# Asleep on the job

## COSTS OF INADEQUATE SLEEP IN AUSTRALIA

Sleep Health Foundation

Improving people's lives through better sleep

www.sleephealthfoundation.org.au

# Preface

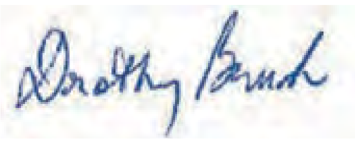
New research suggests that sleep is vital in allowing each cell, in every organ of the body, to continue to function. No wonder sleep deprivation is such a highly effective form of torture.

Yet this report will show that *four out of every ten Australians* are suffering from inadequate sleep. Half of these people experience ongoing pathologically high levels of daytime sleepiness. The rest know that their sleep is routinely insufficient because they can't function at normal levels of alertness, concentration and emotional control.

Such an epidemic of inadequate sleep comes at a cost. This report uses a careful, evidence-based approach to convincingly add up the many billions of dollars that poor sleep has cost the Australian economy in 2016-2017. The numbers are big, the personal and national costs are big and their consequences should not be ignored.

We are proud to bring you this Sleep Health Foundation report by Deloitte Access Economics, its third commissioned report since 2003. These reports are critical in countering the very widespread under-recognition of this absolutely essential part of our health. They provide the foundations for policy changes to improve the wellbeing, health and productivity of all Australians.

Special thanks to Professor David Hillman, Founding Chair of the Sleep Health Foundation, who has worked tirelessly to make these important reports available.



**Emeritus Professor Dorothy Bruck**
Chair, Sleep Health Foundation

This report was made possible by the untied grants of our generous sponsors:

# Asleep on the job

## Costs of inadequate sleep in Australia

Sleep Health Foundation

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Sleep Health
FOUNDATION

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28 April 2017

Dear Professor Hillman

**Asleep on the job: Costs of Inadequate Sleep in Australia**

This report addresses the economic cost of inadequate sleep in Australia, in order to raise awareness of the economic cost of inadequate sleep in Australia, assist the Foundation's advocacy efforts, inform policy making, and ensure available resources are directed towards the most effective interventions.

Yours sincerely,

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Lead Partner, Health Economics and Social Policy, Deloitte Access Economics Pty Limited
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# Glossary

| | |
|---|---|
| ABS | Australian Bureau of Statistics |
| AHI | apnoea-hypopnoea index |
| AIHW | Australian Institute of Health and Welfare |
| AMA | Australian Medical Association |
| CPI | Consumer Price Index |
| DALY | disability adjusted life year |
| DIDO | drive-in drive-out |
| DSM-V | Diagnostic and Statistical Manual of Mental Disorders |
| EDS | excessive daytime sleepiness |
| EDS-SD | excessive daytime sleepiness due to sleep disorders |
| ESS | Epworth Sleepiness Scale |
| FIFO | fly-in fly-out |
| ICD-10 | International Classification of Diseases, Tenth Revision |
| ICSD | International Classification of Sleep Disorders |
| MSLT | Multiple Sleep Latency Test |
| MVA | motor vehicle accident |
| MWT | Maintenance of Wakefulness Test |
| NPV | net present value |
| OSA | obstructive sleep apnoea |
| PAF | population attributable fraction |
| RLS | restless legs syndrome |
| VSLY | value of a statistical life year |
| YLD | years of healthy life lost due to disability |
| YLL | years of life lost due to premature death |

# Executive summary

Inadequate sleep is highly prevalent in Australia. Inadequate sleep includes excessive daytime sleepiness (EDS) and subjective complaint of insufficient sleep. EDS is widely accepted and has validated measurement instruments such as the Epworth Sleep Scale (ESS). Almost one fifth (19.1%) of Australian adults suffer from EDS, as defined by an elevated ESS. When subjective complaint of insufficient sleep is also considered, it was estimated that 39.8% of Australian adults experience some form of inadequate sleep.

