Rise and try to shine: The social and economic cost of sleep disorders in Australia

Sleep Health Foundation

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Preface

Sleep Health Foundation

The Sleep Health Foundation is proud to release this latest instalment in its series of comprehensive reports that detail the economic impacts related to adverse sleep health. This current report: ***Rise and try to shine: The social and economic cost of sleep disorders in Australia**,* focuses on the three most common sleep disorders; namely, obstructive sleep apnoea, insomnia and restless legs syndrome. Capitalising on more recent national and international disease prevalence estimates and greater knowledge of downstream consequences, this report is an update from 2010 estimates. Importantly, it goes further in demonstrating the substantial contribution of common sleep disorders to the collective burden of public health. The combined direct and indirect costs of these sleep disorders to the Australian economy and society more broadly is a staggering $51 billion per annum.

Australia remains at the international forefront for its impact on the sleep health landscape. Our endeavours have been driven by ground breaking research, world leading biotechnology industries, cutting edge clinical practice, and a world first Parliamentary Inquiry into the importance of sleep health. The 2019 Inquiry report, ***Bedtime Reading***, is a roadmap for the future of sleep health. Indeed, despite Australia's remarkable contribution to the science and technology of sleep health, there remains much work to be done. The majority of sleep disorders in the Australian community remain unrecognised and untreated. Resources to address the burden of disease are under-developed and consequently investment in raising awareness and deploying treatments are urgently needed.

Sleep is an essential physiologic function and is fundamental to healthy living. When sleep is disordered, compelling evidence reveals the extent to which every bodily system is affected. Cognitive performance, mental resilience, metabolic and cardiovascular health, workplace productively and safety have become established targets through the optimisation of sleep. Unsurprisingly our most vulnerable community members, the young, the elderly and those with mental health conditions are affected to the greatest extent. From these perspectives, the scale of the economic cost of sleep disorders can be appreciated.

In 2010 the Sleep Health Foundation commissioned Deloitte Access Economics to produce the ***Re-awakening Australia* Report** indicating that the cost of sleep disorders to be $36.4 billion per annum. Developments in the medical literature for the prevalence and consequences of sleep disorders, as well as updates to the economic implications of these and associated conditions has seen the cost estimates for these conditions escalate by 40% in a decade. Although these figures are huge in scale, the methodological approach was at all times careful to adopt conservative estimates. This conservative approach was especially applied to the prevalence of sleep disorders and are more likely to reflect an under-estimate of the actual data.

This report, alongside the **2017 *Asleep on the Job* report,** provides a comprehensive case for an awareness and prevention strategy of sleep disorders and their consequences. As we emerge from a global pandemic, with numerous reports of further adverse impacts on sleep health, we believe the case for action has never been stronger. We are grateful to Professor David Hillman for providing his extensive content expertise.

On behalf of the Sleep Health Foundation, we present: ***Rise and try to shine: The social and economic cost of sleep disorders in Australia 2021.***

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ABS	Australian Bureau of Statistics
AHI	apnoea-hypopnoea index
AIHW	Australian Institute of Health and Welfare
AR-DRG	Australian refined diagnostic-related group
AWE	average weekly earnings
BEACH	Bettering the Evaluation and Care of Health
BITRE	Bureau of Infrastructure, Transport and Regional Economics
CAD	coronary artery disease
CHF	congestive heart failure
CPAP	continuous positive airway pressure
DALYs	disability adjusted life years
DSM-5	Diagnostic and Statistical Manual of Mental Disorders
ESS	Epworth Sleepiness Scale
GP	general practitioner
ICD-10	International Classification of Diseases Tenth Revision
ICER	incremental cost effectiveness ratio
ICSD	International Classification of Sleep Disorders
MVAs	motor vehicle accidents
NHCDC	National Hospital Cost Data Collection
NHMRC	National Health and Medical Research Council
NPV	net present value
OSA	obstructive sleep apnoea
PAF	population attributable fraction
PSG	polysomnography
RLS	restless legs syndrome
SDAC	Survey of Disability, Ageing and Carers
VSLY	value of a statistical life year
WPIs	workplace injuries
YLDs	years of healthy life lost due to morbidity
YLLs	years of life lost due to premature mortality

Executive summary

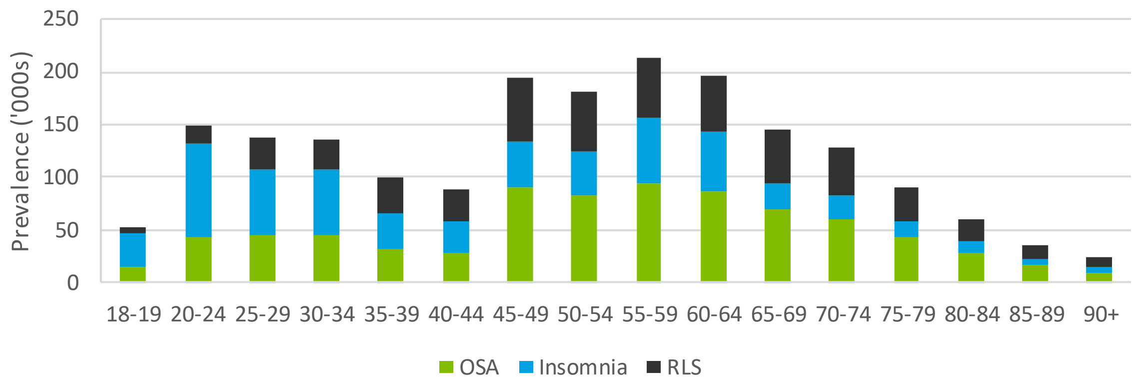
Sleep disorders continue to present significant costs upon Australian society. In Deloitte Access Economics' 2010 report *Re-awakening Australia* these costs were estimated to be $36.4 billion. Deloitte Access Economics was commissioned by the Sleep Health Foundation to re-estimate the cost of sleep disorders based on updated cost information and developments in the literature, to present an up-to-date estimate of the cost of sleep disorders upon Australian society. The updated estimate allows for comparison to other recent reports estimating the cost of inadequate sleep[1] and the cost-effectiveness of continuous positive airway pressure (CPAP) for people with obstructive sleep apnoea[2] (OSA). Providing a contemporaneous time frame from which the costs of sleep disorders have been estimated will allow the community to better understand how the costs are distributed across clinical sleep disorders and across inadequate sleep more generally.

This report provides estimates for three well recognised and researched sleep disorders, OSA, insomnia and restless legs syndrome (RLS), consistent with the 2010 report.

Prevalence

The prevalence of each sleep disorder was calculated in the Australian population aged 15 years or older. It was estimated that there were 0.78 million people with OSA, 0.60 million people with insomnia and a further 0.54 million people with RLS. The prevalence of sleep disorders by age and condition are provided in Chart i.

Chart i: Prevalence of sleep disorders by age and condition, 2019-20



Source: Deloitte Access Economics analysis based on Peppard et al (2013), Ohayon and Reynolds (2009), Allen et al (2005) and Adams et al (2017).

For the purposes of this report, a conservative approach has been taken when modelling costs. A frequently cited prevalence estimate of 3.9% representing moderate to severe OSA plus excessive daytime sleepiness (moderate to severe OSA syndrome) was used as the basis for modelling OSA.[3] For insomnia, while overall prevalence is noted to be of the order of 11.3%, a frequently cited prevalence estimate for insomnia not attributable to other causes of 3.0% was used for modelling all costs. For RLS, a frequently cited prevalence estimate of 2.7% for that associated with frequent, distressing symptoms was used.

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[1] See *Asleep on the job: Costs of inadequate sleep in Australia* (Deloitte Access Economics, 2017).
[2] See *Cost effectiveness of continuous positive airway pressure for obstructive sleep apnoea* (Deloitte Access Economics, 2018).
[3] The prevalence of moderate to severe OSA has been noted to be of the order of 8.3% to 9.3%.

Sleep disorders and other attributable conditions

There is evidence of a causal relationship between sleep disorders and other conditions or injuries. PAFs were used to estimate the proportion of cases and deaths of other conditions which were attributable to sleep disorders. Some PAFs have changed from previous reports to reflect current understanding of the relationship between the sleep disorder and the attributable condition.

The attributable conditions considered in this report included congestive heart failure (CHF), coronary artery disease (CAD), stroke, type 2 diabetes mellitus (T2DM), depression, motor vehicle accidents (MVAs) and workplace injuries (WPIs). The attributable conditions and their respective PAFs for each sleep disorder are presented in Table i.

Table i: Relationship between sleep disorders and other health conditions, 2019-20

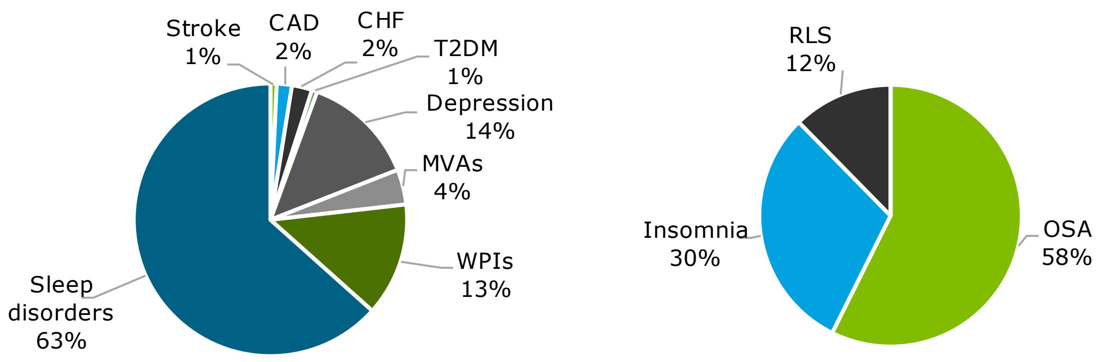
Related condition	PAF (%)			Attributed cases ('000s)	Attributed deaths
	OSA	Insomnia	RLS		
CHF	0.9	1.5	-	2.7	79
CAD	0.2	1.3	-	11.1	297
Depression	4.1	1.6	-	44.6	76
MVAs	5.5	2.3	-	2.9	96
Stroke	4.1	-	-	6.5	359
T2DM	1.3	-	-	14.7	70
WPIs	3.0	5.3	-	66.9	12
Total				**149.4**	**989**

Source: Deloitte Access Economics analysis. Note: components may not sum to totals due to rounding.

Health system costs

The health system costs of sleep disorders comprise the cost of the sleep disorders themselves and the share of health costs from other conditions attributed to sleep disorders. It was estimated that the **total health system costs were $0.9 billion in 2019-20.** Health system costs were primarily due to OSA (58%), which was followed by insomnia (30%) and RLS (12%).

Chart ii: Breakdown of health system costs of sleep disorders by cost component (left) and condition (right), 2019-20



Source: Deloitte Access Economies analysis.

Health system costs included: $338.7 million in inpatient hospital admissions, $465.8 million in out-of-hospital medical expenses, $108.8 million in pharmaceutical costs, and $30.5 million in other costs.

Other financial costs

Other financial costs include productivity losses, the cost of informal carers and the deadweight loss incurred by society. It was estimated that other financial costs associated with sleep disorders and their attributable conditions were $13.4 billion in 2019-20. Of other financial costs, 37% were attributed to OSA ($4.9 billion), 41% were attributed to insomnia ($5.5 billion) with the remaining 22% of costs incurred by people with RLS ($3.0 billion).

Other financial costs were composed of:

- $2.2 billion in absenteeism losses, or absences from work
- $7.5 billion in presenteeism losses, or reduced productivity while at work
- $1.0 billion in reduced employment
- $0.2 billion in premature mortality costs, representing forgone future income where deaths are attributable to sleep disorders
- $0.3 billion in informal care costs
- $0.6 billion in other costs, primarily representing additional costs of accidents (e.g. policing, courts, property damage, etc) including greater reliance on aids and modifications due to long-term or permanent disability
- $1.5 billion in deadweight losses, which are costs that occur due to the need to levy taxes to pay for government-funded services (e.g. health costs) and achieve a budget neutral position.

Wellbeing costs

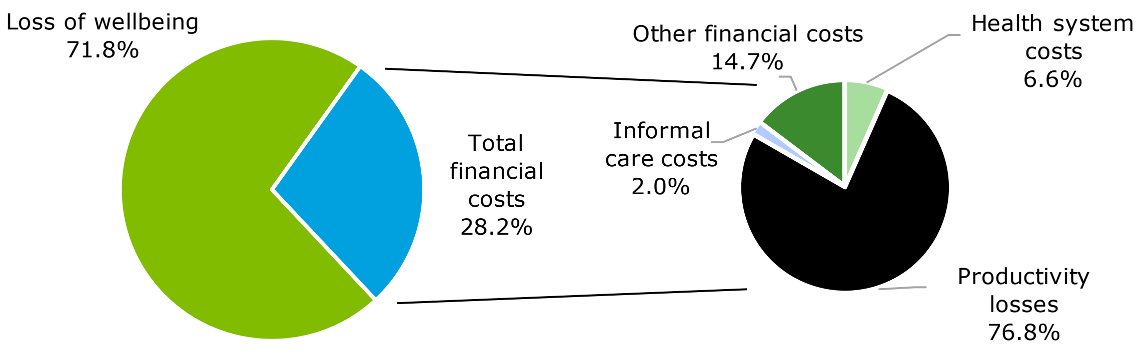
Sleep disorders impose a non-financial cost upon the individual with the condition through a reduction in the person's wellbeing. People with sleep disorders often experience a lower quality of life, which can be measured in disability adjusted life years (DALYs). DALYs lost from OSA, insomnia, RLS and from conditions attributable to sleep disorders were calculated, and adjustments were made to avoid double counting. It was estimated that 173,319 DALYs (undiscounted) were lost due to sleep disorders in 2019-20. OSA contributed 64,788 DALYs, insomnia 62,806 DALYs and RLS 45,724 DALYs.

The total number of DALYs were converted into a dollar value by multiplying each DALY by the value of a statistical life year (VSLY), which was $216,626 in 2019-20. The total reduction in wellbeing was valued at $36.6 billion in 2019-20.

Summary of costs

The total cost of sleep disorders was estimated to be $51.0 billion in Australia in 2019-20.

Chart iii: Breakdown of total costs (left) and total financial costs (right) of sleep disorders by cost component, 2019-20



Source: Deloitte Access Economics analysis.

The total cost was primarily made up of the non-financial reduction in wellbeing due to sleep disorders ($36.6 billion, 72%). Of financial costs, these primarily included productivity losses (77%) and other financial costs (15%) such as deadweight losses and costs of accidents. The remaining 8% was due to health system costs and informal care. The costs due to insomnia ($19.1 billion) were higher than the costs due to OSA ($18.9 billion) and RLS ($13.0 billion).

Hillman et al (2018) estimated the costs of inadequate sleep in 2016-17. To allow for comparison with the present analysis, these costs have been updated to the 2019-20 financial year. The comparison of the updated costs of inadequate sleep compared to the cost of sleep disorders estimated in the present study is presented in Table ii. The total costs of inadequate sleep in 2019-20 (adjusted for inflation and demographic changes since 2016-17) were estimated to be $75,499.4 million.

The costs of inadequate sleep included costs due to sleep disorders, although the prevalence of each sleep disorder was smaller in Hillman et al (2018) than in the present study. This occurs in part because not all people with a sleep disorder will necessarily have experience inadequate sleep. However, it also reflects changes in methodology between *Reawakening Australia* and the current report. The major driver of the difference in costs include changes to prevalence and case definitions, and it was possible to estimate absenteeism and presenteeism costs due to sleep disorders in the current report.

Table ii: Total costs of inadequate sleep and sleep disorders, 2019-20

Condition	Inadequate sleep ($m)	Sleep disorders ($m)
Health system costs	1,990.1	943.8
Productivity losses	21,006.1	11,032.9
Other financial costs	6,641.4	2,393.7
Total financial costs	**29,637.6**	**14,370.5**
Wellbeing costs (non-financial)	**45,861.9**	**36,580.4**
Total costs	**75,499.4**	**50,950.8**

Deloitte Access Economics calculations. Note: components may not sum to totals due to rounding.

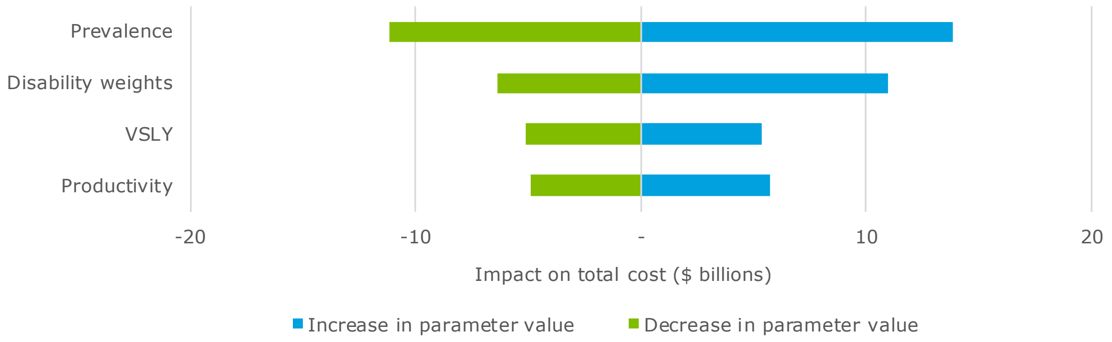
The comparison shows that sleep disorders have around half the financial costs of inadequate sleep, and around 80% of the wellbeing losses compared to inadequate sleep. The total costs of sleep disorders were around two thirds of the cost of inadequate sleep. However, it should be noted that there are methodological differences in the two estimation processes and definitional differences that affect the comparison, so it is not like for like.

Sensitivity analysis

One-way sensitivity analyses were conducted on prevalence, the VSLY, disability weights, and estimated productivity losses (applied to absenteeism and presenteeism). Parameters were generally selected based on the range of values observed in the literature, choosing the upper and lower bounds as inputs.

The results of the sensitivity analysis showed that the possible variation in prevalence has the largest impact on the costs (Chart iv): total costs – financial and non-financial – ranged between $39.8 billion and $64.8 billion.

