)	Relevant subsequent-year costs, $	$5,127
	Relevant stroke lifetime costs	
(6)	Relevant per-stroke lifetime cost	$6,092
(7)	Inflation factor	1.21
(8)	Relevant per-stroke lifetime cost (2008-09)	**$7,352**
	Number of AF-attributable strokes	
(9)	Total number of first-ever strokes in 2008-09	42,203
(10)	Additional strokes due to AF, 2008-09	6,302
(11)	Cost of AF attributable strokes occurring in 2008-9	**$46.3 m**

Notes
(1) (2) From Cadilhac et al (2009)
(3) From Table 17
(4) From Table 20
(5) (3) * (4)
(6) (1) + (5)
(7) Appendix E
(8) (6) * (7)
(9) (10) From Table 8
(11) (8) * (10)

For disability arising from AF-attributable heart failure, we assume that unpaid care costs will be approximately six times the costs of paid care, consistent with PwC analysis of data from the ABS Survey of Disability Ageing and Care. On this basis, the unpaid care costs of AF-attributable heart failure are estimated to be $88.8 million per annum.

Overall then we estimate that the unpaid care costs associated with AF-attributable stroke and heart failure is $135.1 million per annum.

Table 30 Summary : Upaid Care costs due to AF-attributable stroke and heart failure

	Unpaid Care	
AF-attributable stroke	$46.3	m
AF-attributable heart failure	$88.8	m
Total	**$135.1**	**m**

6.3 Comparison with existing literature

In this section, we compare our estimates of the indirect costs of AF with other studies. Various studies have examined the economic cost of atrial fibrillation in Australia, such as McBride et al (2009), Stewart et al (2009), Ringborg et al (2008) and Dewey et al (2001). These papers are focused primarily on identifying and valuing direct health costs.

Studies that extend to consider the productivity costs or the associated transfers and deadweight loss are limited to studies that estimate the economic and societal costs of stroke. Examples include Mihalopoulous et al (2005), Dewey et al (2001) and Dewey et al (2003). These studies provide a valuable source of assumptions around expected productivity impacts associated with the most severe cases of atrial fibrillation, and therefore assist with estimating the productivity costs associated with those cases of atrial fibrillation that lead to severe events and conditions.

Dewey (2001) estimated productivity costs associated with stroke based on a frictional approach to be $34 million in 2001, which accounted for approximately 6% of total first year costs. This estimate is based on an incidence study undertaken in North East Melbourne (NEMESIS). Other stroke related studies include Dewey et al (2003) that generated productivity costs per person across a range of different subtypes of stroke in Australia. The value estimates ranged from $786.89 to $3,343.39, expressed in 2008-09 dollars.

Our study places the indirect costs associated with AF at $786 per person with AF, which is at the lower end of estimates for stroke. This is to be expected – stroke itself is one of the major drivers of cost and disability for those with AF and many people in the AF population live without stroke.

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7 Summary and Discussion

We estimate that the annual costs to the Australian economy in 2008-09 resulting from AF are at least **$1.25 billion** per annum through medical costs, costs of care for the disabled, and lost productive output. This equates to **$5,200** for each person with AF.

Table 31 Costs to Australian society of Atrial Fibrillation, year ending 30 June 2009 ($A000s)

Direct health system costs	$'000
Atrial Fibrillation	
Admitted hospital services	159,143
Non-admitted hospital services	50,582
General practitioner medical	29,978
Specialist medical	95,923
Other professional services	24,696
Pharmaceutical	74,682
Sub-Total - Identifiable AF health costs	**435,005**
Stroke	
Health system costs excluding pharma	**215,750**
Heart Failure	
Hospital services	170,943
Other services	52,097
Total	**223,040**
Total Health system costs	**873,795**
Other Direct Expenditure	
Disability costs	60,179
Residential Aged Care Costs	126,562
Total	**186,741**
Total Other Direct Expenditure	**186,741**
Non-financial costs (human capital approach)	
Atrial Fibrillation	
Productivity - absenteeism	17,348
Productivity - premature death, paid work	10,560
Productivity - premature death, unpaid work	23,653
Productivity - premature death, search & hiring costs	1,904
Sub-Total - Productivity Costs	**53,466**
Unpaid Carer Costs	**135,083**
Total Non-financial costs	**188,549**
Total	**1,249,085**

Table 31 summarises our estimate of the costs of AF. Health system costs are by far the most significant cost, reflecting both the significant number of hospitalisations required for AF, stroke and heart failure and the ongoing cost of regular check-ups with medical practitioners as well as the cost of pharmaceuticals.

We have been conservative when estimating individual component costs, and have not quantified other costs, including (but not limited to) the reduced quality of life that people with AF experience. We note that a recent study into AF costs in Sweden (Ericson 2009) puts the cost significantly higher than for Australia – roughly the same dollar cost in total, but for a population which is half the size of Australia. On a per person basis, Sweden identified a higher prevalence of AF compared to our estimates for Australia, a higher number of hospitalisations for AF, a higher prevalence of heart failure in the community and therefore associated heart failure costs and a significantly higher lifetime cost of stroke. However, there were a number of elements of expenditure which were able to be quantified in the Swedish study which have not been included here. These include the additional cost of hospitalisations and longer length of stay where AF was a secondary diagnosis, and the cost of patient transport to and from health visits, including emergency transport, related to the disease.

By way of comparison with more high profile diseases, the economic costs of AF are lower overall, but per person with the condition, are higher than estimates of the financial costs of cardiovascular disease and osteoarthritis, and over double the estimated financial costs of obesity (Access Economics, 2008).

Table 32 Estimates of financial costs (non-QoL) of various diseases, 2008

	Economic cost $m 2008	Population prevalence ('000)	Annual cost per person with condition
Diabetes	$12,424	1,015	$12,239
CVD	$13,147	3,022	$4,350
Osteoarthritis	$7,434	1,724	$4,313
Obesity	$8,283	3,713	$2,231

Source; Access Economics (2008)

A significant portion of these costs arises as a result of major events associated with AF, including stroke and heart failure. In total, **$797 million**, or **64%** of the costs identified above arise as a result of stroke and heart failure, or as a result of premature mortality associated with AF. To the extent to which these events can be avoided or minimised the burden of the disease can be substantially reduced. .A review of the evidence indicates a case for more investment in preventative approaches. In many cases, AF is only detected after a patient presents with serious complications, such as a stroke, thromboembolism or heart failure (NCCCC, 2006), while studies have estimated that around 30% of AF is diagnosed incidentally when patients are hospitalised for other reasons. (Savelieva and Camm, 2000, Molaschi, 1995).

Uncertainty

Despite the fact that AF results in very significant health impacts and costs to the Australian economy, the evidence regarding the costs of AF and the number of people with AF is incomplete. In arriving at our estimates, we have had to rely significantly on international literature as well as survey-based estimates of health service utilisation for Australia based on small sample sizes. Given the potentially large costs associated with AF, we encourage greater investment in research and data to better understand this disease.

The most significant areas of uncertainty include:

- The population prevalence of AF
- The health system costs directly related to AF, including length of stay in hospital arising from AF as a complicating factor, complications arising from warfarin use and specialist medical and other health professional services outside of hospital,
- The relative risk of specific events such as stroke and heart failure
- The cost of specific events such as stroke, given that evidence indicates that may be more severe, but also associated with higher mortality.

Below, we summarise the results of sensitivity testing around these key assumptions.