Sleep is essential for effective mental and metabolic functioning, and the consequences of inadequate sleep can be far worse than just tiredness. Sleep disorders such as insomnia, restless legs syndrome (RLS) and obstructive sleep apnoea (OSA) can cause heart disease, obesity, depression and a range of other serious health conditions. Inadequate sleep can also directly lead to fatality – for example if it leads to sleep while driving.

Accordingly, this report addresses three different types of 'inadequate sleep':

- EDS due to sleep disorders ('EDS-SD');
- EDS not due to a sleep disorder ('other EDS'); and
- subjective 'insufficient sleep' due to behaviours or other reasons that restrict sleep.

There are substantial overlaps in prevalence, with many people having both EDS and subjective insufficient sleep. Many people also have inadequate sleep and other health conditions. Moreover, some of these other health conditions can both be caused by inadequate sleep and cause inadequate sleep (depression, for example). However, based on a number of previous reports on sleep disorders by (Deloitte) Access Economics and a recent large scale Australian sleep health survey (Adams et al, 2017) it is possible to estimate that:[1]

- 5.8% of Australians have EDS-SD;
- 13.3% have other EDS; and
- 20.7% have insufficient sleep.

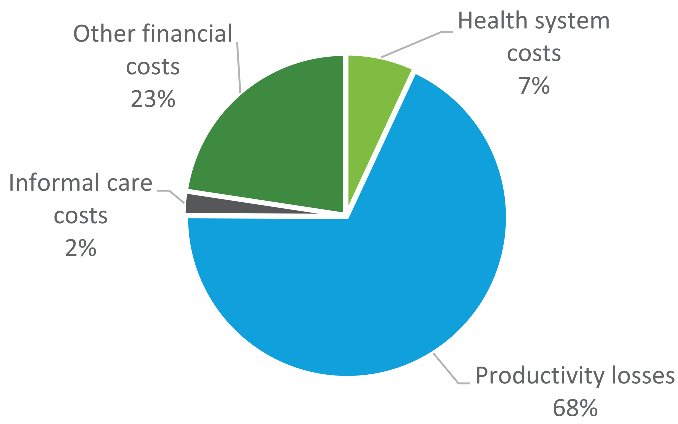
In total, there were **estimated to be 7.4 million** Australian adults who did not regularly get the sleep they need in 2016-17 – defined as "inadequate sleep" in this report. This lack of sleep was estimated to result in 3,017 deaths in 2016-17. It is expected that more than one Australian will die every day (394 over the year) from falling asleep at the wheel of a vehicle or from industrial accidents due to lack of sleep. The remaining mortality is due to sequelae such as heart diseases and diabetes.

Not surprisingly for such a prevalent condition, the costs are also high. Lack of sleep substantially reduces workplace productivity through absenteeism and presenteeism – reduced working days and reduced productivity while at work. While the costs of treating sleep disorders themselves are small, the costs of treating the many conditions caused by lack of sleep are not. The components of financial costs (total $26.2 billion in 2016-17) were estimated to be:

[1] The prevalence estimates have been adjusted to account for the overlap between the different types of inadequate sleep.

- health system costs of $1.8 billion, or $246 per person with inadequate sleep;
- productivity losses of $17.9 billion, or $2,418 per person with inadequate sleep;
- informal care costs of $0.6 billion, or $82 per person with inadequate sleep; and
- other financial costs, including deadweight losses, of $5.9 billion, or $802 per person with inadequate sleep.

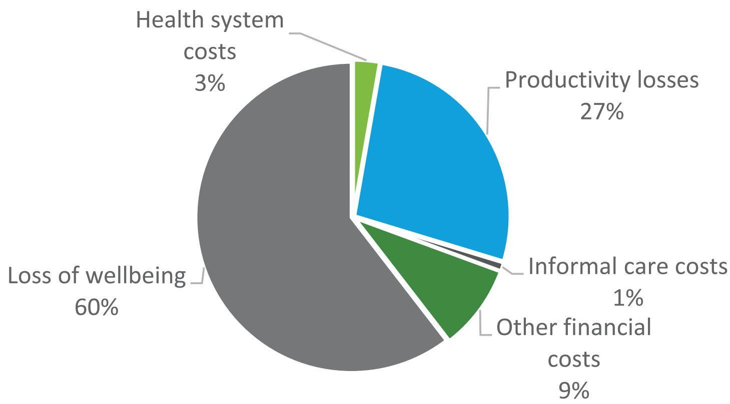
**Chart i: Components of financial costs due to inadequate sleep in Australia, 2016-17**




Source: Deloitte Access Economics calculations.