Chart iv: Tornado diagram showing the impact on total cost of sleep disorders given changes in input parameters, 2019-20



Source: Deloitte Access Economics analysis.

Conclusions

Sleep disorders within Australia pose significant and ongoing challenges. In 2010, the cost of sleep disorders was estimated to be $36.4 billion. Currently, in 2019-20, these costs were conservatively estimated at $51.0 billion. Alongside the costs of inadequate sleep – estimated to be $75.5 billion in 2019-20 – there are likely to be substantial benefits from interventions that aim to improve sleep health in Australia.

In 2019 the Commonwealth Government released findings from the *Inquiry into Sleep Health Awareness in Australia.* The inquiry identified several key recommendations which are summarised briefly as follows:

- Sleep health should be a national priority with its importance to health and wellbeing to be recognised alongside fitness and nutrition.
- Updated guidelines regarding optimal shift structures and a nationally consistent approach to working hours and rest breaks for shift workers.
- A review of the Medicare Benefits Schedule as it relates to sleep health services in Australia.
- Ensure that all Pensioner or Health Care Card holders with moderate to severe OSA have access to a free trial of CPAP therapy and pending the success of the trial, free ongoing CPAP treatment.
- The development of a national sleep health awareness campaign to provide information on the causes and impacts of sleep disorders and to communicate the benefits associated with improved sleep health.
- Assess the current knowledge levels of general practitioners (GPs), nurses and psychologists in relation to sleep health, and develop effective training mechanisms to further improve understanding.
- The Australian Government should fund research focused on the prevalence of sleep disorders in under-researched population groups and in rare sleep disorders which are not well understood. Research should also focus on the effects of long-term shift work on sleep health and the effects of digital devices and electronic media on sleep health.

The findings in this report show that investment in these measures is likely warranted, given the large impact of sleep disorders on Australian society and on the lives of people living with sleep disorders.

Deloitte Access Economics

1 Background

1.1 Introduction

The Sleep Health Foundation engaged Deloitte Access Economics to estimate the social and economic impact of sleep disorders in 2019-20. Three of our previous reports, *Asleep on the Job* (Deloitte Access Economics, 2017), *Reawakening Australia* (Deloitte Access Economics, 2011), and *Wake Up Australia* (Access Economics, 2004), focus on the prevalence and costs of sleep disorders with emphasis on OSA, insomnia and RLS, as well as some of the secondary effects of sleep disorders such as excessive daytime sleepiness, insufficient sleep and inadequate sleep. Together with this report, there is an established evidence base highlighting the significant cost of inadequate sleep and sleep disorders. It is anticipated that this evidence base will support informed policy development in relation to sleep health in Australia.

This report is structured in the following way:

- **Chapter 1** provides an introduction to this report, describes the causes and diagnosis of sleep disorders and how sleep disorders may be treated, and summarises the methodology used to estimate costs.
- **Chapter 2** presents the prevalence estimates of each individual sleep disorder.
- **Chapter 3** summarises the PAFs which have been used to model costs of other conditions that are attributable to sleep disorders.
- **Chapter 4** estimates the health system costs of sleep disorders and the attributed conditions.
- **Chapter 5** calculates the other financial costs related to sleep disorders including the productivity losses, informal care and welfare losses.
- **Chapter 6** derives the non-financial or wellbeing costs of sleep disorders.
- **Chapter 7** provides an update of the current evidence base of the costs of sleep. This places the findings of the report in context of previous estimates.

1.2 Sleep Disorders

1.2.1 Obstructive Sleep Apnoea

OSA is characterised by repetitive episodes of partial or complete airway obstruction during sleep, resulting primarily in sleep fragmentation and reduction in blood oxygen levels. Secondary effects include overstimulation of the sympathetic nervous system and systemic inflammation which, together with the primary effects, contribute to long term sequelae of the syndrome which include depression, cardiovascular disorders and increased risk of injury (see Chapter 3).

The apnoea-hypopnoea index (AHI) is the primary measure used to quantify the severity of OSA. Derived from polysomnography (PSG), it is a measure of the number of obstructive and central apnoea or hypopnoea episodes per hour of sleep. This report adopts dual definitions to capture prevalence of OSA; those with AHI ≥15 events/hour (often categorised as moderate to severe OSA) and those with AHI ≥5 events/hour, plus symptoms of daytime sleepiness. This approach aligns with current literature.

1.2.2 Insomnia

Insomnia can be broadly defined as difficulty initiating or maintaining sleep, not attributable to environmental circumstances or inadequate opportunities for sleep, and associated with daytime consequences. There is heterogeneity in the definition of insomnia both clinically and in medical literature owing to the fact that insomnia can be primary in nature or secondary to another medical condition. There is a lack of consensus across diagnostic standards, such as the Diagnostic and Statistical Manual of Mental Disorders (DSM-5), the International Classification of Sleep Disorders (ICSD), and the International Classification of Diseases Tenth Revision (ICD-10).

This report uses the DSM-5 definition of Insomnia Disorder, which describes a complaint of dissatisfaction with sleep quantity or quality, associated with one or more of difficulty initiating or maintaining sleep, or early-morning waking with inability to return to sleep. Important qualifiers to this definition include duration of at least 3 months, occurs at least 3 nights per week, occurs despite adequate opportunity for sleep and that it causes clinically significant distress or impairment in occupational or academic endeavours.

1.2.3 Restless Leg Syndrome

RLS is an under-recognised neurological disorder characterised by four diagnostic criteria;

- An urge to move the legs, usually accompanied or caused by uncomfortable or unpleasant sensations in the legs;
- The urge to move or unpleasant sensations begin or are worse during periods of rest or inactivity such as lying or sitting;
- The urge to move or unpleasant sensations are partially or totally relieved by movement, such as walking or stretching, at least as long as the activity continues, and;
- The urge to move or unpleasant sensations are worse in the evening or night than during the day or only occur in the evening or night.

There is a close association between RLS and the distinct clinical syndrome periodic limb movement disorder, which is characterised by periodic episodes of repetitive limb movement during sleep caused by muscle contractions. This report focuses only on RLS, given it is more common than periodic limb movement disorder, and because there is more substantive evidence in the literature on its adverse health effects.

Clinically diagnosing RLS is difficult, and clinicians usually rely on patients' descriptions of symptoms, as well as past medical problems, family history, and current medications (Brain Foundation, 2020). If the RLS diagnosis is associated with an underlying disorder such as diabetes or iron deficiency, treating the causal condition is more effective. For individuals with no direct associated medical condition, treatment is focused at reducing symptoms. This mainly includes lifestyle changes, such as reducing consumption of alcohol, caffeine and tobacco, taking supplements for deficiencies in iron, folate and magnesium, regulating sleep patterns, exercising, taking hot baths or massaging the legs. Additionally, there are pharmacological treatment options including dopamine agonists, opioids and gabapentin.

1.3 Diagnosis and treatment

Sleep disorders are most commonly diagnosed using PSG, also known as a sleep study, which involves the combined measuring of various physiological parameters (Abad et al, 2003). This includes measures of brain waves (known as electroencephalogram), blood oxygen level, heart rate, bodily movements and breathing. Generally undertaken overnight, data recorded in a sleep study will be collated and used by doctor along with an interview to identify causes of sleep problems and any potential disorders. Other tools which may assist with a diagnosis include standardised questionnaires such as the Epworth Sleepiness Scale (ESS), clinical interviews, discussion with partners or family members of the patient and the use of a sleep diary recorded by the patient.

The major treatment approaches are described briefly in the following paragraphs.

Following diagnosis of **OSA** there are several approaches to management.

- Lifestyle management: weight loss, reducing alcohol intake, smoking cessation and positional therapy (modifying the position adopted for sleep).
- CPAP: positively pressurised air is used to hold open the upper airway during sleep. This is delivered via a mask worn over the nose - or nose and mouth - which is connected by a tube to a small electric pump (a CPAP device).
- Dental device: splints that keeps the airway open either by holding the lower jaw forward (a mandibular advancement device) or the tongue forward (a tongue retaining device).
- Surgery: a tonsillectomy with adenoidectomy is often used to treat OSA in children. Surgery is less commonly used in adults although surgery to treat anatomical obstruction in the upper airway (e.g. nasal surgery) can be helpful.

Insomnia may lead to higher costs associated with GPs, psychiatrists and other specialists compared to people without insomnia (e.g. see Daley et al, 2009). Insomnia is primarily diagnosed and managed in primary care, with assistance from allied health services. Treatment for insomnia can include:

- pharmacological interventions, which most commonly includes benzodiazepines and other hypnotics
- behavioural interventions: these are aimed at reducing poor sleep habits and psychological barriers to sleeping, for example:
- relaxation therapy: muscle relaxation and meditation can help assist with sleep onset;
- sleep restriction therapy: reducing the amount of time spent in bed lying awake;
- stimulus control therapy: aims to reassociate the bedroom/bed with sleeping only; and
- cognitive therapy: reduces the focus on needing to sleep and the stress generated when sleep is not achieved (Grunstein 2002).

RLS is usually diagnosed by a GP based on symptoms, including difficulty initiating or maintaining sleep and the presence of periodic limb movements in sleep. A person presenting with the symptoms of RLS might be referred to a sleep specialist or a neurologist if they have atypical symptoms, substantial disturbance to sleep or other potentially more severe problems. RLS can be managed in one or both of the following ways (Aurora et al, 2012):

- non-pharmacological intervention: for example increasing iron intake and reducing caffeine, nicotine and alcohol consumptions; and/or
- a pharmacological intervention: typically benzodiazepines, low potency opioids, levodopa, or dopamine agonists (which are used to manage RLS).

The current standard treatment of RLS is pharmacologic, most commonly with dopaminergic drugs, although other non-dopaminergic agents are also used.

1.4 Estimating the costs of sleep disorders in Australia

This section describes the approach taken to estimate the costs of sleep disorders in Australia, and outlines some of the key economic terms, how costs are borne by members of society, and some of the underlying methodology presented throughout the following chapters. Specific methodologies for each of the costs associated with sleep disorders are outlined further in the chapter where they are discussed.

The costs of sleep disorders in Australia were estimated for the financial year 2019-20 using a prevalence approach to cost estimation. A prevalence approach measures the number of people with sleep disorders at a point in time, and estimates the costs incurred due to sleep disorders for a given year (e.g. 2019-20).

The broad types of costs associated with sleep disorders included in this report are:[4]

- **financial costs to the Australian health system**, which include the costs of running hospitals, GP and specialist services reimbursed through Medicare and private funds, the cost of pharmaceuticals and of over-the-counter medications, allied health services (in particular psychologists), research and other health system expenditures (such as health administration).
- **productivity costs**, which include reduced workforce participation, reduced productivity at work, loss of future earnings due to premature mortality, and the value of informal care (lost income of carers of people with sleep disorders or other conditions attributable to sleep disorders).
- **other costs**, which include costs of government services, including court and justice system costs due to accidents.
- **transfer costs**, which comprise the deadweight losses, or reduced economic efficiency, associated with the need to levy taxes to fund the provision of government services.

[4] Cost of illness methodology would typically include administrative costs and other financial costs associated with government and non-government programs such as respite programs, community palliative care, and any out-of-pocket expenses – e.g. formal care, and transport and accommodation costs associated with receiving treatment. These costs were excluded from the scope of the report as the costs are likely relatively minor.

- **wellbeing costs**, which are the costs associated with reduced quality of life and impaired functioning, and premature death[5] that result from sleep disorders. Wellbeing costs are measured in terms of the years of life, or healthy life lost, using the burden of disease methodology.

The costs of sleep disorders are borne by different individuals or sectors of society. Understanding how the costs are shared helps to make informed policy and healthcare decisions regarding interventions. While people with sleep disorders are most severely affected by the condition, other family members and society also face costs as a result of sleep disorders.

From the employer's perspective, work loss or absenteeism can lead to costs such as higher wages (i.e. accessing skilled replacement short-term labour) or alternatively lost production, idle assets and other non-wage costs. Employers might also face costs such as rehiring and retraining due to premature mortality.

Australian governments typically bear costs associated with the health system and other government services such as court and justice system costs (noting there are also out of pocket expenditures and other payers including private health insurers). The analysis in this report shows the first-round impacts on government, employers and individuals. No second round or longer-term dynamic impacts were modelled (i.e. changes in wages or labour market outcomes associated with the economic burden of sleep disorders).

Any future costs ascribed to sleep disorders for the year 2019-20 were estimated in net present value (NPV) terms to reflect the value of utility today rather than in the future. Taking inflation, risk and positive time preference into consideration, a real discount rate of 3% is traditionally used in discounting healthy life, and is also used in discounting other cost streams in this report, for consistency.[6]

It is possible to estimate each of these costs using a top-down or bottom-up approach. The top-down approach provides the total costs of a program element (e.g. hospital costs) due to a condition. A bottom-up approach involves estimating the number of cases incurring each cost item, and multiplying the number of cases by the average cost of each item. A bottom-up approach was used to estimate most of the costs of sleep disorders in this report.[7]

In attributing productivity costs to sleep disorders, controlling for confounding factors is important. For example, people with sleep disorders who had an additional cardiovascular disease attributed to them were assumed to only incur the productivity cost of the cardiovascular disease and not of the sleep disorder itself. A similar approach was taken for wellbeing losses (see chapter 6).

[5] Some mortality due to sleep disorders occurs through other pathways, for example accidents due to sleep disorders.

[6] Generally, the minimum option that one can adopt in discounting expected healthy life streams is to set values on the basis of a risk free assessment about the future that assumes future flows would be similar to the almost certain flows attaching to a long-term Government bond. Another factor to consider is inflation (price increases), so that a real rather than nominal discount rate is used. If there is no positive time preference, the real long-term government bond yield indicates that individuals will be indifferent between having something now and in the future. In general, however, people prefer immediacy, and there are different levels of risk and different rates of price increases across different cost streams.

[7] A top-down approach using national datasets can be more desirable to ensure that the sum of parts is not greater than the whole, although these data are typically difficult to obtain for people with sleep disorders as there are a range of confounding factors.

2 Epidemiology of sleep disorders in Australia

This chapter outlines the approach taken to estimate the prevalence of sleep disorders in Australia. A targeted literature review of both Australian and international studies was undertaken emphasising recent publications where possible. Given the primary aim of this report was to calculate the costs of both sleep disorders and conditions associated with sleep disorders, precedence has been placed on obtaining prevalence estimates based on reliable methodology, and, as far as possible, objective and reproducible case definitions. This ensures that estimates and calculated costs emanating from this report are as accurate and robust as possible.

Key findings

- It was estimated that 1.9 million Australians had a sleep disorder in 2019-20.
- OSA was the most prevalent sleep disorder with an estimated 0.78 million people with the condition in Australia in 2019-20. There were an additional 0.60 million people with insomnia and 0.54 million people with RLS.
- The approach to estimating prevalence was conservative, with recent Australian sleep health surveys suggesting the prevalence of both OSA and insomnia could be much higher (OSA: 8.3% compared to 3.9%; insomnia 11.3% compared to 3.0%).
- There were more cases of OSA in males, representing 76.8% of the total cases. Females were more likely to have insomnia and RLS, accounting for approximately 71.4% and 69.8% of each sleep disorder, respectively.

2.1 Prevalence of obstructive sleep apnoea

Literature has shown that associated adverse health events have been noted when OSA is defined using AHI score ≥5 with symptoms of daytime sleepiness, or an AHI score ≥15 regardless of symptoms (traditionally mild symptomatic, and moderate to severe OSA respectively in disease classification tools).

The Deloitte Access Economics report *Asleep on the Job* (2017) used a prevalence estimate of 8.3% for OSA based on the 2016 Sleep Health Survey of Australian adults (Adams et al, 2017). These prevalence estimates appear to be in line with a definition that is moderate or worse OSA.

Peppard et al (2013) provides a better understanding of the relationships between symptomatic, mild OSA and moderate or worse OSA. Using prospective data obtained over long-term follow-up of a cohort of 1,520 adults aged 30-70 years, Peppard et al (2013) report:

- An estimated 3.9% of people have moderate to severe OSA syndrome plus excessive daytime sleepiness.
- 13% of men and 6% of women have AHI ≥15 (classified as moderate to severe OSA), while 14% of men and 5% of women have AHI ≥5 plus symptoms of daytime sleepiness (mild symptomatic OSA).
- Overall prevalence of mild to severe OSA, the full spectrum of disease, was estimated at 26% among those aged 30-70 years, and 10% for moderate to severe OSA (AHI ≥15).
- However, the sample was based on a working population in the United States, which limits the applicability of the study compared to alternate sources when the prevalence is applied to all adults in Australia.

There have been two recent systematic reviews of literature pertaining to the prevalence of OSA.

- Senaratna et al (2017) note that reported prevalence of OSA varies depending on diagnostic criteria used and age and sex distribution of the study population. Based on their systematic review, which identified 24 suitable studies, this research group reports a prevalence in the

general adult population of 9-38% for AHI ≥5; however, reporting of associated daytime symptoms is not uniform across the included studies. They report a prevalence rate of 6-17% when the AHI ≥15 cut-off is used. Identifiable trends include higher prevalence in males, and with increasing age.
- In a more recent review article, Benjafield et al (2019) sought to estimate global prevalence of OSA, including in Australia. They referenced one Australian study (Marshall et al, 2008) of 380 patients, using home-based OSA testing and the respiratory disturbance index to establish OSA status, showing 25.5% of men and 23.5% of women had AHI ≥5 (with no discussion of daytime symptoms) and 4.7% of men and 4.9% of women had AHI ≥15. The prevalence of moderate to severe OSA ranged from 3.9% in men and 0.2% in women to 49.7% in men and 23.4% in women.
- In the update to the Busselton Healthy Ageing Study in Western Australia (Cunningham et al, 2017), the prevalence of moderate to severe OSA and severe OSA was reported to be 14.7% and 3.4% in people aged 46 to 64 years old, respectively. Prevalence of moderate to severe OSA was higher in males (20.4%) than in females (10.0%).

