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# **Contribution of vascular diseases and risk factors to the burden of dementia in Australia**

Australian Burden of Disease Study 2011

AUSTRALIAN BURDEN OF DISEASE STUDY SERIES NO. 9





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*Authoritative information and statistics  
to promote better health and wellbeing*

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Cat. no. BOD 10

**The Australian Institute of Health and Welfare is a major national agency that provides reliable, regular and relevant information and statistics on Australia's health and welfare.**

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# Abbreviations

AB	attributable burden
ABDS	Australian Burden of Disease Study
ABS	Australian Bureau of Statistics
AHS	Australian Health Survey
AIHW	Australian Institute of Health and Welfare
APOE	apolipoprotein E
BMI	body mass index
CI	confidence interval
CKD	chronic kidney disease
DALY	disability-adjusted life years
DSM	Diagnostic and Statistical Manual of Mental Disorders
ICD	International Statistical Classification of Diseases and Related Health Problems
NINCDS/ ADRDA	National Institute of Neurological and Communicative Disorders and Stroke/ Alzheimer's Disease and Related Disorders Association
P	prevalence of exposure
PAF	population attributable fraction
RR	relative risk
WHO	World Health Organization
YLD	years lived with disability
YLL	years of life lost

# Symbols

kg/m <sup>2</sup>	kilograms per metre squared
mg/dL	milligrams per decilitre
mmHg	millimetres of mercury
>	greater than
≥	greater than or equal to
<	less than
%	per cent
+	plus
±	plus-minus

# Summary

Dementia is a serious and growing health problem in Australia and numerous other countries with an ageing population. The Australian Burden of Disease Study (ABDS) 2011 estimated that dementia was responsible for 3.4% of the total health burden due to disease and injury in Australia in 2011. Among people aged 65 and over, dementia was the second leading cause of total burden (7.8%) and the leading cause of non-fatal burden (10%). There is currently limited effective treatment available and no cure for dementia.

This report looks at a range of modifiable vascular risk factors for dementia, and estimates their individual and combined contribution to the burden of dementia in Australia. Vascular risk factors in this study include: smoking, physical inactivity, midlife high blood pressure and midlife obesity, as well as vascular diseases that act as risk factors for dementia – diabetes, stroke, atrial fibrillation and chronic kidney disease. It uses burden of disease estimates from the ABDS 2011 and evidence in the literature that shows a link between these vascular risk factors and development of dementia in later life.

This report also includes scenario modelling to assess the potential impact on future dementia burden if risk factor exposure levels were reduced to meet the World Health Organization (WHO) targets in 2020 compared with current trends in risk factor prevalence continuing.

## Prospects for prevention

The analysis in this report indicates:

- about 30% of the total dementia burden in Australia was due to the joint effect of the vascular risk factors examined
- the proportion of dementia burden attributable to the combined risk factors increased with age
- the individual risk factors contributing most to the dementia burden were
  - behavioural risks – physical inactivity (contributing 8.0% of dementia burden) and tobacco use (4.8%)
  - metabolic risks – high blood pressure in mid-life (6.0%) and obesity in mid-life (5.6%)
  - diseases-as-risks: chronic kidney disease (8.4%), stroke (6.7%), diabetes (5.3%) and atrial fibrillation (5.2%)
- males experienced a greater proportion than females of the dementia burden attributable to each risk factor, except for physical inactivity (males 7.4%; females 8.3%) and chronic kidney disease (males 7.4%; females 9.0%).

## Impact of risk factor reduction on future dementia burden

Reducing risk factor prevalence to meet targets set by the WHO could result in a 14% reduction in dementia burden attributable to the vascular risk factors in 2020.

The largest health gains are expected from reducing the prevalence of diabetes (48% reduction in dementia burden due to diabetes), obesity in mid-life (26%) and physical inactivity (15%).



# 1 Introduction

Dementia is a serious and growing health problem in Australia and numerous other countries with an ageing population. It is marked by a progressive loss of memory and understanding, and as it advances in those affected, they become more and more unable to function and properly care for themselves. This makes the disease highly debilitating and often distressing for those with dementia, their families, friends and their carers (Norton et al. 2014; Prince et al. 2014). Also, because age is by far the main risk factor for the disease, the ageing of Australia's population means it is becoming much more common. The Australian Institute of Health and Welfare (AIHW) has estimated that, in 2011, dementia accounted for 3.4% of Australia's total burden of disease, which is the overall health impact of ill health and untimely death (see 'The impact of dementia' later in this chapter). Among those aged 65 and over, however, the contribution was 7.8%, making it the second largest cause of burden in older Australians after coronary heart disease (AIHW 2016b).

While research proceeds into treating or curing dementia, and as the population continues to age, it is particularly important to examine the prospects for preventing or modifying the disease to some extent. In fact, a range of factors are known to contribute to the risk of dementia and are potentially modifiable; that is, they can be treated or reduced. They include several diseases and several biomedical or behavioural risk factors: stroke, diabetes, chronic kidney disease (CKD) and atrial fibrillation (a form of irregular heartbeat), as well as smoking, physical inactivity, high blood pressure in mid-life and obesity in mid-life.

Cardiovascular disease, diabetes and CKD (referred to as 'vascular diseases' for the purposes of this report) are among the leading causes of morbidity, mortality and burden of disease in Australia. The relationship between these diseases, associated risk factors and dementia is well documented in the literature (de Bruijn & Ikram 2014; Fillit et al. 2008; Justin et al. 2013; Prince et al. 2014; Qiu & Fratiglioni 2015; Sahathevan et al. 2012).

## 1.1 This report, its aims and analytical approach

In view of the possible benefits of a risk factor approach, this report aims to:

- assess the contribution of modifiable vascular risk factors (including some vascular diseases that are considered risk factors in this context) to the burden of disease from dementia in Australia in 2011
- explore the impact of reducing the prevalence and incidence of these risk factors on future dementia burden.

In choosing which risk factors to examine, this report looks at those for which there is sufficient evidence of an association, and assesses their contribution to the dementia burden as estimated in the Australian Burden of Disease Study (ABDS) 2011. This study extends the standard approach for analysis of risk factors for disease to include selected diseases themselves as risk factors; in this case, vascular diseases as risks for dementia. These are termed 'diseases-as-risks'. The selected risk factors included diseases-as-risks, as well as risk factors for vascular diseases. Refer to Box 1.1 for definitions of the risk factors included in this study.

Another report in this series looks at the impact of diabetes and CKD as risks for other diseases, and uses the same extension of burden of disease methodology to provide a more comprehensive picture of the health loss due to diabetes and CKD (AIHW 2016c).

This AIHW report provides an important resource for population health monitoring, health policy design and service planning, in providing information on those risk factors that could be targeted to help prevent or delay the onset of dementia.

### **Box 1.1: Vascular risk factors**

#### **Defining vascular risk factors**

It is important to understand several key terms as used in this report and the distinction between them.

‘Vascular disease’ traditionally refers to diseases that involve damaged blood vessels, such as cardiovascular disease (including coronary heart disease and stroke). In this study, vascular diseases also encompass diabetes and CKD which can lead to damaged vasculature and increased risk of vascular disease, as well as dementia.

Risk factors for vascular diseases include factors that increase the risk of those vascular diseases, such as ‘behavioural risks’ (smoking and physical inactivity) and ‘metabolic risks’ (midlife high blood pressure and midlife obesity).

‘Vascular risk factors’ in this report refer to risk factors for dementia: this means metabolic and behavioural risk factors *and* some vascular diseases themselves, termed ‘diseases-as-risks’, such as diabetes, stroke, atrial fibrillation and CKD.

#### **Modifiable vascular risk factors used in analyses**

There is a wide range of risk factors for dementia (including genetic, behavioural, biomedical and social determinants). This report looks at those that are considered to be modifiable vascular risk factors for dementia, and where there is sufficient evidence of an association. This comprises diabetes, stroke, atrial fibrillation, CKD, obesity in mid-life, high blood pressure in mid-life, tobacco use and physical inactivity. See chapters 2 and 3 for more information.

This first chapter provides background information on dementia and its impact and likewise the vascular risk factors for dementia. It then describes the ‘burden of disease’ approach used in the subsequent analysis, and finally summarises the content of the following chapters.

## **1.2 Background**

### **More about dementia and its types**

Dementia is characterised by the impairment of higher brain function, including language, memory, perception, personality and cognitive skills. It is not a single specific disease – rather a group of symptoms and signs caused by numerous disorders (Box 1.2). Although the type and severity of symptoms and their pattern of development vary with the type of dementia, it is usually of gradual onset, progressive and irreversible (AIHW 2012). As already mentioned, treatment is limited.

### **Box 1.2: Types of dementia**

Dementia is not a single specific disease. It is an umbrella term describing a syndrome – a group of symptoms and signs – associated with more than 100 different diseases. As reported in the *World Alzheimer report 2014* (Prince et al. 2014), the 2 most common types of dementia are:

- Alzheimer disease – the most common type, accounting for about 50–75% of dementia cases worldwide. In its early stages, it is characterised by short-term memory loss, apathy and depression. Onset is gradual, decline is progressive and it is most common in older people, particularly women
- Vascular dementia – the second most common type, accounting for about 20–30% of dementia cases. Symptoms in the early stages are similar to Alzheimer disease, but memory loss is not as great and mood fluctuations are more prominent. Its onset can be sudden and physical frailty is also evident. The course of the disease is less predictable than for Alzheimer disease, with the decline likely to be more progressive, often with periods of rapid deterioration.

After these, the next most common types of dementia are dementia with Lewy bodies and frontotemporal dementia.

There is emerging evidence of a crossover between the pathologies and causes of Alzheimer disease and vascular dementia – with many people having mixed types of dementia rather than a pure type (de Bruijn & Ikram 2014; Matthews et al. 2009).

#### **Dementia definition for this report includes all types**

The results in this report relate to all types of dementia combined; that is, they are not specific to certain types of dementia, such as Alzheimer disease or vascular dementia. This approach is due to emerging evidence about overlapping causes. Dementia is mainly mixed in an individual, with pure Alzheimer disease and vascular dementia neuropathology rare in people over 80 (Matthews et al. 2009). The vascular risk factors, such as high blood pressure and diabetes, are therefore likely to influence all dementia types (Qiu & Fratiglioni 2015). At the population level, looking at dementia overall is preferred because the policy and health promotion implications are largely similar regardless of the dementia type (Kling et al. 2013).

While dementia carries a significant economic burden and impact on the quality of life for the person affected, their families, friends and carers, this report confines itself to the health burden only.

## **The impact of dementia**

Dementia has profound consequences for the health and quality of life for those with the condition and their family, friends and carers. People with dementia eventually become dependent on their carers in most, if not all, activities of daily living. They typically live for many years after the onset of symptoms of dementia, bringing substantial personal, social and economic consequences (AIHW 2012).

The AIHW has estimated that around 342,800 Australians had dementia in 2015. Based on projections of population ageing and growth, the number with dementia may increase to around 900,000 by 2050 (AIHW 2012). Dementia is primarily a disease of older age and chiefly affects people aged over 65. It is estimated that 1 in 10 Australians aged 65 and over had dementia in 2015, increasing to 3 in 10 for those aged 85 and over.

Dementia is a leading cause of death and burden of disease. More specifically, it was the second leading underlying cause of death in Australia in 2013 (AIHW 2016d); second leading cause of total burden in 2011 among people aged 65 and over; and the leading cause of non-fatal burden among people aged 65 and over (10%) (AIHW 2016b).

Dementia also poses a large demand on health and aged care services. For example, in 2014–15, about 52% of permanent residents in Australian Government-funded aged care facilities had a diagnosis of dementia (AIHW 2016e).

## **Vascular risk factors for dementia and the potential for prevention**

There is increasing evidence of an association between vascular risk factors – including disease, metabolic and behavioural risk factors – and an increased risk of dementia. This evidence has been established for both Alzheimer disease (de Bruijn & Ikram 2014; Hachinski 2011; Hachinski & Munoz 1997; Iadecola 2013; Jagust 2001; Kelleher & Soiza 2013) and vascular dementia (Gorelick et al. 2011; Hayden et al. 2006; Iadecola 2013; Sahathevan et al. 2012).

As already mentioned, this study includes risk factors for vascular disease (such as high blood pressure in mid-life, obesity in mid-life, smoking and physical inactivity) and some vascular diseases themselves (such as diabetes, stroke, atrial fibrillation and CKD) (de Bruijn & Ikram 2014; Fillit et al. 2008; Justin et al. 2013; Prince et al. 2014; Qiu & Fratiglioni 2015; Sahathevan et al. 2012).

It follows that if those risk factors increase the risk of dementia, then reducing them at a population level could reduce its age-specific incidence or delay its onset (Barnes & Yaffe 2011; Norton et al. 2014; Prince et al. 2014; Roman et al. 2012). However, it is important to acknowledge that this could also result in an increase in the overall prevalence of dementia, with more individuals living longer as a result of effective management or prevention of associated risk factors, and being at risk of developing dementia in old age.

## **A lifecourse approach to dementia and its risk factors**

There is increasing evidence that diseases associated with ageing, such as dementia, are influenced by exposure to risk factors across a person's lifecourse (Liu et al. 2010; Whalley et al. 2006). Vascular risk factors associated with dementia may have different impacts depending on when exposure occurs and for how long. For example, having high blood pressure in mid-life but not in late life is associated with increased risk of dementia (Qiu & Fratiglioni 2015; Qiu et al. 2005). This has important implications for the selection and timing of prevention and treatment strategies (Launer 2005).

Accumulating risk across the lifecourse is also likely to influence dementia risk in later life. For example, diabetes in later life is associated with an increased risk of dementia. However, it is likely that the impact of diabetes and other exposures that influence brain health through vascular mechanisms exert their effect over time (Launer 2005; Qiu & Fratiglioni 2015). Prevention and effective management of vascular risk across all ages may therefore contribute to reduced dementia risk through lower overall incidence and reduced length of exposure (Prince et al. 2014; Qiu & Fratiglioni 2015; Roman et al. 2012).

It is important to note that numerous vascular risk factors are not independent of each other. Exposure to one risk factor may result in an increased risk of exposure to another risk factor. For example, diabetes is associated with increased risk of CKD. Interventions that target

diabetes may therefore influence the impact from multiple risk factors associated with dementia.

## **Assessing the impact of risk factors on the burden of dementia**

Burden of disease analysis provides a unique perspective on the relationship between risk factors and dementia and enables assessment of the impact of living with, and dying prematurely from the disease. The findings from investigating potentially modifiable risk factors in this way can be used to inform health promotion and prevention initiatives.

### **What is ‘burden of disease’?**

Burden of disease analysis assesses and compares the health impact of different diseases, conditions or injuries (‘diseases’ for simplicity) and risk factors on a population. It captures the impact of both living with the disease and dying prematurely.

The ABDS 2011 quantified the fatal and non-fatal effects of these diseases in a consistent manner so that they can then be combined into a summary measure of health called the DALY – disability-adjusted life years. The DALY measure combines the estimates of years of life lost due to premature death (YLL) and years lived in ill health or with disability (YLD) to count the total years of healthy life lost from diseases. These and other key terms relating to burden of disease analysis are defined in Box 1.3.

Taking all diseases into account, this health loss represents the difference between the current health status of the population and the ideal situation where everyone lived a long life, free of disease. Burden of disease estimates capture both the quantity and quality of life, and reflect the magnitude, severity and impact of disease and injury within a population in the given year. The analysis also estimates the contribution of various risk factors to health loss, known as the attributable burden. It is important to note that burden described in burden of disease studies is solely the health loss experienced by the individuals with the disease and not the associated social and economic losses – significant though they may be.

Attributable burden reflects the direct relationship between a risk factor and a disease outcome (dementia in the case of this report). It is the amount by which disease (that is, dementia) burden would be reduced if exposure to the risk factor (including diseases-as-risks) had been avoided or reduced to the lowest possible exposure.

For detailed information about the ABDS 2011, and further information on the methods used to calculate disease burden, please refer to *Australian Burden of Disease Study: impact and causes of illness and death in Australia 2011* (AIHW 2016b) and *Australian Burden of Disease Study 2011: methods and supplementary material* (AIHW 2016a).

## **1.3 Structure of this report**

This report provides an analysis of the impact of vascular diseases and risk factors on dementia burden. The structure of this report is:

- Chapter 2 describes the methods used in this report to estimate the dementia burden attributable to selected risk factors.
- Chapter 3 summarises the results of analyses to estimate the impact of vascular risk factors on the burden of dementia, and the results of scenario modelling to look at the potential impact of reductions in risk factor prevalence.