In addition to financial costs, inadequate sleep reduces healthy life in Australia. The World Health Organization's metric of a disability adjusted life year (DALY) measures the impact of morbidity as the proportion of full health lost due a condition times its duration (known as the years of healthy life lost due to disability or YLDs), and the impact of mortality as the years of life lost due to premature death (YLLs). The Australian Government has an official estimate of the value of a statistical life year (VSLY) lost. Together, these allow a dollar value to be put on the loss of wellbeing from inadequate sleep. It was estimated that there will be almost a quarter of million DALYs (228,162) incurred in Australia in 2016-17 due to inadequate sleep, representing $40.1 billion in lost wellbeing.

**Chart ii: Components of total costs due to inadequate sleep in Australia, 2016-17**




Source: Deloitte Access Economics' calculations.

**Key findings:** The total cost of inadequate sleep in Australia was estimated to be $66.3 billion in 2016-17, comprising $26.2 billion in financial costs and $40.1 billion in the loss of wellbeing. This equates to approximately $8,968 per person affected in both financial and wellbeing costs.

## Policy implications

Given the widespread and damaging consequences of inadequate sleep, Deloitte Access Economics recommends that Work Health and Safety (WHS) authorities should tighten regulation in work sectors where sleep is irregular but responsibility is high, such as defence, transport and health.

In particular, changes to shift work should include facilitating: (a) circadian adaptation in permanent shift workers, for example through appropriately timed exposure to light-dark (b) restorative sleep when sleep is required, (c) sustained alertness when working, and (d) shift schedules that minimise disruption to the circadian and sleep wake systems.

Similarly, as lack of sleep causes a large proportion of motor vehicle accidents (MVAs) – estimated to be 23% of the total – police departments should devote as much attention to tired and fatigued drivers as they do to speeding and inebriated ones. Just as there are rules forbidding driving at more than a certain speed or after consuming an excessive amount of alcohol, there may be a case for restrictions on driving where the driver has had less than a set minimum hours of sleep in the past 24 hours, although methods of policing this are yet to evolve.

As use of normal blue light screens after dark has been shown to reduce alertness the following day (Chang et al, 2015), and software that reduces light intensity and filters short wavelengths of light of computer screens after dark is often free, government agencies should set an example by providing such software to their employees (Chang et al, 2015).

While poor sleep behaviour in most cases is an individual choice and thus not suitable for prescriptive action, behavioural economics has shown that carefully worded education campaigns can be both minimal cost and highly effective. Resultant gains in productivity and thus taxation revenue, and savings in health system costs could offset any expenditure outlays.

Ultimately, the responsibility for reducing fatigue must be shared amongst government, industry, the workforce, the public and the scientific community. Hafner et al (2016) recommend educating people and raising awareness of the benefits of sleep, as well as supporting further research and monitoring in the area of sleep in order to establish evidence bases for potential regulation, practice and policy regarding fatigue, sleep and accident risk. A strong case exists for implementing public preventive health measures to promote healthy sleep, as has been done in other areas involving lifestyle choice, such as smoking cessation, alcohol moderation, diet and exercise. As in the case of 'second hand' smoking, public education about drowsy driving needs to also focus on the impact of such behaviour on other road users.

**Deloitte Access Economics**

# 1 Background

## 1.1 Introduction and overview

This report looks at the estimated costs of inadequate sleep in Australia for the financial year 2017. Two previous reports, *Wake Up Australia* (Access Economics, 2004) and *Reawakening Australia* (Deloitte Access Economics, 2011) focused on the prevalence and costs of intrinsic sleep disorders[2], such as obstructive sleep apnoea (OSA), primary insomnia and restless legs syndrome (RLS).