After consideration of the prevalence estimates in the literature and assessment of the methodology underlying them, **Peppard et al (2013) was selected as the most representative estimate of moderate to severe OSA syndrome prevalence in Australia.** The estimated prevalence of 3.9% for moderate to severe OSA syndrome is notably lower than the estimated 8.3% prevalence of moderate to severe OSA in Adams et al (2017). This highlights the conservative approach taken in this report, with Peppard et al (2013) representing the lower bound of OSA estimates and those who are likely to exhibit impacts and therefore costs due to OSA. That is, it is understood that moderate to severe OSA syndrome represents the population at particular risk of causing or incurring economic loss. This includes the estimation of PAFs which rely on moderate to severe OSA case definitions, meaning that selecting a broader definition of prevalence would likely result in an overestimation of costs.

While there is a potential limitation regarding the representativeness of Peppard et al (2013) as the sample was drawn from a cohort of employed persons in the United States, the results are still authoritative: the sleep data are polysomnographically derived, the data are consistent with recent Australian estimates and the focus on symptomatic moderately severe OSA targets those at particular risk of causing or incurring economic loss, as noted.

2.2 Prevalence of insomnia

As there is no accepted single clinical and research definition of insomnia, prevalence estimates vary widely depending on the study design and diagnostic criteria used. Whilst there is broad similarity between the three most widely used diagnostic and classification criteria, namely the DSM-4 and -5, ICSD-3 and ICD-10 criteria, there are key differences, particularly in duration of symptoms. These differences result in widely variable prevalence when each is applied to a given population.[8]

It is difficult to find comparable international studies that use a general adult population sample and DSM-5 diagnostic criteria.[9] Given the recency, general population cohort, robust determination of insomnia status and Australian setting, this report particularly notes the insomnia prevalence estimates of Adams et al (2017), which is an Australian population sleep health survey of 1,011 adults aged 18 years or older. Adams et al (2017) found an overall prevalence of insomnia disorder using the DSM-5 criteria of 11.3%, including 6.6% in males and 15.9% in females.

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[8] For example, Reynolds et al (2019) found an overall prevalence of insomnia disorder using the DSM-5 criteria of 12.2%, including 13.7% in males and 10.9% in females. The more conservative nature of prevalence estimates using DSM-5 criteria is highlighted in the same report which also reported prevalence according to ICSD-3 criteria of 14.8%, and by previous Australian prevalence estimates that range from 13-33% (Cunnington et al, 2013).

[9] Using DSM-5 criteria would be preferred for this report since it is based on the more restrictive criteria for symptom duration compared to the other diagnostic standards. This somewhat counteracts the subjective nature of reporting insomnia symptoms and makes prevalence estimates more reproducible.

This estimate lies within the range of prevalence described in an exacting study, using DSM-4 criteria, by Ohayon and Reynolds (2009). They reported a gradation of prevalence of insomnia symptoms (34.5% of their sample reported at least one), symptoms plus daytime consequences (9.8% of the sample), satisfaction of insomnia diagnostic criteria (6.6% of the sample) and exclusion of other underlying causes (leaving a 'primary' insomnia prevalence of 3.0%).

This report takes a conservative approach to estimating insomnia prevalence given the widely variable estimates that exist, and the lack of comparable international studies. For this reason only **'primary' insomnia prevalence was estimated, relying on the evidence reported in Ohayon and Reynolds (2009).** The focus on primary insomnia acts to ensure that it is clinical insomnia, independent of other causes to avoid mis-attributing costs to those associated with other disorders, such as mental health issues, or behaviours, such as poor sleep secondary to lifestyle choice or other priorities.

2.3 Prevalence of restless leg syndrome

There is more uniformity of RLS case definition in the literature over the past two decades as a result of application of the International Restless Legs Syndrome Study Group minimal diagnostic criteria. There are, however, themes in RLS literature that make estimation of population prevalence challenging, including the tendency for RLS studies to be performed in specific populations such as those with certain comorbidities. Similarly, it is also common for asymptomatic RLS to be diagnosed incidentally on sleep studies which are performed for other reasons.

The 2016 Sleep Health Survey of Australian Adults (Adams et al, 2017) found that 18% of respondents reported a history of diagnosed RLS, however there was no objective assessment of symptoms according to diagnostic criteria. The divergence in prevalence estimates when RLS diagnostic criteria are strictly applied is highlighted by the findings of Allen et al (2005), who report estimates ranging from 5-10% on this basis. This influential study included 16,202 adult participants and utilised validated diagnostic questions to establish presence and severity of RLS.

Allen et al (2005) reported prevalence of 7.2% when the frequency of RLS symptoms is not restricted. However, prevalence is markedly lower (only 2.7%) when RLS is restricted to cases where symptoms occur at least twice weekly and participants report a moderate to severe level of distress. **The latter restricted definition from Allen et al (2005) still appears to be the most robust estimate of RLS prevalence and has been used again in this report**.

2.4 Prevalence estimates

Table 2.1 shows the estimated prevalence and number of cases of OSA, insomnia and RLS in 2019-20. OSA was found to be the most prevalent sleep disorder in both men and women, with 784,000 estimated cases. Cases were substantially higher in men (602,000 cases) compared to women (182,000 cases). Insomnia was the next most prevalent condition with 603,000 cases in 2019-20. Women were approximately two times more likely to have insomnia compared to men. Approximately 543,000 cases of RLS (where RLS is frequent and causes distress) occurred in 2019-20, with women over twice as likely to be diagnosed than men. Prevalence of sleep disorders generally increases with age across all three conditions, although there is greater variation in insomnia.

Table 2.1: Prevalence of sleep disorders in Australia, % and people ('000s), 2019-20

Age / gender	OSA	Insomnia	RLS	OSA	Insomnia	RLS
	%	%	%	'000s	'000s	'000s
Male						
18–24	3.7	3.0	0.6	44.9	36.8	6.8
25–34	3.6	1.9	0.9	66.9	36.5	18.3
35–44	2.6	1.1	1.2	45.3	18.9	20.1
45–54	8.4	1.5	2.2	133.5	24.4	35.2
55–64	9.5	2.4	2.3	137.8	34.1	33.0
65+	8.8	1.1	2.6	170.5	22.1	50.7
Male total	*6.1*	*1.8*	*1.7*	*601.7*	*172.7*	*164.1*
Female						
18–24	1.0	7.3	1.2	12.3	85.4	14.2
25–34	1.0	4.6	2.1	20.0	89.0	40.0
35–44	0.8	2.7	2.5	13.2	46.6	44.3
45–54	2.4	3.7	4.8	39.8	61.6	79.6
55–64	2.7	5.7	5.0	41.4	86.8	75.2
65+	2.5	2.8	5.7	55.5	60.9	125.2
Female total	*1.8*	*4.2*	*3.7*	*182.2*	*430.3*	*378.6*
Person total	**3.9**	**3.0**	**2.7**	**783.9**	**603.0**	**542.7**

Source: Deloitte Access Economics estimates based on Peppard et al (2013), Ohayon and Reynolds (2009), Allen et al (2005), and Adams et al (2017). Note: overall prevalence estimates from Peppard et al (2013), Ohayon and Reynolds (2009) and Allen et al (2005) have been distributed across age/gender groups using relativities from Adams et al (2017). Components may not sum to totals due to rounding.

3 Conditions attributable to sleep disorders

This section estimates PAFs for sleep disorders, based on literature linking sleep disorders to other health impacts.

Key findings

- There is robust evidence that a number of health conditions may in part be attributed to sleep disorders. The fraction of each condition attributable to sleep disorders was estimated for a number of conditions, including: CHF (2.4%), CAD (1.5%), depression (5.6%), MVAs (7.8%), stroke (4.1%), T2DM (1.3%) and WPIs (8.3%).
- It was estimated that the following number of cases were attributable to sleep disorders in 2019-20: CHF – 2,710, CAD – 11,100, depression – 44,570, MVAs – 2,930, stroke – 6,480, T2DM – 14,660, and WPIs – 66,940. It was also estimated that 989 deaths from these conditions were attributable to sleep disorders in 2019-20.

3.1 Relationship between sleep disorders and secondary health conditions

A range of health conditions can be attributed in part to primary sleep disorders. To estimate the prevalence of conditions attributed to inadequate sleep, it is necessary to use a PAF approach.[10] PAFs refer to the proportion of one health condition, injury or risk factor that can be directly attributed to another.

This chapter estimates PAFs for OSA, insomnia and RLS with secondary health conditions based on information obtained through a targeted literature scan. The evidence of a relationship between sleep disorders and other conditions is strongest for:

- Some cardiovascular disease, including CHF, CAD and stroke
- Some metabolic and other conditions, including T2DM and depression
- Accidents, including both MVAs and WPIs.

Table 3.1: Link between sleep disorders and other health conditions

Condition	OSA (%)	Insomnia (%)	RLS (%)
CHF	0.9	1.5	-
CAD	0.2	1.3	-
Depression	4.1	1.6	-
MVAs	5.5	2.3	-
Stroke	4.1	-	-
T2DM	1.3	-	-
WPIs	3.0	5.3	-

Source: evidence is provided in Table 3.2, and Appendix A.

Evidence has been included in this report where a causal relationship appears to be evident, along with possible explanatory mechanisms or pathways through which each relationship occurs (as already noted). The evidence in this chapter focuses on prospective longitudinal study designs,

[10] The methodology underlying the PAF approach is explained further in Appendix A.

where a group of people with a sleep condition (but not the secondary condition) are followed over time to determine the increased odds or risk of developing secondary conditions.

Further, evidence has been selected based on whether each study was able to control for a range of confounding factors, such as other comorbid conditions the participants may have had at baseline. This was done to reduce the chance of bias impacting on the estimated PAFs in this report. However, it should be noted that the effect of sleep and sleep disorders on secondary conditions is an emerging field of research. As such, the results in this study should still be treated with some caution, and in some cases further research is needed to robustly identify the impact of sleep disorders on broader health.

Data used to estimate prevalence of the conditions related to sleep disorders were taken from the most up-to-date sources available. The prevalence of CHF, CAD, stroke and T2DM in 2019-20 were based on the Australian Bureau of Statistics' (ABS) National Health Survey 2017–18 (ABS 2018a). The National Health Survey is a representative survey of approximately 21,300 individuals and 16,000 households in Australia, collecting information on demographic and socioeconomic factors, health risk factors and chronic health conditions. Results collected are then weighted to provide whole-of-population estimates (ABS, 2018a).[11]

Prevalence estimates for depression were taken from the 2007 National Survey of Mental Health and Wellbeing conducted by the ABS (ABS 2008). The survey undertook diagnostic interviews with 8,800 households with questions relating to several common mental health conditions, and is the only national Australian survey to use structured interviews to determine a diagnosis. Responses were weighted to the population to provide Australian level estimates.

Rates of WPIs (accidents) were obtained from the ABS Multipurpose Household Survey 2017-18 (ABS, 2018b), of which 28,200 individuals competed interviews related to workplace accidents. Data on MVAs was compiled by the Bureau of Infrastructure, Transport and Regional Economics (BITRE; 2019) using data from the National Injury Surveillance Unit of Flinders University and the Australian Institute of Health and Welfare (AIHW). Data were compiled based on hospitalised injuries attributed to MVAs and were available up to the 2016–17 financial year.

The overall prevalence rates, the odds or increased risk of developing the secondary conditions (along with the relevant source), and the resulting PAFs are summarised in Table 3.2. The underlying evidence body is discussed further in Appendix A, where supporting articles have been briefly discussed alongside the articles used in the analysis.

[11] Prevalence estimates from the 2009 National Health Survey were used in the previous 2017 report.

Table 3.2: Relationships between sleep disorders and other health conditions

Related condition	Sleep disorder prevalence (%)	Condition prevalence (%)	Relationship with sleep disorder (OR/RR/HR)			PAF (%)			Sources:
			OSA	Insomnia	RLS	OSA	Insomnia	RLS	
CHF	OSA: 3.9 Insomnia: 3.0 RLS: 2.7	0.5	1.23	1.52	NS	0.9	1.5	-	OSA: Gottlieb et al (2010)* Insomnia: Taugsand et al (2010) RLS: NS
CAD	OSA: 3.9 Insomnia: 3.0 RLS: 2.7	3.0	1.04	1.45	NS	0.2	1.3	-	OSA: Gottlieb et al (2010)* Insomnia: Sofi et al (2014) RLS: NS
Depression	OSA: 3.9 Insomnia: 3.0 RLS: 2.7	4.1	2.18	1.53	NS	4.1	1.6	-	OSA: Chen et al (2013) Insomnia: Hertenstein et al (2019) RLS:NS
MVAs	OSA: 3.9 Insomnia: 3.0 RLS: 2.7	0.2	2.5	1.78	NS	5.5	2.3	-	OSA: Tregear et al (2009) Insomnia: Philip et al (2010) RLS: NS
Stroke	OSA: 3.9 Insomnia: 3.0 RLS: 2.7	0.8	2.1	NS	NS	4.1	-	-	OSA: Li et al (2014) Insomnia: NS RLS: NS
T2DM	OSA: 3.9 Insomnia: 3.0 RLS: 2.7	5.3	1.35	NS	NS	1.3	-	-	OSA: Reutrakul et al (2017) Insomnia: NS RLS:NS
WPIs	OSA: 3.9 Insomnia: 3.0 RLS: 2.7	3.1	1.80	2.87	NS	3.0	5.3	-	OSA: Uehli et al (2013) Insomnia: Uehli et al (2013) RLS: NS

Source: further supporting evidence is summarised in Appendix A. Note: OR is odds ratio, RR is relative risk, HR is hazard ratio. NS indicates that sufficient, high quality evidence examining the relationship between the sleep disorder and related condition was not available. * indicates that the results were based on those available in the article: the chosen relationship reflects a weighted average of results for moderate to severe OSA for men and women.

In some cases, the prevalence of each sleep disorder was adjusted to best reflect the definition used in the prospective studies: for example, if the study reported that severe OSA was associated with an increased risk of cardiovascular disease, it was assumed that people with mild to moderate OSA did not have an increased risk of cardiovascular disease, and only the prevalence of severe OSA was used to calculate the PAF.

3.2 Prevalence and mortality of conditions attributable to sleep disorders

The number of secondary health conditions attributed to sleep disorders are outlined in Table 3.3. The PAFs were based on the data presented in Table 3.2.

Table 3.3: Prevalence of health conditions attributed to sleep disorders, 2019-20

Condition	Prevalence (%)	Prevalence ('000s)	PAF (%)	Attributed cases ('000s)
CHF	0.6	111.7	2.4	2.7
CAD	3.7	746.3	1.5	11.1
Depression	3.9	791.0	5.6	44.6
MVAs	0.2	37.7	7.8	2.9
Stroke	0.8	157.6	4.1	6.5
T2DM	5.4	1,088.7	1.3	14.7
WPIs	4.0	802.9	8.3	66.9
Total				**149.4**

Source: Deloitte Access Economics calculations. Note: components may not sum or multiply to totals due to rounding.

Mortality rates for conditions related to sleep disorders were taken from the AIHW's General Record of Incidence of Mortality data set for 2017. This is the most up-to-date source on cause of death information available. Deaths due to WPIs were based on data published by Safe Work Australia (2020) for 2018. The respective mortality rates were multiplied by demographic estimates by age and gender for 2019-20 to estimate the total number of deaths due to each condition in that year.

Deaths attributable to depression were calculated by adjusting the Australian suicide rate according to the number of suicide deaths where depression was identified as an associated cause using data from AIHW (2010). The PAF for depression was then applied to this adjusted rate to generate the number of deaths attributable to depression where a sleep disorder was the underlying cause.

Deaths attributed to sleep disorders were calculated by generating an estimated count of deaths for each of the attributable conditions in 2019-20 and applying the PAF to these deaths to determine the number of deaths attributable to sleep disorders. A breakdown of deaths attributable to sleep disorders is provided in Table 3.4. No deaths were directly due to sleep disorders in this model: however, **989 deaths were attributed to underlying sleep disorders in 2019-20**.

Table 3.4: Number of deaths due to sleep disorders and its consequences, 2019-20

Condition	Mortality rate (%)	Deaths	PAF (%)	Attributed deaths
CHF	0.016	3,244	2.4	79
CAD	0.099	19,965	1.5	297
Depression	0.007	1,344	5.6	76
MVAs	0.006	1,239	7.8	96
Stroke	0.043	8,730	4.1	359
T2DM	0.026	5,227	1.3	70
WPIs	0.001	144	8.3	12
Total				**989**

Source: Deloitte Access Economics calculations. Note: components may not sum or multiply to totals due to rounding.

4 Health system costs

The health system costs of sleep disorders comprise both the cost of the sleep disorders themselves and the share of other attributable conditions and injuries. Sleep disorders may be managed in hospital (e.g. upper airway surgery for OSA) or in primary and secondary care settings (e.g. seeing a GP or sleep physician). People with sleep disorders are also more likely to access allied health services such as a psychologist, and to receive pharmacological interventions. The most common management approaches for OSA, insomnia and RLS are described in section 4.1, along with the costs of diagnosis and management. Health system costs of cardiovascular and metabolic conditions, and accidents, are also attributed to sleep disorders in section 4.2.

Key findings

- The total health system cost due to sleep disorders was estimated to be $0.9 billion in 2019-20, or $489 per person with a sleep disorder. Of total health system costs, $598.2 million was due to care directly for the individual's sleep disorder, while an additional $345.7 million was attributable to sleep disorders for the care of other health condition (e.g. cardiovascular disease, depression and accidents).
- Most of the health system costs due to sleep disorders were for out-of-hospital medical services ($465.8 million) which was followed by inpatient hospital ($338.7 million), pharmaceuticals ($108.8 million) and other costs ($30.5 million).
- Health system costs were primarily due to OSA (58%), which was followed by insomnia (30%) and RLS (12%).

4.1 Cost of treating sleep disorders

Each sleep disorder may require hospital care, although they are most commonly managed in the community. The major treatment approaches are described briefly as follows (see also section 1.3):

- OSA is often managed using lifestyle management (e.g. weight loss or positional therapy), CPAP therapy, dental devices and less commonly surgery where first line treatments are not effective.
- Insomnia is primarily managed in primary care, with assistance from allied health providers, and treatments often include pharmacological interventions and behavioural interventions, cognitive behavioural therapy or relaxation therapy. No costs were available for these latter interventions, although costs of referrals to psychologists have been estimated.
- RLS is usually diagnosed by a GP based on symptoms, although a person may be referred to a sleep specialist or neurologist. RLS is often managed using pharmacological interventions (e.g. dopamine agonists or levodopa), although non-pharmacological interventions may also be used (e.g. iron supplements, or reduced caffeine intake).