Table 33 Sensitivity Analysis

	Total cost	Difference	%
Baseline	$1,249 m		
Increase prevalence of AF to 1.2%	$1,333 m	$84 m	7%
Increase prevalence of AF to 1.5%	$1,601 m	$352 m	28%
Increase portion of strokes / heart failure caused by AF by 5%	$1,302 m	$53 m	4%
Decrease portion of strokes / heart failure caused by AF by 5%	$1,196 m	-$53 m	-4%
Increase lifetime cost of stroke by 10%	$1,289 m	$40 m	3%
Increase per person AF health costs by 10%	$1,293 m	$44 m	3%
Increase per person AF health costs by 25%	$1,358 m	$109 m	9%

Increasing the assumed portion of the population with AF by 0.1% (from 1.1% to 1.2%) has a significant impact on the results, increasing the overall cost by 7%. Increasing population prevalence further – from 1.1% to 1.5% (as in the Swedish study), increases costs substantially, by some 28% or $352 million per annum. Our estimates of population prevalence are at the lower end of the range of observed levels internationally (1% to 2%) although this is part reflects the fact that Australia's population is relatively younger than other countries studied. Nevertheless, an increase of this magnitude is certainly within realistic bounds.

Also very significant is the impact of adjusting the direct health system costs arising as a result of AF. A 25% increase would bring the per person costs of AF into line with the cost identified in the Swedish study and leads to an increase of $109 million or 9%.

If all these impacts were combined, the overall economic cost of AF could be some 45% higher - as high as $1.8 billion per annum.

Despite these areas of uncertainty, it remains clear that the burden of AF is very significant in the context of the Australian economy, with high health system costs, disability impacts and significant impact on quality of life.

Appendix A Prevalence of AF

Table 34 Prevalence of AF in Europe

Country	Turkey		Scotland		Spain		
Study	Uyarel, ATSCard, 2008		Stewart, Heart, 2001 - Renfrew/ Paisley study		Cea-Calvo, RevEspCardiol, 2007		
Age group	Women	Men	Women	Men	Women	Men	All
30-34 years			No data	No data	No data	No data	No data
35-39 years			No data	No data	No data	No data	No data
40-44 years			No data	No data	No data	No data	No data
45-49 years			3.80%	3.00%	No data	No data	No data
50-54 years			3.90%	4.00%	No data	No data	No data
55-59 years	0.60%	0.31%	4.00%	12.00%	No data	No data	No data
60-64 years			8.00%	14.00%	3.3%	5.2%	4.2%
65-69 years	2.49%	1.64%	No data	No data	5.0%	6.6%	5.8%
70-74 years			No data	No data	6.2%	8.5%	7.3%
75-79 years			No data	No data	12.1%	13.8%	12.8%
80-84 years			No data	No data	12.4%	18.0%	14.8%
>=85 years	3.15%	1.88%	No data	No data	21.2%	11.0%	16.5%
Sample size	1,743	1,707	8,354	7,052	3,802	3,294	7,108
Overall rate					7.9%	9.3%	8.5%
Method of diagnosis			Screening: - battery of health questionnaires and diagnostic tests. - six lead ECG classified by a cardiologist according to the Minnesota coding system.		Patient's medical history and an ECG performed during the study.		

Table 35 Prevalence of AF in Asia/Pacific

Country	Australia (WA)			China		Korea	
Study	Lake, Aus NZ JMed, 1989			Zhou, Jepi, 2008		Jeong, JKMS, 2005	
Age group	Women	Men	All	Women	Men	Women	Men
30-34 years	No data	No data	No data	0.00%	0.00%	No data	No data
35-39 years	No data	No data	No data	0.00%	0.00%	No data	No data
40-44 years	No data	No data	No data	0.05%	0.24%		
45-49 years	No data	No data	No data	0.28%	0.29%	0.06%	0.12%
50-54 years	No data	No data	No data	0.55%	0.53%		
55-59 years	No data	No data	No data	0.55%	0.46%	0.40%	0.70%
60-64 years	2.3%	1.1%	1.7%	1.00%	1.08%	0.20%	1.80%
65-69 years	2.7%	3.3%	3.0%	1.27%	1.84%	1.00%	3.90%
70-74 years	5.5%	8.6%	7.0%	2.58%	3.02%	1.10%	2.50%
75-79 years				2.60%	4.82%	0.50%	3.40%
80-84 years				7.00%	5.00%		
>=85 years	8.4%	15.0%	11.6%	8.57%	15.38%	3.50%	4.50%
Sample size			1,770	15,521	13,558	7,967	6,573
Method of diagnosis				Every participant underwent: - ECG - phisical examination - interviewer-led questionnaire/s.		Participants answered questionnaires (medical history) and underwent examinations: blood pressure, ECG, total cholesterol, and fasting glucose.	

Table 36 Prevalence of AF in USA

Country	USA, California (Kaiser)		USA, Minnesota					
Study	Go, JAMA, 2001		Miyasaka, Circ, 2008 Modeled – prevalence	Miyasaka, Circ, 2008 – Survey prevalence 1986	Miyasaka, Circ, 2008 – Survey prevalence 1993-1995			
Age group	Women	Men	Not gender specific	Not gender specific	Not gender specific	Women	Men	All
30-34 years			No data	No data	No data	No data	No data	No data
35-39 years			No data	No data	No data			
40-44 years			No data	No data	No data	0.0%	0.0%	0.0%
45-49 years								
50-54 years	0.10%	0.20%				0.5%	0.5%	0.5%
55-59 years	0.40%	0.90%						
60-64 years	1.00%	1.70%	1.90%	1.10%	0.70%	1.5%	1.0%	1.2%
65-69 years	1.70%	3.00%						
70-74 years	3.40%	5.00%	6.20%	4.60%	7.10%	3.0%	6.0%	4.6%
75-79 years	5.00%	7.30%						
80-84 years	7.20%	10.30%	11.40%		14.70%			
>=85 years	9.10%	11.10%	18.20%	13.70%	23.40%	12.2%	16.1 %	13.7 %
Sample size	7,795	10,179						2,122
Method of diagnosis	Patients identified by searching the following databases: - clinical database containing diagnoses from all ambulatory visits for a diagnosis of AF (code 427.31 from the ICD-9 - ECG database for physician-confirmed diagnoses of AF - hospital discharge diagnosis database for principal discharge diagnoses of atrial fibrillation.		Medical records were reviewed. Final inclusion in the study population required ECG confirmation of AF and verification that the AF episode was the first recognised AF event for the person.					

Country	USA, Cardiovascular Health			USA
Study	Furberg, AmJCard, 1994			Wolf, Stroke, 1991 Framingham Study
Age group	Women	Men	All	All
40-44 years	No data	No data	No data	
45-49 years	No data	No data	No data	0.1%
50-54 years	No data	No data	No data	
55-59 years	No data	No data	No data	0.5%
60-64 years	No data	No data	No data	
65-69 years	2.8%	5.9%	4.0%	1.8%
70-74 years				
75-79 years	5.9%	5.8%	5.8%	4.8%
80-84 years				
>=85 years	6.7%	8.0%	7.3%	8.8%
Sample size			5,201	5,070
Method of diagnosis				AF was identified on biennial examination and sought on review of all interim hospitalisations. Onset was considered to be the time of first documentation on a hard-copy ECG tracing.

Appendix B Prevalence of heart failure

Table 37 displays the prevalence of heart failure for adults from selected UK studies. Given the lack of Australian data, these prevalence rates have been averaged to provide the prevalence which we use for the calculations in this report.