Deloitte Access Economics (2015) then undertook a scoping study into EDS, as measured by a score of 10 or more on the ESS.

This report includes elements of all of the above research, and incorporates more subjective and loosely defined, but still evidence-based, measures of inadequate sleep.

There are several ways of assessing inadequate sleep, including:

- objective polysomnographic assessment of sleep duration and quality under laboratory conditions or at home;
- wearable devices such as actigraphs, ideally supplemented by sleep diaries, to determine length and distribution of sleep and wakefulness;
- objective measures of daytime sleepiness, such as the multiple sleep latency test or maintenance of wakefulness test;
- subjective assessment of EDS using validated tools such as the ESS; and
- subjective responses to questionnaires asking a series of questions about sleep – quality or quantity – although there is no universally accepted definition of insufficient sleep[3].

The first method is impractical for obtaining population-scale prevalence estimates. The first three methods do have agreed diagnostic criteria, whereas the last two will mean different things to different people. EDS from large scale surveys is the preferred prevalence measure in this report.

There are three main causes of inadequate sleep:

- sleep disorders such as insomnia, OSA and RLS;
- other health conditions such as obesity, anxiety, depression, pain, breathlessness and side effects of medications that impact on sleep quality and quantity, and
- lifestyle / behavioural factors such as studying, working or partying too long, or shift work and other forms of circadian disruption.

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[2] An intrinsic sleep disorder is one that is not caused by another health condition, such as depression or obesity. A secondary disorder is one that is caused by such a secondary condition.

[3] In this report, "insufficient sleep" represents self-reported subjective inadequate sleep not associated with EDS, as defined by an ESS of 10 or greater. Insufficient sleep can include waking unrefreshed, getting less than x hours of sleep, difficultly falling / staying asleep, waking early and a variety of other measures. "Inadequate sleep" is the umbrella term covering EDS and insufficient sleep.

Lallukka et al (2014) have shown that the productivity costs per case of sleep disorders are around double those for EDS, which in turn are around double those for subjective insufficient sleep. Accordingly, this report focuses on three levels of severity of inadequate sleep in Australia.

- EDS as defined by ESS ≥ 10 that stems from a sleep disorder and is therefore intractable ('EDS-SD') – "severe";
- EDS as defined by ESS ≥ 10 not due to a sleep disorder ('other EDS') – "moderate"; and
- subjective 'insufficient sleep' due to behaviours or other reasons that restrict sleep – "mild".

Where a person has **EDS-SD**, their EDS is assumed to be caused by the disorder. Their inadequate sleep also results in secondary health conditions such as depression and obesity. As these secondary health conditions are a direct consequence of lack of sleep, they are included in the costs of inadequate sleep.

However, conditions such as kidney diseases, obesity, anxiety, depression, and those associated with pain or breathlessness can also cause lack of sleep. Where a person has **other EDS**, the presumption is that the EDS is caused by the secondary condition, rather than vice versa. That said, there are some secondary conditions that have been shown to be caused by EDS – mostly injuries, but also some depression and stroke. These are also included in the costs of inadequate sleep.

Subjective insufficient sleep that is not severe enough to result in EDS appears to be mostly due to behavioural factors, but causation is not a material factor for this report. Apart from some MVAs and workplace injuries, **insufficient sleep** without EDS is assumed not to be associated with other comorbid health conditions, although it can still have direct productivity impacts.

Conceptually, this is illustrated by Figure 1.1. Inadequate sleep is defined as (measurable) EDS or subjective insufficient sleep ("ISF"). All the areas containing "EDS" represent people who have EDS as defined by ESS ≥ 10, and thus the cost categories 'EDS-SD' and 'other EDS'. All the areas containing "ISF" represent people who have insufficient sleep (with or without EDS). All the areas containing "SD" represent people who have sleep disorders (but not necessarily inadequate sleep).