In Australia, treatment for these conditions is highly variable, and costs may differ substantially by region. Unfortunately, there are limited data available to robustly estimate region specific costs, although the scope of this work was to provide estimates at a national level.

Although there is evidence that people with sleep disorders are more likely to access medical services it is difficult to identify all costs that are incurred due to a sleep disorder. In this report, costs due to conditions attributed to sleep disorders (e.g. comorbid cardiovascular conditions that developed as a result of the sleep disorder) have also been included.

4.1.1 Hospital costs

The total cost of hospitalisation for sleep disorders was estimated by multiplying the number of separations for sleep disorders by an estimated average cost of hospitalisation.

The number of hospitalisations was based on separation statistics from the Principal Diagnosis data cube under ICD-10-AM Edition 10, 2017-18 (AIHW, 2019a) for ICD-10 codes that capture sleep disorders. The ICD-10 codes were based on a mapping between ICSD and ICD-10 at the three-digit level — this meant that not all sleep disorders could be mapped to the available data. The number of separations data was inflated to 2020 using the cumulative growth rate for each ICD-10 code from 2016 to 2018.

A cost was attached to these separations using data from the National Hospital Cost Data Collection (NHCDC) (Independent Hospital Pricing Authority, 2020). The mapping between each ICD-10 sleep disorder and diagnostic related group (DRG) is shown in Table 4.1.[12] The cost of a sleep apnoea separation was based on the weighted average of the DRGs for minor and major sleep apnoea (E63A, E63B). Most other sleep conditions were based on the cost of the weighted average of the DRGs for minor and major anxiety disorders (U65A, U65B), due to a lack of data on more specific costs and given that in practice ICD-10 codes for sleep disorders map to the DRG for anxiety disorders (based on expert opinion).

The average cost per bed day was calculated using the cost of a separation in a public hospital divided by the average length of stay. The costs were inflated from 2020 dollars using the national efficient price determination (1.8%) found in National Efficient Price Determination 2019-20 (Independent Hospital Pricing Authority, 2020). The average cost for each sleep disorder is shown in Table 4.1.

It was estimated that sleep disorders cost the hospital system $118.58 million in 2019-20.

[12] This mapping was based on the ICD-10 to AR-DRG mapping provided in DoHA (2006), which was also used in Deloitte Access Economics (2011) and Access Economics (2006).

Table 4.1: Hospital costs for sleep disorders in 2019-20

ICD-10[(a)]	Description	Diagnostic related group	Separations	Average length of stay	Average cost (2020)	Total cost
			No. (2020)[(b)]		*Public (per separation per day)*	*$m (2020)*
F51.0	Nonorganic insomnia	U65Z	44	3	1,692.51	0.22
F51.9	Nonorganic sleep disorder, unspecified	U65Z	5	8	1,692.51	0.06
G47.2	Disorders of the sleep-wake schedule	U65Z	2,314	3	1,692.51	12.99
G47.3	Sleep apnoea	E63Z	65,784	1	1,457.91	101.86
G47.8	Other sleep disorders	U65Z	417	1	1,692.51	0.91
G47.9	Sleep disorder, unspecified	U65Z	842	2	1,692.51	2.55
Total			**71,952**	**1.21**	**1,692.51**	**118.58**

Sources: Average cost retrieved from Independent Hospital Pricing Authority, *Appendix 1. NHCDC Round 20 to 22 summary, actual, by jurisdiction and stream, 2017-18* (Independent Hospital Pricing Authority, 2020). Separations retrieved from AIHW, *Principal Diagnosis data cube under ICD-10-AM Edition 10, 2017-18* (2019). Deloitte Access Economics analysis.

Notes: [a] While ICD-10 codes G47.0, G47.4, F51.1, F51.2, F51.8 and R06.3 were included in the previous report, they were excluded from this analysis as they were not included in the Principal Diagnosis data cube data. [b] Number of separations data was retrieved for 2018 and inflated to 2020 using the cumulative growth rate for each ICD-10 code from 2016 to 2018. Components may not sum or multiply to totals due to rounding.

4.1.2 Primary and secondary care

Primary and secondary care costs, which generally occur out-of-hospital, include the costs of sleep studies and professionals who manage sleep-related problems including GPs, sleep physicians and allied health professionals. These costs are estimated in the following sections.

Investigative sleep studies

Based on a patient history and reported symptoms a person with a suspected sleep disorder may be referred directly for a sleep study. Alternatively, the person might first be referred to a sleep physician or other specialist. There are four types of sleep studies:

- Level 1 — a PSG conducted at a sleep laboratory (in a public or private hospital or a private clinic) overnight in the presence of sleep technician who can adjust equipment as required (Kee and Naughton 2009).
- Level 2 — PSG conducted without a technician present, usually in the person's home, meaning that they are responsible for setting the test up themselves based on instructions provided. This test has a higher failure rate than an attended sleep study (Kee and Naughton 2009).
- Level 3 — cardiopulmonary monitoring, which can be conducted at home or in hospital and monitors airflow, respiratory effort, oximetry and electrocardiogram (Kee and Naughton 2009).
- Level 4 — single channel cardiopulmonary monitoring (Kee and Naughton 2009).

Medicare reimburses the procedural cost and medical interpretation of a level 1 sleep study. If the sleep study is performed at a private hospital or sleep centre then there may be a bed fee charged, which is paid for privately (often covered by private health insurance) (Marshall et al, 2007). Medicare also reimburses the cost of level 2 sleep studies.

The cost of out-of-hospital services for OSA was based on the number of sleep studies claimed though the Medicare Benefits Schedule in 2018-19, which was then adjusted to 2019-20 using historical changes in the number of sleep disorder claims over the last five years. The item numbers, descriptions, number of claims and schedule fees are shown in Table 4.2. The total cost of sleep studies was $76.0 million in 2019-20.

Table 4.2: Estimated expenditure on sleep studies, 2019-20

Item	Description	Claims[(a)]	Schedule fee	Total cost
		No.	*$*	*$'000*
12203	Overnight diagnostic assessment of sleep to confirm diagnosis of a sleep disorder.	64,167	597.40	38,333.5
12204	Overnight assessment of positive airway pressure.	9,581	597.40	5,723.6
12205	Follow-up study for a patient with a sleep-related breathing disorder.	2,873	597.40	1,716.1
12207	Overnight investigation for a sleep-related breathing disorder.	161	597.40	96.2
12208	Overnight investigation for sleep apnoea.	50	597.40	29.6
12250	Overnight investigation of sleep to confirm diagnosis of obstructive sleep apnoea.	87,137	340.65	29,683.3
12258	Maintenance of wakefulness test for the assessment of the ability to maintain wakefulness.	444	928.30	412.0
Total		**164,413**		**75,994.4**

Sources: Schedule fee retrieved from DOH, Medicare Benefits Schedule Book Operating from 1 March 2020. Claims (2019) retrieved from DHS, *Medicare Group Reports (2019).* Deloitte Access Economics analysis.

Notes: [a] Claims were retrieved from 2019 Medicare Statistics data and inflated to 2019-20 using the average annual growth rate of the claims for all items from 2014-15 to 2018-19. Components may not sum or multiply to totals due to rounding.

GP and specialist consultations

To estimate the costs of care specific for sleep disorders, data from the Bettering the Evaluation and Care of Health (BEACH) database were used, similar to the approach used in *Wake Up Australia*. Two studies informed the analysis, one for OSA (Cross et al, 2016) and one for Insomnia (Miller et al, 2017). Each study reported on the time trends in the management of these conditions in general practices in Australia. RLS costs were estimated based on data obtained from a literature review. The approaches are further described in the following paragraphs.

Cross et al (2016) reported on the management of snoring and sleep apnoea in Australian primary care between 2000 and 2014 using the BEACH data. The BEACH study is a nationally representative cross-sectional survey of general practice activity in Australia. The management rate of OSA rose from 94 to 296 per 100,000 encounters in Australia, while management of snoring rose from 15 to 25 per 100,000 encounters (Cross et al, 2016).

Miller et al (2017) reported on the management of insomnia in Australian primary care between 2000 and 2015 using the BEACH data. The management rate of insomnia was approximately 1.31 per 100 encounters between 2008 and 2015. Pharmacotherapy was used in approximately 90% of encounters, while nonpharmacological advice was given at approximately 20%, and onward referral at approximately 1% of insomnia-related encounters (Miller et al, 2017).

The results from Cross et al (2016) and Miller et al (2017) are summarised in Table 4.3.

Table 4.3: Management rate per 100 encounters for OSA and insomnia

Management type	OSA	Insomnia
Clinical treatments	30.8	25.0
Referrals	59.0	2.0
Medical referrals (% of referrals)	*90.4*	*90.0*
Surgical referrals (% of referrals)	*3.2*	*0.0*
Other referrals (% of referrals)	*6.4*	*10.0*
Pathology	15.7	0.0
Imaging	0.8	0.0
Medications	5.0	90.0
Procedural treatments	2.7	0.0

Source: Cross et al (2016), Miller et al (2017).

Referrals were primarily made to medical specialists (e.g. a sleep physician) for both OSA and Insomnia. However, there were also a small number of referrals to surgical doctors or other professionals (e.g. allied health professionals). For OSA, approximately 90% of referrals were to a medical practitioner, 3.2% to a surgical practitioner and 6.4% to other health professionals (Cross et al, 2016). For insomnia, most referrals were to psychologists and sleep physicians (around 90%), while the remaining 10% of referrals were to other professionals such as counsellors (Miller et al, 2017).

In Australia in 2018-19, there were 158.3 million encounters, which grew at an average of 2.4% in the two years to the end of 2018-19. This rate of growth was multiplied by the number of encounters in 2018-19 to estimate total encounters in 2019-20, which was 162.1 million. The total number of encounters was then multiplied by the management rates to estimate the number of consultations in Australia for OSA and insomnia in 2019-20. These values are shown in Table 4.4.

It was not possible to observe how many referrals result in an actual consultation, nor to estimate where a script may not have been filled. For this analysis, it was assumed that 100% were used, which while some people may not choose to receive further care, it was also not possible to observe how often individuals may return to each professional for a follow up, for example.

No studies were identified that reported **healthcare resource utilisation for RLS** using BEACH data. However, the literature review identified a number of studies from the United States of America where claims databases had been used to identify resource use in people with RLS. Utilisation of GPs, specialists, pathology and medications was based on the average across two studies: Allen et al (2011) and Meyers et al (2011). On average, it was assumed that people with RLS with regular symptoms and moderate or worse distress would require **an additional 1.17 GP visits per year, 0.93 specialist visits per year, 0.76 diagnostic investigations per year** (primarily assumed to be pathology related tests: e.g. an iron test), **and 2.26 prescriptions per year**.

- Allen et al (2011) used an online survey that included a screening questionnaire covering the four diagnostic criteria of RLS, and a RLS diagnosis. A random sample of people with all four diagnostic criteria of RLS were then asked to fill in a supplementary survey that ruled out conditions associated with RLS (e.g. leg cramps). The remaining participants were then asked to fill in the online burden questionnaire, which included healthcare resource use over the last three months. Results were taken for the group who reported symptoms at least twice per week with moderate to severe distress. On average, this group reported **1.13 additional GP visits for RLS per year, 0.55 additional specialist visits, 2.26 medication prescriptions and 0.76 diagnostic investigations due to RLS** (results were annualised by multiplying by four).
- Meyers et al (2011) adopted the use of dopamine agonists to identify people with RLS, where each person also had to have a diagnosis of RLS before and after the use of the dopamine agonist. The analysis was conducted using the LifeLink database, which is a national claims database in the United States of America encompassing 95 managed care organisations and 61 million lives between 1997 and 2008. Resource utilisation was based on the 12-month period immediately following the first reported use of dopamine agonists following diagnosis of RLS. On average, this group reported **1.21 additional GP visits per year related to RLS, and 1.30 specialist visits**. Given that this study required the use of a dopamine agonists to identify cases, it was not used to inform the estimated number of medications in this report.

Table 4.4: Estimated resource utilisation, 2019-20, thousands of units

Cost component	OSA	Insomnia	RLS
GP encounters	480.4	2,121.6	635.3
Referrals	283.4	42.4	298.3
Medical (sleep physicians)	*256.1*	*38.2*	250.6
Surgical	*9.1*	*0.0*	0.0
Other health professionals (e.g. allied health)	*18.2*	*4.2*	47.7
Pathology tests	75.4	0.0	414.3
Imaging tests	3.8	0.0	NE
Prescriptions	24.0	1,909.4	1,226.3

Source: Deloitte Access Economics analysis based on Cross et al (2016), Miller et al (2017), Allen et al (2011) and Meyers et al (2011). Note: NE = not estimated due to lack of data.

Unit costs for each resource were primarily based on latest available Medicare Benefits Scheme or Pharmaceutical Benefits Scheme data. The following unit costs were used in the analysis:

- GP costs were based on the average across all Medicare data, including an adjustment for bulk billing rates and the average out-of-pocket costs for individuals. The average unit cost was $57.28 in 2019-20 (Department of Health, 2020a). Data from BEACH show that 1.543 problems are managed at each encounter, so the unit price was adjusted to $37.13 (=$57.28/1.543) to attribute costs equally to each problem.

- Sleep physician and surgical costs were based on the average across all Medicare specialists, again including an adjustment for bulk billing rates and the average out-of-pocket costs for individuals. The average unit cost was $140.23 (Department of Health, 2020a).
- Costs of referrals to other health professionals were based on the average across all allied health items, again including an adjustment for bulk billing rates and the average out-of-pocket costs for individuals. The average unit cost was $95.68.
- Costs for pathology and imaging were based on the average pathology and imaging item reimbursed through Medicare, which was $23.80 and $163.81 respectively after adjusting for bulk billing rates and out-of-pocket costs (Department of Health, 2020a).
- The average cost of a script for insomnia was estimated to be $13.65 in 2019-20, which was based on Department of Health (2020b) Date of Supply data for the Pharmaceutical Benefits Scheme. Data from Miller et al (2017) were used to inform the split by medication type (e.g. approximately 50% of scripts are for temazepam, while oxazepam, nitrazepam, zolpidem and melatonin each made up between 6-10% of total scripts).
- The average cost of a script for RLS was estimated to be $35.23 in 2019-20, which was estimated in a similar way as for insomnia. The average cost per script was based on Department of Health (2020b), while Meyers et al (2011) was used to inform the approximate splits across medications (approximately 13% gabapentin, 81% pramipexole and 6% levodopa). The average cost per script for each medication in 2018-19 was $27.18, $29.30 and $131.46 respectively, giving a weighted average of $35.23, which was then inflated to 2019-20 dollars.
- It was also assumed that OSA scripts were primarily for conditions other than OSA as there are no specific pharmacological treatments that are used as a first line therapy to manage OSA.

Table 4.5: Estimated resource cost, GPs, specialists, imaging and pathology and prescriptions, 2019-20

Cost component	Unit cost ($)	OSA ($m)	Insomnia ($m)	RLS ($m)	Total ($m)
GP encounters	37.13	17.8	78.8	23.6	120.2
Referrals					
Medical (sleep physicians)	*140.23*	35.9	5.4	35.1	76.4
Surgical	*140.23*	1.3	-	-	1.3
Other health professionals (e.g. allied health)	*95.68*	1.7	0.4	4.6	6.7
Pathology tests	23.80	1.8	-	9.9	11.7
Imaging tests	163.81	0.6	-	-	0.6
Prescriptions	13.65 (Insomnia), 35.23 (RLS)	-	26.1	43.2	69.3
Total		**59.2**	**110.6**	**116.4**	**286.1**

Source: Deloitte Access Economics analysis based on Cross et al (2016), Miller et al (2017), Allen et al (2011) and Meyers et al (2011). Note: components may not sum to totals due to rounding.

The **total costs of GP and specialist consultations due to sleep disorders were estimated to be $286.1 million** in 2019-20.

This estimate may be an underestimate of the actual cost of primary care for OSA and insomnia. As data were sourced from the BEACH collection, it would not have been possible to observe multiple attendances at specialists (note CPAP therapy has been estimated separately in section 4.1.3 and data for RLS indicates that people may only visit a specialist once per year, on average), nor would any procedures conducted by specialists have been included - excluding sleep studies, and hospitalisations for surgery which were estimated in section 4.1.1. For example, mandibular devices are also a common therapy for OSA, although no data on their use in Australia was found.

These costs may also exclude other resources such as dental visits more generally or community mental health services, among other services.

4.1.3 Medical equipment

For this report, the cost of CPAP therapy was based on the average costs of care reported in Streatfeild et al (2019), while the number of people using CPAP therapy was based on Munks et al (2019). In *Reawakening Australia*, CPAP therapy costs were based on the sales of CPAP devices, which informed an estimate of the total size of the CPAP market in Australia. No other medical equipment (e.g. mandibular devices were included as there were insufficient information to estimate these costs in Australia).

Munks et al (2019) conducted a follow up from the Busselton Healthy Ageing Study to investigate the healthcare-seeking behaviour and utilisation of treatment in a community-based screening study for obstructive sleep apnoea in Busselton, Western Australia. There were 192 people who had moderate to severe OSA (defined as AHI score ≥15). Of these, 53 started any treatment, which was CPAP therapy in 72% of cases (38). Based on analysis conducted in Streatfeild et al (2019), it was assumed that 57% of cases would be adhere to treatment (long-term follow up), which would be equal to about 22 people when applied to the Munks et al (2019) data. Based on these rates, it can be estimated that 11.3% of people with moderate to severe OSA may be using CPAP, while 8.6% were initiated on CPAP but no longer use their machine.[13]

The rate of moderate to severe OSA was based on Peppard et al (2013), who provided prevalence of moderate to severe OSA plus excessive daytime sleepiness (moderate to severe OSA syndrome). This was for consistency with the approach outlined in section 2.4. These data indicate that approximately 783,900 people had moderate to severe OSA syndrome, and likely would have required CPAP therapy in 2019-20.