- Chapter 4 provides commentary on the implications of the findings, limitations of the study and concluding remarks.
- Appendix A provides information on the selection of relative risks used in this report for the association between each of the risk factors and vascular diseases examined, and the risk of dementia.
- Appendix B provides information on the methods used for the scenario modelling to look at the impact of reductions in risk factor prevalence on the burden of dementia, as well as detailed results from this analysis.

### **Box 1.3: Key terms used in this report**

**attributable burden:** The disease burden attributed to a particular risk factor. It is the reduction in burden that would have occurred if exposure to the risk factor had been avoided (or, more precisely, had been at its theoretical minimum).

**comparative risk assessment:** The process for estimating the burden of disease attributable to selected risk factors. It involves 5 key steps: selection of risk–outcome pairs; estimation of exposure distribution; estimation of effect sizes; choice of theoretical minimum risk exposure level; and the calculation of attributable burden.

**DALY (disability-adjusted life years):** Years of healthy life lost, either through premature death or equivalently through living with disability due to illness or injury.

**diseases-as-risks:** Diseases that represent a greater risk of developing another disease. For example, diabetes and stroke are risk factors for the development of dementia. That is, people with diabetes or people who experience a stroke have a greater risk of developing dementia compared with people who do not have diabetes or who have not had a stroke.

**effect size:** A statistical measure of the strength of the relationship between 2 variables (in this context, between a risk exposure and a disease outcome), expressed, for example, as a relative risk.

**joint effect:** The total proportion attributable to risk factors of interest, taking into account risk factors on the same causal pathway.

**population attributable fraction (PAF):** For a particular risk factor and causally linked disease or injury, the percentage reduction in burden that would occur for a population if exposure to the risk factor was avoided or reduced to its theoretical minimum.

**relative risk (RR):** The risk of an event relative to exposure, calculated as the ratio of the probability of the event occurring in the exposed group to the probability of it occurring in the non-exposed group. A relative risk of 1 implies no difference in risk; a RR <1 implies the event is less likely to occur in the exposed group; and a RR >1 implies the event is more likely to occur in the exposed group.

**risk factor (for health):** Any factor that causes or increases the likelihood of a health disorder or other unwanted condition or event.

**YLD (years lived with disability):** Measure the years of what could have been a healthy life that were instead spent in states of less than full health. YLD represent non-fatal burden.

**YLL (years of life lost):** Measure years of life lost due to premature mortality. YLL represent fatal burden.

Refer to the Glossary for a full list of terms.

## 2 Methods

The dementia burden attributable to selected risk factors was estimated using the comparative risk assessment (CRA) methodology (Murray et al. 2003). In this study, the steps followed were:

- select risk factors, and the effect size of risk factors on dementia
- estimate the risk factor exposure and define the theoretical minimum risk exposure distribution (TMRED)
- calculate the population attributable fraction (PAF)
- quantify the dementia burden attributable to the selected risk factors.

These individual steps taken to calculate the dementia burden attributable to selected risk factors form the structure of this chapter. These methods are further explored and described in more detail in appendixes A and B.

### 2.1 Selecting risk factors and relative risks for dementia

Several vascular risk factors (including diseases, metabolic and behavioural risk factors) were investigated for inclusion in this report. Current evidence of the association between vascular risk factors and dementia was assessed against the following criteria:

- sufficient evidence for an association between exposure and dementia outcome based on high-quality epidemiological studies
- evidence based on an exposure definition that is appropriate for Australia and consistent between studies
- sufficient data to estimate population exposure to the risk factor
- a plausible biological mechanism linking the risk factor and dementia
- the risk factor is modifiable or preventable (Appendix A).

Following this assessment, 8 risk factors met these criteria: 4 diseases-as-risks (diabetes, stroke, atrial fibrillation and CKD); 2 metabolic risks (obesity in mid-life and high blood pressure in mid-life); and 2 behavioural risks (tobacco use and physical inactivity). The level of evidence for an association between risk factor exposure and development of dementia was 'convincing' for all risk factors except CKD, where the level of evidence was 'possible' to 'probable' (Appendix A, Table A1).

Relative risks (RRs) were selected from published meta-analyses or prospective studies (Table A1). RRs were adjusted for confounders and other risk factors that are included in this study. The RRs used in this study were for all types of dementia (rather than for specific types).

### 2.2 Population exposure to selected risk factors

Estimates of risk factor exposure were calculated to align, or most closely align, with definitions used by the studies from which RRs were sourced. Exposure prevalence was

sourced from relevant Australian data, by age and sex, in the finest possible increments (Table 2.1). As the exposure estimates for behavioural and metabolic risk factors were based on survey data, to reduce the impact of survey error, data were extracted at a level where the relative standard error (see Glossary) was 25% or less.

In this analysis, exposure was treated as a dichotomous categorical variable; that is, exposed to the risk factor or not exposed to the risk factor. The proportion not exposed to a risk factor is referred to as the theoretical minimum risk exposure level. For example, the proportion of the population with a systolic blood pressure of 120–139 mmHg in mid-life is the theoretical minimum exposure level, or the proportion ‘not exposed’. Those with a systolic blood pressure greater than or equal to 140 mmHg (‘high’ blood pressure) in mid-life are the ‘exposed’ population and at risk of dementia.

**Table 2.1: Risk factor population exposure definition and data source, 2011**

Risk factor	Definition of exposure	Data source
<b>Behavioural risks</b>		
Physical inactivity	Prevalence of physical inactivity (people classified as inactive or insufficiently active for health) among people aged 45 and over	ABS AHS 2011–12
Tobacco use	Prevalence of current tobacco use among people aged 45 and over	ABS AHS 2011–12
<b>Metabolic risks</b>		
High blood pressure in mid-life	Prevalence of systolic blood pressure $\geq 140$ mmHg among people aged 35–64	ABS AHS 2011–12
Obesity in mid-life	Prevalence of obesity (body mass index $\geq 30$ kg/m <sup>2</sup> ) among people aged 35–64	Australian Bureau of Statistics (ABS) Australian Health Survey (AHS) 2011–12
<b>Diseases-as-risks</b>		
Stroke	Prevalence of previous stroke among people aged 45 and over	AIHW burden of disease database, 2011
Diabetes	Prevalence of diagnosed and undiagnosed diabetes in people aged 65 and over	AIHW burden of disease database, 2011
Atrial fibrillation	Prevalence of atrial fibrillation among people aged 45 and over	AIHW burden of disease database, 2011
Chronic kidney disease (CKD)	Prevalence of CKD, stages 3 to 5, among people aged 45 and over	AIHW burden of disease database, 2011

*Note:* Exposure is estimated using different age groups to reflect the ages where being exposed to the risk factor is associated with the development of dementia.

## Mid-life risk factor exposure

For some risk factors, it is past exposure rather than current exposure that is associated with dementia risk (Anstey et al. 2011; Barnes & Yaffe 2011; Qiu et al. 2005). Therefore, to estimate population exposure to high blood pressure and obesity, prevalence was calculated as the probability of being both exposed to the risk factor (for example, high blood pressure) and being in mid-life (defined for this analysis as aged 35–64). A similar method was used in analyses by Barnes and Yaffe (2011) and Norton and others (2014), where the prevalence of midlife exposure was estimated from the total adult population (aged 25 and over).

The prevalence of midlife exposure was calculated as:

$$\text{Prevalence}(\text{mid-life}) = \frac{\text{Number exposed aged 35-64}}{\text{Total population aged 25 and over}}$$

Note, the denominator used in this calculation refers to people aged 25 and over which represents the total adult population at risk of dementia due to these risk factors.

## Diabetes exposure

Diabetes was the only disease risk factor where exposure was limited to people aged 65 and over. This report aligned diabetes exposure to the RR selected from available literature that supported a consistent and convincing association with diabetes prevalence in late life (65 years and over) and risk of any dementia. At the time of this analysis, there was insufficient evidence linking the development of dementia with diabetes exposure in mid-life. The selection of RRs for diabetes is described further in Appendix A.

It is important to note that the RRs differ by age. For example, diabetes, high blood pressure and obesity in mid-life do not contribute to dementia burden under the age of 65. That is, the RR for developing dementia in this age group is 1; that is, no additional risk.

## 2.3 Calculation of population attributable fractions and attributable burden

Population attributable fractions (PAFs) determine the proportion of a particular disease that could have potentially been avoided if the population had never been exposed to a risk factor (Box 1.3).

The key data inputs for calculating PAFs were:

- the effect size; in this case, the RR of the risk factor on the outcome of interest (in this case, dementia)
- the prevalence (P) of risk factor exposure in the population.

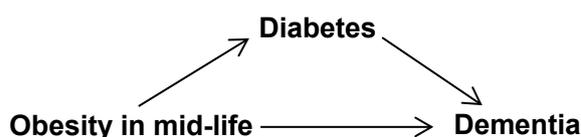
The age- and sex-specific PAFs were then applied to the dementia burden estimates from the ABDS 2011, to determine the burden due to each risk factor (attributable burden). For details of this method and the formulae used in this calculation, see Appendix B.

### Estimating the joint effect

In this study, as a general rule, risk factors are assessed independently. This means that the attributable burden estimated for each risk factor cannot be added together (see Box 2.1). Rather, the joint effect is estimated, which is the attributable burden from all risk factors combined, taking into account risk factors that are on the same causal pathway. The joint effect formula is described in Appendix B.

### Box 2.1: Why risk factor estimates cannot simply be added together

For the majority of the analysis in this report, the risk factors are analysed independently. It is important to note that it is not possible to add or combine the separate estimates for different risk factors without further analysis. This arises from the complex relationships and interactions between risk factors. That is, a risk factor may be in the causal pathway for another risk factor. For example, obesity in mid-life is a risk factor for diabetes which is also a risk factor for dementia. The arrow diagram in this box provides an example of the interplay between risk factors.



Although RRs used in this study have been adjusted for potential confounders, this does not allow risk factor estimates to be added together. Further analysis is needed to combine risk factors. In this report, a PAF has been calculated for 'all risk factors combined'. It is referred to as the 'joint effect' of all risk factors in this study.

## 2.4 Scenario modelling

To investigate the potential impact of changes in risk factor prevalence on the burden of dementia, 2 scenarios were used to calculate the attributable burden for dementia. The difference in attributable burden between these scenarios provides an indication of the amount of future dementia burden associated with the risk factors that could be avoided.

The scenarios used for these estimates were as follows:

- *Trend scenario* – used an estimate of future dementia burden to calculate the amount attributable to vascular risk factors assuming current trends in risk factor exposure in Australia continue until 2020.
- *WHO target scenario* – used an estimate of future dementia burden to calculate the amount attributable to vascular risk factors if exposure to these risk factors in Australia was aligned to meet targets in the World Health Organization (WHO) Global Action Plan for the Prevention and Control of Noncommunicable Diseases 2013–2020 (WHO 2013). These targets propose reducing or halting disease and risk factor prevalence by 2025 compared with a baseline of the 2010 prevalence in Australia (see Table 3.5).

The year 2020 was chosen as the basis of these calculations because dementia burden in that year could be estimated from published projections of dementia prevalence in 2020 (AIHW 2012), as well as assessing the potential impact of being on track in 2020 to meet the WHO targets by 2025.

The key inputs into this scenario analysis were the total estimated dementia burden (measured in DALY) in 2020 as well as projected estimates of risk factor exposure in 2020 for the *Trend scenario* and the *WHO target scenario*.

Under each scenario, the joint effect of vascular risk factors as well as the impact of individual risk factors were calculated.

The difference in attributable DALY between the 2 scenarios reflects the amount of future dementia burden that could be avoided if current trends in risk factor prevalence continue, compared with if Australia is on track in 2020 to meet the WHO targets set for 2025.

In these scenarios, it was not possible to take into account interactions between the risk factors that occur in the same causal pathway or the impact of interventions, diagnosis and treatment on future dementia prevalence and risk factor exposure. These scenarios also assume that the impact of dementia risk factors not discussed in this report remains stable, as it was not possible to account for these in the calculation of future dementia burden.

Further details on the methods used for scenario modelling in this report, including detailed results, key assumptions and limitations, are described in Chapter 3 and Appendix B.

## 3 Dementia burden attributable to risk factors

This chapter begins by describing the burden due to dementia in Australia in 2011 as estimated in the ABDS 2011. It then reports estimates of the dementia burden attributable to each risk factor examined in this study (and all risk factors combined). The results of scenario modelling to look at the impact on dementia burden that would result with a reduction in risk factor prevalence is also included, with further detail included in Appendix B.

### 3.1 Dementia burden

In 2011, the burden due to dementia was 151,308 DALY (Table 3.1), representing 3.4% of total burden due to all diseases and injuries in Australia. Females (95,716 DALY) had more dementia burden compared with males (55,593 DALY) (Table 3.1).

Almost all (99%) dementia burden occurs among people aged 45 and over and 81% of dementia burden was experienced by people aged 75 and over (AIHW 2016b). As most dementia occurs after age 45, burden experienced before age 45 is excluded from the remaining analysis.

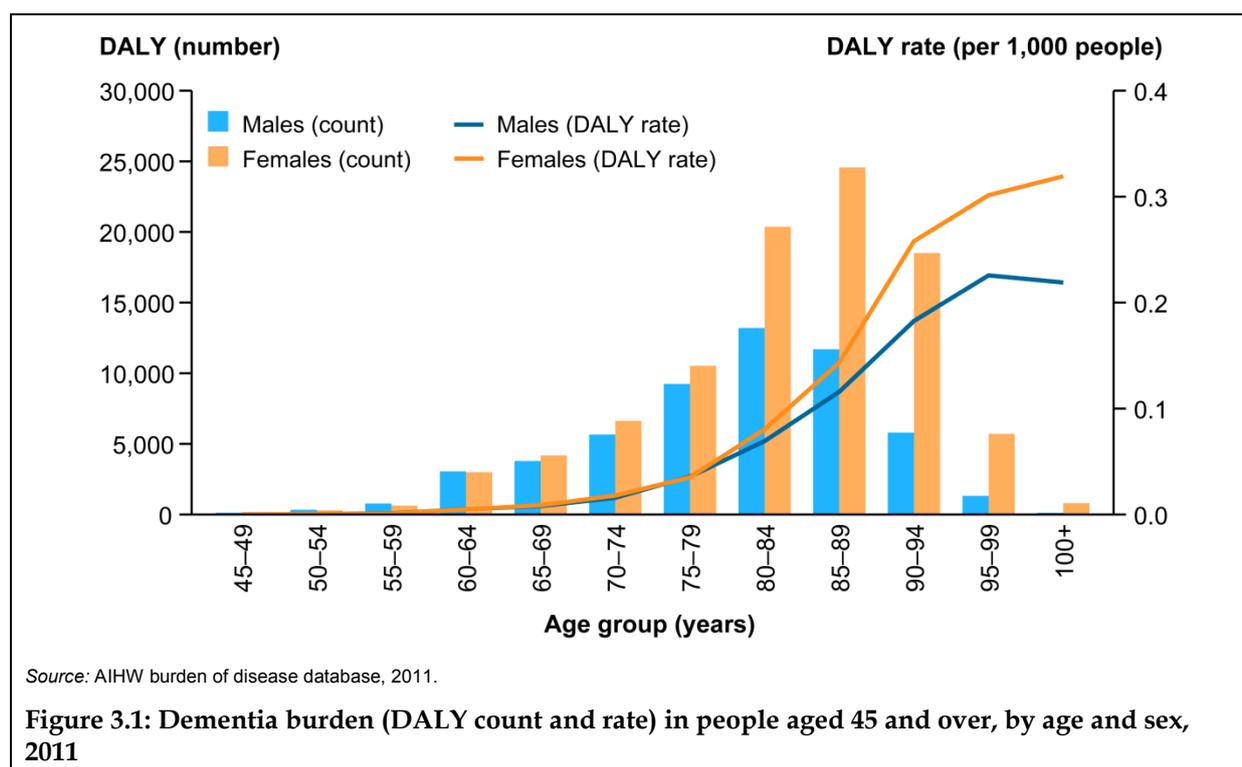
**Table 3.1: Dementia burden and percentage of burden by age and sex, 2011**

Age group (years)	Males		Females		Persons	
	DALY	%	DALY	%	DALY	%
Under 45	495	0.9	364	0.4	859	0.6
45–64	4,290	7.7	4,069	4.3	8,359	5.5
65–74	9,437	17.0	10,812	11.3	20,249	13.4
75–84	22,440	40.4	30,893	32.3	53,333	35.2
85 and over	18,930	34.1	49,578	51.8	68,509	45.3
<b>All ages</b>	<b>55,593</b>	<b>100.0</b>	<b>95,716</b>	<b>100.0</b>	<b>151,308</b>	<b>100.0</b>

*Note:* Numbers may not sum to the total due to rounding.