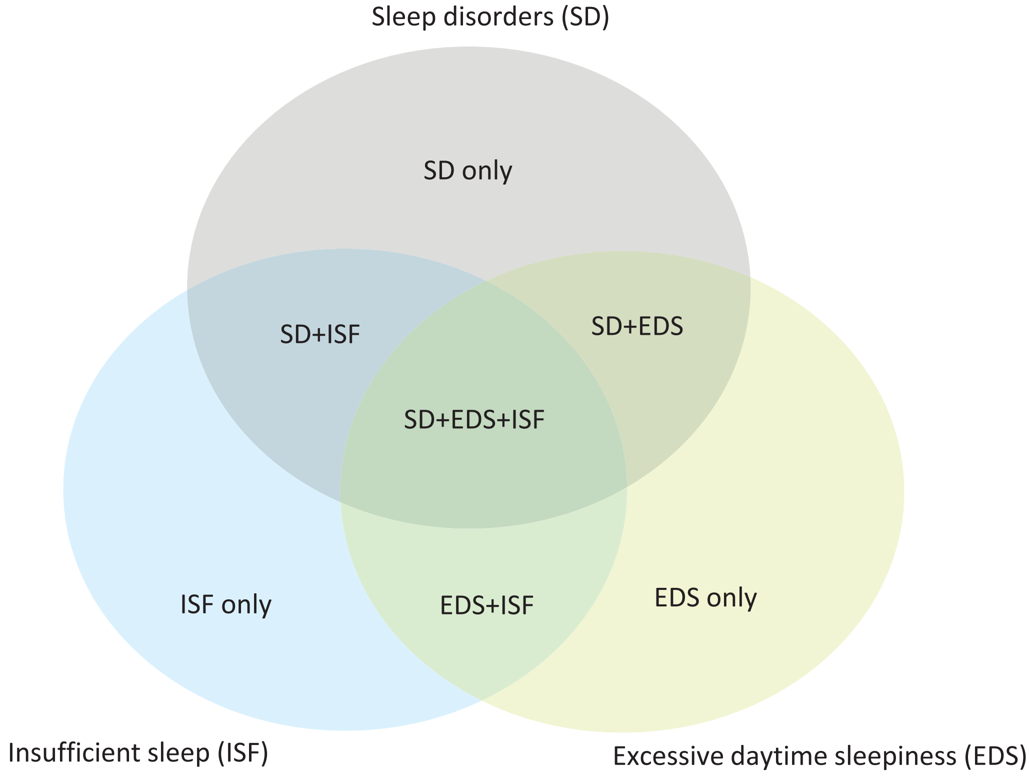
- When previous reports (Access Economics 2004, Deloitte Access Economics 2011) were written, the three sleep disorders were divided into primary (or organic) and secondary categories. Only the primary conditions were included in costings for those reports. However, in the interim, this distinction is no longer universally applied to sleep disorders. Accordingly, there are now a small proportion of people who have a sleep disorder, which would previously have been classified as secondary, that is not severe enough to either result in EDS, or impacts adverse enough to make people to complain about having insufficient sleep. Adams et al (2017) reported that 25% of people with sleep disorders neither had EDS nor complained about insufficient sleep.[4]
- It is possible that sleep disorders can cause secondary conditions through pathways other than through lost sleep (as measured by EDS or insufficient sleep). For example, apnoeic

[4] People in this category are assumed to have secondary sleep disorders.

episodes in OSA reduce blood oxygen levels, which could cause depression directly[5]. This is independent of the lack of sleep caused by the patient having to repeatedly arouse or awake. Any such consequences would, in principle, not be included in this report since they are not directly associated with inadequate sleep, but rather the underlying cause. The costs of secondary sleep disorders that do not result in inadequate sleep are excluded – meaning people with a sleep disorder but not EDS, nor subjective insufficient sleep ("SD only" in Figure 1.1).