When the prevalence of moderate to severe OSA syndrome was multiplied by the rates observed in Munks et al (2019), almost 88,300 people would be using CPAP therapy (adherent) and an additional 67,500 people were estimated to have started CPAP therapy (assumed to be in this year) but may not adhere to therapy. Streatfeild et al (2019) reported that the average annual cost of CPAP therapy for people who adhere to treatment was $818.25 while it was $514.53 for people who do not adhere to treatment (costs of therapy were inflated to 2019-20 dollars). Based on these costs and the number of people being treated, **the total cost of CPAP therapy was estimated to be $107.0 million in 2019-20**.

4.1.4 Research costs

Research expenditure is included within health system costs since, in the absence of sleep disorders, there would not be a need for any research into the condition. To estimate health research expenditure on sleep disorders in Australia in 2019-20, this report utilised data published based on the National Health and Medical Research Council (NHMRC) grants database. The database includes all NHMRC research grant funding from 2000 and provides a description of the projects and key outcomes achieved.

In 2014-15, the NHMRC reported that there was $11.0 million in grants allocated to fund research on sleep disorders and its relationships with other conditions. Between 2005-06 and 2014-15, the total value of NHMRC grants was estimated to be $76.9 million, and the amount of research increased by approximately $760,000 per annum over that period. A linear trend was estimated based on the 10 years of research funding to inform **the value of research in 2019-20, which was estimated to be $15.7 million**.

4.1.5 Direct care costs of sleep disorders

The total cost of care for sleep disorders was estimated to be $598.2 million in 2019-20 (Table 4.6). These are costs associated with the direct care of sleep disorders, although they do not include costs of conditions attributable to sleep disorders.

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[13] It is possible that the community screening for OSA may have led to higher OSA diagnosis rates compared to other regions in Australia. No other data were identified that enabled an estimate of the undiagnosed rate in all cases in Australia.

Table 4.6: Estimated costs of sleep disorders for direct health care only, 2019-20, $m

Management type	OSA	Insomnia	RLS	Total
Hospital	101.9	16.7	-	118.6
Sleep studies	76.0	-	-	76.0
GP encounters	17.8	78.8	23.6	120.2
Referrals				
Medical (sleep physicians)	35.9	5.4	35.1	76.4
Surgical	1.3	-	-	1.3
Other health professionals (e.g. allied health)	1.7	0.4	4.6	6.7
Pathology tests	1.8	-	9.9	11.7
Imaging tests	0.6	-	-	0.6
Prescriptions	-	26.1	43.2	69.3
CPAP	107.0			107.0
Research	8.6	1.9	-	10.4
Total	**352.6**	**129.2**	**116.4**	**598.2**
Per person with condition	**450**	**214**	**214**	**310**

Source: Deloitte Access Economics analysis. Note: Components may not sum to totals due to rounding.

The largest health system cost item was GP visits ($120.2 million), followed by hospital expenditure ($118.6 million) and CPAP therapy ($107.0 million). The cost of care for those with a sleep disorder was estimated to be $310 per person in 2019-20.

4.2 Costs of treating conditions attributed to sleep disorders

Costs related to stroke, CAD, CHF, depression and MVAs were based on the latest available AIHW disease expenditure data (AIHW, 2019b) for individuals aged 15 years or older.[14] Costs for WPIs were based on Safe Work Australia's cost of injury and illness by age and sex (Safe Work Australia, 2015).

All historical health system expenditure was inflated to 2019-20 using the health price index (AIHW, 2019d), which was estimated for 2019-20 using 10-year average historical growth in the index.[15]

For each condition, it was assumed that each person who acquires the condition due to their sleep disorder has the same average cost as all people with the condition. Thus, the PAF was applied to the total cost for each condition in 2019-20 to estimate the costs attributable to sleep disorders.

Overall, $345.7 million in health expenditure was attributable to sleep disorders in 2019-20 (Table 4.7). Expenditure due to depression and WPIs accounted for $253.9 million of the total attributed costs.

[14] The AIHW constructs cost estimates using a top-down approach and bottom-up approach – the AIHW uses total health system expenditure and then allocates it across diseases using information from hospital morbidity records and case-mix data, Medicare, the Pharmaceutical Benefits Scheme, the Pharmacy Guild Survey and the BEACH survey of general practice. Each condition is adjusted so that the sum of the components does not exceed total possible allocated health expenditure.

[15] No adjustments were made for the change in the number of cases (or growth in prevalence) that would be expected over the same period, as it can be expected that there would be a lag between the prevalence of the sleep disorders and the incidence of the condition attributable to the sleep disorder. It was assumed that these competing effects (the lag and the increase in prevalence due to changing demographics) would counter each other and so the total prevalence of each attributed condition was not adjusted.

Table 4.7: Health system costs of conditions attributable to sleep disorders

Condition	Cost ($m), year of estimate	Year of estimate	Cost ($m), 2019-20	PAF (%)	Attributed costs ($m), 2019-20	As % of total sleep disorders health system costs
CHF	856.9	2015-16	930.4	2.4	22.6	2%
CAD	1,048.3	2015-16	1,138.3	1.5	16.9	2%
Depression	2,077.9	2015-16	2,256.2	5.6	127.1	13%
MVAs	465.6	2015-16	505.5	7.8	39.3	4%
Stroke	155.9	2015-16	169.3	4.1	7.0	1%
T2DM	408.3	2015-16	443.3	1.3	6.0	1%
WPIs	1,324.0	2012-13	1,520.8	8.3	126.8	13%
Total	**6,336.8**		**6,963.8**		**345.7**	

Source: Deloitte Access Economics analysis based on AIHW (2019a, 2019b) and Safe Work Australia (2015). Note: Components may not sum or multiply to totals due to rounding.

4.3 Summary of health system costs

The **total cost of direct care for sleep disorders was estimated to be $598.2 million** in 2019-20 (section 4.1). In addition, another **$345.7 million in health expenditure was attributable to sleep disorders** in 2019-20. Thus, **the total health system costs due to sleep disorders was estimated to be $943.8 million** in 2019-20.

Table 4.8 presents the breakdown of costs attributed to sleep disorders in Australia in 2019-20 by age and gender groups, and type of health system cost. It should be noted that the data sources did not enable the direct costs of sleep disorders to be broken down by age and gender, so the same average cost was applied across each group. However, the attributed costs were available by age and gender.

A large part of the health system costs due to sleep disorders were out-of-hospital medical services ($465.8 million) which was followed by inpatient hospital ($338.7 million), pharmaceuticals ($108.8 million) and other costs ($30.5 million).

Chart 4.1 provides a breakdown of costs attributable to sleep disorders. Outside of care specifically for sleep disorders, depression contributed most to total cost (14%) which was followed by WPIs (13%), cardiovascular conditions (4%) and MVAs (4%). Health system costs were primarily due to OSA (58%), which was followed by insomnia (30%) and RLS (12%).

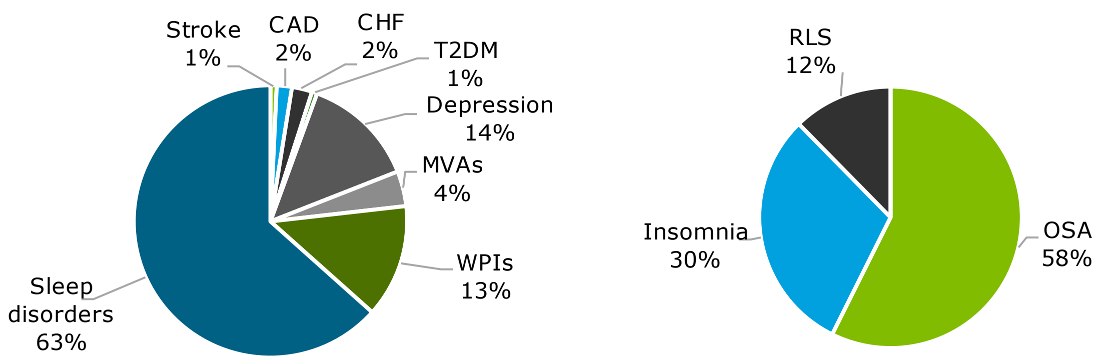
Health system costs in 2019-20 were primarily borne by the Federal Government ($441.0 million), which was followed by State and Territory Governments ($220.8 million), individuals and their families ($180.1 million) and other payers ($102.0 million).

Table 4.8: Costs attributable to sleep disorders and associated conditions, by type of cost, age and gender, 2019-20 ($ million)

Age group	Admitted hospital	Out-of-hospital medical	Pharmaceutical	Other	Total
Male					
15-29	42.5	38.2	7.6	4.3	92.6
30-39	31.3	27.4	6.0	3.4	68.1
40-49	30.7	34.1	7.8	3.2	75.8
50-59	28.9	45.4	10.4	2.6	87.2
60-69	23.0	38.8	9.8	1.6	73.2
70-79	18.5	25.5	7.0	1.1	52.1
80-89	8.6	10.6	3.0	0.5	22.7
90+	1.7	2.0	0.6	0.1	4.4
Male total	185.1	222.0	52.3	16.8	476.2
Female					
15-29	34.9	48.1	9.0	3.3	95.3
30-39	24.9	34.5	7.1	2.7	69.2
40-49	23.7	36.2	8.4	2.4	70.7
50-59	24.2	45.8	10.7	2.2	82.9
60-69	19.4	39.0	9.8	1.5	69.8
70-79	15.3	24.5	6.8	1.0	47.6
80-89	8.7	12.1	3.7	0.5	25.0
90+	2.5	3.5	1.1	0.1	7.2
Female total	**153.6**	**243.8**	**56.5**	**13.7**	**467.6**
Total	**338.7**	**465.8**	**108.8**	**30.5**	**943.8**

Source: Deloitte Access Economics analysis. Note: components may not sum to totals due to rounding.

Chart 4.1: Proportion of health system costs by condition (left) and sleep disorder (right), 2019-20



Source: Deloitte Access Economics analysis.

5 Other financial costs of sleep disorders

Financial costs of sleep disorders other than health system expenditures include productivity losses, informal care costs, costs such as aids and modifications, legal costs and insurance costs attributed to MVAs and WPIs, as well as less obvious efficiency losses that result from increased taxation rates. These are outlined in the following sections.

Key findings

- Individual productivity losses due to sleep disorders were estimated to be $11.0 billion in 2019-20. This comprised $1.0 billion in reduced employment, $2.2 billion in absenteeism, $7.5 billion in presenteeism and $220.0 million in premature mortality costs.
- In addition to the individual productivity losses, informal care for conditions attributed to sleep disorders was estimated to cost $286.4 million. Other costs included deadweight losses ($1.5 billion) and other costs of WPIs and MVAs ($597.1 million).
- Most of the burden of other financial costs (non-health system costs) of $13.4 billion fell on employers ($7.2 billion, or 54%) while the remaining costs were borne by individuals and their families ($1.8 billion or 13%), government ($2.9 billion, or 22%) and society ($1.5 billion, or 11%).

5.1 Productivity losses for people with sleep disorders

Sleep disorders and their related symptoms, such as inadequate sleep, can have a substantial impact on an individual's ability to engage and attend work. Primary impacts on work include reduced chance of employment, early retirement, or exit from the workforce due to premature mortality. As such, sleep disorders may impose a range of productivity costs which affect not only individuals, but also their employers and government. These costs are real costs to the economy. For example, if worker productivity is lower for people with a condition caused by sleep disorders, a firm's output may be reduced, resulting in a cost to the firm and to government (through reduced taxes).

A human capital approach was adopted to estimate productivity losses. This involved the calculation of the difference in employment or production of people with inadequate sleep compared to that of the general population, multiplied by average weekly earnings (AWE). Productivity losses from premature mortality are estimated in terms of the NPV of future income streams lost.

The four potential productivity losses are:

- premature workforce separation, which is classified as early retirement or other workforce withdrawal;
- temporary absenteeism where a worker may be unwell more often than average and taking time off work, while remaining in the workforce;
- presenteeism, or lower productivity at work, where a worker produces less output while at work; and
- premature mortality, where for a person who dies early due to sleep disorders (e.g. due to MVA) would no longer receive future income streams (in discounted NPV terms).

A detailed condition specific approach was taken to estimate the productivity losses due to sleep disorders in Australia, comprising the productivity impacts of cardiovascular diseases, T2DM, depression, MVAs and WPIs. Productivity losses were based on the prevalence estimates for attributed conditions and sleep disorders as in Table 3.2. The attributed cases of each condition were split by age and gender.

There is the potential to double count productivity impacts due to sleep disorders itself and the conditions that may be caused by sleep disorders. If a person has a condition attributed to sleep disorders, their productivity impacts were assumed to be the same as for the attributed condition and no additional productivity losses were assigned to this group. That is, it was assumed that having a sleep disorder does not compound the probability or extent of productivity impacts for people with an attributed condition.

The following sections calculate productivity losses for people with sleep disorders. People who have sleep disorders can be more likely to report difficulty with concentration, impatience with others and boredom, decreased productivity, and greater absenteeism – e.g. Swanson et al (2011) discusses the impact of sleep disorders on work outcomes for people with sleep disorders relative to people without sleep disorders.

5.2 Reduced employment participation

Sleep disorders and the conditions attributed to sleep disorders may reduce the likelihood of a person participating in the workforce, either through disadvantage in the job-seeking process or self-selection out of the workforce. The productivity cost of any disadvantages to employment were calculated by determining the difference in employment rates between people with sleep disorders (or the attributable conditions) and the general population and multiplying the difference by the age and gender adjusted AWE (ABS 2020a; ABS 2020b).

5.2.1 Reduced employment of attributable conditions

The reduction in employment rates for people with chronic conditions attributable to their sleep disorder was calculated by comparing the employment rates of people with the condition to the employment rates of the general population using the Survey of Disability Ageing and Carers (SDAC; ABS 2018c). As noted, it was assumed that there was no multiplicative effect of having both an attributable condition as well as a sleep disorder.

The employment rate for each condition was calculated for the working age population (ages 15-64) for males and females and compared to the general population employment rates. Where there were sufficient data available, further disaggregation into 5 or 10 year age groups was applied.[16] The estimated reduction in employment for each condition is provided in Table 5.1.

The total cost of reduced employment was calculated by multiplying the estimated reduction in employment by the estimated prevalence of people with the condition (as a result of sleep disorders). This was then multiplied by the average annual earnings (adjusted for age and gender). The breakdown of these productivity losses is provided in Table 5.1.

The cost of WPIs was most recently estimated by Safe Work Australia (2015). The report estimated the number of accidents and the corresponding length of absence from work. Table B.1 provides the detailed breakdown of the proportion of people likely to experience each type of absence. It was assumed that people who experienced full incapacity as a result of their injury would not return to work. It was therefore estimated that 0.19% of WPIs resulted in a permanent reduction in employment. This was then multiplied by the total number of WPIs attributable to sleep disorders and the age and gender adjusted expected lifetime earnings.

Unlike WPIs, not everyone involved in MVAs was employed at the time of the accident. To account for this, it was assumed that people involved in MVAs were employed at the same rate as the general population (adjusted for age and gender).

It was assumed that the distribution of injuries resulting from MVAs where the person was hospitalised followed the same distribution as has previously been estimated by BITRE (2009). It was assumed that 2.2% of injuries resulted in profound permanent disability, 1.9% of injuries resulted in severe permanent disability, 5.8% resulted in moderate permanent disability and 5% resulted in mild permanent disability. For people who experienced these injuries it was assumed

[16] It was not possible to control for other possible confounding factors beyond age and gender when estimating reduction in employment rates. For example, a person with T2DM may also have depression which may be due to their T2DM or another cause and the depression may lead to further reductions in employment. Noting these issues, a more conservative approach was considered when estimating PAFs instead (see section 2.4).

that 3% of those with a severe disability would return to work at some point in their career, 50.6% of those with moderate injuries would return to work, and 99% of people with mild injuries would return. No one with a profound disability was assumed to return to work (BITRE, 2009). It was therefore estimated that 6.9% of MVAs attributable to sleep disorders resulted in a permanent reduction in employment.

Table 5.1: Estimated reduction in employment due to conditions attributable to sleep disorders

Condition	Male	Female
CHF	20.7%	24.5%
CAD	20.7%	24.5%
Depression	29.0%	25.5%
MVA	6.9%	6.9%
Stroke	33.2%	30.6%
T2DM	12.0%	20.5%
WPI	0.2%	0.2%

Source: ABS (2018c), Deloitte Access Economics calculations. Note: The estimated reductions in employment for each condition as shown in Table 5.1 are the average reduction for people aged 15-64. Where data were available, estimated reductions in employment were disaggregated further into 5 year age groups in the modelling to control for differences across age and gender groups.

Table 5.2 summarises the reduced employment costs of the conditions attributed to sleep disorders. **It was estimated that the value of reduced employment was $1.0 billion, which was $543 per person with a sleep disorder in 2019-20.**

Table 5.2: Total costs of reduced employment due to conditions attributable to sleep disorders, 2019-20

Condition	OSA	Insomnia	RLS	Total
CHF	2.9	5.1	-	8.0
CAD	4.2	35.9	-	40.1
Depression	441.3	169.7	-	611.0
MVA	127.7	52.9	-	180.6
Stroke	39.6	0.0	-	39.6
T2DM	46.0	0.0	-	46.0
WPI	44.1	77.5	-	121.6
Total	**705.9**	**341.1**	**-**	**1,046.9**

Source: Deloitte Access Economics calculations. Note: components may not sum to totals due to rounding.

5.3 Premature mortality

In addition to the productivity loss associated with reduced employment, there is also productivity forgone from premature mortality due to each of the illnesses or injuries attributed to a sleep disorder.

The productivity lost due to premature deaths was calculated by multiplying the estimated number of deaths from each condition by the lifetime potential earnings at the time of death. Lifetime earnings were based on age and gender and adjusted for the probability of employment, full-time or part-time. Assuming a retirement age of 65, the remaining years of employment were calculated for each age group based on the average for a person of each age in the group.

The annual productivity loss from premature death was valued using 2019 average annual earnings data by workforce age and gender group. Future streams of income were discounted to a present value using a 3% real discount rate.