Table 37 Prevalence of heart failure, adults, latest available year, UK studies compared

Study	Setting	MEN Age group	MEN Prevalence %	WOMEN Age group	WOMEN Prevalence %
General Practice Study (Majeed et al, 2005)	Kent, Surrey and Sussex, 2002/03	0-34	0.0	0-34	0.0
		35-44	0.0	35-44	0.0
		45-54	0.1	45-54	0.1
		55-64	0.6	55-64	0.3
		65-74	2.4	65-74	1.5
		75-84	6.8	75-84	6.1
		85+	12.6	85+	12.5
		All ages	0.7	All ages	1.0
Heart of England Screening Study (Davies et al, 2001)	West Midlands, 1995/99	45-54	0.3	45-54	0.0
		55-64	2.7	55-64	0.9
		65-74	4.2	65-74	1.7
		75-84	7.3	75-84	6.6
		85+	22.0	85+	12.0
Key Health Statistics from General Practice (Office for National Statistics, 2000)	England and Wales, 1998	45-54	0.3	45-54	0.2
		55-64	1.4	55-64	0.9
		65-74	4.5	65-74	3.6
		75-84	10.9	75-84	9.9
Small General Practice Study (Mair et al, 1996)	Liverpool, 1994	55-64	2.7	55-64	1.2
		65-74	5.3	65-74	5.1
		75+	10.4	75+	13.3
WHO MONICA Project (McDonagh et al, 1997)	Glasgow, 1992	55-64	2.5	55-64	2.0
		65-74	3.2	65-74	3.6
4th National Study of Morbidity Statistics from General Practice (Royal College of General Practitioners, 1995)	England and Wales, 1991/92	45-64	0.5	45-64	0.4
		65-74	3.2	65-74	2.3
		75-84	8.0	75-84	7.1

Source of table:

British Heart Foundation, http://www.heartstats.org/datapage.asp?id=1125

Studies are included in the reference list.

Appendix C   Attributable risk of Heart Failure

Attributable Risk (AR) is an incidence statistic quantifying the difference in the probability that a member of a high risk population group will have a health event compared to a member of a neutral or low risk group.

In our study, the AF population is the high risk group, while people without AF are the low risk group. An episode of heart failure is the health event measured. As such, the AR of heart failure with respect to AF attempts to quantify how much AF increases one's risk of heart failure, as compared to if the AF was not present in the individual.

Because our study is conducted on a prevalence—as opposed to on an incidence—basis, we have calculated a statistic similar to AR quantifying how much more often the condition of HF **is present in an individual**, as opposed to the increase in the **number of events that occur**, as would typically be used in an AR calculation. We will also refer to our calculated statistic as AR.

In mathematical terms, the AR of stroke with respect to AF is calculated as the:

(Number of people with both AF and HF) / (Number of all people with HF)
less
<u>(Number of people with AF but without HF) / (Number of all people without HF)</u>
Attributable Risk of HF with respect to AF

The following calculations are based on the prevalence rates for AF and HF which we have derived from available research. The relative risk of HF when AF is present is also a key input into this calculation, and has also been taken from the available research.

Prevalence of Heart Failure (HF) in the population

Like stroke, the prevalence of heart failure—and the interaction with AF—are key components of our study. Heart failure is the inability of the heart to pump sufficient blood to meet the body's needs due to structural or functional impairments. There is limited incidence and prevalence data on heart failure that is Australian-specific. Two major barriers in determining the incidence and prevalence of heart failure in Australia are the lack of a universally agreed definition and difficulties in diagnosis, particularly when the condition is mild (AIHW: Field B 2003). Therefore we have based our prevalence statistics on the following studies from the UK, which are available through the British Heart Foundation:

- Majeed et al's (2005) general practice study of Kent, Surrey and Sussex in 2002-03
- The Heart of England Screening Study of the West Midlands in 1995-99 (Davies et al, 2001)
- Key Health Statistics from General Practice in England and Wales for 1998 (Office for National Statistics, 2000)
- A 1994 Small General Practice Study in Liverpool (Mair et al, 1996)
- The WHO MONICA Project in Glasgow, 1992 (McDonagh et al, 1997)
- The 4th National Study of Morbidity Statistics England and Wales from General Practice, 1991-92 (Royal College of General Practitioners, 1995).

Based on the above studies, we selected heart failure prevalence rates to apply to the Australian population. Like AF, the prevalence of heart failure increases steeply with age. As displayed in Table 38, the overall heart failure prevalence is 0.9% which equates to approximately 200,000 people with heart failure in Australia. We note that this is lower than the AIHW's estimate of 263,000 based on the 2004-05 National Health Survey. However unpublished data provided to PwC from the 2007 National

Health Survey indicates that the prevalence of heart failure measured from that survey was significant lower – closer to 89,200. As a result, we believe that our estimate is reasonable, given the uncertainty in the AIHW estimates.

Table 38 Heart failure prevalence and number of people with heart failure in Australia

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Australian Population (30 June 2009)			Heart Failure Prevalence			Australian Heart Failures		
Age	Male	Female	Total	Male	Female	Total	Male	Female	Total
0-4	705,546	668,856	1,374,402	0.02%	0.01%	0.02%	141	67	208
5–9	708,711	674,042	1,382,753	0.02%	0.01%	0.02%	142	67	209
10–14	740,956	702,599	1,443,556	0.02%	0.01%	0.02%	148	70	218
15–19	762,299	722,351	1,484,650	0.02%	0.01%	0.02%	152	72	225
20–24	783,110	757,051	1,540,161	0.02%	0.01%	0.02%	157	76	232
25–29	752,178	736,763	1,488,940	0.02%	0.01%	0.02%	150	74	224
30–34	754,855	758,581	1,513,436	0.02%	0.01%	0.01%	151	76	227
35–39	801,693	811,453	1,613,146	0.02%	0.03%	0.03%	160	243	404
40–44	778,649	788,141	1,566,790	0.02%	0.03%	0.03%	156	236	392
45–49	776,660	792,076	1,568,736	0.19%	0.10%	0.15%	1,498	792	2,290
50–54	710,032	719,791	1,429,823	0.19%	0.10%	0.15%	1,369	720	2,089
55–59	652,224	655,896	1,308,120	1.72%	0.93%	1.33%	11,228	6,122	17,349
60–64	549,566	547,595	1,097,162	1.72%	0.93%	1.33%	9,460	5,111	14,571
65–69	412,188	420,288	832,475	3.80%	2.97%	3.38%	15,663	12,469	28,132
70–74	320,838	345,399	666,237	3.80%	2.97%	3.37%	12,192	10,247	22,439
75–79	261,577	307,684	569,261	7.33%	6.81%	7.05%	19,171	20,961	40,132
80–84	177,608	250,075	427,683	7.33%	6.81%	7.03%	13,017	17,036	30,053
85+	117,389	237,372	354,761	13.78%	11.15%	12.02%	16,182	26,458	42,640
Total	**10,766,081**	**10,896,012**	**21,662,093**	**0.94%**	**0.93%**	**0.93%**	**101,138**	**100,896**	**202,034**

(1) - (3)	From Appendix E - Population trends
(4) - (5)	From Apendix B - Prevalence of Heart Failure
(6)	=(9) / (3)
(7)	= (1) * (4)
(8)	= (2) * (5)
(9)	= (7) + (8)

Attributable risk (AR) and relative risk (RR) of heart failure due to AF

Stewart et al (2002) found that AF more than triples the risk for HF when they analysed results from the Scottish Renfrew/Paisley study. The relative risk of HF due to AF in the survey was 3.4 for men with a 95% Confidence Interval (CI) of 1.7 to 6.8 and 3.4 for women with a 95% CI of 1.9 to 6.2. These relative risks are not adjusted by age. Using this relative risk and our selected HF prevalence, the population attributable risk of heart failure which is due to AF is provided below. We have based our attributable risk calculations on the AF prevalence selected in Table 5, the heart failure prevalence selected above, and Stewart et al's relative risk of heart failure due to AF of 3.4. Table 39 presents a summary of our calculations. For all ages, the attributable risk of heart failure due to AF is 18.1%.