- As a general rule, sleep disorders (including their sequelae) cost more to treat than EDS, and EDS (and its sequelae) costs more to treat than insufficient sleep. Accordingly, those people who have sleep disorders and EDS (EDS-SD) are included in the sleep disorder costings. Similarly, those people who have EDS and insufficient sleep are included in the EDS costings. However, in the interests of conservatism, those people who have sleep disorders that do not cause EDS (as defined by ESS ≥ 10), but result in subjective insufficient sleep are costed in the insufficient sleep category.

**Figure 1.1: Inadequate sleep schema, by cause**




Notes: Figure is illustrative, size of circles does not indicate relative prevalence.

[5] As discussed at http://fallingasleep.net/sleep-disorders/apnea

In summary, costs and prevalence are quantified according to the following three categories in this report:

- People who have a sleep disorder and EDS were quantified as having EDS due to a sleep disorder ('EDS-SD'), which will be referred to as **'costs from EDS-SD'**. This also includes the costs of treating the underlying sleep disorders.
- People who have EDS for other reasons were quantified as having EDS due to other causes ('other EDS'), which will be referred to as ***'costs from other EDS'***.[6]
- The remaining categories – people who have insufficient sleep due to other causes, or insufficient sleep and a sleep disorder without EDS were quantified as having 'insufficient sleep', which will be referred to as ***'costs from insufficient sleep'***.[7]
- The combination of the above three categories will be referred to as *'costs from inadequate sleep'* – noting that these categories are mutually exclusive.

## 1.2 Sleep disorders

There are three primary sleep disorders discussed in this report, which build on work undertaken by Deloitte Access Economics (2011) and Access Economics (2004). These are OSA, insomnia and RLS. These are discussed briefly in the following sections.

### 1.2.1 Obstructive sleep apnoea

Sleep apnoea refers to abnormal reductions or pauses in breathing during sleep. OSA is a type of sleep apnoea characterised by sleep-related intermittent upper airway obstruction, which may be associated with episodes of oxygen desaturations and sleep fragmentation.

OSA is commonly measured by the apnoea-hypopnoea index (AHI), which measures the number of obstructive and central apnoea or hypopnoea episodes per hour of sleep. The measure of the prevalence for OSA which has been adopted in this report is those with AHI ≥ 15 (often described as moderate to severe OSA).

Epidemiological studies usually report results in terms of those with AHI ≥ 15. This is because a number of epidemiological studies have found that OSA only affects health outcomes if AHI levels are above 15, or in some cases 30. For example Redline et al (2010) found that the effect of OSA on strokes is only observed among those with AHI≥30.

### 1.2.2 Insomnia

Insomnia is broadly defined as difficulty initiating or maintaining sleep or the perception of poor quality sleep (World Health Organization, 2016). Analysis of insomnia is complex because insomnia can arise independently or as a result of other medical conditions, including other sleep disorders. Until recently, it has been considered important to

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[6] People who have SD+EDS+ISF in Figure 1.1 were included in this group due to data limitations surrounding the crossover between all three categories. This represents a conservative approach.

[7] People who have SD+ISF were included in this group due to data limitations surrounding the crossover between all three categories. This represents a conservative approach.

distinguish between primary insomnia, which is not attributable to any other health condition, and secondary insomnia which is attributable to other physical and mental conditions (such as anxiety or depression). However, since 2013, the Diagnostic and Statistical Manual of Mental Disorders (DSM-V) now only recognises insomnia disorder, without any distinction between primary and secondary forms.

The criteria for a diagnosis of insomnia syndrome are not uniform. There are three insomnia classification standards – namely, the aforementioned DSM-V, the International Classification of Sleep Disorders (ICSD) and the International Classification of Mental and Behavioural Disorders from the International Classification of Diseases, Tenth Revision (ICD-10). In this report the ICD-10 definition was used because the data used to calculate health system costs are based on this classification system. The ICD-10 criteria for primary (non-organic) insomnia syndrome is:

- a complaint of difficulty falling asleep, maintaining sleep, or non-refreshing sleep;
- the sleep disturbance occurs at least three times per week for at least one month;
- the sleep disturbance results in marked personal distress or interference with personal functioning in daily living; and
- the absence of any known causative organic factor, such as a neurological or other medical condition, psychoactive substance use disorder or a medication (World Health Organization, 1992).