The total **cost of conditions attributed to sleep disorders due to premature mortality was estimated to be $220.0 million, which was $114 per person with a sleep disorder in 2019-20.** The breakdown of costs of premature mortality by attributable condition is provided in Table 5.3.

Table 5.3: Productivity cost of premature mortality due to sleep disorders, 2019-20

Condition	OSA	Insomnia	RLS	Total
CHF	0.4	0.7	-	1.0
CAD	2.3	19.3	-	21.5
Depression	52.9	20.4	-	73.3
MVA	62.3	25.8	-	88.1
Stroke	19.1	0.0	-	19.1
T2DM	5.6	0.0	-	5.6
WPI	4.1	7.2	-	11.4
Total	**146.7**	**73.4**	**-**	**220.0**

Source: Deloitte Access Economics calculations. Note: components may not sum to totals due to rounding.

5.4 Absenteeism

People with chronic conditions such as sleep disorders and other associated conditions may take more days off work due to their condition. Absenteeism was measured by looking at the number of work days missed by people with chronic conditions relative to the rest of the population for attributed conditions.

The AIHW (2009) reported that people with chronic disease, including depression and cardiovascular disease, reported missing 0.48 days of work per fortnight compared with 0.25 days per fortnight missed by people without a chronic disease. This amounts to an average of 11.5 days of sick leave per year for a person with a chronic condition compared to 6 days for a person without a chronic disease. The cost of absenteeism for each condition caused by a sleep disorder was therefore assumed to be 5.5 days per person employed. An average was taken across several studies to estimate mean absences from work for T2DM, which suggested people with T2DM were absent from work for 2.1 additional days compared to the general population (Goetzel et al, 2004; American Diabetes Association, 2013; Collins et al, 2005; Vijan, Harward and Langa, 2005; Tunceli et al, 2005). The cost of a missed day of work for each condition was based on the number of people employed and the age and gender weighted average weekly earnings for each condition.

Safe Work Australia (2015) estimated the breakdown of WPIs by severity of injury and the corresponding length of absence for 2012-13. The adapted table from Safe Work Australia is provided in Table B.1. It was assumed that people with an injury causing short absence, long absence or partial incapacity were able to return to work after the respective absence periods. It was estimated that the average absence due to WPIs was 25.2 days.

Absenteeism associated with MVAs was derived from BITRE (2009). The report estimated the distribution of hospitalised MVAs by severity, and the corresponding length of absence before the person returned to work. The adapted table from BITRE (2009) is provided in Table B.2. It is noted that people with profound impairments were assumed to never return to the workforce, with the costs deriving from these people calculated in section 5.2. It was estimated that the average absence due to MVAs was 22.0 days.

It is noted that people injured in MVAs or WPIs could also incur an absenteeism cost once they return to work because they may have ongoing health issues as a result of their injury, which require days off work. Due to data limitations this cost could not be calculated. Table 5.4 presents the assumed rates of absenteeism due to sleep disorders in 2019-20.

Absenteeism rates for people with a sleep disorder and no other attributable condition were estimated based on the available literature. Details of the sources considered are provided in Table B.3. It is noted that studies were only included in the analysis where the study controlled for possible confounding factors including comorbidities.

Table 5.4: Cost of absenteeism due to sleep disorders and attributable conditions

Condition	Absenteeism days	Source
OSA	5.0	Stepnowsky et al (2019)
Insomnia	4.5	Kessler et al (2011), Bolge et al (2009), Daley et al (2009), DiBonaventura et al (2015)
RLS	7.0	Durgin et al (2015), Allen et al (2009), Swanson et al (2008), Dodel et al (2010)
CHF	5.5	AIHW (2009)
CAD	5.5	AIHW (2009)
Depression	5.5	AIHW (2009)
MVA	22.0	BITRE (2009)
Stroke	5.5	AIHW (2009)
T2DM	2.1	DAE (2014)
WPI	25.2	Safe Work Australia (2015)

Source: Deloitte Access Economics' estimates.

The estimated cost of sleep disorders due to absenteeism is provided in Table 5.5. **It was estimated that the absenteeism cost of sleep disorders was $2.2 billion, which was $1,153 per person with a sleep disorder in 2019-20.**

Table 5.5: Breakdowns of cost of absenteeism due to sleep disorders, 2019-20 ($ millions)

Condition	OSA	Insomnia	RLS	Total
CHF	0.3	0.6	-	0.9
CAD	0.5	4.1	-	4.6
Depression	41.8	16.1	-	57.9
MVA	9.5	3.9	-	13.5
Stroke	3.5	0.0	-	3.5
T2DM	3.2	0.0	-	3.2
WPI	122.2	214.5	-	336.6
No attributable condition	648.2	576.1	580.6	1,804.8
Total	**829.2**	**815.3**	**580.6**	**2,225.1**

Source: Deloitte Access Economics' estimates. Note: components may not sum to totals due to rounding.

5.5 Presenteeism

Presenteeism captures the cost of people attending work who experience reduced productivity due to their condition. Increases in presenteeism result in reduced work output or a reduction in the quality of work produced. To estimate the effect of sleep disorders upon presenteeism, it was assumed that people with an attributable condition only experienced the presenteeism effect of that condition, with no additive effect from the sleep disorder. People who only have a sleep disorder were assigned a reduction in productivity associated with that sleep disorder.

Table 5.6 summarises the assumed impact of sleep disorders and attributed conditions on presenteeism. A greater overview of the literature considered in relation to sleep disorders is provided in Table B.3. It is noted that similar to absenteeism, studies were only included in the analysis where the study controlled for possible confounding factors including comorbidities.

It is noted that no estimate was made to account for presenteeism due to WPIs and MVAs. This was largely due to data limitations, as no estimated impact of presenteeism was measured in BITRE (2009) or Safe Work Australia (2015) reports. This may result in an underestimation of total costs of presenteeism due to sleep disorders, as it is possible that some people who suffer a a long-term or permanent disability in an accident may experience reduced productivity when they return to work.

Table 5.6: The impact of sleep disorders and attributed conditions on presenteeism

Condition	Presenteeism (%)	Source
OSA	6.8%	Stepnowsky et al (2019)
Insomnia	11.3%	Kessler et al (2011), Bolge et al (2009), Daley et al (2009), DiBonaventura et al (2015)
RLS	10.8%	Durgin et al (2015), Allen et al (2009), Swanson et al (2008), Dodel et al (2010)
CHF	6.8%	Victoria Institute of Strategic Economic Studies (2016)
CAD	6.8%	Goetzel et al (2004)
Depression	15.3%	Goetzel et al (2004)
Stroke	6.8%	Victoria Institute of Strategic Economic Studies (2016)
T2DM	11.4%	Goetzel et al (2004)

Source: Deloitte Access Economics analysis.

The total **cost of sleep disorders and the attributed conditions due to presenteeism was estimated to be $7.5 billion, which was $3,908 per person with a sleep disorder in 2019-20.**

Table 5.7: The total cost of sleep disorders and their attributed conditions due to presenteeism, 2019-20

Condition	OSA	Insomnia	RLS	Total
CHF	0.8	1.3	-	2.1
CAD	1.0	8.9	-	9.9
Depression	226.2	87.0	-	313.2
Stroke	9.8	0.0	-	9.8
T2DM	33.1	0.0	-	33.1
No attributable condition	1,963.0	3,169.6	2,040.1	7,172.8
Total	**2,233.9**	**3,266.8**	**2,040.1**	**7,540.8**

Source: Deloitte Access Economics analysis. Note: components may not sum to totals due to rounding.

5.6 Informal care

Informal care costs measure the time spent by family and friends of people with sleep disorders providing assistance and support to the person. Informal care occurs outside of the formal care sector. While informal carers are not paid a wage for their care, the time they spend is not free in an economic sense. Time spent caring involves forfeiting time that could have been spent on paid work or undertaking leisure activities.

The opportunity cost method was used to estimate the formal sector productivity losses associated with caring, as time devoted to caring responsibilities is time which cannot be spent in the paid workforce.

This section estimates the cost of informal care due to conditions attributable to sleep disorders. As with previous reports, it was **assumed that there would be no care requirements due to the sleep disorders themselves.**

The average hours of informal care per person with each attributable condition was estimated using data from the SDAC (ABS 2018c). The average hours of care for each condition was determined by estimating the weekly average hours of care provided to the person, where the condition was the main reason the person received care. The proportion of people receiving care was estimated by dividing the number of people receiving care for each condition by the total number of people with the condition, where the condition was also their main condition.[17] The results are presented in Table 5.8.

[17] It was not possible to control for other possible confounding factors beyond age and gender when estimating reduction in employment rates. For example, a person with T2DM may also have depression which may be due to their T2DM or another cause and the depression may lead to further reductions in employment. Noting these issues, a more conservative approach was considered when estimating PAFs instead (see section 2.4).

Table 5.8: Hours of informal care for people with conditions attributable to sleep disorders

Condition	Average hours of care for recipients	Proportion receiving care (%)
CHF	18.3	12%
CAD	18.0	15%
Depression	24.3	4%
MVA	35.0	9.8%
Stoke	27.5	20%
T2DM	12.6	4%

Source: ABS (2018c), Deloitte Access Economics calculations.

The cost of informal care for MVAs was based on BITRE (2009). The average number of hours of care presented in BITRE (2009) was used to estimate the number of hours of informal care provided to people who sustain injuries in a road traffic crash resulting in permanent disabilities. It was estimated that people with profound disability received 105 care hours per week, severe disability resulted in 28.5 hours of care per week and moderate disability was attributed 9 hours of care per week. It was assumed that people with mild disability or no disability do not receive any informal care. Based on the proportion of people with each level of severity of permanent disability, it was estimated that people received 35.0 hours of care per week. It was assumed that the number of hours of care required would remain constant over the lifetime of the person injured.[18] Because data for injuries by disability level for ages was unavailable, a uniform distribution in each age group was assumed.

The cost of informal care for WPIs was estimated to be $36 million in 2012-13, or approximately $67.95 per injury (Safe Work Australia, 2015). This cost was adjusted for inflation and updated to reflect the number of injuries attributable to sleep disorders. As no age/gender breakdown was available, it was assumed that the costs of informal care were distributed in line with prevalence. It was estimated that informal care from WPIs attributable to sleep disorders cost $5.0 million in 2019-20.

It was estimated that the **total cost of informal care was $286.4 million, which was $148 per person with a sleep disorder in 2019-20.** The breakdown in costs is presented in Table 5.9.

Table 5.9: Cost of informal care due to sleep disorders, 2019-20, $ millions

Condition	OSA	Insomnia	RLS	Total
CHF	2.9	4.9	-	7.8
CAD	2.8	23.9	-	26.7
Depression	34.7	13.4	-	48.1
MVA	107.7	44.6	-	152.3
Stroke	39.2	0.0	-	39.2
T2DM	7.1	0.0	-	7.1
WPI	1.9	3.3	-	5.2
Total	**196.3**	**90.1**	**-**	**286.4**

[18] With care commencing from the time of injury and ongoing for the remaining expected years of life. Life expectancy was derived from the ABS life tables (2019).

Source: Deloitte Access Economics calculations. Note: components may not sum to totals due to rounding.

5.7 Other costs of MVAs and WPIs

Other costs attributed to MVAs and WPIs include legal costs, costs of investigation, premature funeral costs, aids and equipment, travel delays and vehicle repair costs.

With regard to WPIs, legal costs, investigations, travel cost and aids and modifications were estimated to total $6,719 per accident based on Deloitte Access Economics (2011) and inflated to 2019-20 dollars. Applied to the prevalence of WPIs attributable to sleep disorders, it was estimated that there was **an additional $449.8 million in other costs of WPIs attributable to sleep disorders.**

Other costs of MVAs include disability-related costs including aids and modifications, vehicle related costs including repairing vehicles, costs of emergency services, insurance administration costs, legal costs, premature deaths, investigations and the likes. **The lifetime costs of MVAs attributable to sleep disorders were estimated to be $147.4 million.**

5.8 Deadweight losses

Many of the costs associated with sleep disorders are publicly funded. These include some direct health care system costs, social security (transfer) payments, correctional services, coronial costs and the cost of emergency and police services.

Publicly funding costs means the government must effectively increase tax revenue to achieve a budget neutral position. To look at it another way, if all sleep disorders were avoided, the government would need to raise less taxation revenue.

Imposing taxes on a market reduces the efficiency of resource allocation within that market because it changes the price of those goods or services being taxed. For example, an increase in income tax rates will increase the relative price of work compared to leisure and therefore create a disincentive to work. This market distortion creates a reallocation of resources within the market being taxed and therefore creates an allocative efficiency loss. This is an economic cost to society because it results in less welfare through a reduction in producer and consumer surplus.

Although transfer payments are not an economic cost in themselves (they do not involve the use of resources) they have been estimated, along with public funding of health care for sleep disorders and attributed shares of other diseases and injuries, to calculate the cost associated with a loss in allocative efficiency.

5.8.1 Welfare payments

There are several social security payments available to people with disability or unable to work, the main one being the Disability Support Pension. The Disability Support Pension is paid to people over the age of 16 who have disabilities that preclude them from working for at least 15 hours per week at or above the relevant minimum wage or able to return to such work for at least the next two years due to a disability.

Based on Deloitte Access Economics (2011), it was estimated that transfer payments in 2019-20 ranged between $88 and $305 per person with a condition or long-term injury due to a sleep disorder. As no data were available on the number of people receiving welfare due to a sleep disorder, it was assumed that all welfare payments are due to the attributed conditions, rather than the underlying sleep disorder. On average, people with sleep disorders who are of working age (assumed to be aged 15 to 64 years old) were estimated to receive $14.29 in welfare payments in 2019-20, which was equivalent to $29.6 million in Australia in 2019-20.

5.8.1 Taxation revenue

Reduced earnings from lower employment participation and lower output result in reduced taxation revenue collected by the Government. Alongside lower income taxation, there would also be a fall in indirect (consumption) taxes, as those with lower incomes spend less on the consumption of goods and services. Lost taxation revenue was estimated by applying an average personal income tax rate and average indirect taxation rate to lost earnings. Rates were assumed to be the same as in Hillman et al (2018). The respective tax rates used in the calculation of deadweight losses were:

- 22.4% average personal income tax rate, and 12.1% average indirect tax rate; and
- 23.7% average company tax rate.

Applying these tax rates to the total productivity impacts (including informal care costs), the total lost individual income tax revenue was estimated to be $642.9 million (including lost carer taxes), while the total lost company tax revenue was estimated to be $2.2 billion in Australia in 2019-20.

5.8.2 Deadweight loss of taxation payments and administration

To estimate the deadweight loss due to lost taxation revenue (given an assumption of no change in spending), taxes were assumed to be maintained by taxing either individuals or companies more as necessary (to replace the lost tax from either stream). Each tax in the economy imposes various burden on the efficiency of society. Analysis by KPMG (2010) and Cao et al (2015) report the marginal burden of various government taxes (both State and Commonwealth).

Briefly:

- income tax was estimated to impose a burden of $0.25 for every $1 raised;
- company tax was estimated to impose a burden of $0.50 for every $1 raised;
- goods and services tax was estimated to impose a burden of $0.19 for every $1 raised;
- state taxes were estimated to impose a burden of $0.45 for every $1 raised based on the respective shares of revenue raised through major state taxes including gambling, insurance, motor vehicle taxes, payroll tax and stamp duties (KPMG, 2010; ABS, 2016).

It is important to consider taxes levied by state and territory governments as they also pay for some health services. Based on the 2016-17 budget papers (Commonwealth of Australia, 2016), approximately 70% of state health expenditure is paid for by state taxes, while the remaining 30% is paid for by transfers from Commonwealth. Thus, the relevant burden imposed by taxation to pay for state health expenditure is allocated to both income taxes, and the weighted state taxes. Consistent with the approach in Hillman et al (2018):

- reduced income for individuals results in a 23.7% efficiency loss;
- reduced income for employers results in a 50.8% efficiency loss;
- welfare payments and Commonwealth health expenditure result in a 29.5% efficiency loss; and
- state health expenditure results in a 36.9% efficiency loss.

Table 5.10 shows the estimated reduced income, transfer payments, and health expenditure payments, the applied efficiency loss of levying taxes, and the resulting deadweight losses associated with sleep disorders in Australia in 2019-20. All rates of efficiency loss include a 0.8% administrative loss which covers expenses of administering taxation (Australian Taxation Office, 2016). The **total deadweight losses associated with sleep disorders were estimated to be $1.5 billion** in 2019-20.

Table 5.10: Deadweight losses due to sleep disorders, 2019-20

Cost component	Total cost ($m)	Rate of efficiency loss (%)	Resulting deadweight loss ($m)
Commonwealth health system expenditure	441.0	29.5%	130.1
State and territory health expenditure	220.8	36.9%	81.5
Welfare	29.6	29.5%	8.7
Consumer tax	544.0	23.7%	129.1
Company tax	2,236.9	50.8%	1,137.3
Carer tax	98.8	23.7%	23.4

Total	**3,571.2**	**-**	**1,510.2**

Source: Deloitte Access Economics calculations. Note: components may not sum or multiply to totals due to rounding.

5.9 Summary of non-health system costs

The total costs associated with sleep disorders outside of the health system are summarised in Table 5.11. Other financial costs were estimated to cost $13.4 billion in 2019-20. Most of this cost was due to productivity losses ($11.0 billion). The remaining costs were due to deadweight losses ($1.5 billion), informal carers ($0.3 billion) and other costs ($0.6 billion).

Table 5.11: Summary of the costs of sleep disorders, 2019-20

Cost component	Total cost ($m)	Cost per person ($)
Productivity losses	11,032.9	5,717
Informal care costs	286.4	148
Other costs	597.1	309
Deadweight losses	1,510.2	783
Total	**13,426.6**	**6,958**

Source: Deloitte Access Economics estimates. Note: components may not sum to totals due to rounding.

6 Loss of wellbeing

Sleep disorders present not only health system and other financial costs, but also costs to the individual such as loss of quality of life through loss of leisure or physical pain. These costs, although less tangible, can be as significant or even more significant than the financial costs of a condition.

The loss of wellbeing (including loss of life due to premature mortality) from both sleep disorders and other attributed health conditions was estimated using the burden of disease methodology.