*Source:* AIHW burden of disease database, 2011.

Figure 3.1 shows dementia burden (DALY counts and rates per 1,000 population) in males and females aged 45 and over. Dementia DALY rates increased with age, and were similar for males and females aged 45–79, after which DALY rates were higher among females compared with males. In these age groups, females experienced more dementia burden than males. The largest burden occurred among males and females aged 80–89.



Around half of the dementia burden was fatal (53%) and half was non-fatal (47%) (Table 3.2). This indicates that dementia causes both years of life lost due to premature death (YLL) and years of life lost due to living in ill health (YLD). In males, a higher proportion of dementia burden is fatal (56%) when compared with females (52%).

**Table 3.2: Number and percentage of dementia burden by type (fatal and non-fatal) and sex, 2011**

	Males		Females		Persons	
	Number	%	Number	%	Number	%
Non-fatal (YLD)	24,273	43.7	46,385	48.5	70,658	46.7
Fatal (YLL)	31,320	56.3	49,330	51.5	80,650	53.3
<b>DALY</b>	<b>55,593</b>	<b>100.0</b>	<b>95,716</b>	<b>100.0</b>	<b>151,308</b>	<b>100.0</b>

Note: Numbers may not sum to the total due to rounding.

Source: AIHW burden of disease database, 2011.

## 3.2 Dementia burden attributable to all risk factors combined

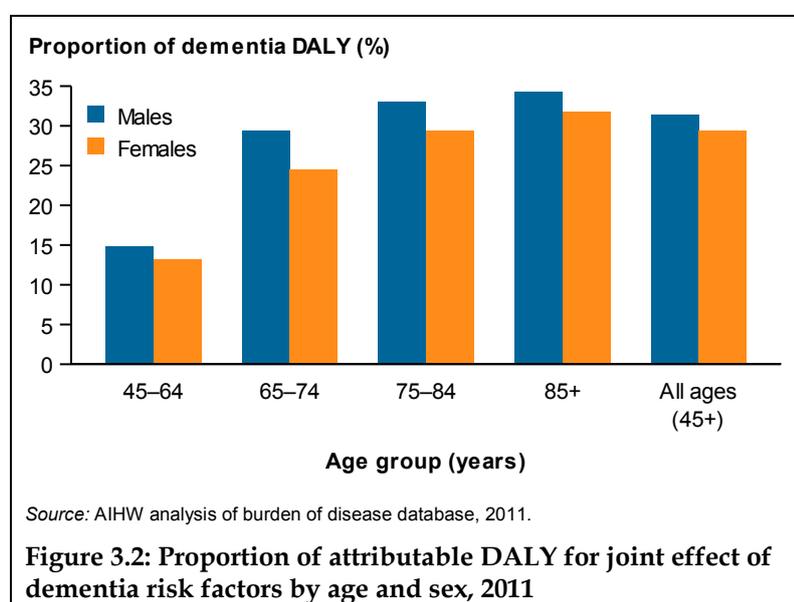
The joint effect of all vascular risk factors was 30% of the total dementia burden in 2011 (Table 3.3), and was similar for males (31%) and females (29%) (Figure 3.2). Refer to Box 2.1 for a description of the joint effect and why it is not possible to simply add individual risk factor estimates together.

**Table 3.3: Number and percentage of attributable DALY for joint effect of dementia risk factors, by age, 2011**

Age group (years)	Attributable DALY	
	Number	%
45–64	1,170	14.0
65–74	5,415	26.7
75–84	16,486	30.9
85 and over	22,216	32.4
<b>All ages (45+)</b>	<b>45,287</b>	<b>30.1</b>

Source: AIHW analysis of burden of disease database, 2011.

For those aged 65 and over, the impact on dementia burden of all risk factors combined increased from 29% of males aged 65–74 to 34% among males aged 85 and over (Figure 3.2). In females, the joint effect was slightly lower compared with males in all age groups and increased from 24% in females aged 65–74 to 32% aged 85 and over.



**Figure 3.2: Proportion of attributable DALY for joint effect of dementia risk factors by age and sex, 2011**

### 3.3 Which risk factors contribute the most dementia burden?

The **individual** contribution of each risk factor was calculated as the number of DALY attributable to dementia.

Physical inactivity was responsible for 8.0% of the dementia DALY, followed by stroke (6.7%), high blood pressure in mid-life (6.0%) and obesity in mid-life (5.6%) (Table 3.4). Although CKD was responsible for 8.4% of dementia DALY, the current evidence supporting this causal association is not as high as other included risk factors, and should be interpreted with this in mind.

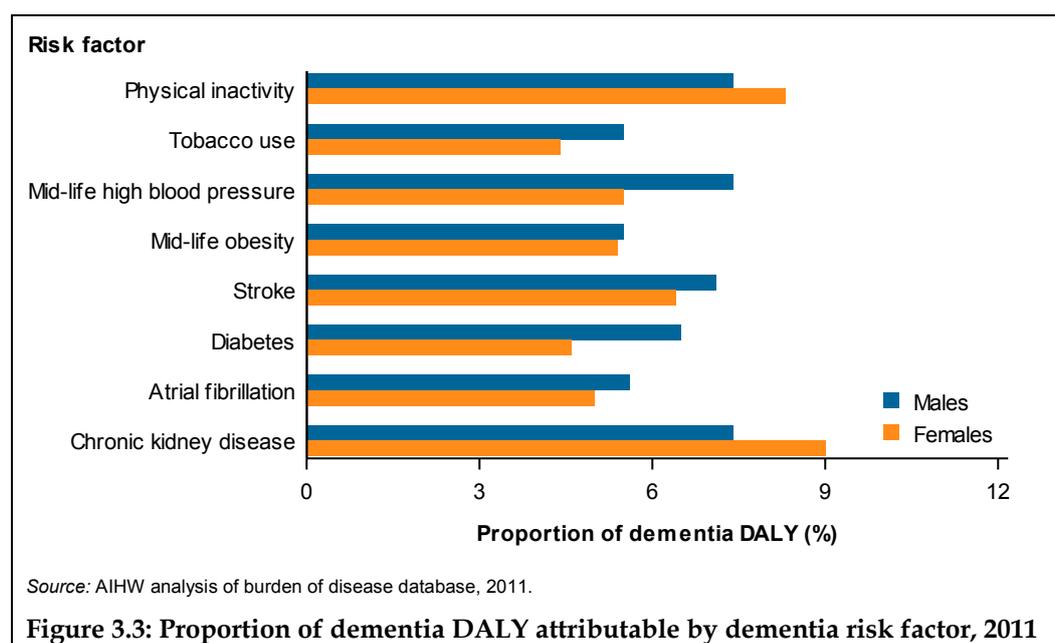
Males experienced a greater proportion of dementia burden attributable to each risk factor, with the exception of CKD (males 7.4%; females 9.0%) and physical inactivity (males 7.4%; females 8.3%) (Figure 3.3).

**Table 3.4: Dementia burden (number of DALY and %) attributable to vascular risk factors, 2011**

Risk factor	Males		Females		Persons	
	Number	%	Number	%	Number	%
<b>Behavioural risks</b>						
Physical inactivity	4,091	7.4	7,878	8.3	11,969	8.0
Tobacco use	3,036	5.5	4,225	4.4	7,260	4.8
<b>Metabolic risks</b>						
High blood pressure in mid-life	4,091	7.4	5,232	5.5	9,070	6.0
Obesity in mid-life	3,036	5.5	5,147	5.4	8,408	5.6
<b>Diseases-as-risks</b>						
Stroke	3,921	7.1	6,105	6.4	10,027	6.7
Diabetes	3,597	6.5	4,421	4.6	8,018	5.3
Atrial fibrillation	3,099	5.6	4,787	5.0	7,886	5.2
Chronic kidney disease <sup>(a)</sup>	4,067	7.4	8,611	9.0	12,678	8.4
<b>Joint effect</b>	<b>17,295</b>	<b>31.4</b>	<b>27,992</b>	<b>29.4</b>	<b>45,287</b>	<b>30.1</b>

(a) Relative risk used in attributable burden calculation for chronic kidney disease is based on available evidence from a small-scale study.

Source: AIHW analysis of burden of disease database, 2011.



**Figure 3.3: Proportion of dementia DALY attributable by dementia risk factor, 2011**

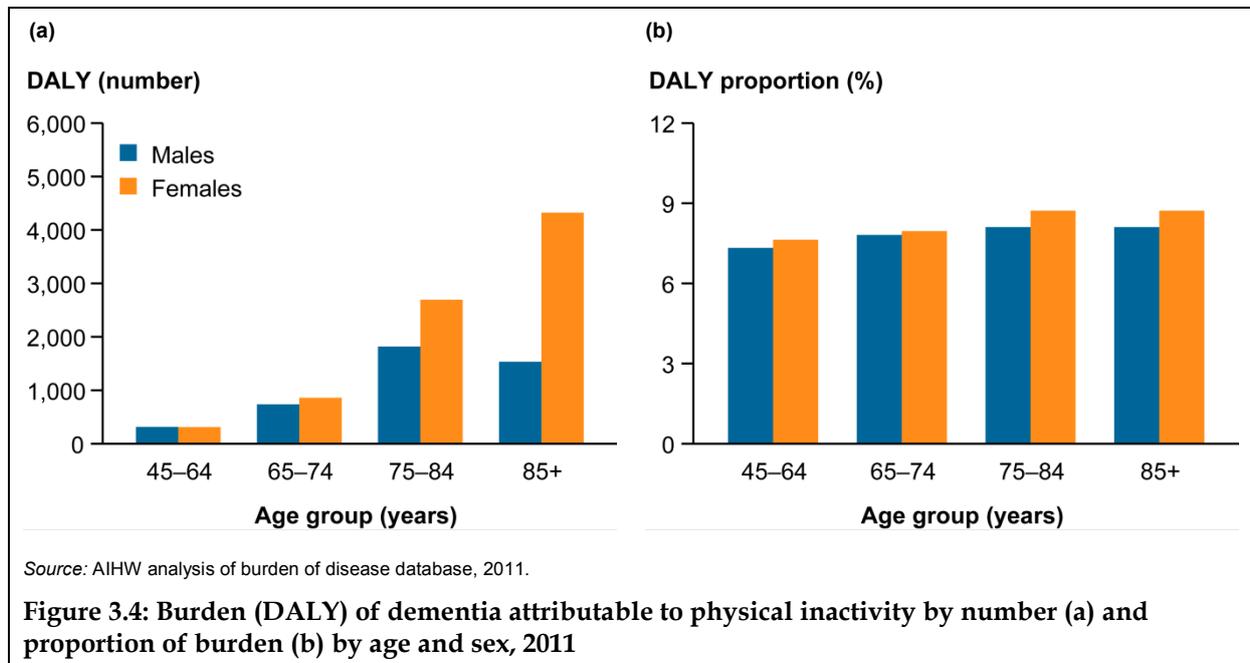
## Behavioural risk factors

Behavioural risk factors for dementia include physical inactivity and tobacco use. Physical inactivity refers to people aged 45 or over who are inactive or insufficiently active. This included people exposed to less than 150 minutes of physical activity (including walking for fitness and moderate and vigorous physical activity for fitness, recreation or sport, stretching, walking for transport and gardening) in the previous week. Tobacco use refers to current tobacco smokers aged 45 and over.

### Physical inactivity

In 2011, 8.0% of dementia burden (11,969 DALY) was attributable to physical inactivity. Females accounted for almost twice the number of DALY (7,878) attributable to physical inactivity as males (4,091 DALY) (Table 3.4).

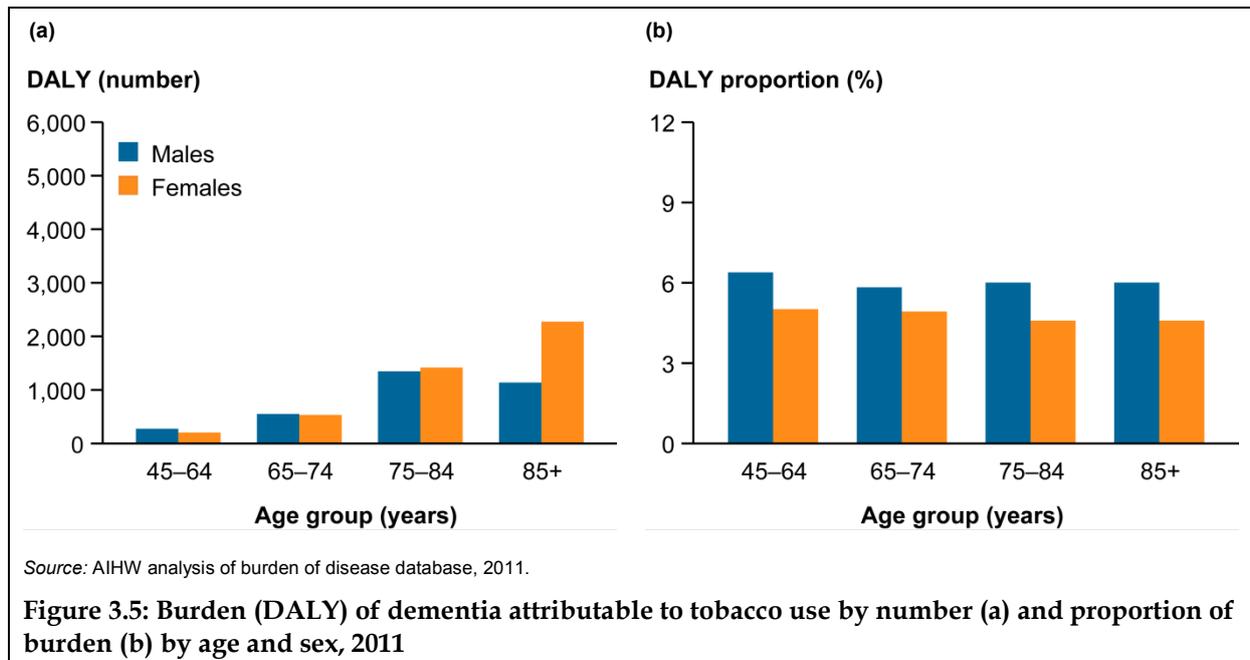
The proportion of dementia burden due to physical inactivity was higher for females (8.3% compared with 7.4% for males) (Table 3.4). The proportion of dementia burden in each age group was relatively similar for males and females; but slightly higher in females after age 75 and over, which accounted for this difference (Figure 3.4).



## Tobacco use

In 2011, 4.8% of dementia burden was attributable to tobacco use, or 7,260 DALY (Table 3.4).

Females experienced a greater number of DALY (4,225) compared with males (3,036 DALY); however, the proportion of dementia burden due to tobacco use was higher for males (5.5% compared with 4.4% for females) (Table 3.4). This reflects the higher prevalence of tobacco use among males. Dementia burden due to tobacco use was very similar across age groups (Figure 3.5).



## Metabolic risk factors in mid-life

The metabolic risk factors included in this study were high blood pressure and obesity in mid-life. Exposure definitions in mid-life (ages 35-64) for each as a risk for dementia include:

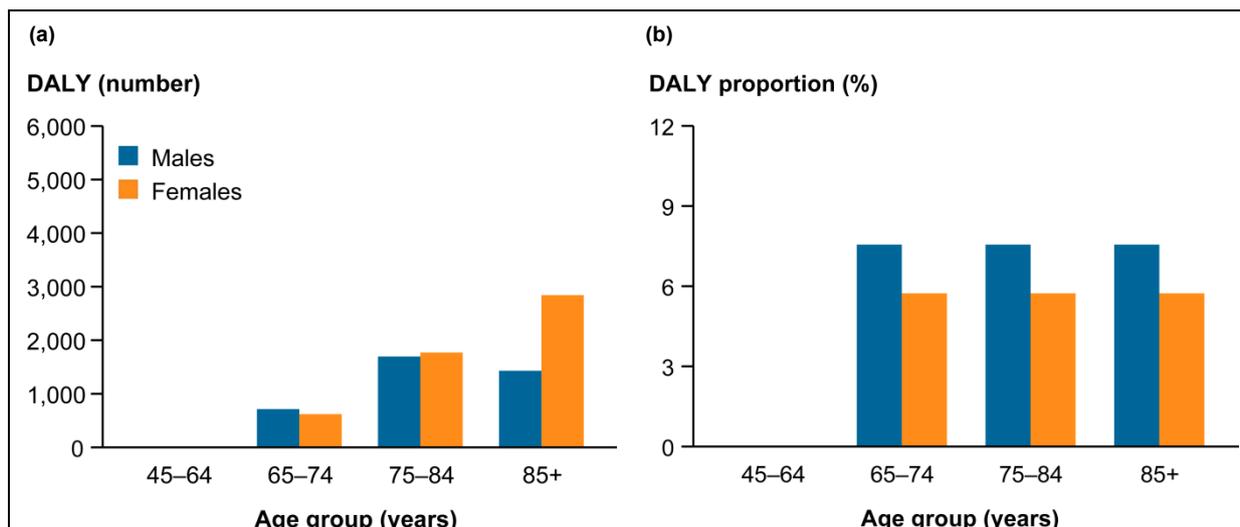
- people with a systolic blood pressure greater than or equal to 140 mmHg
- people with a body mass index greater than or equal to 30 kg/m<sup>2</sup>.