### 1.2.3 Restless legs syndrome

RLS is a common, under-diagnosed and treatable central nervous system disorder characterised by disagreeable leg sensations that cause an almost irresistible urge to move the legs. Allen et al (2003) defined and diagnosed RLS according to the following four 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 worsen 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.

RLS is closely related to periodic limb movement disorder. The latter is characterised by periodic episodes of repetitive limb movements caused by contractions of the muscles during sleep. This report focuses on RLS because it is more prevalent than periodic limb movements disorder (Ohayon and Roth, 2002). There is also a greater body of evidence on the relationship between RLS and other health impacts.

# 1.3 Excessive daytime sleepiness (EDS)

Unlike sleep disorders, which have clinical diagnostic criteria, there is no universally accepted definition of EDS. For example, the *Merck Manual of Diagnosis and Therapy*[8], which is billed as one of the world's "most complete" medical reference books, simply defines EDS as "the tendency to fall asleep during normal working hours".

Hypersomnia and EDS are sometimes used interchangeably. However, the ICD-10 defines hypersomnia as "a condition of either EDS and sleep attacks … or prolonged transition to the fully aroused state upon awakening". That is, EDS is a symptom of hypersomnia, not the condition itself.

Slater and Steier (2012) note that the prevalence of EDS in the general population has proved difficult to estimate because of this lack of a standard definition of EDS. Some studies ask subjects to estimate the severity of their daytime sleepiness, and others the number of days per week that they experience EDS.

While EDS is often caused by sleep disorders, there a great variety of other medical conditions, behavioural and other factors that can cause EDS (Table 1.1).

**Table 1.1: Causes of EDS**

| Sleep deprivation | Fragmentation of sleep | Primary CNS hypersomnias | Neurological | Psychiatric | Other organic diseases | Medications |
|---|---|---|---|---|---|---|
| Behavioural<br>Circadian rhythm sleep disorders<br>Altered sleep phase<br>Jet lag | Obstructive sleep apnoea<br>Restless legs syndrome<br>Periodic limb movement disorder<br>Environmental causes of fragmented sleep | Narcolepsy with/ without cataplexy<br>Idiopathic hypersomnia<br>Parasomnias<br>Cyclic or episodic hypersomnias<br>Menstrual-related sleep disorder<br>Kleine-Levin syndrome | Parkinson's disease and other neuro-degenerative disorders<br>Multiple sclerosis<br>Stroke<br>Epilepsy<br>Structural brain disorder<br>CNS tumours | Depression/ other mood disorder<br>Anxiety disorders<br>Schizophrenia / other psychotic illness<br>Post-traumatic stress disorder | Congestive heart failure<br>Chronic renal failure<br>Liver failure<br>Malignancy and para-neoplastic syndromes<br>Obesity hypo-ventilation syndrome | Benzodiazepines<br>Barbiturates<br>Alcohol<br>Gamma-hydroxybutyric acid<br>Opiates<br>Anti-epileptics<br>Stimulant withdrawal |

Source: Slater and Steier (2012).

## 1.3.1 Measures of EDS

### 1.3.1.1 The Epworth Sleepiness Scale

Recently a consensus has been emerging among empirical researchers that an Epworth score of 10 or more on the widely used ESS is an effective working definition of EDS (Haley et al, 2014).

[8] This manual is available at http://www.merckmanuals.com/professional/neurologic-disorders/sleep-and-wakefulness-disorders/insomnia-and-excessive-daytime-sleepiness-eds

The ESS is an Australian designed questionnaire used internationally to measure the level of EDS that is present in subjects, and is specific to daytime sleepiness. It is “by far the most widely used subjective measure of sleepiness” (Slater and Steier, 2012).

The ESS is a self-administered questionnaire that measures sleep propensity on a 0 to 3 scale in eight standardised daily situations. It has been well validated and has shown good reliability and internal consistency (Johns, 1992). ESS scores can range from 0 to 24, with higher scores signifying increased daytime sleepiness. An example of an ESS questionnaire is shown in Figure 1.2.