Key findings

- Overall, it was estimated that there were 158,595 years of heathy life lost due to disability and 14,724 years of life lost due to premature mortality (discounted at 3% per year) due to sleep disorders in Australia in 2019-20. Thus, 173,319 years of healthy life were lost due to sleep disorders.
- Converted to a dollar estimate using the VSLY, the total value of reduced wellbeing from sleep disorders was estimated to be $36.6 billion in 2019-20.
- Most of the reduction in wellbeing was due to sleep disorders directly ($28.5 billion), although an additional $8.1 billion was due to conditions attributable to sleep disorders.

6.1 Methodology

The 'burden of disease' method used in this chapter was developed by the World Health Organization to provide a comprehensive measure of mortality and disability through a non-financial method of interpreting pain, suffering and premature mortality in terms of DALYs. DALYs are the sum of both:

- Years of healthy life lost due to morbidity (YLDs), which are estimated for a given year by multiplying a "disability weight" (see section 6.1.1) by prevalence.
- Years of life lost due to premature mortality (YLLs), which are estimated by aggregating the loss of future years of life (based on average life expectancy) at the age of death for all deaths due to a condition.

DALYs are presented on a scale of zero to one, zero being a year of perfect health and one being death, and other health states falling between these two extremes, reflecting loss of quality of life. For example, a disability weight of 0.2 can be interpreted as a 20% loss of quality of life as compared to perfect health.

DALYs can be converted into a dollar figure using an estimate of the VSLY, an estimate of the value society places on an anonymous life. The Department of Prime Minister and Cabinet (2019) estimated the net VSLY (that is, subtracting financial costs borne by individuals) to be $213,000 in 2019 dollars, or approximately $216,626 when inflated to 2019-20 dollars.

6.1.1 Disability weights

A common method for converting SF-36 health utility scores to disability weights is to subtract the calculated SF-36 health utility score for a particular condition from the population norm SF-36 health utility scores for a person of that age and sex (Haagsma et al, 2009).

A literature scan was undertaken to identify average utility scores in people with OSA, insomnia and RLS, and in the general population. Utility scores can vary substantially with the tool used and other factors such as language, so where possible, comparable data were sought (e.g. the population norm was also taken from the same country and for a similar age group as those with the condition).

The results of the literature scan are summarised in Table 6.1. The disability weights for OSA, insomnia and RLS were estimated to be 0.053, 0.090 and 0.084, respectively. These were estimated as follows:

- The quality of life experienced by those with **OSA** was based on the incremental difference in utility observed in Stepnowsky et al (2019), who provided incremental differences in utility for OSA (with and without excessive sleepiness) compared to a comparator group drawn from the 2016 United States National Health and Wellness Survey.
- For **insomnia**, health utilities were taken from Léger et al (2012), which is a possible lower bound observed in the literature. For example, Dibonaventura et al (2015) and Mishima et al (2015) have both reported that utility in people with insomnia is about 0.14 to 0.15 units lower than comparator groups. However, as these studies do not report differences in utility when controlling for possible confounding factors, the lower bound from Léger et al (2012) – a difference of 0.09 units, observed in a United States-based cohort, was used in the modelling.
- Disability weights for those with **RLS** were derived based on EQ-5D utility scores in Germany and the US. Happe et al (2009)[19] and Allen et al (2011) found that the average EQ-5D health utility score for those diagnosed with RLS was 0.75, An average weighted by sample size of the difference between these values and the population averages (based on representative age groups from Janssen et al, 2019) gives a disability weight of 0.084.

Table 6.1: Disability weights for sleep disorders

Condition / study	Study details	Sample size	Utility score	Population norm utility score	Implied disability weight
OSA					
Stepnowsky (2019)	United States	2,183	0.677	0.73	0.053
Insomnia					
Léger (2012)	United States	4,067	0.63	0.72	0.09
	France	1,858	0.57	0.67	0.10
	Japan	911	0.67	0.77	0.10
Lower bound					*0.09*
RLS					
Happe (2009)	Germany	519	0.75	0.860	0.110
Allen (2011)	United States	251	0.75	0.809	0.059
Simple average					*0.084*

Source: as noted in table. Population norm utility scores were based on Perneger et al (2010), Janssen et al (2019), and Kind et al (1999).

Disability weights for conditions associated with sleep disorders were based largely on the Global Burden of Disease study (GBD collaborators, 2017 and Salomon et al, 2015). The disability weights for WPIs were derived based on severity of injury from Access Economics (2004b). These weights were used directly for any conditions that were attributable to sleep disorders.[20]

[19] Another study, Dodel et al (2010), also reported on the same sample as Happe et al (2009) and has been excluded from the modelling. Of note however, Dodel et al (2010) reported that people with RLS experienced lower visual analogue scale utility scores than people with Parkinson's disease, multiple sclerosis, narcolepsy and people recovering from stroke. This result was unexpected and may indicate that the disability weights applied to people with RLS in this report are conservative.

[20] It is common for a multiplicative model to be used to estimate disability weights for comorbid conditions. A multiplicative model ensures that the sum of disability weights does not exceed one, but it also attributes more weight (greater reduction in healthy life) to people who have multiple conditions. For the purposes of this analysis, it was considered that a multiplicative model would unreasonably attribute a higher reduction in wellbeing to these cases as it was not possible to further adjust for other comorbid conditions in individuals. Similarly, it is not clear that the sleep disorders would still co-exist with the attributed conditions, noting there is a time lag before the incidence of the attributed conditions.

Table 6.2: Disability weights for associated conditions

Condition	Weight	Source
CHF	0.097	Global Burden of Disease Collaborators (2017)
CAD	0.079	Salomon et al (2015)
Stroke	0.309	Global Burden of Disease Collaborators (2017)
T2DM	0.049	Global Burden of Disease Collaborators (2017)
Depression	0.400	Global Burden of Disease Collaborators (2017)
WPIs	0.080	Access Economics (2004)
MVAs	0.049	Salomon et al (2015)

Source: as noted in table.

6.2 Loss of wellbeing due to sleep disorders

YLDs were estimated by multiplying the number of cases of each sleep disorder and their comorbid conditions by their respective disability weights. YLLs were derived by multiplying age-gender mortality rates, which underly the estimates described in section 3.2, by expected years of life remaining for each age-gender group, using life expectancy tables from the ABS (2019). YLLs were not calculated directly for sleep disorders without attributed conditions, since there is limited evidence of an increased risk of mortality due to sleep disorders in isolation from other health conditions.

It was estimated that **158,595 YLDs and a further 14,724 YLLs (undiscounted) were attributable to sleep disorders in Australia in 2019-20** (Table 6.3)**.** When future years of life were discounted at 3% per annum, 10,269 YLLs were attributable to sleep disorders in 2019-20. Overall, **there were 173,319 DALYs due to sleep disorders in 2019-20** in undiscounted terms, and this was reduced to 168,864 DALYs when discounting was applied (Table 6.4). Multiplying DALYs by the VSLY, the value of healthy life lost due to sleep disorders was estimated to be $36.6 billion. While the value of healthy life lost is a non-financial cost and is not included within measures of economic activity, it provides a useful comparison with other conditions and a view of the total impact of sleep disorders in Australia. That is, the value of healthy life lost should not be interpreted as a monetary cost to the economy, but rather the value of a loss in the stock of health capital.

Most of the reduction in wellbeing was due to sleep disorders directly ($28.5 billion), although an additional $8.1 billion was due to conditions attributable to sleep disorders.

Table 6.3: YLDs and YLLs from sleep disorders in Australia, 2019-20

Condition	YLDs ('000s)				YLLs, discounted ('000s)			
	OSA	Insomnia	RLS	Total	OSA	Insomnia	RLS	Total
CHF	0.1	0.2	-	0.3	0.2	0.3	-	0.5
CAD	0.1	0.8	-	0.9	0.3	2.3	-	2.5
Depression	2.0	-	-	2.0	2.8	-	-	2.8
MVAs	0.7	-	-	0.7	0.6	-	-	0.6
Stroke	12.9	5.0	-	17.8	1.2	0.4	-	1.6
T2DM	1.9	3.4	-	5.4	0.1	0.2	-	0.3
WPIs	0.1	0.0	-	0.1	1.3	0.6	-	1.9
No attributed condition	37.5	48.2	45.7	131.4	-	-	-	-
Total	**55.3**	**57.6**	**45.7**	**158.6**	**6.5**	**3.7**	**-**	**10.3**

Source: Deloitte Access Economics calculations. Note: components may not sum to totals due to rounding.

Table 6.4: DALYS and value of healthy life lost due to sleep disorders in Australia, 2019-20

Condition	DALYs, discounted ('000s)				DALYs ($m)			
	OSA	Insomnia	RLS	Total	OSA	Insomnia	RLS	Total
CHF	0.3	0.5	-	0.8	60	104	0	165
CAD	0.4	3.0	-	3.4	77	658	0	735
Depression	4.8	-	-	4.8	1,050	0	0	1,050
MVAs	1.4	-	-	1.4	296	0	0	296
Stroke	14.0	5.4	-	19.4	3,040	1,169	0	4,210
T2DM	2.0	3.6	-	5.6	442	775	0	1,217
WPIs	1.4	0.6	-	2.0	313	130	0	442
No attributed condition	37.5	48.2	45.7	131.4	8,121	10,440	9,905	28,466
Total	**61.9**	**61.3**	**45.7**	**168.9**	**13,399**	**13,276**	**9,905**	**36,580**

Source: Deloitte Access Economics calculations. Note: components may not sum or multiply to totals due to rounding.

7 Sleep disorders cost summary

There is now a significant body of literature that has estimated the costs of sleep disorders and poor sleep health in Australia over the last decade. Recent analyses include *Re-awakening Australia, Cost effectiveness of continuous positive airway pressure for obstructive sleep apnoea,* and *Asleep on the job: Costs of inadequate sleep in Australia*. This chapter summarises the costs of the present analysis and contextualises the costs through comparison to previous work.

7.1 Total costs of sleep disorders

It was estimated that the cost of sleep disorders was $51.0 billion in Australia in 2019-20. This included $943.8 million in health system costs, $13.4 billion in productivity losses and other financial costs and $36.6 billion in reduced wellbeing. The breakdown of costs by specific sleep disorder is provided in Table 7.1.

Table 7.1: Cost of sleep disorders in 2019-20, by component and sleep disorder, $ millions

Component	OSA	Insomnia	RLS	Total
Health system costs				
Direct	352.6	129.2	116.4	598.2
Attributed	188.6	157.1	-	345.7
Total	541.2	286.3	116.4	943.8
Productivity costs				
Direct	2,611.2	3,745.7	2,620.7	8,977.6
Attributed	1,304.5	750.8	-	2,055.3
Total	3,915.7	4,496.4	2,620.7	11,032.9
Informal care				
Direct	-	-	-	-
Attributed	196.3	90.1	-	286.4
Total	196.3	90.1	-	286.4
Other costs of accidents				
Direct	-	-	-	-
Attributed	267.4	329.7	-	597.1
Total	267.4	329.7	-	597.1
Deadweight losses				
Direct	365.4	489.2	349.7	1,204.4
Attributed	186.0	119.9	-	305.9
Total	551.4	609.1	349.7	1,510.2
Wellbeing costs				
Direct	8,120.6	10,439.9	9,905.1	28,465.6

Component	OSA	Insomnia	RLS	Total
Attributed	5,278.3	2,836.4	-	8,114.7
Total	13,398.9	13,276.3	9,905.1	36,580.4
Overall				
Direct	11,449.9	14,804.0	12,991.9	39,245.8
Attributed	7,421.1	4,283.9	-	11,705.5
Total	**18,871.0**	**19,087.9**	**12,991.9**	**50,950.8**

Source: Deloitte Access Economics analysis. Note: components may not sum to totals due to rounding. * some health system costs could not be attributed directly to OSA, insomnia or RLS, so these have been labelled as "other" sleep disorders.

7.2 Comparison with previous work

Streatfeild et al (2019) estimated the cost effectiveness of CPAP therapy for people with OSA in 2018. Adjusted for inflation, it was estimated that CPAP therapy would cost $573 per person per year from a health system perspective in 2019-20. It was calculated that CPAP therapy would avoid 0.0305 DALYs per person per year, which, from a health system perspective led to an estimated incremental cost effectiveness ratio (ICER) of $18,787 per DALY averted in 2019-20. From the perspective of society, the ICER was estimated to be dominant – meaning the intervention both saved money (savings of approximately $490 per person per year) and improved wellbeing.

Hillman et al (2018) estimated the costs of inadequate sleep in 2016-17. To allow for comparison with the present analysis, these costs have been updated to the 2019-20 financial year, adjusting for expected changes in prevalence and inflation (Table 7.2). The comparison shows that sleep disorders have around half the health system costs of inadequate sleep, some 47% of the total financial costs, but approximately the same wellbeing losses, resulting in around 80% of the total costs. However, it should be noted that there are methodological differences in the two estimation processes and definitional differences that affect the comparison, so it is not like for like.

Table 7.2: Total costs of inadequate sleep and sleep disorders, 2019-20, $ billions

Condition	Inadequate sleep	Sleep disorders
Health system costs	1.99	0.94
Absenteeism	2.88	2.23
Presenteeism	7.71	7.54
Reduced employment	8.71	1.05
Premature mortality	1.01	0.22
Informal care	0.69	0.29
Deadweight loss	2.56	1.51
Other costs	4.09	0.60
Total financial costs	**29.64**	**14.37**
Wellbeing costs (non-financial)	**45.86**	**36.58**
Total costs	**75.50**	**50.95**

Source: Deloitte Access Economics calculations based on Hillman et al (2018). Note: components may not sum to totals due to rounding.

7.3 Sensitivity analysis

One-way sensitivity analyses were conducted on prevalence, the VSLY, disability weights, and estimated productivity losses (applied to absenteeism and presenteeism). The choice of parameter value was either consistent with the literature that has been cited earlier (e.g. choosing the upper and lower bound from the results), or within the 95% confidence interval of estimated base case values.

Table 7.3 shows the percentage impact on the inputs (e.g. prevalence of all three sleep disorders was 25% lower, which had a flow on effect to PAFs) and the resulting cost of sleep disorders under each scenario. The results of the sensitivity analysis showed that the possible variation in prevalence has the largest impact on the costs in the modelling with total costs – financial and non-financial – ranging between $39.8 billion and $64.8 billion. Under the low and high cost scenarios – where all parameters were changed at once – the cost of sleep disorders was estimated to range between $20.2 billion and $95.9 billion.

Table 7.3: Impact of one-way sensitivity analyses on the cost of sleep disorders, 2019-20, $ billions

Case	Health system	Productivity and informal care	Other financial costs	Loss of wellbeing	Total
Base case	**0.94**	**11.32**	**2.11**	**36.58**	**50.95**
Prevalence					
Lower (-25%)	0.88	8.82	1.72	28.41	39.82
Upper (+32%)	1.03	14.44	2.59	46.78	64.83
VSLY					
Lower (-14%)	0.94	11.32	2.11	31.44	45.81
Upper (+15%)	0.94	11.32	2.11	41.92	56.29
Disability weights					
Lower (-22%)	0.94	11.32	2.11	30.25	44.62
Upper (+39%)	0.94	11.32	2.11	47.58	61.95
Productivity impacts (absenteeism and presenteeism)					
Lower (-56%)	0.94	6.96	1.59	36.58	46.07
Upper (+65%)	0.94	16.44	2.72	36.58	56.68
Effect of changing attributions					
No T2DM or depression	0.81	10.15	1.96	32.86	45.79
No T2DM, depression or cardiovascular impacts	0.76	9.95	1.94	31.24	43.89
No attributions	0.60	9.06	1.21	30.73	41.60
Low combined	0.57	3.76	0.57	15.33	20.24
High combined	1.03	21.09	3.38	70.34	95.85

Deloitte Access Economics calculations. Note: it is not possible to combine lower or higher bound sensitivity analyses to derive the results shown in 'low combined' and 'high combined' as some parameters may have flow on effects in the model – for example, changing prevalence will also change the costs attributed to sleep disorders by altering the associated PAFs, so the combination of the scenarios "no attributions" and "lower prevalence" is higher than when these are simultaneously changed in the modelling. Components may not sum to totals due to rounding.

7.4 Conclusions

In 2019 the Commonwealth Government released findings from the *Inquiry into Sleep Health Awareness in Australia.* The inquiry identified several key recommendations which are summarised briefly as follows:

- Sleep health should be a national priority with its importance to health and wellbeing to be recognised alongside fitness and nutrition.
- Updated guidelines regarding optimal shift structures and a nationally consistent approach to working hours and rest breaks for shift workers.
- A review of the Medicare Benefits Schedule as it relates to sleep health services in Australia.
- Ensure that all Pensioner or Health Care Card holders with moderate to severe OSA have access to a free trial of CPAP therapy and pending the success of the trial, free ongoing CPAP treatment.
- The development of a national sleep health awareness campaign to provide information on the causes and impacts of sleep disorders and to communicate the benefits associated with improved sleep health.
- Assess the current knowledge levels of general practitioners, nurses and psychologists in relation to sleep health, and develop effective training mechanisms to further improve understanding.
- The Australian Government should fund research focused on the prevalence of sleep disorders in under-researched population groups and in rare sleep disorders which are not well understood. Research should also focus on the effects of long-term shift work on sleep health and the effects of digital devices and electronic media on sleep health.

Sleep disorders within Australia pose significant and ongoing challenges. In 2010, the cost of sleep disorders was estimated to be $36.4 billion. Today, in 2019-20, these costs were conservatively estimated at $51.0 billion. Alongside the costs of inadequate sleep – estimated to be $75.5 billion in 2019-20 – there are likely to be substantial benefits from interventions that aim to improve sleep health in Australia.

The main driver of the change in the cost of sleep disorders over time is the change in prevalence sources, including differences in how each condition is defined. However, the costs in this report are also a more complete picture than they have been in Deloitte Access Economics' previous reports – for example, this is the first time that it has been possible to estimate the potential impact of sleep disorders directly on work absences and reduced productivity for people working with a sleep disorder, and these costs were estimated at $11.0 billion in 2019-20. In past reports, it was only possible to estimate the impact of conditions attributable to sleep disorders on work productivity and absences, which only accounted for 7.2% of the estimated $11.0 billion in absenteeism and presenteeism costs in 2019-20.