Table 39 Attributable risk of heart failure due to AF

	Attributable Risk of Heart Failure due to Atrial Fibrillation		
	0-64	65+	Total
Males	3.2%	18.5%	19.0%
Females	3.4%	15.4%	17.2%
Total	**3.3%**	**16.9%**	**18.1%**

Heart failure prevalence attributable to AF

Using the relative risk of heart failure due to AF and heart failure prevalence, we have estimated the number of people with AF who have heart failure in Table 40. Of the estimated 200,000 people with heart failure in Australia, 19.0% (38,500/200,000) have AF.

Table 40 Heart failure prevalence in the AF population

	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)
	Relative Risk of	AF Population			Non-AF Heart Failure Prevelance			Heart Failures in AF Population			Heart Failures in non-AF Population		
Age	HF due to AF	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total
0-4		0	0	0	0.02%	0.01%	0.02%	0	0	0	141	67	208
5–9		0	0	0	0.02%	0.01%	0.02%	0	0	0	142	67	209
10–14		0	0	0	0.02%	0.01%	0.02%	0	0	0	148	70	218
15–19		0	0	0	0.02%	0.01%	0.02%	0	0	0	152	72	225
20–24		0	0	0	0.02%	0.01%	0.02%	0	0	0	157	76	232
25–29		0	0	0	0.02%	0.01%	0.02%	0	0	0	150	74	224
30–34		0	0	0	0.02%	0.01%	0.01%	0	0	0	151	76	227
35–39		0	0	0	0.02%	0.03%	0.03%	0	0	0	160	243	404
40–44		0	0	0	0.02%	0.03%	0.03%	0	0	0	156	236	392
45–49		3,883	3,734	7,617	0.19%	0.10%	0.14%	25	13	38	1,473	780	2,252
50–54		4,362	4,216	8,578	0.19%	0.10%	0.14%	28	14	42	1,341	706	2,047
55–59		6,243	6,278	12,521	1.68%	0.91%	1.30%	357	195	552	10,870	5,927	16,797
60–64		7,999	9,187	17,187	1.66%	0.90%	1.28%	452	280	733	9,008	4,831	13,839
65–69		18,047	10,790	28,836	3.44%	2.79%	3.12%	2,110	1,025	3,135	13,553	11,443	24,997
70–74		20,255	15,247	35,501	3.30%	2.68%	2.99%	2,273	1,391	3,663	9,919	8,856	18,776
75–79		26,700	22,690	49,390	5.89%	5.79%	5.83%	5,344	4,465	9,809	13,827	16,495	30,322
80–84		21,427	21,164	42,591	5.68%	5.66%	5.67%	4,141	4,074	8,215	8,876	12,962	21,838
85+		15,181	22,128	37,309	10.52%	9.11%	9.60%	5,430	6,853	12,283	10,752	19,605	30,357
Total	**3.4**	**124,097**	**115,433**	**239,530**				**20,160**	**18,310**	**38,470**	**80,978**	**82,586**	**163,564**

(1) - (9) Shown in Table 8, "Heart Failure prevelance and number of people with HF in Australia"
(10) Stewart et al. "A Population-Based Study of the Long-term Risks Associated with Atrial Fibrillation: 20-Year Follow-up of the Renfrew/Paisley Study," 2002
(11) - (13) From Table 3, "AF prevalence and population in Australia"
(14) = (7) / [(10) * (11) + (1) - (11)]
(15) = (8) / [(10) * (12) + (2) - (12)]
(16) = (9) / [(10) * (13) + (3) - (13)]
(17) = (10) * (11) * (14)
(18) = (10) * (12) * (15)
(19) = (17) + (18)
(20) = (7) - (17)
(21) = (8) - (18)
(22) = (20) + (21)

Not all heart failure in the AF population is linked to the individual's AF condition. The prevalence of heart failure due to AF is 13.3% overall (refer to Table 41 below, calculated as heart failure prevalence due to AF/total heart failure prevalence), or 26,900 people. This is lower than the 19.0%, or 38,500 individuals with both AF and heart failure in Australia.

Table 41 Summary: Heart failure prevalence due to AF

	Heart Failure Prevalence due to Atrial Fibrillation		
	0-64	65+	Total
Males	2.5%	17.5%	13.8%
Females	2.6%	14.4%	12.8%
Total	**2.5%**	**15.9%**	**13.3%**

	Heart Failure Population		
	AF Population	w/o AF Population	% with AF
Males	20,160	80,978	19.9%
Females	18,310	82,586	18.1%
Total	**38,470**	**163,564**	**19.0%**

Appendix D Health inflation

In Table 42 we document Australia's health inflation for June 1997 to June 2009. The latest data available was for the year ending 30 June 2007. Therefore we have selected a rate for 2007-08 and 2008-09 which is the average of 2005-2007. We have used health inflation, in combination with population trends, to standardise data to 30 June 2009.

Table 42 Australian health inflation

	(1)	(2)	(3)	(4)	(5)
Year	Health inflation		Index		
ending	Historical	Selected	Annual	From 1997	To 2009
June 1997				1.000	1.487
June 1998	2.1%		1.021	1.021	1.456
June 1999	2.5%		1.025	1.047	1.421
June 2000	2.5%		1.025	1.073	1.386
June 2001	3.8%		1.038	1.113	1.336
June 2002	3.3%		1.033	1.150	1.293
June 2003	3.5%		1.035	1.190	1.249
June 2004	3.5%		1.035	1.232	1.207
June 2005	4.1%		1.041	1.283	1.159
June 2006	4.0%		1.040	1.334	1.115
June 2007	3.4%		1.034	1.379	1.078
June 2008		3.8%	1.038	1.432	1.038
June 2009		3.8%	1.038	1.487	1.000

(1) AIHW "Health Expenditure Australia 2006/07," Table 2.5
(2) Average of (1 2005 - 2007)
(3) = (1 or 2) + 1
(4) = (3 Prior Year) * (3)
(5) = (4 2009) / (4)

Appendix E Population trends

In Table 43 we present the Australian population and index relative to the year ending 30 June 2009. We have used this to determine the Australian population by age and gender for the year ending 30 June 2009, as displayed in Table 44.