This section outlines their impact on dementia burden.

### High blood pressure in mid-life

In 2011, 6.0% of dementia burden was attributable to high blood pressure in mid-life or 9,070 DALY (Table 3.4).

Females experienced a higher number of DALY (5,232) compared with males (4,091 DALY); however, the proportion of dementia due to midlife high blood pressure was higher in males (7.4%) compared with females (5.5%) (Table 3.4). The percentage of dementia burden attributable to midlife high blood pressure was similar across age groups (Figure 3.6).



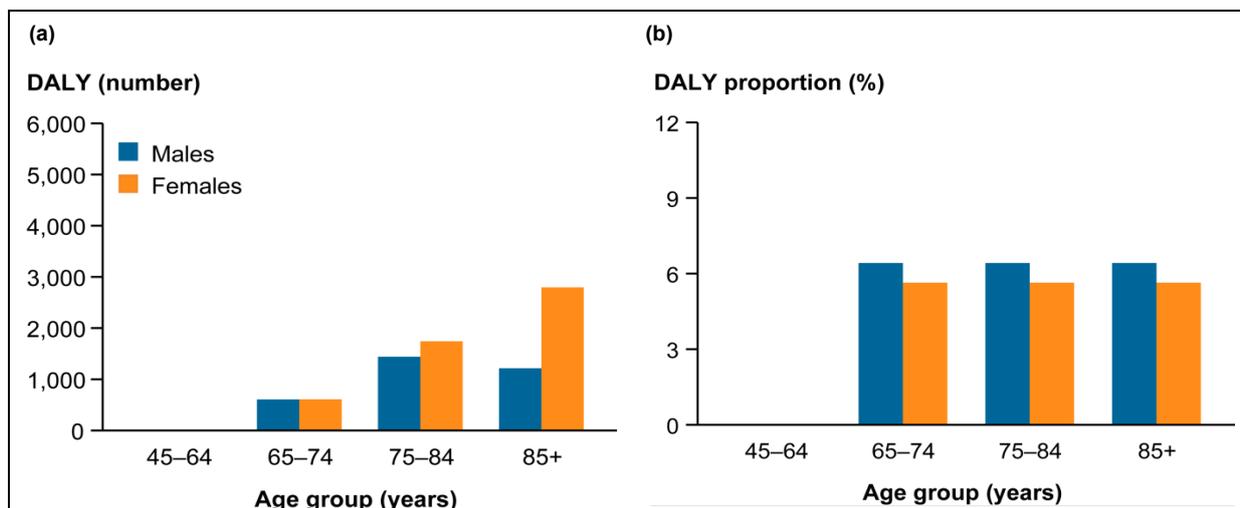
Note: Attributable burden was not calculated for ages 45-64, as the causal association is in dementia in late life (ages 65 and over).  
 Source: AIHW analysis of burden of disease database, 2011.

**Figure 3.6: Burden (DALY) of dementia attributable to high blood pressure in mid-life by number (a) and proportion of burden (b) by age and sex, 2011**

### Obesity in mid-life

In 2011, 5.6% of dementia burden was attributable to obesity in mid-life, or 8,408 DALY (Table 3.4).

Females experienced a higher number of DALY (5,147) compared with males (3,036 DALY); however, the proportion of dementia due to midlife obesity was similar in males and females (5.5% and 5.4%, respectively) (Table 3.4). The percentage of dementia burden attributable to midlife obesity was similar across age groups (Figure 3.7).



Note: Attributable burden was not calculated for ages 45-64, as the causal association is in dementia in late life (ages 65 and over).  
 Source: AIHW analysis of burden of disease database, 2011.

**Figure 3.7: Burden (DALY) of dementia attributable to obesity in mid-life by number (a) and proportion of burden (b) by age and sex, 2011**

## Diseases as risk factors

The diseases-as-risks examined in this study included stroke, diabetes, atrial fibrillation and CKD. Exposure definitions for each, as a risk for dementia include:

- people aged 45 and over who have had single or multiple strokes (excluding transient ischaemic attacks)
- late-life (aged 65 and over) prevalence of diagnosed and undiagnosed type 1 and type 2 diabetes
- people aged 45 and over with atrial fibrillation
- prevalence of CKD at stages 3 to 5.

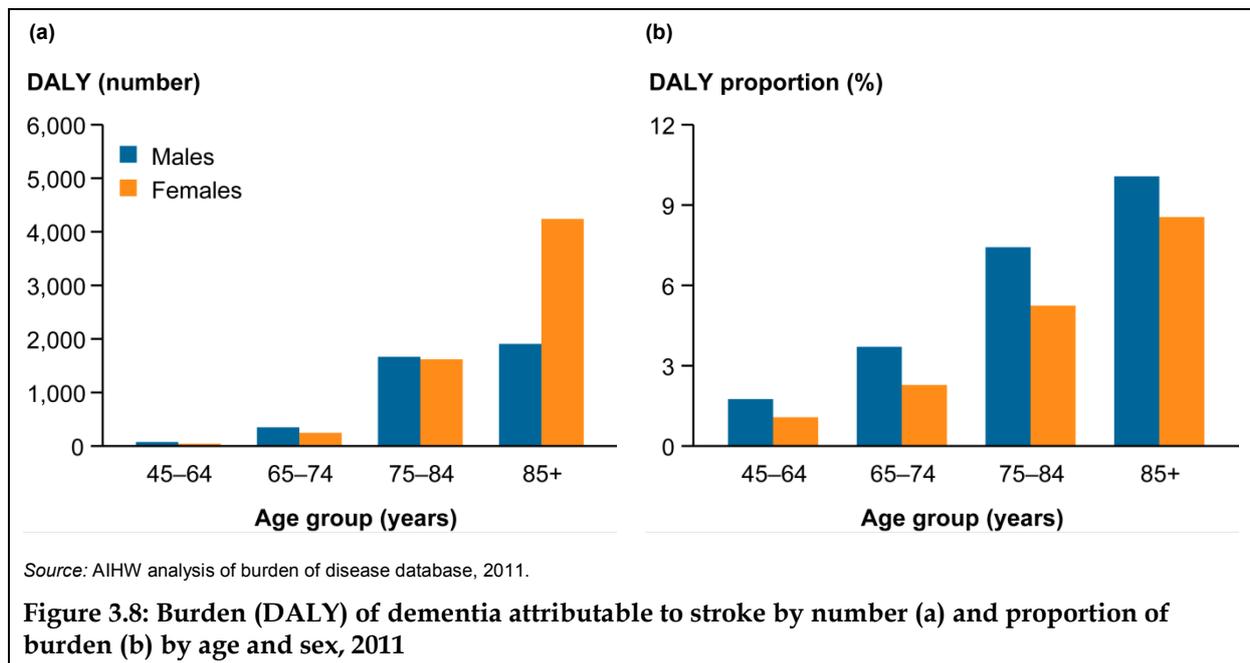
This section outlines their individual impact on dementia burden.

### Stroke

In 2011, 6.7% of dementia burden was attributable to stroke or 10,027 DALY (Table 3.4).

Females experienced a higher number of DALY (6,105) compared with males (3,921 DALY); however, the proportion of dementia burden due to stroke was higher for males (7.1% compared with 6.4% for females) (Table 3.4).

The percentage of dementia burden attributable to stroke increased with age (Figure 3.8). In people aged 85 and over, 10.4% of the dementia burden was due to stroke (Table 3.4); it was highest in the same age group for males (10.1%) and females (8.6%) (Figure 3.8).

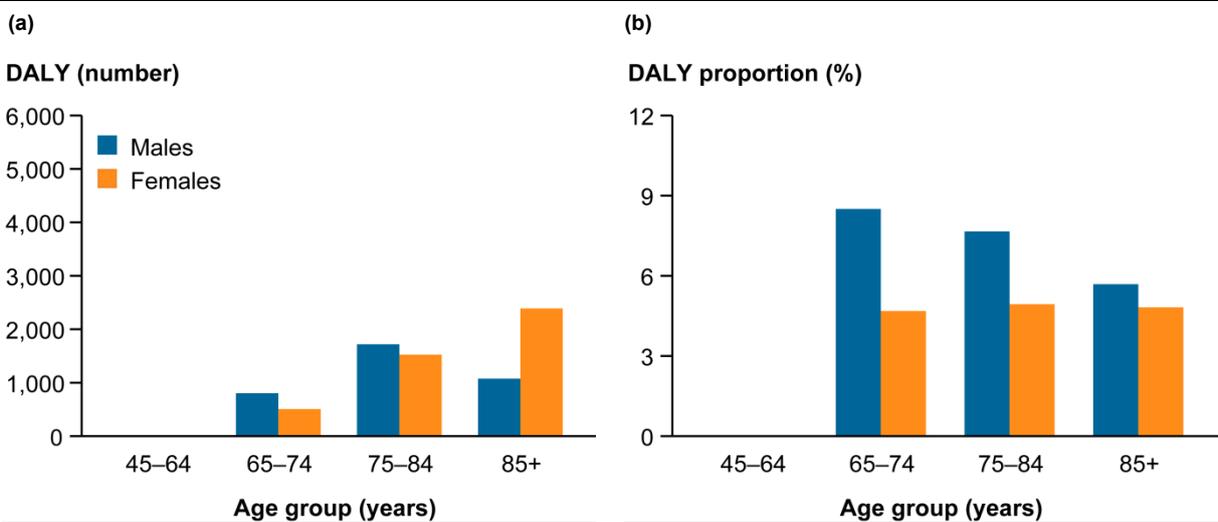


### Diabetes

In 2011, 5.3% of dementia burden was attributable to diabetes, or 8,018 DALY (Table 3.4).

Females experienced a higher number of DALY (4,421) compared with males (3,597 DALY); however, the proportion of dementia burden due to diabetes was higher for males (6.5% compared with 4.6% for females) (Table 3.4).

The percentage of dementia burden attributable to diabetes decreased with age in males; however, it was similar across age groups in females. In males, it was highest in ages 65–74 (8.5%), whereas it was highest in ages 75–84 (4.9%) for females (Figure 3.9).



Note: Attributable burden was not calculated in ages 45–64, as the association is in diabetes in late life (ages 65 and over).

Source: AIHW analysis of burden of disease database, 2011.

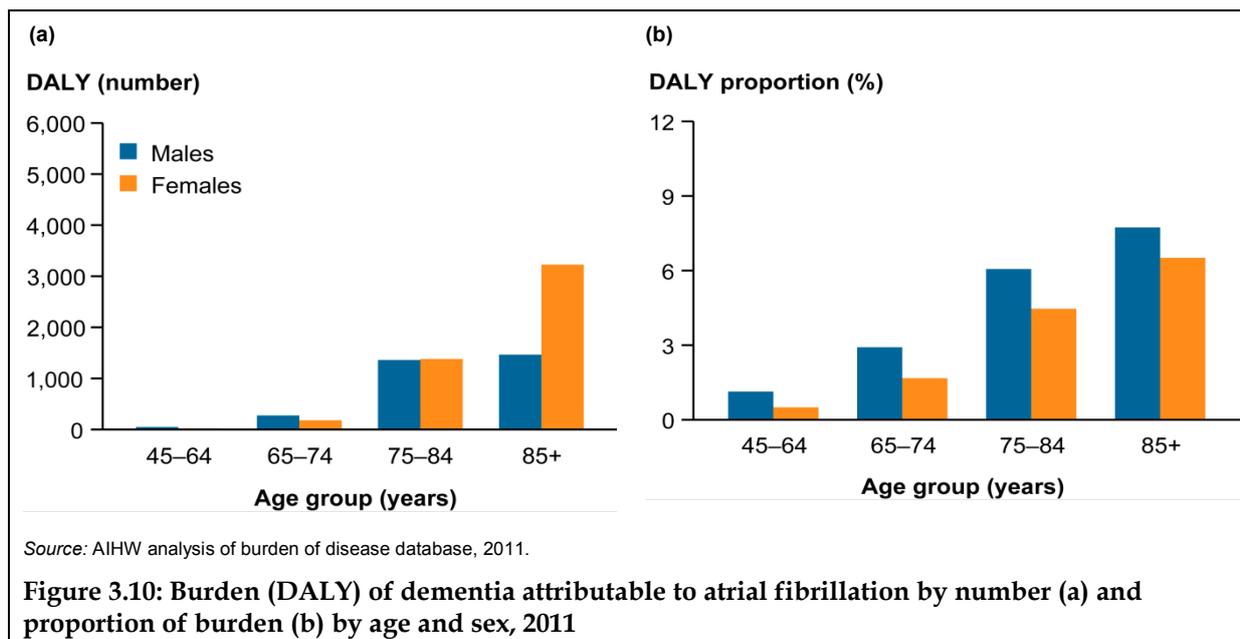
**Figure 3.9: Burden (DALY) of dementia attributable to diabetes by number (a) and proportion of burden (b) by age and sex, 2011**

**Atrial fibrillation**

In 2011, 5.2% of dementia burden was attributable to atrial fibrillation, or 7,886 DALY – independent of stroke (Table 3.4).

Females experienced a higher number of DALY (4,787) compared with males (3,099 DALY); however, the proportion of dementia burden due to atrial fibrillation was slightly higher for males (5.6% compared with 5.0% for females) (Table 3.4).

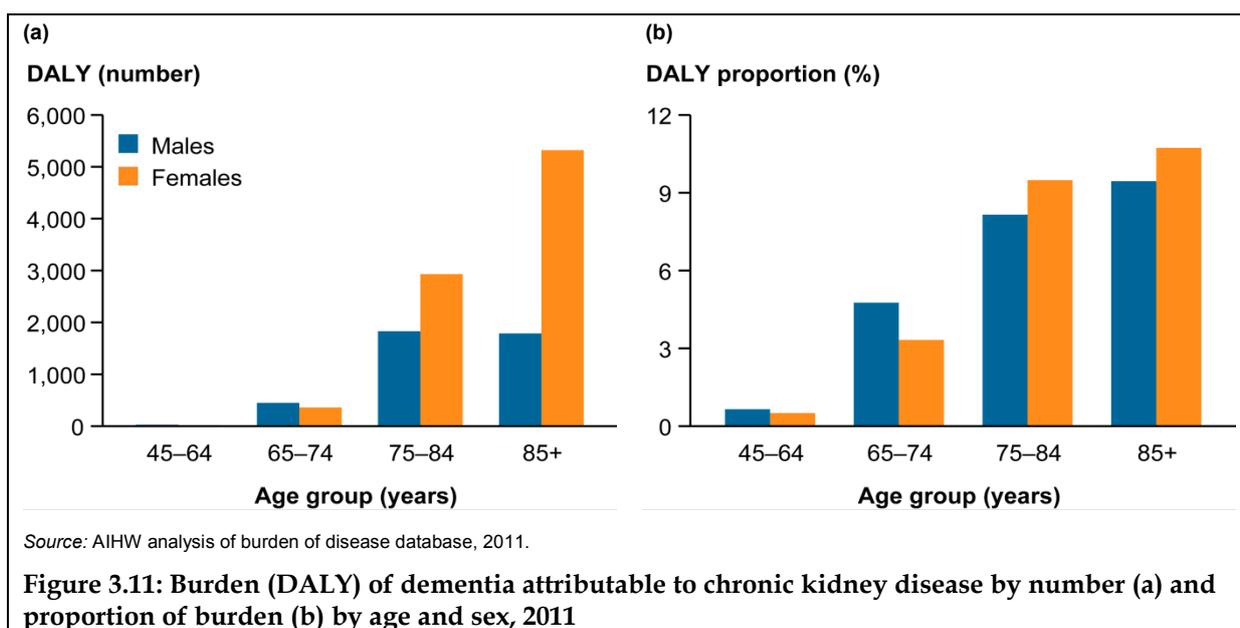
The percentage of dementia burden attributable to atrial fibrillation increased with age; higher in males and females aged 85 and over (7.7% and 6.5%, respectively) (Figure 3.10).