While this is the most comprehensive estimate of the cost of sleep disorders in Australia to date, there is still a need to better understand costs of sleep disorders. Future research should continue to focus on broad case definitions to identify average incremental costs for all people with a sleep disorder, for OSA, insomnia and RLS, but also for narcolepsy, bruxism, sleep talking, sleep walking and a number of other sleep disorders.

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Appendix A

Methodology to calculate PAFs

Where evidence from clinical studies of a causal relationship between inadequate sleep and another health condition was provided in terms of odds ratios, PAFs were calculated using the following method based on Eide and Heuch (2001). First, the following two equations were solved simultaneously:

$$q1.s1+q2.s2 = p1 \qquad (1)$$
$$q1/(1-q1)/(q2/(1-q2)) = OR \qquad (2)$$

Where:

- q1 = probability of having the associated heath condition given that an individual has a sleep disorder
- q2 = probability of having the associated health condition given that an individual does not have a sleep disorder
- s1 = probability of having a sleep disorder
- s2 = probability of not having a sleep disorder
- p1 = probability of having the associated health condition
- OR = odds ratio of having the associated health condition for individuals with a sleep disorder, compared to those without.

After solving these equations for q1 and q2, the following equation is derived:

$$PAF = ((q1-q2).s1)/p1 \qquad (3)$$

Equation (3) was used to determine the PAF for each condition due to OSA, insomnia and RLS. Where epidemiological studies reported relationships in terms of a hazard ratio, the hazard ratios were assumed to approximate relative risk ratios. The PAF was calculated using the following equation, taken from Eide and Heuch (2001).

$$PAF = (s1.(RR-1))/(s1.(RR-1)+1) \qquad (4)$$

Where:

- s1 = probability of having a sleep disorder
- RR = relative risk of having the associated health condition for individuals with a sleep disorder compared to those without.

Evidence of relationships between sleep disorders and secondary health conditions

The following sections discuss prospective longitudinal studies or meta-analyses examining the relationship between sleep disorders and secondary health conditions, including:

- CHF
- CAD or coronary heart disease
- Depression
- MVAs
- Stroke
- T2DM
- WPIs.

The evidence summarised in the following sections does not comprehensively cover all relevant studies, but rather those that inform the modelling.

Congestive heart failure

CHF and OSA

There is an established link between OSA and CHF in the literature, and evidence that OSA worsens outcomes for patients with established heart failure. Shahar et al (2001) studied this relationship and found an OR of 2.38 for heart failure for patients with OSA.

Gottlieb et al (2010) utilised the same dataset over a longer follow up and reported an adjusted HR for incident heart failure of 1.58 for those with severe OSA (AHI > 30) compared to those without OSA (AHI <5). The effect was reduced for moderate OSA. Given the broader prevalence of OSA in this report, results from Gottlieb et al (2010) were pooled across severity and gender so they could be applied in the model. The resulting HR was 1.23.

A review by Sarkar et al (2018) suggests Gottlieb et al (2010) is still one of the most influential studies that has assessed the relationship between OSA and cardiovascular disease.

CHF and insomnia

The largest available longitudinal study examining the relationship between insomnia and heart failure was conducted by Laugsand et al (2014), following 54,279 Norwegian men and women for 11.3 years. They reported an association between self-reported symptoms of insomnia and incident heart failure after adjustment for confounders, with a hazard ratio of 1.52. Further analysis showed those with three symptoms of insomnia had a HR of 5.25 compared to HR 1.43 for those with one symptom, and that difficulty initiating sleep was the insomnia symptom most closely correlated with heart failure.

CHF and RLS

There was insufficient evidence found in the literature to support the relationship between CHF and RLS, and so it was not included in this analysis.

Coronary artery disease

CAD and OSA

Gottlieb et al (2010) was used to inform the relationship with CAD, consistent with CHF also. In the fully adjusted model, the HR of developing incident CAD was 1.33 for men with severe OSA (AHI > 30) compared to those without OSA (AHI <5). However, the relationship did not appear for women or for more moderate OSA.

There are a number of other studies that have found a relationship with CAD outcomes. For example, Lee et al (2016) found OSA was significantly associated with revascularisation of the target coronary vessel, with a HR of 1.26. Similarly, a follow up from the Wisconsin Sleep Cohort Study found that, after adjustment for confounders, baseline AHI independently predicted future carotid artery intima thickness, plaque presence and plaque score (Gunnarsson et al, 2014).

As cardiovascular disease outcomes often occur together in follow up studies, the results from Gottlieb et al (2010) were pooled across severity and gender so they could be applied in the model. The resulting HR was 1.04.[21]

CAD and insomnia

Sofi et al (2014) provides a meta-analysis of studies looking into the relationship between CAD and insomnia. It found a RR of 1.45 for self-reported insomnia and risk of developing or dying from cardiovascular disease. However, the studies included in the meta-analysis showed heterogeneity in case definitions and outcome measures.

Laugsand et al (2011) sought to correlate first myocardial infarction, a marker of coronary heart disease, with insomnia symptoms. The study found an adjusted HR of 1.45 for people with difficulty initiating sleep almost every night, and HR 1.30 for people with difficulty maintaining sleep almost every night.

Based on both studies, a RR of 1.45 was used for this analysis.

CAD and RLS

Correlation of RLS with CAD is not as well established in the literature as the other sleep disorders due to a range of factors. Notably, this is due to the lower prevalence of symptomatic RLS and high degree of sleep disorder comorbidity and subsequent confounding of study results.

Some recent studies have suggested that RLS may be an important factor in CAD. For example, Yatsu et al (2019) observed a co-existence of CAD and RLS. However, further studies are still required to indicate that RLS can be associated with incident coronary heart disease.

Stroke

Stroke and OSA

As with CAD and CHF, several studies have examined the relationship between OSA and incident stroke outcomes. An authoritative meta-analysis by Li et al (2014) reported that OSA was associated with fatal or non-fatal stroke with a RR 2.10, which was used in the modelling.

More recent articles still support these findings. For example, Alexiev et al (2018) found a two times increased risk of stroke in patients with untreated OSA, and Jehan et al (2018) reported a dose response relationship, with increasing severity of OSA associated with increased stroke incidence, particularly with AHI >25.

Stroke and insomnia

The link between insomnia and stroke is less clear, in part due to the inherent heterogeneity in the definition of insomnia across studies. McDermott et al (2018) noted self-reported insomnia may be associated with incident stroke outcomes. However, it is generally not possible to control for confounding health conditions and sleep disorders in self-report studies. As no studies were identified that used DSM-5 to measure insomnia (therefore controlling for other sleep disorders), the relationship between stroke and insomnia has not been modelled in this analysis.

Stroke and RLS

Several studies have observed a high rate of RLS in stroke patients that is generally higher than the population prevalence of RLS (e.g. Shiina et al, 2018).

However, McDermott et al (2018) noted that identification of an independent association between RLS and stroke remains elusive, in part due to the high rate of comorbidity between RLS and OSA. Elwood et al (2006) found an OR for stroke of 1.67 for those with RLS, although the study was excluded from previous Deloitte Access Economics' analysis as cases were self-reported limiting the ability to control for confounding factors.

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[21] It is noted the result would unlikely reach significance, however, the relationship has still been modelled for moderate to severe OSA given the broader findings for cardiovascular disease in the literature.

One recent study in veterans in the United States observed that RLS may be associated with incident stroke (Molnar et al, 2016). However, the relationship has been conservatively excluded given the restricted sample and limited evidence overall.

Type 2 diabetes mellitus

T2DM and OSA

The relationship between T2DM and OSA was outlined by Wang et al (2013), a meta-analysis of prospective cohort studies. The study found a relationship between OSA and T2DM, particularly for moderate to severe OSA. Questions of the directionality of the relationship were addressed in a large population-based cohort study in the US (Huang et al, 2018), where OSA was found to be a significant T2DB predictor even after controlling for patient weight. Conversely, diabetes was not found to be a significant risk factor for incident OSA after controlling for body mass and waist circumference. Hang Xu et al (2019) also identified this relationship, finding OSA is an independent risk factor for diabetes, and a significant reduction in diabetes incidence in individuals receiving treatment for OSA (in the form of CPAP).

This relationship was confirmed in Reutrakul and Mokhlesi (2017), a meta-analysis covering over 60,000 patients, finding that OSA is associated with incident T2DM with an adjusted RR of 1.35. Interestingly, the study concludes that OSA is a greater contributor to the development of T2DM than physical inactivity, one of the lifestyle factors typically associated with incident T2DM. The results from Reutrakul and Mokhlesi (2017) were included in the model.

T2DM and insomnia

Demonstration of the association between insomnia and T2DM is limited by the as previously mentioned heterogeneity in definition and diagnostic methods for insomnia across studies. While there are reported associations between sleep duration <5 hours (both self-reported and documented on PSG) and incident T2DM (Khan and Aouad, 2017), similar association for insomnia using strict DSM-5 definition was not available in the identified literature.

As such, no relationship between T2DM and insomnia has been included in this analysis.

T2DM and RLS

There is a limited number of prospective studies with sufficient sample size to demonstrate a robust association between RLS and T2DM. Akin et al (2019) recruited 318 patients with T2DM and documented a prevalence of RLS of 28.3%; they conclude that RLS is 7-8 times more prevalent in T2DM patients than in the general population, which may suggest a relationship.

However, as this relationship could not be strengthened through a further review of the literature, it was concluded that there was insufficient evidence on which to base a calculation of a PAF. Therefore, the relationship between T2DM and RLS was not included in this analysis.

Depression

Depression and OSA

It is generally accepted that there is higher prevalence of OSA among patients suffering depression than in the general population. Hein et al (2017) summarises prevalence of depression estimates from 13-39% for OSA among cohorts of patients with depression.

Chen et al (2013) attempted to quantify this relationship, reporting an OR of 2.18 for depression among those with OSA. This is broadly in line with Peppard et al (2006), which demonstrated a dose response relationship whereby those with more severe OSA were at greater risk of depression. The study found that those with mild OSA (AHI 5-15) had 2 times greater odds of depression, while those with moderate to severe OSA (AHI > 15) had 2.6 times greater odds of depression.

Given the similarities in the OR identified across the studies, Chen et al (2013) was used to generate the assumption in this analysis, and an OR of 2.18 was used.

Depression and insomnia

There have been numerous studies reporting a relationship between depression and insomnia. Li et al (2016) provides an authoritative meta-analysis of prospective cohort studies, including over 170,000 patients and 36 studies. Hertenstein et al (2019) provided updated estimates for clinical or primary insomnia, where they carefully only included studies in the meta-analysis provided that each study met the strict inclusion criteria (e.g. people with insomnia had to have daytime symptoms in addition to night-time symptoms). A pooled RR of 1.53 was used in the modelling for this analysis.

Depression and RLS

There is some inconsistency in the literature in delineating the relationship between RLS and depression. Koo et al (2016) report an adjusted OR of 2.85 for depression among patients with moderate to severe RLS. In contrast, Tully et al (2020) found no significant association between probable RLS and depression, but did find a relationship between RLS and generalised anxiety disorder.

Given the contrasting results, the relationship between RLS and depression has been conservatively excluded from this analysis.

Motor vehicle accidents

MVAs and OSA

There is a robust evidence base to indicate that OSA, particularly symptomatic OSA, can lead to increased risk of MVAs. Tregear et al (2009) conducted a meta-analysis of such studies and reported that patients with OSA have a crash risk 2.5 times that of individuals without OSA. A data linkage study in Western Australia of 2,909 diagnosed OSA suffers found almost 10% had MVAs in the 5 years preceding their OSA diagnosis, which was substantially higher that the rate for all adults across Western Australia, although the authors were not able to include a control group in their study (Ward et al, 2018).

Furthermore, Gottlieb et al (2018) sought to delineate the relationship between OSA, short sleep duration, and daytime sleepiness with MVAs. They reported increasing odds of MVAs for every hour decrease in usual sleep duration. Importantly, they found that OSA was associated regardless of self-reported excessive sleepiness, confirming that OSA is an independent risk factor for MVAs.

The results from Tregear et al (2009) were used in the modelling, and the resulting PAF was comparable to the results reported by Gottlieb et al (2018) (11% compared to 10% for OSA).

MVAs and insomnia

Again, the link between insomnia and MVAs is more difficult to characterise due in part to heterogeneity among study methods and definitions of insomnia.

Philip et al (2010) found people with physician diagnosed insomnia (self-reported) had 1.78 times greater odds of MVAs compared to those without insomnia.

Similarly, in a secondary analysis Garbarino et al (2017) found that insomnia – using ICSD-3 diagnostic criteria for insomnia – was associated with 1.82 times greater odds of being in MVAs compared to people without insomnia. Given the similar findings between both studies, an OR of 1.78 was used in this analysis.

MVAs and RLS

There is limited reliable data identifying an association between RLS and MVAs in the literature. Therefore, the relationship was excluded from this analysis.

Workplace injuries

WPIs and OSA

There are several studies examining the relationship between WPIs (often used interchangeably with accidents) and OSA.

Uehli et al (2013) conducted a meta-analysis and found that workers with breathing-related problems (assumed to proxy OSA) had 1.80 times greater risk of having an occupational accident compared to those without OSA.

WPIs and insomnia

As with OSA, several studies have estimated the relationship between insomnia and WPIs. Uehli et al (2013) conducted a systematic review on the relationship of sleep problems to WPIs. Only three studies assessed the relationship between insomnia and WPIs. Uehli et al (2013) estimated that the RR was 2.87.

WPIs and RLS
There is insufficient evidence in the literature to associate RLS with WPIs, and therefore this relationship was not included in this analysis.

Appendix B

Table B.1: Duration of absence from work for WPIs in 2019-20

Condition	Short absence	Long absence	Partial incapacity	Full incapacity	Fatality
Distribution of workplace injury	61.3%	32.0%	6.4%	0.2%	0.1%
Duration of absence from work (in weeks)	0.2	6.4	45.0	39.7	2.6

Source: Safe Work Australia (2015).

Table B.2: Duration of absence from work for MVAs in 2019-20

Severity of MVA	Proportion of returning population	Duration of absence (days)
Severe	0.06%	220.5
Moderate	3.14%	220.5
Mild	5.30%	23
Injuries not resulting in a permanent impairment	91.50%	15

Source: BITRE (2009), Deloitte Access Economics calculations.

Table B.3: Summary of literature associating sleep disorders with absenteeism and presenteeism

Source	Sleep Disorder	Country	Sample	Absenteeism	Presenteeism
Insomnia					
Kessler et al (2011)	Insomnia	United States	National sample of 7,428 employed health plan subscribers (aged 18+)	No significant impact on absenteeism.	Increased presenteeism equivalent to 7.8 days off work.
Bolge et al (2009)	Insomnia	United States	5,161 insomnia patients, 14,550 patients with no insomnia	10.7% absenteeism	WPAI presenteeism mean of 29.2 (with insomnia) compared to 7.1 (no insomnia). 22.1% increase
Swanson et al (2008)	All	United States	109 people with insomnia, 247 with OSA and 108 with RLS. 633 comparators 'not at risk'.	Absenteeism scores: Insomnia=1.1 OSA=1.1 RLS=1.0 Not at risk=1.0	Presenteeism scores: Insomnia =2.3 OSA=1.9 RLS=2 Not at risk=1.7
Daley et al (2009)	Insomnia	Canada	948 patients, 147 with insomnia	4.36 days lost due to insomnia compared to	27.56 days lost due to insomnia compared to

Source	Sleep Disorder	Country	Sample	Absenteeism	Presenteeism
				0.34 in good sleeper group	2.77 days in 'good sleepers'.
DiBonaventura et al (2015)	Insomnia	United States	4,147 patients with insomnia	8.17% absenteeism in insomnia compared to 3.28% in matched control group	27.96% presenteeism in insomnia compared to 10.74% in matched control group
Espie et al (2018)	Insomnia	United States	2798 employees	-	Staff reported 22.8% productivity loss due to poor sleep
RLS					
Allen et al (2009)	RLS	United States	103 employees with RLS	0.3 hours missed per week (1.1% absenteeism)	13.5% reduction in productivity
Cirillo and Wallace (2012)	RLS	United States	1,008 elders born before 1947	-	Individuals with RLS were significantly more likely to be limited at work
Durgin et al (2015)	RLS	United States	2,392 RLS patients matched to non-RLS patients	8.1% absenteeism in people with RLS compared to 3.9% non RLS.	RLS patients had 26.5% presenteeism compared to 15.8 percent presenteeism in non-RLS patients
Fehnel et al (2008)	RLS	United States	702 adults with RLS symptoms, 275 employed	Respondents reported missing 9.6% of their work time because of health (not necessarily due to RLS)	Respondents reported experiencing 36.9% presenteeism (not necessarily due to RLS)
OSA					
Stepnowsky et al (2019)	OSA	United States	731 OSA with ES, 1452 OSA eithout ES and 86,961 non-OSA controls	OSA-ES: 7.9% OSA: 5.7% Control: 3.9%	OSA-ES:26.0% OSA:19.2% Control:14.8%
Omachi et al (2009)	OSA	United States	150 employed people, 83 with OSA	OSA: 18% reported missing full work day and 46% reported missing half day in last 4 weeks. Control group responded 9% and 32% respectively.	OSA: 65% reported decreased job effectiveness in last 4 weeks Control: 46% reported decreased job effectiveness last 4 weeks.

Source: As noted.

Table B.4: Summary of literature linking chronic conditions to presenteeism

Source	Country	Sample	Conclusions
Collins et al (2005)	United States	7,707 survey respondents	Mean Impairment scores: Depression: 36.3 Heart/circulatory problem: 19.9 Diabetes: 17.8
Goetzel et al (2004)	United States		Depression: 15.3% Diabetes: 11.4% Heart disease: 6.8%

Source: As noted.

Limitation of our work

General use restriction

This report is prepared solely for the use of the Sleep Health Foundation. This report is not intended to and should not be used or relied upon by anyone else and we accept no duty of care to any other person or entity. The report has been prepared for the purpose of estimating the economic impact of sleep disorders in Australia. You should not refer to or use our name or the advice for any other purpose

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