Table 43 Australian population growth

Year ending	Population	Index to year ending June 2009
June 1980	14,695,356	1.474
June 1981	14,923,260	1.452
June 1982	15,184,247	1.427
June 1983	15,393,472	1.407
June 1984	15,579,391	1.391
June 1985	15,788,312	1.372
June 1986	16,018,350	1.352
June 1987	16,263,874	1.332
June 1988	16,532,164	1.310
June 1989	16,814,416	1.288
June 1990	17,065,128	1.270
June 1991	17,284,036	1.253
June 1992	17,494,664	1.238
June 1993	17,667,093	1.226
June 1994	17,854,738	1.213
June 1995	18,071,758	1.199
June 1996	18,310,714	1.183
June 1997	18,517,564	1.170
June 1998	18,711,271	1.158
June 1999	18,925,855	1.145
June 2000	19,153,380	1.131
June 2001	19,413,240	1.116
June 2002	19,651,438	1.102
June 2003	19,895,435	1.089
June 2004	20,127,363	1.076
June 2005	20,394,791	1.062
June 2006	20,697,880	1.047
June 2007	21,015,042	1.031
June 2008	21,339,473	1.015
June 2009	21,664,561	1.000

(1) From ABS publications 3105.0.65.001 "Australian Historical Population Statistics, 2008" and

ABS 3222.0 "Population Projections, Australia, 2006 to 2101" (projection Series B)

(2) = (1 Year end 30 June 2009) / (1 Year End 30 June 19)

Table 44 Australian population by age and gender

Age	Population year ending June 2007			Population trend factor	Population year ending June 2009		
	Male	Female	Total		Male	Female	Total
0-4	684,393	648,803	1,333,196		705,546	668,856	1,374,402
5–9	687,463	653,834	1,341,297		708,711	674,042	1,382,753
10–14	718,742	681,535	1,400,277		740,956	702,599	1,443,556
15–19	739,445	700,694	1,440,139		762,299	722,351	1,484,650
20–24	759,632	734,354	1,493,986		783,110	757,051	1,540,161
25–29	729,627	714,674	1,444,301		752,178	736,763	1,488,940
30–34	732,224	735,838	1,468,062		754,855	758,581	1,513,436
35–39	777,658	787,125	1,564,783		801,693	811,453	1,613,146
40–44	755,305	764,512	1,519,817		778,649	788,141	1,566,790
45–49	753,375	768,329	1,521,704		776,660	792,076	1,568,736
50–54	688,745	698,211	1,386,956		710,032	719,791	1,429,823
55–59	632,670	636,232	1,268,902		652,224	655,896	1,308,120
60–64	533,090	531,178	1,064,268		549,566	547,595	1,097,162
65–69	399,830	407,687	807,517		412,188	420,288	832,475
70–74	311,219	335,044	646,263		320,838	345,399	666,237
75–79	253,735	298,459	552,194		261,577	307,684	569,261
80–84	172,283	242,578	414,861		177,608	250,075	427,683
85+	113,870	230,255	344,125		117,389	237,372	354,761
Total	**10,443,306**	**10,569,342**	**21,012,648**	**1.031**	**10,766,081**	**10,896,012**	**21,662,093**

(1) - (3) ABS 3235.0 "Population by Age and Sex, Regions of Australia"

(4) Calculated in "Australian Population Growth" table

(5) - (7) = (1 or 2 or 3) * (4)

Appendix F ICD-10-AM and AR-DRG codes

	ICD-10-AM
Atrial fibrillation	I48
Heart Failure	I50
Stroke[4]	I60, I61, I61.0, I61.1, I61.2, I61.3, I61.4, I61.5, I61.6, I61.7, I61.8, I61.9, I62.0, I62.1, I62.9 , I63.0, I63.1, I63.2, I63.3, I63.4, I63.5, I63.6, I63.8, I63.9, I64

[4] The Stroke ICD-10-AM case inclusion criteria was supplied by the Stroke Foundation

Appendix G Methodology and structure of the literature scan

The purpose of the literature scan was to identify and summarise:

- the evidence base for the prevalence of Atrial Fibrillation, including the impact of diagnosed versus undiagnosed AF
- symptoms and types of AF
- risk factors for developing AF
- morbidity and mortality impacts of AF – with an emphasis on the risk of stroke and AF and the risk of heart failure and AF
- quality of life and effects of AF
- detection and prevention of AF
- treatment methods for AF.

The literature scan involved searching peer-reviewed journals, government policy documents, grey literature and project reports from studies in Australia and internationally.

The search methodology for the literature scan is included in Table 1 below.

Websites/ Databases	Australian Institute of Health and Welfare (AIHW) Cochrane Library Medline National Heart Foundation of Australia website National Stroke Foundation – Australia website Pub Med Science Direct		
Search terms	Amiodorane Anticoagulation Arrhythmia Asymptomatic Atrial Fibrillation Burden Cardiovascular disease Carer Chronic Congestive heart failure Control Cost Diagnosed	Disability Drug prescription Factor Frequency Guidelines Heart disease Heart failure Incidence Ischaemic heart disease Management Morbidity Mortality	Outcomes Prevalence Progression Quality of life Rate Rhythm Risk Stroke Symptomatic Treatment Undiagnosed Warfarin
Search Dates	Various dates between 22 April 2009 and 27 April 2010		

Appendix H References

Access Economics (2006) The Economic Costs of Obesity. Report prepared by Access Economics for Diabetes Australia, Canberra.

Access Economics (2008) The Growing Costs of Obesity in 2008. Report prepared by Access Economics for Diabetes Australia, Canberra.

Ansell JE, Buttaro ML, Thomas OV, Knowlton CH. (1997) Consensus guidelines for coordinated outpatient oral anticoagulation therapy management. Anticoagulation Guidelines Task Force. Ann Pharmocother. 1997;31:604-15.

Australian Bureau of Statistics (ABS). (2003). Disability, Ageing and Carers: Summary of Findings Australia. Publication 4430.0. Accessed via: www.abs.gov.au

Australian Bureau of Statistics (ABS). Australian Historical Population Statistics, 2008. Publication 3105.0.65.001. Accessed via: www.abs.gov.au

Australian Bureau of Statistics (ABS). Average Weekly Earnings, Australia, Feb 2009. Publication 6302.0. Accessed via: www.abs.gov.au

Australian Bureau of Statistics (ABS). Causes of Death, Australia, 2007. Publication 3303.0. Accessed via: www.abs.gov.au

Australian Bureau of Statistics (ABS). Census Tables 2007. Publication 2068.0. Accessed via: www.abs.gov.au

Australian Bureau of Statistics (ABS). Consumer Price Index, Australia. Released quarterly. Publication 6401.0. Accessed via: www.abs.gov.au

Australian Bureau of Statistics (ABS). Employee Earnings, Benefits and Trade Union Membership, Australia, August 2008. Publication 6310.0. Accessed via: www.abs.gov.au

Australian Bureau of Statistics (ABS). National Health Survey 2007-08. Selected data request on Atrial Fibrillation.

Australian Bureau of Statistics (ABS). Population by Age and Sex, Regions of Australia. Publication 3235.0. Accessed via: www.abs.gov.au

Australian Bureau of Statistics (ABS). Population Projections, Australia, 2006 to 2101 (projection Series B). Publication 3222.0. Accessed via: www.abs.gov.au

Australian Commonwealth Department of Health and Ageing (DoHA). Medicare statistics, March 2009. Accessed via:
http://www.health.gov.au/internet/main/publishing.nsf/Content/medstat-mar09-tables-c
http://www.health.gov.au/internet/main/publishing.nsf/Content/medstat-mar09-analysis-b-ave

Australian Commonwealth Department of Health and Ageing (DoHA). National Admitted Patient Care Collection (NAPCC). Clinical profiles for public hospitals, AR-DRG v5.1, Australia, 2004-05. Accessed via:
http://www.health.gov.au/internet/main/publishing.nsf/Content/NAPPC-data_2004-05_cppub

Australian Commonwealth Department of Health and Ageing (DoHA). Pharmaceutical Benefits Scheme (PBS). Expenditure and prescriptions twelve months to 30 June 2008. Data and Modelling Section Pharmaceutical Policy and Analysis Branch. Accessed via:
http://www.health.gov.au/internet/wcms/publishing.nsf/Content/pbs_expenditure_prescriptions-copy1

Australian General Practice Statistics and Classification Centre Family Medicine Research Centre, University of Sydney at Westmead Hospital. A collaborating unit of the Australian Institute of Health and Welfare (AIHW). BEACH-SAND Report (Bettering the Evaluation and Care of Health): Atrial fibrillation / atrial flutter in general practice patients. Data collection period: 20/01/2009 – 23/02/2009.