### Chronic kidney disease

In 2011, 8.4% of dementia burden was attributable to CKD, or 12,678 DALY (Table 3.4). Note the relative risk for CKD in this study is based on available evidence from a small-scale study, and the evidence supporting this association was not as high as for the other included risk factors.

Females experienced more dementia burden attributable to CKD than males (8,611 DALY or 9.0% compared with 4,067 DALY and 7.4%) (Table 3.4). This was mainly because both CKD prevalence and dementia burden increase with age and are consequently higher among females who have a longer life expectancy than males. The percentage of dementia burden attributable to CKD increased from 4.0% in ages 65-74 to 10.4% in ages 85 and over (Figure 3.11).



### 3.4 Impact of reduction in risk factors on dementia burden in 2020 under 2 different scenarios

Two scenarios were investigated to assess the impact of estimated risk factor prevalence in 2020 on dementia burden in 2020:

- *Trend scenario* – provides an estimate of the potential dementia burden in 2020 attributable to the risk factors examined in the study if current trends over time in exposure to these risk factors continues until 2020.
- *WHO target scenario* – provides an estimate of the potential dementia burden due to the risk factors in this study if reductions in risk factor prevalence align by 2020 to meet WHO 2025 targets (in the Global Action Plan for the Prevention and Control of Noncommunicable Diseases 2013–2020).

Under each scenario, the amount of predicted dementia burden attributable to each risk factor was estimated using the predicted prevalence of risk factors in 2020 for each respective scenario.

A summary of the WHO prevalence targets for 2025 is in Table 3.5. The WHO targets use country-specific prevalence in 2010 as the baseline. For example, the target for high blood pressure is a 25% relative reduction in high blood pressure compared with the prevalence in 2010. Suitable targets for stroke and atrial fibrillation were not available and a 10% relative reduction in prevalence was used for this report. Note that for diseases risk factors, the year 2011 was used as a baseline due to the availability from ABDS 2011.

**Table 3.5: Summary of WHO prevalence targets for 2025, by risk factor**

Risk factor	WHO target for 2025
<b>Behavioural risks</b>	
Physical inactivity	10% relative reduction in prevalence of physical inactivity
Tobacco use	30% relative reduction in prevalence of current tobacco use in persons aged 15 and over
<b>Metabolic risks</b>	
High blood pressure	25% relative reduction in prevalence of high blood pressure
Obesity	0% increase in prevalence rate of obesity
<b>Diseases-as-risks</b>	
Stroke	Not available, 10% relative reduction in prevalence of stroke applied
Diabetes	0% increase in prevalence rate of diabetes
Atrial fibrillation	Not available, 10% relative reduction in prevalence of atrial fibrillation applied
Chronic kidney disease	Not available, diabetes target applied (0% increase in prevalence rate of CKD)

*Note:* In this report, the target prevalence was calculated as a reduction in prevalence rate from the baseline according to the amount specified by the WHO targets.

*Source:* WHO 2013.

In estimating the burden in 2020, it was not possible to take into account interactions between risk factors that occur in the same causal pathway (for example, smoking is a risk factor for high blood pressure). It was also not possible to take into account other factors that may impact on future dementia burden, such as interventions, diagnosis and treatment of risk factors or dementia, or declines in mortality from other diseases (which may increase the

number of people living to an older age, thereby increasing their risk of developing dementia), as well as other risk factors that were not analysed in this report.

The aim of the analysis is to compare and isolate the vascular risks that may have the most impact on future dementia burden. A summary of the results of this scenario analysis is presented in this chapter. Further detail on the methods and results can be found in Appendix B.

## Risk factor exposure in 2020

The contribution of vascular risk factors to dementia burden in 2020 is dependent on the exposure – defined as the risk factor prevalence. Thus, any variation in attributable burden between scenarios will be due to the differences in risk factor prevalence. The proportions of people exposed to each risk factor under the *Trend scenario* and *WHO target scenario* in 2020 are shown in Table 3.6.

If Australia was on track to meet WHO targets rather than following current trends, the difference in risk factor prevalence is a reduction of:

- 20.6% for obesity in mid-life
- 9.5% for diabetes
- 7.0% for physical inactivity.

The remaining prevalence differences between scenarios were less than 2%.

For tobacco use, the prevalence was similar in the *Trend scenario* (11.5%) compared with the *WHO target scenario* (11.4%). Other studies have found that Australia is on track to meet targets for tobacco smoking (see, for example, McNamara et al. 2015).

**Table 3.6: Proportion exposed in 2010 and under the *Trend scenario* and the *WHO target scenario* in 2020, by risk factor**

Risk factor	Prevalence in 2010 (%)	Projected prevalence in 2020 (%)		Difference between 2020 scenarios <sup>(a)</sup>	% change between 2020 scenarios <sup>(b)</sup>
		Trend scenario	WHO target scenario		
<b>Behavioural risks</b>					
Physical inactivity	52.3	58.7	51.7	-7.0	-11.9
Tobacco use	13.5	11.5	11.4	-0.1	-0.9
<b>Metabolic risks</b>					
High blood pressure in mid-life	11.7	12.7	11.5	-1.2	-9.3
Obesity in mid-life	15.6	36.2	15.6	-20.6	-56.9
<b>Diseases-as-risks</b>					
Stroke	2.1	1.8	1.6	-0.2	-12.5
Diabetes	9.2	18.7	9.2	-9.5	-50.8
Atrial fibrillation	4.0	4.0	3.6	-0.4	-11.1
Chronic kidney disease	6.9	8.6	6.9	-1.7	-19.8

(a) 'Difference between 2020 scenarios' is projected prevalence in 2020 under the *WHO target scenario* minus projected prevalence in 2020 under the *Trend scenario*.

(b) '% change between 2020 scenarios' is expressed as a percentage of potential dementia burden in 2020 under the *WHO target scenario* compared with the *Trend scenario* for that risk factor.

## Projected dementia burden in 2020

Table 3.7 shows the estimated total dementia DALY in 2020 under these 2 scenarios.

If trends continue, dementia burden in 2020 is estimated to be 204,919 DALY (80,098 for males and 124,821 for females) in individuals aged 45 and over. In comparison, the estimated burden under the *WHO target scenario* is 195,994 DALY.

Under both scenarios, the burden in 2020 is greater than that experienced in 2011 as described in the ABDS 2011 – a consequence of both population growth and ageing.

**Table 3.7: Projected dementia burden (DALY) in 2020 under different scenarios, aged 45 and over, by sex**

	Potential dementia DALY in 2020		DALY avoided under WHO scenario <sup>(a)</sup>	DALY avoided (%) <sup>(b)</sup>
	Trend scenario	WHO target scenario		
Males	80,098	76,723	3,375	-4.2
Females	124,821	119,270	5,551	-4.4
Persons	204,919	195,994	8,925	-4.4

(a) DALY avoided refer to the difference between future dementia burden for each sex if WHO targets were met compared with the potential dementia burden in 2020.

(b) DALY avoided expressed as a percentage of potential dementia burden in 2020 under the *Trend scenario*.

Source: AIHW analysis of burden of disease database, 2011.

## Dementia burden attributable to all risk factors combined in 2020

If Australia was on track to meet WHO targets in 2020, the joint effect for all risk factors included in the study is expected to be reduced by 14%, compared with current trends continuing. It would reduce by 15% for females and by 13% for males (Table 3.8).

Under the *WHO target scenario*, 8,926 DALY could be avoided compared with the *Trend scenario*.

**Table 3.8: Attributable burden (DALY) for joint effect of risk factors estimated in 2020 under different scenarios, aged 45 and over, by sex**

	Attributable DALY		DALY avoided under WHO scenario <sup>(a)</sup>	DALY avoided (%) <sup>(b)</sup>
	Trend scenario	WHO target scenario		
Males	26,641	23,724	3,375	-13.4
Females	37,897	32,917	5,551	-15.2
Persons	64,538	56,641	8,926	-14.4

(a) DALY avoided refer to the difference between future attributable burden for each sex if WHO targets were met compared with the expected attributable burden under current trends.

(b) DALY avoided expressed as a percentage of projected attributable burden in 2020 under the *Trend scenario*.

Source: AIHW analysis of burden of disease database, 2011.

## Attributable burden for dementia in 2020 by risk factor

Table 3.9 shows the estimated future dementia burden in 2020 attributable to each risk factor and the differences between the 2 scenarios.

The risk factor having the greatest difference between the 2 scenarios is diabetes. The impact of diabetes on dementia burden would be 9,808 DALY (or 48%) lower under the *WHO target scenario* compared with the *Trend scenario* (Figure 3.12). This reduction is due to the large difference in estimated diabetes prevalence in 2020 if trends continue, compared with meeting WHO targets. The dementia burden attributable to obesity in mid-life is also lower under the *WHO target scenario* by 3,825 DALY (or 26%).

Dementia burden attributable to physical inactivity, stroke and atrial fibrillation is estimated to be lower under the *WHO target scenario* by 2,257, 1,861 and 986 DALY, respectively, compared with the *Trend scenario*. Note, the WHO target for reducing the prevalence of physical inactivity was not as high (10% relative prevalence reduction) as for other WHO targets used in this analysis, and an arbitrary 10% reduction was used for stroke and atrial fibrillation as there were no specific targets for these conditions set by the WHO. The dementia burden attributable to CKD would be 1,846 DALY lower under the *WHO target scenario*, compared with the *Trend scenario*.

Future dementia burden attributable to tobacco use is estimated to be similar under both scenarios. This is because current trends are in line with meeting the WHO target for smoking.

**Table 3.9: Dementia DALY attributable to vascular risk factors in 2020 under different scenarios**

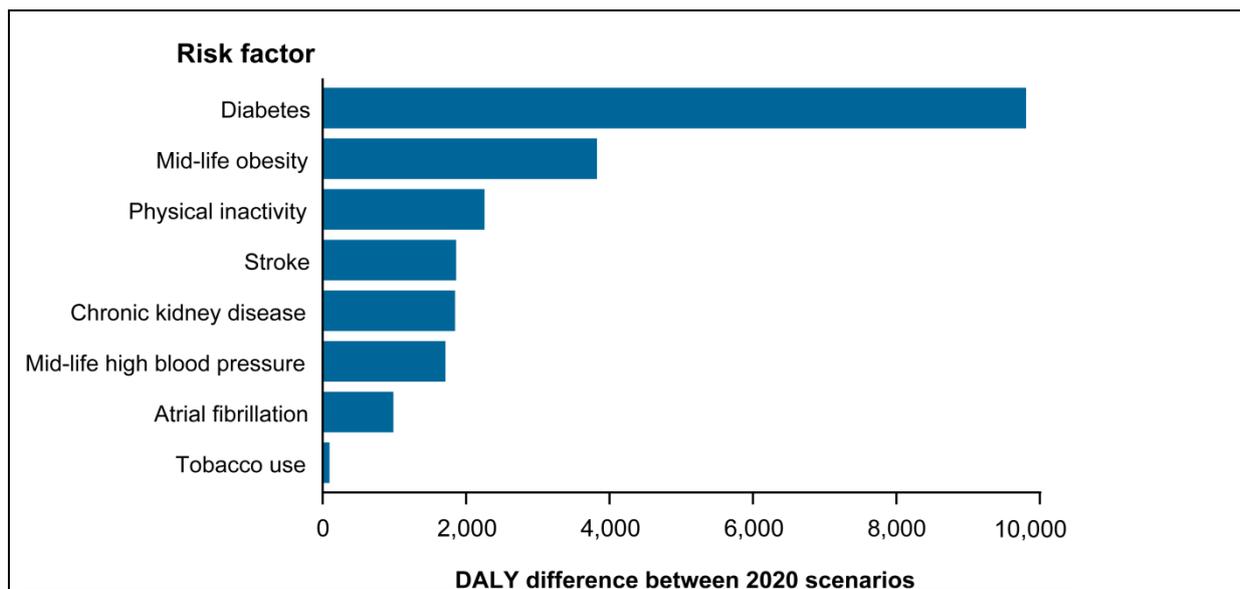
	Attributable DALY		Difference between 2020 scenarios <sup>(a)</sup>	% change <sup>(b)</sup>
	Trend scenario	WHO target scenario		
<b>Behavioural risks</b>				
Physical inactivity	15,552	13,295	2,257	-14.5
Tobacco use	2,780	2,685	95	-3.4
<b>Metabolic risks</b>				
High blood pressure in mid-life	13,661	11,950	1,711	-12.5
Obesity in mid-life	14,868	11,044	3,825	-25.7
<b>Diseases-as-risks</b>				
Stroke	14,054	12,194	1,861	-13.2
Diabetes	20,285	10,476	9,808	-48.4
Atrial fibrillation	10,447	9,461	986	-9.4
Chronic kidney disease <sup>(c)</sup>	18,301	16,455	1,846	-10.1

(a) Difference between scenarios is projected prevalence in 2020 under the *Trend scenario* minus projected prevalence in 2020 under the *WHO target scenario*.

(b) % change expressed as a percentage of projected attributable burden under the *WHO target scenario* in 2020 compared with the *Trend scenario*.

(c) Relative risk for chronic kidney disease used in attributable burden calculation is based on available evidence from a small-scale study.

Source: AIHW analysis of burden of disease database, 2011.



Source: AIHW analysis of burden of disease database, 2011.

**Figure 3.12: Attributable DALY difference between *Trend scenario* and *WHO target scenario*, 2020**

## 4 Discussion

This report demonstrates the contribution of vascular risk factors (including diseases which act as risk factors) to dementia burden in Australia in 2011. The report describes the individual contribution of diabetes, stroke, atrial fibrillation, CKD, high blood pressure in mid-life, obesity in mid-life, smoking and physical inactivity to dementia burden, as well as their combined contribution. Results from scenario modelling are also presented, which estimated the amount of future dementia burden that could be avoided if exposure to these risk factors were reduced to be on track to meet targets set by the WHO.

### 4.1 Key findings

#### **Dementia burden from vascular risk factors and how it varies**

Together the vascular risk factors were responsible for approximately 30% of the total burden of dementia (45,287 DALY) in Australia in 2011.

The total proportion of dementia burden attributable to vascular risk factors was slightly greater for males (31%) compared with females (29%). However, the overall amount of attributable burden was higher in females (27,992 DALY) compared with males (17,295 DALY). This is because the prevalence of dementia and overall dementia burden is greater for females. Around half of the dementia burden was fatal (53%) and half was non-fatal (47%); indicating that dementia is a condition that causes both years of life lost due to ill health and years of life lost due to premature death.

The risk factors assessed as having a convincing causal association with dementia that contributed the most to dementia burden were physical inactivity (8.0%), stroke (6.7%) and high blood pressure in mid-life (6.0%). CKD was assessed as having a probable causal association with dementia and was responsible for 8.4% of dementia DALY.

The effects of individual vascular risk factors on dementia burden differed by sex, with diabetes, stroke, high blood pressure in mid-life and tobacco use responsible for a greater proportion of dementia burden in males, whereas CKD and physical inactivity were responsible for more dementia burden in females.

The effect of individual vascular risk factors on dementia burden also differed by age, with variation reflecting differences in the prevalence of these risk factors by age. For example, stroke and atrial fibrillation increase incrementally with age, whereas CKD contributes to significantly more burden in those aged 75 and over.

#### **Combined effect of vascular risk on dementia burden**

The joint effect for all risk factors included in this study of 30% is similar to the combined risk factor result published by Norton and others (2014) of 28–31%. That study estimated the population attributable risk (referred to as PAF in this report) for 7 risk factors that have consistent evidence of a causal association with Alzheimer disease, using published relative risks and prevalence data for each of the 7 risk factors worldwide and in the USA, UK, and Europe. The risk factors included in that study were diabetes, smoking, physical inactivity, high blood pressure in mid-life and obesity in mid-life; but also included depression and low educational attainment, which were out of scope for this report.

The joint effect provides a theoretical maximum for the proportion of dementia burden attributable to vascular risk factors. It further highlights the overlapping nature of vascular risk and the potential for large health gains through reducing population-level exposures to common risk factors for dementia, such as diabetes, obesity in mid-life and physical inactivity.

## **Impact of reduction in risk factor exposure on future dementia burden**

To investigate the impact of changes in risk factor prevalence on the future burden of dementia, 2 scenarios were examined. These scenarios provide an indication of the amount of dementia burden that may be avoided if the exposure to these risk factors was reduced to be on track in 2020 to meet prevalence targets set for 2025 by the WHO in the Global Action Plan for the Prevention and Control of Noncommunicable Diseases 2013–2020, compared with if the current trends in risk factor prevalence continue until 2020.

The vascular risks for dementia included in this study, for which prevalence is increasing, and where the greatest reductions are required to be on track in 2020 to meet WHO targets were diabetes, obesity in mid-life and physical inactivity. This analysis suggested that if the risk factors included in the study were reduced to meet relevant WHO targets, then 14% of future attributable burden for dementia could be avoided.

The largest future gains were estimated to be made from reductions in diabetes prevalence (resulting in 9,808 fewer dementia DALY), obesity in mid-life (3,825 fewer dementia DALY) and physical inactivity (2,257 DALY). This is partly a reflection of the difference in estimated prevalence in 2020 between the 2 scenarios, as well as the size of the impact of each risk factor on dementia burden. An arbitrary target of a 10% relative prevalence reduction compared with 2010 was used for stroke and atrial fibrillation, as there were no appropriate WHO targets; however, current trends suggest that dementia burden due to stroke will decrease, and dementia burden due to atrial fibrillation may decrease slightly between 2011 and 2020.

## **4.2 Potential for prevention**

There is increasing evidence that reduction in vascular diseases and vascular risk factors could, at a population level, reduce the age-specific incidence of dementia or delay its onset (Barnes & Yaffe 2011; Norton et al. 2014; Prince et al. 2014; Roman et al. 2012).

The vascular risk factors included in this study show the potential for reducing dementia-related burden in the population. A reduction in dementia burden attributable to these risk factors relies on a reduction in the prevalence of these risk factors. Physical inactivity was the behavioural risk factor that contributed the most to dementia burden and so large gains could be made by reducing rates of physical inactivity in the population. This in turn may also lead to a reduction in the prevalence of other vascular risk factors for dementia that are associated with physical inactivity (such as obesity and diabetes), thereby increasing the effect on dementia attributable burden. Intervention effectiveness (including cost-effectiveness) will be a key factor in determining preventive efforts to make the largest gains.

This research highlights the importance of a lifecourse approach to the prevention of dementia. Vascular risk factors associated with dementia have different impacts depending

on when exposure occurs. For some risk factors, such as high blood pressure and obesity, exposure in mid-life is associated with increased risk of dementia in late life (Barnes & Yaffe 2011; Pedditizi et al. 2016). This has important implications for selection and timing of prevention and treatment strategies (Launer 2005). As these risk factors are associated with chronic diseases, as well as increased risk of all-cause mortality and lower life expectancy (Hughes & Ganguli 2009), any reductions in exposure are beneficial. For example, research suggests dementia risk is greater in those who have experienced longer exposure to diabetes (Bedse et al. 2015; Roberts et al. 2014; Zoungas et al. 2014). Despite the limitations associated with modelling previous history and length of exposure (see 'Limitations of this study' later in this chapter), there is potential for prevention of dementia arising from population-level reductions in, and management of, vascular risk factors across all ages.

The results from this study may also have implications for provision of care for patients with dementia and for dementia-related services (for example, increased monitoring of patients with atrial fibrillation for symptoms of dementia). There is also a role for general practitioner and patient education; for example, encouraging midlife screening of vascular risk factors.

It is important to acknowledge that because our population is growing older, more Australians are likely to encounter dementia in the years ahead, either as sufferers or as carers. Furthermore, a reduction in exposure to the associated risk factors included in this study could also result in an increase in the overall prevalence of dementia, with more individuals living longer and being at risk of developing dementia in old age.

### **4.3 Strengths of this study**

A key strength of this study is that it quantifies, for the first time, the contribution of vascular risk factors on the burden due to dementia in Australia; both in terms of living with dementia and of dying prematurely. This estimate can only be achieved using burden of disease methodology in contrast to other studies which may describe prevalence only. This work builds on the ABDS 2011, which measured and compared the impact of 200 diseases and injuries in Australia.

This study has further strengths in that the risk factor exposure estimates, obtained from Australian data sources, are more relevant than those used in international studies. Consequently, the results are more policy relevant to the Australian health context.

The estimates of attributable burden reported in this study rely on the best available evidence on RRs from recent Australian and international studies and meta-analyses. These were deemed to be relevant for Australia and demonstrated a convincing or probable association between the risk factor and dementia.

This study illustrates the use of burden of disease data to undertake scenario modelling to look at the future impact of reductions in disease prevalence and risk factor exposure on disease burden; in this case, dementia burden. The results of the scenario analyses presented in this report show how different trajectories in risk factor prevalence might affect the future dementia burden, and therefore highlight the benefits at the population level of addressing key vascular risk factors in preventing or delaying the onset of dementia.

### **4.4 Limitations of this study**

Estimates of dementia prevalence in Australia used in this study are based on international studies, as there is no recent Australian data source that provides this information. This

highlights a major data gap in which estimates could be improved with a national data source on the prevalence of dementia being developed and made available in the future.

While, in this study, a large proportion of dementia burden was attributable to CKD (8.4%), the evidence of an association between CKD and dementia was probable and in this case based on a single study. As more research is done in this area, this estimate is likely to shift. Furthermore, some evidence suggests that high cholesterol is a possible risk factor for dementia; however, this factor was excluded from this report due to inconsistencies between studies and no suitable published RRs. Further research is likely to update RRs included in this study, and to identify new risk factors that could be included in future studies of dementia burden.

The impact of age on dementia burden may be more complex and greater than could be accounted for in our study with the available data. The Global Burden of Disease (GBD) 2013 study found that the size of the association between the vascular risk factors and other disease–outcome pairs reduces with age. They found evidence that the RR reduced to 1 (no increased risk) by age 110 years. It is possible that the same association holds for vascular risk factors and dementia but there is currently no literature to support this analysis. Furthermore, because of the late age of dementia onset, the age at which the association reduces to no increased risk may be different to the outcomes studied by the GBD study.

The method to calculate attributable burden may also overestimate risk factor attribution where risk factors and disease outcomes occur simultaneously, particularly for diseases-as-risks. This was evident in the large proportion of dementia burden attributable to CKD and diabetes. Both diseases are more prevalent in older age groups, as well as in the female population. This may overestimate the contribution of CKD, as well as the contribution of diabetes to dementia burden.

When using scenarios to estimate the impact of reduced exposure to individual risk factors on dementia burden, it is not possible to quantify the flow-on effects to other risk factors, or diseases in the causal pathway that may occur in reality. For example, estimating the impact on dementia burden by reducing exposure to physical inactivity is independent of measuring the impact of any potential reduction in exposure to obesity in mid-life that might arise from reducing exposure to physical inactivity. In this study, the impact of such risk factors was assessed independently.

In the scenario modelling analysis, as there were no specific targets set by the WHO for reducing stroke and atrial fibrillation in the population, a 10% reduction in prevalence compared with 2010 was used. As this was an arbitrary target and not based on any real-world evidence, this may not be the most appropriate target if a review of the current evidence was conducted.

The estimate of dementia burden calculated for 2020 used in the scenario modelling was based on the assumption that the current rate of dementia onset prevails until 2020, and was used as a baseline to determine the attributable burden for both scenarios. Changes in exposure to other risk factors could also alter the future incidence of dementia; however, it was not possible to account for this in estimating 2020 dementia burden due to interplay between risk factors and the influence of unknown factors on the development of dementia.

## 4.5 Conclusion

This study demonstrates the potential for preventing dementia and reducing dementia-related burden. The largest gains are likely to be made by reducing the prevalence of the vascular risk factors currently contributing the most to dementia burden, which in this study was physical inactivity; and reducing the prevalence of vascular risk factors expected to make a significant contribution to future dementia burden (for example, diabetes). Reducing risk factors that act in the causal pathway as other risk factors for dementia, such as obesity in mid-life and high blood pressure in mid-life, may also lead to a reduction in the age-specific incidence of dementia and dementia-related burden in the future. This study highlights the importance of a lifecourse approach to the prevention of dementia.

# Appendix A: Selection of relative risks

Burden of disease studies use relative risks (RRs) to measure the strength of association between a disease or risk factor and a linked disease outcome. RRs used in this project were identified following review of relevant literature and were restricted to studies with a prospective longitudinal design, where the outcome was clinically diagnosed dementia.

The vascular risk factors (including diseases, metabolic and behavioural risk factors) investigated for inclusion in this analysis were: stroke, coronary heart disease, diabetes, atrial fibrillation, peripheral artery disease, chronic kidney disease (CKD), high cholesterol, high blood pressure, risky alcohol consumption, tobacco use, physical inactivity and obesity. For a risk factor to be included there must be convincing or probable evidence of a causal association following exposure to dementia, preferably from a meta-analysis or cohort study. This aligns with the World Cancer Research Fund criteria of convincing or probable evidence for a causal association (see Box A1).

## **Box A1: Evidence criteria for a causal association**

Evidence for inclusion was categorised as convincing or probable based on the robustness and volume of studies demonstrating a relationship. Convincing evidence included risk factors with a well-known causal relationship or where numerous high-quality studies applicable to Australia demonstrated a causal relationship after adjusting for confounders.

A probable level of evidence included risk factors where a causal relationship had been identified by high-quality studies; however, supporting evidence was not as robust as those categorised as convincing. The main reason for classifying as probable evidence was that a meta-analysis had not been conducted, or only a few high-quality studies were available from which to select.

A possible level of evidence included risk factors where a relationship had been identified by some high-quality studies but findings were not consistent. The main reason for classifying as possible evidence was that there was significant inconsistency between studies or an applicable exposure definition was not available.

An insufficient level of evidence included risk factors where there were inconsistent findings from a limited number of studies. The main reason for classifying as insufficient evidence was that there were not enough studies available to determine whether there was or wasn't a relationship between risk factor and outcome.

Following a review of the current evidence, 8 vascular risk factors were included in the study: 4 diseases-as-risks (diabetes, stroke, atrial fibrillation and CKD), 2 metabolic risks in mid-life (obesity and high blood pressure) and 2 behavioural risks (tobacco use and physical inactivity).

The level of evidence for CKD causing dementia is lower compared with the other risk factors included in this report. This is because there are limited studies demonstrating a causal association between CKD and clinically defined dementia (Helmer et al. 2011; Miwa et al. 2014; Sasaki et al. 2011; Seliger et al. 2004). A systematic review of the evidence found the association to be consistent between studies for CKD as a risk factor for cognitive decline, but no meta-analyses have been conducted (Deckers et al. 2015). Furthermore, differences in

definitions and measurement of exposure to CKD, study populations and distinction between cognitive decline and dementia were not consistent upon re-evaluation. Therefore, the level of evidence for CKD was assessed to be possible/probable in this report and results should be interpreted with caution.

Despite midlife high cholesterol identified in the literature as a possible risk factor for dementia, this was not included in this report. This is because no suitable RRs for midlife cholesterol and dementia were published and further research is required to confirm which type of exposure to high cholesterol (high cholesterol in mid-life or a large decline in cholesterol between mid-life and late life) is associated with dementia (Anstey et al. 2008; Kivipelto et al. 2002; Stewart et al. 2007). High cholesterol, however, is a risk factor for the vascular diseases included as risk factors in this study.

Other risk factors were excluded because there was insufficient evidence of an association (for example, risky alcohol consumption) and others, such as depression and social engagement, were not investigated because they were out of scope for this study – which is limited to vascular risk factors.

A summary of all RRs used in this report and their sources are listed in Table A1 and study details are summarised in Table A2.

**Table A1: Relative risks and sources for included risk factors**

Risk factor	Level of evidence	Relative risk (95% CI)	Source of relative risk
Diabetes	Convincing	1.50 (1.30–1.73)	Prince et al. 2014
Stroke	Convincing	2.10 (1.55–2.81)	Reitz et al. 2008
Atrial fibrillation	Convincing	1.42 (1.17–1.72)	Santangeli et al. 2012
Chronic kidney disease	Probable/possible	1.37 (1.06–1.78)	Seliger et al. 2004
Obesity in mid-life	Convincing	1.41 (1.20–1.66)	Pedditizi et al. 2016
High blood pressure in mid-life	Convincing	1.61 (1.16–2.24)	Barnes & Yaffe. 2011
Tobacco use	Convincing	1.30 (1.13–1.73)	Zhong et al. 2015
Physical inactivity	Convincing	1.14 (1.04–1.32)	Blondell et al. 2014

## Disease risk factors

### Diabetes

There is strong and consistent evidence of a causal association between diabetes and dementia (Prince et al. 2014). Numerous prospective studies have demonstrated this as summarised in several systematic reviews (Biessels et al. 2006; Cukierman et al. 2005; Lu et al. 2009; Luchsinger 2010; Profenno et al. 2010). The association is also supported by recent meta-analyses (Cheng et al. 2012; Gudula et al. 2013; Lu et al. 2009; Ninomiya 2014; Prince et al. 2014).

The RR used in this study is from Prince and others (2014) as this was assessed as the most up-to-date meta-analysis, including the largest number of studies with an outcome of any dementia.

In total, 11 studies were included in Prince and others (2014) with a pooled RR of 1.50 for the association between any dementia and diabetes (ages 65 and over) (Ahtiluoto et al. 2010;

Akomolafe et al. 2006; Cheng et al. 2011; Hassing et al. 2002; Hayden et al. 2006; MacKnight et al. 2002; Ohara et al. 2011; Ott et al. 1999; Peila et al. 2002; Raffaitin et al. 2009; Xu et al. 2004). This RR was consistent (RR = 1.50) when analysis was restricted to 7 studies that included both diagnosed and undiagnosed diabetes (Akomolafe et al. 2006; MacKnight et al. 2002; Ohara et al. 2011; Ott et al. 1999; Peila et al. 2002; Raffaitin et al. 2009; Xu et al. 2004).

The results from Prince and others (2014) are in accordance with previous reviews and are comparable to other recent meta-analyses (Barnes & Yaffe 2011; Lu et al. 2009; Ninomiya 2014; Prince et al. 2014; Ronnema et al. 2011).

There are several biologically plausible mechanisms through which diabetes could increase dementia risk. However, there is currently no clear consensus on the direct causal relationship (Ninomiya 2014; Prince et al. 2014). Diabetes is associated with atherosclerosis and stroke (Mankovsky & Ziegler 2004) which, in turn, increase the risk of dementia (Savva & Stephan 2010). In addition, defective binding of insulin to receptors in the brain may contribute to accumulation of amyloid which is toxic to brain cells (Besde et al. 2015). Brain imaging studies demonstrate an association between brain metabolism consistent with Alzheimer disease and insulin resistance (Baker et al. 2011) and diabetes (Roberts et al. 2014). Finally, common genetic pathways may underlie the development of both diabetes and dementia (Akomolafe et al. 2006).

## Stroke

The association between acute stroke and dementia is well documented (Leys et al. 2005); however, the prevalence of stroke preceding dementia is conflicting – varying from 6% (Madureira et al. 2001) to more than 30% (Heron et al. 2001). Poststroke dementia refers to any dementia following stroke and may be the result of vascular lesions, Alzheimer pathology or a combination of both (Leys et al. 2005). There are a numerous facets to the association between stroke and subsequent dementia, including: an increased incidence of stroke in people with dementia (Jin et al. 2006); the role of pre-stroke cognition on poststroke dementia likelihood (Pendlebury & Rothwell 2009); and involvement of other cardiovascular and genetic risk factors (Qiu et al. 2010; Savva & Stephan 2010; Zhu et al. 2000). Limitations in study design, case ascertainment, exclusion criteria and length of follow-up also influence the observed association (Pendlebury & Rothwell 2009).

The RR (2.10) used in this analysis was drawn from the Rotterdam Study (Reitz et al. 2008). This RR was the most applicable to the Australian Burden of Disease Study (ABDS) stroke population exposure estimates since, similar to the data behind the ABDS stroke prevalence, the study was population-based with a long follow-up period. The Rotterdam Study is a large population-based longitudinal study of 6,724 stroke-free individuals at baseline. Incident stroke and subsequent dementia are assessed over a mean follow-up of 7 years, controlling for sex, age, education and apolipoprotein E (APOE) genotype (Reitz et al. 2008). The Rotterdam Study is the first large population-based study relating incident stroke to long-term risk of dementia in a cohort without stroke or dementia at baseline. This study demonstrates that stroke is a risk factor for dementia independent of other assessed risk factors, including pre-stroke cognitive decline, vascular risk factors and APOE genotype (Reitz et al. 2008).

## **Atrial fibrillation**

There is strong and consistent evidence of an association between atrial fibrillation and dementia (Bunch et al. 2010; de Bruijn et al. 2015a, 2015b; Dublin et al. 2011; Kwok et al. 2011; Marengoni et al. 2009; Ott et al. 1997; Peters et al. 2009; Rusanen et al. 2014; Santangeli et al. 2012). This relationship has shown to be independent of stroke (Bunch et al. 2010; Santangeli et al. 2012), for which atrial fibrillation is also a key risk factor.