Australian Government Department of Health and Ageing (DoHA). Pharmaceutical Benefits Scheme (PBS) Data. Accessed via:
http://www.pbs.gov.au/html/industry/home

Australian Government Medicare Australia. Medicare Benefits Schedule Statistics (March 2009). Accessed via:
http://www.medicareaustralia.gov.au/provider/medicare/mbs.jsp#N10030

Australian Institute of Health and Welfare (AIHW 2005). Health system expenditure on disease and injury in Australia, 2000–01. Second edition. AIHW cat. no. HWE 28 Canberra: AIHW (Health and Welfare Expenditure Series no. 21).

Australian Institute of Health and Welfare (AIHW 2008a). Health expenditure Australia 2006–07. Health and Welfare Expenditure Series no. 35. Cat. no. HWE 42. Canberra: AIHW.

Australian Institute of Health and Welfare (AIHW 2008b). Residential aged care in Australia 2006–07: a statistical overview. Aged care statistics series 26. Cat. no. AGE 56. Canberra: AIHW.

Australian Institute of Health and Welfare (AIHW). National Hospital Morbidity Database. Accessed via:
http://www.aihw.gov.au/hospitals/datacubes/index.cfm

Australian Institute of Health and Welfare (AIHW). Recurrent health expenditure per person; age by area of expenditure, Australia 1993 – 94. Unpublished data from the 1998 versions of Australian Institute of Health and Welfare Disease Costs and Impact Studies and Health Expenditure databases. Access via:
http://www.aihw.gov.au/publications/age/oag/oag-c36.html

Australian Institute of Health and Welfare (AIHW): Field B 2003. Heart failure...what of the future? Bulletin no. 6. AIHW Cat. No. AUS 34. Canberra: AIHW.

Australian Institute of Health and Welfare (AIHW): Senes, S. (2006). How we manage stroke in Australia. AIHW cat. no. CVD 31. Canberra: Australian Institute of Health and Welfare. Accessed on 15 May 2009 via http://www.aihw.gov.au/cdarf/data_pages/incidence_prevalence/index.cfm

Begg S, Vos T, Barker B, Stevenson C, Stanley L, Lopez AD. (2007). The burden of disease and injury in Australia 2003. PHE 82. Canberra: AIHW.

Benjamin EJ et al. (2009). Prevention of Atrial Fibrillation, Report from a National Heart, Lung, and Blood Institute Workshop. *Circulation.* 119:606-618.

Benjamin EJ, Wolf PA, D'Agostino RB, Silbershatz H, Kannel WB, Levy D. (1998). Impact of atrial fibrillation on the risk of death: the Framingham Heart Study. *Circulation*. 98:946 –952.

Britt H, Miller GC, Charles J, Henderson J, Bayram C, Harrison C, Valenti L, Fahridin S, Pan Y, O'Halloran J. (2008). General practice activity in Australia 2007–08. General practice series no. 22. Cat. no. GEP 22. Canberra: Australian Institute of Health and Welfare.

Burton JH, Vinson DR, Drummond K et al. (2004). Electrical cardioversion of emergency department patients with atrial fibrillation. *Annals of Emergency Medicine.* 44(1):20–30.

Bush, D.E., Ziegelstein, R.C., Patel, U.V., et al. (2005). Post-Myocardial Infarction Depression. Dorian, et al. (2000). Quality of Life in AF. *JAFF*, vol.36 no.4 October, pp.1303-1309.

Cadilhac D, Carter R, Thrift A, Dewey H (2009) Estimating the Long-Term Costs Of Ischemic and Hemorrhagic Stroke for Australia. *Stroke*. March 2009 pp 915-921.

Carels, R.A. (2004). The Association between Disease Severity, Functional Status, Depression and Daily Quality of Life in Congestive Heart Failure Patients. Qual Life Res, vol.13, pp.63-72.

Cea-Calvo, L., Redón, J., Lozano, J.V., Fernández-Pérez, C., et al on behalf of the investigators of the PREV-ICTUS study. (2007). Prevalence of Atrial Fibrillation in the Spanish Population Aged 60 Years or More.The PREV-ICTUS Study. *Rev Esp Cardiol.* 60(6):616-24.

Clark, R. McLennan, S. Dawson, A. Wilkinson, D. Stewart, S. (2004) Uncovering a Hidden Epidemic: A Study of the Current Burden of Heart Failure in Australia. Heart Lung and Circulation 2004;13:266–27

Conen, D., Tedrow, U.B., Cook, N.R., et al. (2008). Alcohol Consumption and Risk of Incident Atrial Fibrillation in Women. JAMA. 300(21):2489-2496.

Cordina, J., Mead, G. (2005). Pharmacological cardioversion for atrial fibrillation and flutter. Cochrane Database Syst Rev. 1: CD002903.

Davies, M.K., Hobbs, F.D.R., Davis, R.C., Kenkre, J.E., Roalfe, A.K., Hare, R., Wosornu, D., Lancashire, R.J. (2001). Prevalence of left-ventricular systolic dysfunction and heart failure in the Echocardiographic Heart of England Screening study: a population based study. The Lancet 358:439-444.

Dewey, H.M., Thrift, A.G., Mihalopoulos, C., Carter, R., Macdonell, R.A., McNeil, J.J., Donnan, G.A. (2001). Cost of stroke in Australia from a societal perspective: results from the North East Melbourne Stroke Incidence Study (NEMESIS). Stroke. 32:2409–2416.

Dewey, H.M., Thrift, A.G., Mihalopoulos, C., et al. (2003). Lifetime cost of stroke subtypes in Australia. Findings from the North East Melbourne Stroke Incidence Study (NEMESIS). Stroke. 34:2502-2507.

Dorian, P. et al (2002). Quality of Life Improves with Treatment in the Canadian Trial of Atrial Fibrillation. Am Heart J, vol.143, pp.984-990.

Dorian, P., Jung, W., Newman D., Paqutte, M., Wood, K., Ayers, G.M., Camm, J., Akhtar, M., Luderitz, B. (2000). The impairment of health-related quality of life in patients with intermittent atrial fibrillation: implications for the assessment of investigational therapy. *Journal of the American College of Cardiology*. 36; 4:1303-1309.

Dulli D.A., Stanko, H., Levine, R.L. (2003). Atrial fibrillation is associated with severe acute ischemic stroke. *Neuroepidemiology*. 22(2):118-23.

Ericson, L. and Bjorholt, I. (2009) Atrial Fibrillation – the Cost of Illness in Sweden. Nordic Health Economics Research AB, Goteborg, Sweden,

Feinberg, W.M., Blackshear, J.L., Laupacis, A., Kronmal, R., Hart, R.G. (1995). Prevalence, Age Distribution, and Gender of Patients With Atrial Fibrillation
Analysis and Implications. *Archives of Internal Medicine.* 155: 469-473.

Fitzmaurice, D.A., Hobbs, F.D., Jowett, S., Mant, J., Murray, E.T., Holder, R., Raftery, J.P., Bryan, S., Davies, M., Lip, G.Y., Allan, T.F. (2007). Screening versus routine practice in detection of atrial fibrillation in patients aged 65 or over: cluster randomised controlled trial. BMJ. 335:383.
Flaker, G.C., Belew, K., Beckman, K., Vidaillet, H., et al. (2005). Asymptomatic Atrial Fibrillation: Demographic Features and Prognostic Information From the Atrial Fibrillation Follow-up Investigation of Rhythm Management (AFFIRM) Study. American Heart Journal. 149(4):657-663.