The RR (1.42) used in this project is from a 2012 meta-analysis of 8 prospective longitudinal studies, with a sample size of over 77,000 people (Santangeli et al. 2012). Studies that included stroke or cognitive impairment at baseline were excluded to minimise the potential for confounding. Six studies showed an increased risk of dementia independent of diabetes, and 7 studies demonstrated increased risk independent of high blood pressure. The meta-analysis supports previous findings demonstrating the increased risk of dementia in people with atrial fibrillation, independent of other baseline confounders, including stroke (Santangeli et al. 2012).

There are several proposed mechanisms underlying the association between atrial fibrillation and dementia. Atrial fibrillation is proposed to be linked with dementia through various pathways: first, via stroke, of which atrial fibrillation is a known risk factor; and, second, through lower cardiac output leading to chronic decreased blood flow to the brain, resulting in brain damage (Kwok et al. 2011).

## **Chronic kidney disease (CKD)**

There is strong evidence for CKD causing cognitive decline (Etgen et al. 2012). Cognitive decline is less severe than dementia and not all people with cognitive decline go on to have dementia, with a dementia diagnosis requiring severe cognitive decline and meeting diagnostic criteria.

Three studies have reported that impaired kidney function is associated with higher risk of dementia after adjusting for confounding factors, brain atrophy and small blood vessel disease (Miwa et al. 2014; Sasaki et al. 2011; Seliger et al. 2004). Another study showed no association between low kidney function at baseline and dementia but found that a fast decline in kidney function – probably reflecting more severe kidney damage or impairment – was associated with an increased risk of dementia (Helmer et al. 2001).

The RR (1.37) used in this study is taken from a 2004 study of 3,349 people age over 65 undertaken in the United States of America (Seliger et al. 2004). Moderate renal impairment was defined as elevated serum creatinine levels according to gender-specific cut-offs ( $\geq 1.3$  mg/dL for women and  $\geq 1.5$  mg/dL for men) (Seliger et al. 2004). Based on available evidence, this was the most applicable measure of CKD for Australian prevalence estimates. It was also the most comparable study for an Australian context, with other prospective longitudinal studies undertaken in Japanese and South-East Asian populations (Miwa et al. 2014; Sasaki et al. 2011).

Several biologically plausible mechanisms may explain how impaired kidney function leads to increased risk of dementia (Bugnicourt et al. 2013). Among these are anaemia, atherosclerosis, increased risk of stroke and micro infarcts as well as elevated homocysteine – all more common in people with CKD and associated with increased dementia risk (Bugnicourt et al. 2013; Etgen 2015).

# Metabolic risk factors

## Obesity in mid-life

There is increasing and consistent evidence supporting an independent age-dependent association between obesity and dementia (Anstey et al. 2011; Beydoun et al. 2008; Pedditizi et al. 2016). Obesity (body mass index  $\geq 30$  kg/m<sup>2</sup>) in mid-life (ages 35–64) has been found to be positively associated with increased risk of dementia in later life (Anstey et al. 2011; Pedditizi et al. 2016), including Alzheimer disease (Beydoun et al. 2008; Profenno et al. 2010).

The RR (1.41) used for this project is drawn from a recent meta-analysis (Pedditizi et al. 2016) that built upon previous work demonstrating an age-dependent association between obesity and dementia (Anstey et al. 2011). The findings are in accordance with previous reviews (Anstey et al. 2011; Barnes & Yaffe 2011; Loef & Walach 2013). This meta-analysis used the most adjusted RRs available from included studies to minimise the potential distorting effect of confounding (Pedditizi et al. 2016). The independent association of obesity in mid-life and late-life dementia has been demonstrated previously (Gorospe & Dave 2007).

The biological mechanism for the association between midlife obesity and dementia is likely to be due to both vascular and metabolic pathways (Prince et al. 2014). Adiposity may directly impact brain tissue through advanced glycosylation end products, insulin resistance and release of inflammatory cytokines, such as adipokines which have direct effects on brain regions implicated in dementia (Emmerzaal et al. 2015; Gustafson & Luchsinger 2013).

## High blood pressure in mid-life

There is strong and consistent evidence to support an age-dependent association between high blood pressure and dementia (Barnes & Yaffe 2011; Prince et al. 2014; Qiu et al. 2005). High blood pressure (systolic blood pressure  $\geq 140$  mmHg) in mid-life (35–64 years) is positively associated with increased risk of dementia in later life, with findings from 4 of 5 studies showing positive associations (Freitag et al. 2006; Kivipelto et al. 2001; Launer et al. 2000; Prince et al. 2014; Ronnemaa et al. 2011; Whitmer et al. 2005; Wu et al. 2003; Yamada et al. 2003). High blood pressure in late life is associated with vascular dementia (Sharp et al. 2011) but not Alzheimer disease or any dementia, with 8 of 13 studies finding non-significant associations (Barnes & Yaffe 2011).

The RR (1.61) used in this project is drawn from a meta-analysis on midlife high blood pressure and Alzheimer disease undertaken by Barnes and Yaffe (2011). Although specified for Alzheimer disease, assessment of the dementia criteria used in the included studies shows that several refer to all-cause dementia and not Alzheimer disease specifically, supporting the applicability of this RR to any dementia in our analysis. Use for any dementia is also supported by Barnes and Yaffe (2011) and Norton and others (2014), both indicating that as the majority of dementia in older persons shows mixed pathology, estimates may be applied to the most common forms of dementia in older populations (Norton et al. 2014).

The biological mechanism is proposed as being due to severe atherosclerosis arising from long-term exposure to high blood pressure in mid-life (Qiu et al. 2005). Atherosclerosis has been shown to be associated with Alzheimer disease pathology changes in the brain (Sparks et al. 1995). High blood pressure is also a risk factor for stroke and thus may also result in excess accumulation of micro infarcts which are also associated with amyloid cascade and Alzheimer disease pathology.

# Behavioural risk factors

## Tobacco use

There is now consistent evidence to support an association between current tobacco use and dementia; however, there is insufficient evidence for increased risk of dementia in past smokers (Anstey et al. 2007; Prince et al. 2014; Zhong et al. 2015). The impact of tobacco use on health is well documented (Eriksen et al. 2013).

The RR (1.30) used in this project is from a recent meta-analysis of over 900,000 subjects across 17 studies (Zhong et al. 2015). It builds upon a previous high-quality meta-analysis that stratified results according to exposure definition to address heterogeneity of pooled estimates due to exposure classification (Anstey et al. 2007). This study includes an additional 20 studies released between 2008 and 2014 not included in other reviews (Barnes & Yaffe 2011; Norton et al. 2014; Zhong et al. 2015). It also provides RRs applicable to all-cause dementia that were either inconsistent or unavailable in previous reviews due to the limited number of studies included (Anstey et al. 2007; Beydoun et al. 2014; Cataldo et al. 2010; Peters et al. 2008).

Previous reviews and meta-analyses on the association between smoking and dementia were limited due to the small number of longitudinal studies, differences in exposure classification (current smoker/ever smoked/pack-years) as well as conflicting findings from industry-funded case-control studies (Almeida et al. 2002) that suggested a protective effect of nicotine on dementia risk (Cataldo & Glantz 2010; Prince et al. 2014).

Along with its impact on vascular health, tobacco use or smoking more broadly is also thought to contribute to development of Alzheimer disease neuropathology through oxidative stress and its subsequent impact on brain health (Burke & Fitzgerald 2003; Durazzo et al. 2014). Prevalence of tobacco use is higher among certain population groups that are at higher risk of dementia, which could confound association. For example, tobacco use is higher in persons with traumatic brain injury and certain mental health conditions, such as schizophrenia, both groups of which are at higher risk of dementia independent of tobacco use (Durazzo et al. 2014; Prince et al. 2014; Ribe et al. 2015). However, adjusted estimates control for such potential confounders and the role of tobacco use and dementia risk is likely independent of such confounding.

## Physical inactivity

The association between physical activity and health across the lifecourse has made it a risk factor of key interest in dementia research (Beydoun et al. 2014; Hamer & Chida 2009; Morgan et al. 2012; Rolland et al. 2008). Physical activity and its role in the prevention of type 2 diabetes, cardiovascular disease and premature mortality more broadly, is well documented (Haskell et al. 2007, 2009; Reiner et al. 2013).

A large number of studies have looked at the association between physical activity and dementia, as summarised in numerous systematic reviews and meta-analyses (Aarsland et al. 2010; Beydoun et al. 2014; Blondell et al. 2014; Bowen 2012; de Bruijn et al. 2013; Hamer & Chida 2009; Morgan et al. 2012; Rolland et al. 2008; Sofi et al. 2011; Verdelho et al. 2012). There are, however, limitations associated with quantifying the association between physical activity and dementia. This includes potential for reverse causality (dementia onset often precedes a decline in physical activity) and the subjective nature of assessing exposure in

some studies (physical activity) (Blondell et al. 2014; Prince et al. 2014). Despite these limitations, the protective role of physical activity on cognition has been demonstrated in randomised controlled trials, confirming the protective role physical activity has on cognitive health across the lifecourse (Smith et al. 2010).

The RR (1.14) used in this project is from a recent meta-analysis that expanded upon previous reviews and included the largest number of studies (Blondell et al. 2014). Similar analyses have applied RRs for physical inactivity of RR = 1.8 for Alzheimer disease and RR = 1.39 for any-cause dementia (Barnes & Yaffe 2011; Hamer & Chida 2009). Due to the limitations associated with risk estimates, the most conservative estimate was used for this analysis (Blondell et al. 2014). To minimise issues of heterogeneity between studies, Blondell and others (2014) utilised a quality effects method for calculating pooled estimates. This meta-analysis built upon previous reviews (Hamer & Chida 2009; Sofi et al. 2011) and included 21 studies—9 from previous reviews and 12 additional studies (Blondell et al. 2014). RRs reported in Blondell and others (2014) reflected the protective effects of physical activity on dementia and therefore the inverse of these was used to reflect the risk association with physical inactivity.

**Table A2: Source of relative risk used in calculation of attributable burden, by risk factor**

Risk factor	Reference	Study type	Number of studies	Study date	Sample size	Age at exposure	Length of follow-up	Exposure definition	Outcome definition	RR (95% CI)	Notes
Diabetes	Prince et al. 2014	Meta-analysis	11 prospective studies	Up to January 2012	35,342	Range = 60–88 years	2 to 13 years	Diagnosed and undiagnosed diabetes	All-cause dementia (clinically diagnosed)	RR 1.50 (1.30, 1.73)	Adjusted for age, sex, education and other potential risk factors
Stroke	Reitz et al. 2008	Prospective longitudinal population study	1 prospective study	1990–1993 to 2005	6,724	Mean = 69 ± 8.9 years	7.3 years	Incident stroke Identified through linked health data	All-cause dementia (clinically diagnosed DSM-III)	RR 2.10 (1.54, 2.93)	Adjusted for age, sex, education and APOE genotype Excluded patients with a history of stroke
Atrial fibrillation	Santangelo et al. 2012	Meta-analysis	8 prospective studies	2004–2012	77,668	Range = 61–84 years	Mean 7.7 ± 9.1 years	Clinically diagnosed atrial fibrillation (electrocardiogram (ECG) and/or ICD codes)	All-cause dementia (clinically diagnosed DSM-III/IV and ICD-9/10)	RR 1.42 (1.17, 1.72)	Adjusted for age, sex, education as well as past/current CVD, diabetes, BMI and alcohol consumption Excluded studies with stroke patients
Chronic kidney disease	Seliger et al. 2004	Prospective longitudinal population study	1 prospective study	1989–90 and 1992–93 to 1999	3,349	Mean = 76 ± 4.9 years	Median 6 years	Moderate renal impairment Elevated serum creatinine Females ≥1.3 mg/dL; males ≥1.5 mg/dL	All-cause dementia (clinically diagnosed DSM-IV)	RR 1.37 (1.06, 1.78)	Adjusted for age, sex, education ethnicity, BMI, coronary heart disease, hypertension, diabetes, smoking, APOE genotype

(continued)

**Table A2 (continued): Source of relative risk used in calculation of attributable burden, by risk factor**

Risk factor	Reference	Study type	Number of studies	Study date	Sample size	Age at exposure	Length of follow-up	Exposure definition	Outcome definition	RR (95% CI)	Notes
Obesity in mid-life	Peditizi et al. 2016	Meta-analysis (mid-life)	7 prospective studies	Up to Sep 2014	62,425	Range = 42–50 years	23 to 42 years	BMI $\geq 30$ kg/m <sup>2</sup> (obese)	All-cause dementia (clinically diagnosed DSM-III/IV and NINCDS/ADRDA)	RR 1.41 (1.20, 1.65)	Adjusted for age, sex, education. And for some; APOE genotype, diet, physical activity, smoking, stroke, other CVD, diabetes
High blood pressure in mid-life	Barnes & Yaffe 2011	Meta-analysis (mid-life)	4 prospective studies	2001–2006	29,287	Range = 40–50 years	7 to 30 yrs	Systolic blood pressure $\geq 140$ mmHg	Alzheimer's disease and all-cause dementia (clinically diagnosed DSM-III/IV and medical records)	RR 1.61 (1.16, 2.24)	Adjusted for age, sex, education. And for some; APOE genotype, BMI, diet, physical activity, smoking, stroke, other CVD, diabetes
Physical inactivity	Blondell et al. 2014	Meta-analysis	21 prospective studies	Up to Jan 2014	40,384	Range = 56–90+ years	1 to 26 years	High versus low physical activity levels via questionnaire	All-cause dementia (clinically diagnosed DSM-III/IV)	RR 1.14 (1.04–1.32)	Adjusted for age and education. And for some; sex, depression, APOE genotype, BMI, use of non-steroidal anti-inflammatory drugs, smoking, stroke, other CVD, diabetes
Tobacco use	Zhong et al. 2015	Meta-analysis	37 prospective studies	Up to March 2014	937,392	Mean range = 42–80 years	2 to 40 years	Current smoker	All-cause dementia (clinically diagnosed DSM-III/IV, NINCDS/ADRDA and ICD-9/10)	RR 1.30 (1.13–1.73)	Most adjusted for age, sex, education. And for some; APOE genotype, BMI, alcohol, hypertension, diabetes

*Note:* APOE = apolipoprotein E; BMI = body mass index; CI = confidence interval; CVD = cardiovascular disease; DSM = Diagnostic and Statistical Manual of Mental Disorders; ICD = International Statistical Classification of Diseases and Related Health Problems; NINCDS/ADRDA = National Institute of Neurological and Communicative Disorders and Stroke/Alzheimer's Disease and Related Disorders Association; RR = relative risk.

# Appendix B: Detailed methods

## Calculation of population attributable fractions

Population attributable fractions (PAFs) determine the proportion of a particular disease that could have potentially been avoided if the population had never been exposed to a risk factor (Box 1.3).

The key data inputs for calculating attributable burden are:

- the effect size; in this case, the relative risk (RR), of the risk factor on the outcome of interest (in this case, dementia)
- the prevalence (P) of risk factor exposure in the population.

These inputs are used to calculate the PAF as:

$$PAF = \frac{P(RR - 1)}{P(RR - 1) + 1}$$

Attributable burden (AB) is calculated as:

$$AB = PAF \times C$$

where *C* = the total burden (DALY) of a specific outcome, for example, dementia.

Dementia burden—in disability-adjusted life years (DALY)—was sourced from the Australian Burden of Disease Study (ABDS) 2011 where DALY represents the sum of fatal and non-fatal burden.

In the ABDS 2011, Fatal burden (years of life lost, or YLL) was estimated using deaths data from the Australian Institute of Health and Welfare's (AIHW) National Mortality Database and a standard life table developed in the Global Burden of Disease (GBD) 2010 study (Murray et al. 2012). The fatal burden estimates for dementia are considered to be of high quality.

In the same report, non-fatal burden (years lived with disability, or YLD) was estimated using dementia prevalence from *Dementia in Australia* (AIHW 2012) and disability weights from the Global Burden of Disease (GBD) 2013 study (AIHW 2016b). The *Dementia in Australia* report based estimates of prevalence on international studies, as there were no recent Australian data. These estimates could be improved with Australian prevalence estimates, and should be interpreted with this in mind.