Furberg CD, Psaty BM, Manolio TA, Gardin JM, Smith VE, Rautaharju PM. (1994). Prevalence of atrial fibrillation in elderly subjects (the Cardiovascular Health Study). Am J Cardiol. 74:236-241.

Fuster V, Ryden LE, Asinger RW, Cannom DS, Crijns HJ, Frye RL, et al. (2001). ACC/AHA/ESC guidelines for the management of patients with atrial fibrillation: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines and the European Society of Cardiology Committee for Practice Guidelines and Policy Conferences (committee to develop guidelines for the management of patients with atrial fibrillation) developed in collaboration with the North American Society of Pacing and Electrophysiology. *Eur Heart J* . 22:1852-923.

Glader EL, Stegmayr B, Norrving B, et al. (2004). Large variations in the use of oral anticoagulants in stroke patients with atrial fibrillation: A Swedish national perspective. *J Intern Med.* 255:22.

Go, A.S., Hylek, E.M., Phillips, K.A., et al. (2001). 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. 285(18):2370-2375.

Gure TR. Kabeto MU. Blaum CS. Langa KM. (2008) Degree of disability and patterns of caregiving among older Americans with congestive heart failure. Journal of General Internal Medicine. 23(1):70-6, 2008 Jan.

Heart Foundation Atrial Fibrillation Fact Sheet. Accessed via www.heartfoundation.org.au

Heeringa, J., Kors, J.A., Hofman, A. (2008). Cigarette smoking and risk of atrial fibrillation: The Rotterdam Study. *American Heart Journal.* 156(6):1163-1169.

Heeringa, J., van der Kuip, D.A.M., Hofman, A., Kors, J.A., et al. (2006). Prevalence, incidence and lifetime risk of atrial fibrillation: the Rotterdam study. European Heart Journal. 27, 949–953.

Iqbal, M.B., Taneja, A.K., Lip, G.Y.H. and Flather, M. (2005). Recent developments in atrial fibrillation. BMJ. 330;238-243.

Jeong, J.H. (2005). Prevalence of and Risk Factors for Atrial Fibrillation in Korean Adults Older than 40 Years. J Korean Med Sci. 20: 26-30.

Kannel WB, Abbott RD, Savage DD, McNamara PM. (1982). Epidemiologic features of chronic atrial fibrillation: the Framingham study. *N Engl J Med.* 306:1018-22.

Kaufman, E.S. and Waldo, A.L. (2004). The Impact of Asymptomatic Atrial Fibrillation (editorial). Journal of the American College of Cardiology. 43:1.

Kimura, K. Minematsu, K. and Yamaguchi, T. (2005) Atrial fibrillation as a predictive factor for severe stroke and early death in 15 831 patients with acute ischaemic stroke. J. Neurol. Neurosurg. Psychiatry 2005;76;679-683

Koopmanschap, M.A. and Ineveld, M.V. (1992). Towards a New Approach for Estimating Indirect Costs of Disease. Soc. Sci. Med. Vol. 34, No. 9. pp. 1005-1010.

Krahn AD, Manfreda J, Tate RB, Mathewson FA, Cuddy TE. The natural history of atrial fibrillation: incidence, risk factors, and prognosis in the Manitoba Follow-up Study. Am J Med. 1995; 98:476–484.

Lattimore R (1997) Research and Development Fiscal Incentives in Australia: Impacts and Policy Lessons, Paper Presented to the OECD Conference on Policy Evaluation in Innovation, Paris, 26 27 June, 81:574-577

Lake. R.R., Cullen, K.J, deKlerk, N.H., McCall, M.G., Rosman, D.L. (1989). Atrial fibrillation in an elderly population. Aust NZ J Med. 19:321-326.

Lane, D. and Lip, G. (2009). Quality of Life In Older People with Atrial Fibrillation. Springer Science and Business Media, 20 November.

Lin, H.J., Wolf, P.A., Kelly-Hayes, M., Beiser, A.S., Kase, C.S. MD; Benjamin, E.J., D'Agostino, R.B. (1996). Stroke Severity in Atrial Fibrillation: The Framingham Study.
Stroke. 27(10):1760-1764.

Lip GY, Golding DJ, Nazir M et al. (1997). A survey of atrial fibrillation in general practice: the West Birmingham Atrial Fibrillation Project. *British Journal of General Practice.* 47(418):285–289.

Lip GY, Tean KN, Dunn FG. (1994). Treatment of atrial fibrillation in a district general hospital. *British Heart Journal.* 71(1):92–95.

Lowenstein SR, Gabow PA, Cramer J et al. (1983). The role of alcohol in new–onset atrial fibrillation. *Archives of Internal Medicine.* 143(10):1882–1885.

Mair, F.S., Crowley, T., Bundred, P. (1996). Prevalence, aetiology and management of heart failure in general practice. British Journal of General Practice; 46: 77-79.

Majeed, A., Moser, K., Carroll, K. (2001). 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.* 86:284–288.

Majeed, A., Williams, J., de Lusignan, S., Chan, T. (2005). Management of heart failure in primary care after implementation of the National Service Framework for Coronary Heart Disease: a cross-sectional study. Public Health 119: 105-111.

McBride, D., Mattenklotz, A.M. Willich, S.N., Brüggenjürgen, B. (2009). The Costs of Care in Atrial Fibrillation and the Effect of Treatment Modalities in Germany. International Society for Pharmacoeconomics and Outcomes Research (ISPOR). 12,2: 293-301.

McDonagh, T.A., Morrison, C.E., Lawrence, A., Ford, I., Tunstall-Pedoe, H., McMurray, J.J.V. (1997). Symptomatic and asymptomatic left ventricular systolic dysfunction in an urban population. The Lancet 350: 829-833.

Michael JA, Stiell IG, Agarwal S et al. (1999). Cardioversion of paroxysmal atrial fibrillation in the emergency department. *Annals of Emergency Medicine.* 33(4):379–387.

Mihalopoulos, C., Cadilhac, D.A., Moodie, M.L., Dewey, H.M., Thrift, A.G., Donnan, G.A., Carter, R.C. (2005). Development and application of Model of Resource Utilization, Costs, and Outcomes for Stroke (MORUCOS): An Australian economic model for stroke. International Journal of Technology Assessment in Health Care, 21:4, 499–505.

Mitchell, G.F., Vasan R.S., Keyes M.J., Parise H., Wang T.J., Larson M.G., D'Agostino, R.B., Kannel W.B., Levy, D., Benjamin, EJ (2008) Pulse Pressure and Risk of New-Onset Atrial Fibrillation. JAMA. 2007;297:709-715

Miyasaka, Y. Barnes, M.E., Gersh, B.J., Cha, S.S., et al. (2006). Secular Trends in Incidence of Atrial Fibrillation in Olmsted County, Minnesota, 1980 to 2000, and Implications on the Projections for Future Prevalence. Circulation. 114;119-125

Molaschi, M., Ponzetto, M., Romin, R., Berrino, E., Fabris, F. (1995). Changes in the electrocardiogram in the elderly patient: the limits between normality and pathology [Ital]. Recenti Progressi in Medicina 86:32-36.

National Collaborating Centre for Chronic Conditions. (2006). Atrial fibrillation: national clinical guideline for management in primary and secondary care. London: Royal College of Physicians.

National Health and Medical Research Council (2008). Rate or Rhythm Control for Recurrent Atrial Fibrillation: A summary of best available evidence and information on current clinical practice. NHMRC: Canberra

National Stroke Foundation (2007). Clinical Guidelines for Acute Stroke Management. National Stroke Foundation: Australia

Office for National Statistics (2000) Key Health Statistics from General Practice. The Stationery Office: London.