Both the prevalence of a risk factor and the size of the effect (size of the RR) influence attributable burden. That is, the attributable burden can be greater for a risk factor with a low RR and high prevalence compared with a risk factor with a high RR and low population prevalence. Therefore, this analysis is dependent on accurate prevalence estimates for included risk factors. Box B1 provides an example of the calculation of attributable burden.

### Box B1: Calculation of attributable burden

In the population, a proportion of dementia is considered to be due to tobacco. This is estimated using the population attributable fraction (PAF) which takes into account the number of people who are exposed (that is the prevalence,  $P$ , or the proportion of the population that use tobacco) and the size of the association (the relative risk,  $RR$ ) between tobacco use and developing dementia.

Suppose that in the population, 14% of people smoke tobacco. The  $RR$  of developing dementia from tobacco use is 1.3. Using the formula (described more fully in the preceding text),

$$PAF = \frac{P(RR - 1)}{P(RR - 1) + 1}$$

we get:

$$PAF = \frac{0.14(1.3 - 1)}{0.14(1.3 - 1) + 1}$$

$$PAF = 0.04$$

Suppose further that in the population there were 150,000 DALY for dementia. The attributable burden (AB) is an estimate of the amount of this dementia burden that is due to tobacco use. This is calculated by multiplying the PAF and the linked disease burden,

$$AB = PAF \times DALY$$

$$AB = 0.04 \times 150,000$$

$$AB = 6,000$$

Therefore, 6,000 DALY from dementia would be attributed to tobacco use. This equates to 4% of the dementia DALY in this population.

Note that this is an example and the calculations in this report are made separately for each age and sex group.

## Estimating the joint effect

To combine risk factors the following formula was used:

$$PAF = 1 - \prod(1 - PAF_r)$$

where:

$PAF$  is the population attributable fraction of burden attributable to a disease from all risk factors combined

$PAF_r$  is the population attributable fraction for risk factor ' $r$ ' and linked disease  
the product  $\prod$  runs over all risk factors within the cluster.

This formula, which has been used in several other burden of disease studies, has the desirable property of placing a cap on the estimated combined attributable burden and therefore avoids the possibility of it ever exceeding 100% of the total burden of disease.

However, the formula assumes that risk factors are independent; it does not take into account risk factors that are in the same causal pathway. To account for this, an adjustment factor of 50% was used for risk factors that are secondary to other factors in the same causal

pathway (Murray et al. 2003). The risk factors attenuated include the diseases-as-risks (diabetes, stroke, atrial fibrillation and chronic kidney disease) and high blood pressure in mid-life as they were found to be in the causal pathway for other risk factors included in this study in the ABDS 2011.

## Method for scenario modelling

Two scenarios were investigated to look at the impact of changes in risk factor prevalence on future burden of dementia:

- *Trend scenario* – provides an estimate of the expected future dementia burden attributed to the vascular risk factors examined in the study if current trends in risk factor exposure continue until 2020.
- *WHO target scenario* – provides an estimate of the expected future dementia burden due to vascular risk factors if risk factor exposure was reduced to be on track in 2020 to meet the World Health Organization (WHO) 2025 targets.

In these scenarios, it was not possible to take into account interactions between the risk factors that occur in the same causal pathway or the impact of interventions, diagnosis and treatment on future dementia prevalence and risk factor exposure.

As well as estimates of the risk factor exposure in 2020, both these scenarios first require an estimate of the expected dementia burden in 2020, in order to estimate the burden attributable to those risk factors.

The following steps were taken to estimate future dementia burden attributable to vascular risks:

1. The total dementia burden (DALY) for the *Trend scenario* was projected to 2020 using estimates of projected dementia prevalence in 2020 (AIHW 2012), and trends in fatal burden due to dementia from the ABDS 2011. This provided the total dementia burden in 2020.
2. Projected estimates of risk factor exposure (for 2020) were based on linear and log-linear trends, using health survey data or ABDS 2011 estimates. The baseline estimate for the *WHO target scenario* was calibrated to 2010.
3. The joint effect of vascular risks under each scenario in 2020 was calculated, and the attributable burden estimated using the dementia DALY calculated in Step 1 and the prevalence projections estimated in Step 2.
4. To estimate total dementia burden in 2020 for the *WHO target scenario*, the difference in the joint effect estimate in Step 3 was subtracted from the projected 2020 dementia prevalence.
5. Under each scenario, using dementia burden in 2020 estimated in Step 1 and Step 4, the joint effect of vascular risk factors as well as the impact of individual risk factors was calculated.

The difference in attributable DALY between the 2 scenarios was then calculated for the joint effect and for each individual risk factor. The difference in attributable DALY reflects the amount of future dementia burden that could be avoided if current trends in risk factor prevalence continue, compared with if Australia is on track in 2020 to meet the WHO targets set for 2025.

## Methods to obtain dementia burden in 2020

### Trend scenario

As there are no direct dementia prevalence estimates for Australia, the non-fatal dementia burden (YLD) was estimated using projected dementia prevalence for the year 2020, which only accounts for population growth and ageing, from *Dementia in Australia* (AIHW 2012) and disability weights from ABDS 2011 (AIHW 2016b). The disability weights were initially sourced from the Global Burden of Disease (GBD) 2013 study and then adjusted in the ABDS 2011 to account for comorbidity in 2011. The comorbidity adjustment is based on the relative prevalence of all of the conditions included in the ABDS in 2011. The use of these adjusted disability weights assumes that comorbidity does not vary greatly between 2020 and 2011.

As there were changes in the recording of dementia deaths since 2006 (AIHW 2016d: Box 7.1), it was not possible to estimate the fatal dementia burden in 2020 from past trends. Instead, the fatal dementia burden (YLL) in 2020 was estimated by applying the age-sex specific non-fatal:total burden ratio in 2011 to the estimated non-fatal burden in 2020.

By adding these estimates together, dementia burden in 2020 was estimated to be 204,919 DALY (80,098 for males and 124,821 for females) and is considered the most appropriate to use as a base for the *Trend scenario*. The burden is 35% higher in 2020 under the *Trend scenario* compared with 2011, as a consequence of population growth and ageing.

### WHO target scenario

As the dementia burden is relative to the burden of all other diseases, it is difficult to predict the impact of changes in other diseases that are, themselves, underlying risk factors for dementia. To overcome this problem, the estimated dementia burden in 2020 under the *WHO target scenario* was calculated by subtracting the DALY difference between the joint effects under each scenario.

## Methods to obtain risk factor exposure in 2020

### Trend scenario

This scenario assumes that the current trends for each risk factor will continue until 2020.

For the *Trend scenario*, estimates of age- and sex-specific prevalence of metabolic and behavioural risks were projected using the linear or log-linear trends of actual prevalence in Australia using successive Australian Bureau of Statistics (ABS) Australian Health Surveys (AHS). The type of trend was chosen according to its best fit with the data points. The definition of exposure was the same as for 2011 (Table 2.1).

The trend in tobacco smoking was based on the ABS AHS in 2007–08, 2011–12 and 2014–15. The trend in high blood pressure was based on measured systolic blood pressure measurements from the Australian Diabetes, Obesity and Lifestyle (AusDiab) Study and ABS AHS in 2011–12 and 2014–15. The trend in obesity was based on ABS AHS with measured body mass index results in 1995, 2001, 2007–08 and 2011–12.

Due to changes in survey methodology, the trend in physical inactivity was calculated using comparable estimates by sex published by the AIHW and based on the years 1989, 1995, 2001, 2004–05, 2007–08 and 2011 (AIHW 2016e).

Sensitivity analysis was done to compare the methodological choices made. We investigated the impact of limiting the number of estimates (years, sex and age groups) included for the trend. When the estimates were more variable, a larger number of time points were included. Sensitivity analyses were also performed to test the use of log-linear trends but were found less fitting, with the exception of high blood pressure in older age groups.

For diseases-as-risks exposure in 2020, the *Trend scenario* was estimated using the same annual rate of change in prevalence between 2003 and 2011 from the ABDS 2011 and extrapolated linearly to 2020 to projected 2020 populations. Limitations of estimating disease prevalence in 2020 based on this approach is that the rate of change is based on 2 time points (2003 and 2011) only and is constrained by the ABDS 2011 methods for estimating disease prevalence in 2003 and 2011. Updated prevalence estimates for these diseases may provide opportunity for future extrapolations based on more than 2 time points, leading to increasing accuracy.

### **WHO target scenario**

The WHO 2025 targets for each risk factor are shown in Chapter 3 (Table 3.5). The targets use 2010 as the baseline with targets to be achieved by 2025. Therefore, exposure used in the analysis under the *WHO target scenario* is the expected exposure prevalence in 2020 if Australia was on track to meet the WHO targets set for 2025. In this analysis, we used prevalence rates to calculate the target prevalence for 2020. For the diseases-as-risks (diabetes, chronic kidney disease, stroke and atrial fibrillation), 2011 prevalence rates from the ABDS 2011 were assumed to be equivalent to prevalence rates in 2010.

In the *WHO target scenario* analysis, exposure targets for diseases-as-risks were constrained by those available in the WHO's Global Action Plan for the Prevention and Control of Noncommunicable Diseases 2013–2020 (WHO 2013). Specifically, the only relevant target in this framework for disease prevalence was for diabetes. In the absence of targets for the other 3 diseases-as-risks, the same exposure level expected for diabetes was applied to chronic kidney disease; that is, to halt the rise in prevalence by 2025 (operationalised here as no change in prevalence rates between 2011 and 2020). This target exposure level was not considered appropriate to apply to stroke as this is showing a declining trend in prevalence, or to atrial fibrillation, which has shown no clear trend between 2003 and 2011 based on data in the ABDS 2011. Instead, an arbitrary target of a 10% relative prevalence reduction compared with 2011 was used.

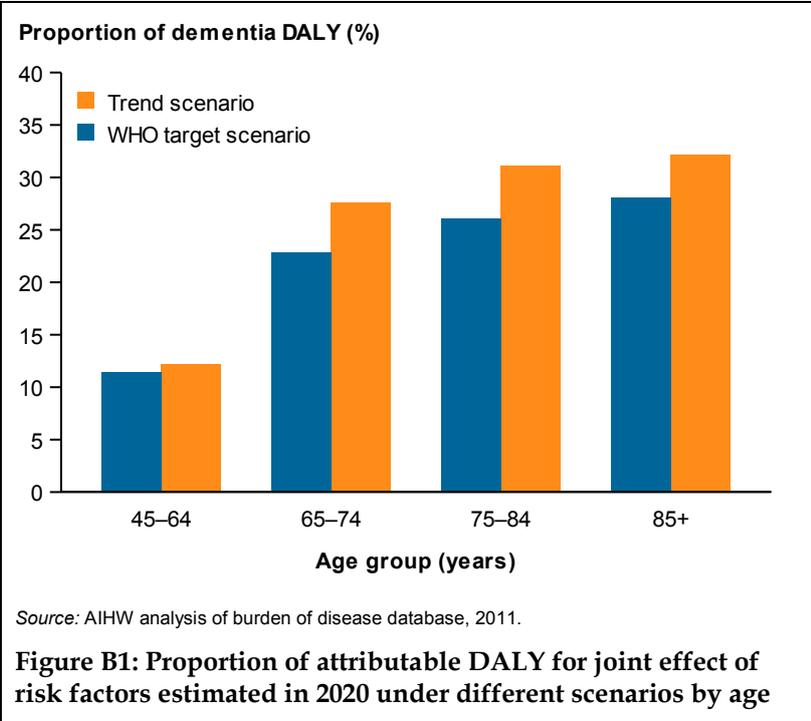
To estimate exposure prevalence in 2020 for the *WHO target scenario*, the 2011 exposure estimates were used to estimate a baseline for 2010 for Australia. The 2020 exposure estimates were then calculated using a 2-point linear trend from the 2010 estimated baseline to the 2025 target.

This scenario assumes that risk factor exposure in 2020 in Australia is aligned to meet WHO 2025 targets by 2025.

### **Dementia burden attributed to the vascular risk factors in 2020 under different scenarios**

Figure B1 shows the percentage of dementia burden attributable to the joint effect of the 8 risk factors for different age groups. Like current estimates, in both scenarios, the proportion of attributable burden increases with age.

Under the *WHO target scenario*, the proportion of dementia DALY attributable to the vascular risk factors is consistently lower than the *Trend scenario* estimates in every age group. The dementia burden attributable to these risk factors is around 4.5% lower under the *WHO target scenario* than under the *Trend scenario* for each age group.



# Glossary

**APOE (apolipoprotein E):** APOE is the principal cholesterol carrier in the brain. There are 3 major alleles: ApoE- $\epsilon$ 2 ApoE- $\epsilon$ 3 and ApoE- $\epsilon$ 4. The  $\epsilon$ 4 variant is a known risk factor for Alzheimer disease. However, it is not a determinant for disease nor are only those with high-risk alleles at risk of Alzheimer disease.

**attributable burden:** The disease burden attributed to a particular risk factor. It is the reduction in burden that would have occurred if exposure to the risk factor had been avoided (or, more precisely, had been at its theoretical minimum).

**comparative risk assessment:** The process for estimating the burden of disease attributable to selected risk factors. It involves 5 key steps: selection of risk–outcome pairs; estimation of exposure distribution; estimation of effect sizes; choice of counterfactual; and the calculation of attributable burden.

**counterfactual:** The alternative risk factor exposure distribution chosen for comparison with the observed distribution, in order to estimate the contribution of that risk factor to the burden of disease.

**DALY (disability-adjusted life years):** measure (in years) of healthy life lost, either through premature death defined as dying before the expected life span at the age of death (YLL) or, equivalently, through living with ill health due to illness or injury (YLD).

**effect size:** A statistical measure of the strength of the relationship between 2 variables (in this context, between a risk exposure and a disease outcome), expressed, for example, as a **relative risk**.

**joint effect:** The total proportion attributable to the risk factors of interest, taking into account other risk factors of interest on the same causal pathway.

**population attributable fraction (PAF):** For a particular risk factor and causally linked disease or injury, the percentage reduction in burden that would occur for a population if exposure to the risk factor was avoided or reduced to its theoretical minimum.

**relative risk (RR):** The risk of an event relative to exposure, calculated as the ratio of the probability of the event occurring in the exposed group to the probability of it occurring in the non-exposed group. A relative risk of 1 implies no difference in risk; RR <1 implies the event is less likely to occur in the exposed group; RR >1 implies the event is more likely to occur in the exposed group.

**relative standard error:** The standard error expressed as a percentage of the estimate. This provides an indication of the percentage of errors likely to have occurred due to sampling.

**Risk–outcome pairs:** Conditions that are causally linked to a risk factor.

**YLD (years lived with disability):** Measure the years of what could have been a healthy life that were instead spent in states of less than full health. YLD represent non-fatal burden.

**YLL (years of life lost):** Measure years of life lost due to premature mortality. YLL represent fatal burden.

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## Related publications

This report, *Contribution of vascular diseases and risk factors to the burden of dementia in Australia*, and other AIHW publications can be downloaded for free from the AIHW website <<http://www.aihw.gov.au>>. The website also includes information on ordering printed copies.

The following AIHW publications relating to dementia or burden of disease in Australia might also be of interest:

- AIHW 2012. *Dementia in Australia*. Cat. no. AGE 70. Canberra: AIHW.
- AIHW 2016a. *Australian Burden of Disease Study: impact and causes of illness and death in Australia 2011*. Australian Burden of Disease Study series no. 3. Cat. no. BOD 4. Canberra: AIHW.
- AIHW 2016b. *Australian Burden of Disease Study 2011: methods and supplementary material*. Australian Burden of Disease Study series no. 5. Cat. no. BOD 6. Canberra: AIHW.
- AIHW 2016c. *Australian Burden of Disease Study: impact and causes of illness and death in Aboriginal and Torres Strait Islander people 2011*. Australian Burden of Disease Study series no. 6. Cat. no. BOD 7. Canberra: AIHW.
- AIHW 2016d. *Diabetes and chronic kidney disease as risks for other diseases*. Australian Burden of Disease Study series no. 8. Cat. no. BOD 9. Canberra: AIHW.



This report describes a range of modifiable vascular risk factors for dementia, and estimates their individual and combined contribution to the burden of dementia in Australia. Vascular risk factors in this study include smoking, physical inactivity, mid-life high blood pressure and mid-life obesity, as well as vascular diseases that act as risk factors for dementia—diabetes, stroke, atrial fibrillation and chronic kidney disease. It uses burden of disease estimates from the Australian Burden of Disease Study 2011 and evidence in the literature that shows a link between these vascular risk factors and development of dementia in later life. It shows that about 30% of the total dementia burden in Australia is due to the joint effect of the vascular risk factors examined; highlighting the potential for preventing dementia and reducing dementia-related burden.