Ong, L., Irvine, J., Nolan, R., Cribbie, R., et al. (2005). Gender Differences and Quality of Life in Atrial Fibrillation: The Mediating Role of Depression. Journal of Psychosomatic Research, vol.61, pp.769-774.

Ott, A., Breteler, M.M., de Bruyne, M.C., van Harskamp, F., Grobbee, D.E., Hofman, A. (1997). Atrial Fibrillation and dementia in a population-based study: the Rotterdam Study. *Stroke.* 28:316-321.

Page, R.L., Tilsch, T.W., Connolly, S.J., Schnell, D.J., Marcello, S.R., Wilkinson, W.E., Pritchett, E.L.C. (2003). Asymptomatic or "Silent" Atrial Fibrillation: Frequency in Untreated Patients and Patients Receiving Azimilide. Prepared for the Azimilide Supraventricular Arrhythmia Program (ASAP) Investigators. *Circulation*. 107;1141-1145.

Paquette, M., et al. (2000) Role of Gender and Personality on Quality of Life Impairment in Intermittent Atrial Fibrillation. Am J Cardiol, vol.86, pp.764-768.

Productivity Commission (2003) "Evaluation of the Pharmaceutical Industry Investment Program" Research Report, AusInfo, Canberra.

Psaty, B.M., Manolio, T.A., Kuller, L.H., Kronmal, R.A., Cushman, M., Fried, L.P., White, R., Furberg, C.D., Rautaharju, P.M. (1997). Incidence of and risk factors for atrial fibrillation in older adults. Circulation. 96:2455–2461.

Reiffel, J. (2008). A Contemporary Look at Classic Trials in Atrial Fibrillation: What Do They Really Show and How Might They Apply to Future Therapies? American Journal of Cardiology online.
Reynolds, M.R., Lavelle, T., Essebag, V., Cohen, D.J., Zimetbaum, P. (2006). Influence of Age, Sex and Atrial Fibrillation Recurrence on Quality of Life Outcomes in a Population of Patients with New-Onset Atrial Fibrillation: The Fibrillation Registry Assessing Costs, Therapies, Adverse Events and Lifestyle (FRACTAL) Study. *American Heart Journal*, vol.152, pp.1097-1103.

Reserve Bank of Australia (RBA). Historical Exchange Rates. Accessed via: http://www.rba.gov.au/Statistics/HistoricalExchangeRates/index.html

Rienstra, M. et al. Van Veldhuisen, D.J., Hagens, V.E., Ranchor, A.V., et al. (2005). Gender-related Differences in Rhythm Control Treatment in Persistent Atrial Fibrillation: Data of the Rate Control Versus Electrical Cardioversion (RACE) Study. J Am Coll Cardiol, vol.46, pp.1298-1306.

Ringborg, A., Nieuwlaat, R., Lindgren, P., Jönsson, B., Fidan, D., Maggioni, A.P., Lopez-Sendon, J., Stepinska, J., Cokkinos, D.V., Crijns, H.J. (2008). Costs of atrial fibrillation in five European countries: results from the Euro Heart Survey on atrial fibrillation. Apr;10(4):403-11.

Risk factors for stroke efficacy and antithrombotic therapy in atrial fibrillation: analysis of pooled data from five randomised controlled trials. Arch Intern Med. 1994; 154:1449-1457.

Royal College of General Practitioners, the Office of Population Censuses and Surveys and the Department of Health (1995) Morbidity Statistics from General Practice, Fourth National Study 1991-1992. HMSO: London.

Ruo, et al. (2003). Depressive Symptoms and Health-Related Quality of Life. JAMA vol.290, pp.215-221.

Savelieva, I., Camm, A.J. (2000). Clinical relevance of silent atrial fibrillation: prevalence, prognosis, quality of life, and management. J Intervent Cardiac Electrophysiol. 4:369–382.

Schnabel, R.B, Sullivan, L.M, Levy, D., Pencina, M.J. et al. (2009). Development of a risk score for atrial fibrillation (Framingham Heart Study): a community-based cohort study. Lancet 2009; 373: 739-45.

Schoonderwoerd BA, Smit MD, Pen L, Van Gelder IC. (2008). New risk factors for atrial fibrillation: causes of ‘not-so-lone atrial fibrillation. *Europace.* 2008; 10: 668-673.

SCRGSP (Steering Committee for the Review of Government Service Provision) 2009, Report on Government Services (ROGS) 2009, Productivity Commission, Canberra.

Steger C, Pratter A, Martinek-Bregel M, et al. (2004). Stroke patients with atrial fibrillation have a worse prognosis than patients without: Data from the Austrian stroke registry. *Eur Heart J.* 25:1734.

Stewart S, Hart C, Hole DJ, McMurray JJV. (2002). 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.* 113:359-364.

Stewart, S., Hart, C.L., Hole, D.J. and McMurray, J.J.V. (2001). Population prevalence, incidence, and predictors of atrial fibrillation in the Renfrew/Paisley study. *Heart.* 86;516-521.

Summary, Evidence Report/Technology Assessment: Number 123. AHRQ Publication Number 05-E018-1, May 2005. Agency for Healthcare Research and Quality, Rockville, MD. http://www.ahrq.gov/clinic/epcsums/midepsum.htm

Thrall, G., Lane, D., Carroll, D., and Lip, G.Y.H. (2006). Quality of Life in Patients with Atrial Fibrillation: A Systematic Review. *American Journal of Medicine*. 119, 448.e1-448.e19.

Thrall, G., Lip, G.Y.H., Carroll, D., Lane, D. (2007). Depression, Anxiety, and Quality of Life in Patients With Atrial Fibrillation. *Chest.* 132;1259-1264.

Thrift A, Dewey H, Macdonell R, McNeil J, Donnan G. (2000). Stroke Incidence on the East Coast of Australia : The North East Melbourne. *Stroke 2000;31;2087-2092*

Tsang, T.S.M., Barnes, M.E., Miyasaka, Y. Cha, S.S., Bailey, K.R. Verzosa, G.C., Seward, J.B. and Gersh, B.J. (2008). Obesity as a risk factor for the progression of paroxysmal to permanent atrial fibrillation: a longitudinal cohort study of 21 years. *European Heart Journal.* 29, 2227–2233.

Voeller RK, Schuessler RB, Damiano RJ Jr. (2008). Surgical Treatment of Atrial Fibrillation. Cohn LH, ed. *Cardiac Surgery in the Adult.* New York: McGraw-Hill, 1375-1394.

Wang TJ et al. (2003). Temporal Relations of Atrial Fibrillation and Congestive Heart Failure and Their Joint Influence on Mortality: The Framingham Heart Study. *Circulation.* 107: 2920-2925.

Wolf PA, Abbott RD, Kannel WB. (1991). Atrial Fibrillation as an independent risk factor for stroke: The Framingham Study. Stroke. 22:983.

Wolf PA, Mitchell JB, Baker CS et al. (1998). Impact of atrial fibrillation on mortality, stroke, and medical costs. *Archives of Internal Medicine.* 158(3):229–234.

Zarifis J, Beevers G, Lip GY. (1997). Acute admissions with atrial fibrillation in a British multiracial hospital population. *British Journal of Clinical Practice.* 51(2):91–96.

Zhou, Z. and Hu, D. (2008). An Epidemiological Study on the Prevalence of Atrial Fibrillation in the Chinese Population of Mainland China. J Epidemiol. 18(5): 209-216.