While the ESS is self-reported, Hayley et al (2014) note that several studies have demonstrated that self-reported data on perceived sleepiness correlates well with laboratory tests of objective measures of sleepiness.

In most studies which use the ESS, a threshold score of 10 or higher is taken to be indicative of EDS, which has been validated empirically. Gooneratne et al (2003) used a case control study to estimate a threshold level from the ESS that could be used as an indicator for EDS. The case group consisted of those who reported problems with feeling sleepy or struggling to stay awake on most days. This group had a mean ESS score of 9.4, compared with the control group’s mean ESS score of 4.9.

Johns and Hocking (1997) studied 507 Australian workers aged 22 to 59, using the ESS and a sleep questionnaire. They found that normal sleepers, without any evidence of a sleep disorder, had ESS scores between 0 and 10. These subjects were “clearly separated” from ‘sleepy’ patients suffering from narcolepsy or idiopathic hypersomnia, whose ESS scores were in the range of 12 to 24.

### Figure 1.2: Epworth Sleepiness Scale

Using the rating scale below, rate each of the following statements as it best applies to you:

| Would never doze | Slight chance of dozing | Moderate chance of dozing | High chance of dozing | |
|---|---|---|---|---|
| 0 | 1 | 2 | 3 | |
| | | | | Sitting and reading |
| | | | | Watching TV |
| | | | | Sitting inactive in a public place (e.g. cinema or in a meeting) |
| | | | | Being in a car for an hour as a passenger (without a break) |
| | | | | Lying down to rest in the afternoon (when possible) |
| | | | | Sitting and chatting to someone |
| | | | | Sitting quietly after lunch (not having had alcohol) |
| | | | | In a car when you stop in traffic for a few minutes |

Calculate Score

Your Score

It Means

| Result | What your ESS result indicates |
|---|---|
| **Less than 10** | **You are most likely getting enough sleep**<br><br>However, if you have noticed a change in your normal sleep routine, you may want to discuss this with your doctor. |
| **10 - 16** | **Your may be suffering from excessive daytime sleepiness**<br><br>You should see you Doctor to determine the cause of your sleepiness and possible treatment.<br><br>Your Doctor may refer you to Sleep Services Australia for a home-based sleep study to assist in your diagnosis. |
| **16+** | **You are dangerously sleepy**<br><br>**It is imperative that you see your Doctor** to determine the cause of your sleepiness, and to investigate treatment as soon as possible. Your Doctor can refer you to Sleep Services Australia for a sleep study to assist in your diagnosis. |

Source: Sleep Services Australia (2015).

### 1.3.1.2 Other measures of EDS

EDS can also be objectively assessed through methods such as the Multiple Sleep Latency Test (MSLT), and the Maintenance of Wakefulness Test (MWT) (Johns, 2000).

The MSLT measures the time elapsed from the start of a daytime nap period to the first signs of sleep, which is referred to as sleep latency. The test is based on the idea that the sleepier people are, the faster they will fall asleep. The test conventionally follows an overnight sleep study to determine the duration and quality of preceding sleep and consists of four or five 20-minute nap opportunities set two hours apart. During the test, data such as the patient's brain waves, muscle activity, and eye movements are monitored and recorded. The entire test normally takes about seven hours during the course of a day. While arguably a more scientific test than the ESS, the resources and time required renders it impractical for large scale application.

The MWT measures a person's ability to stay awake for a certain period of time, essentially measuring the time one can stay awake during the day. The test isolates a person from factors that can influence ability to sleep such as temperature, light, and noise. The patient is requested to not take any hypnotics, drink alcohol, or smoke before or during the test. After allowing the patient to lie down on the bed, in quiet dark room and instructing him/her to stay awake, the ability to do so is monitored with the time between lights off and falling asleep (if it occurs) measured and used to determine daytime sleepiness. As with the MSLT, this test is also time and resource intensive.

Johns (2000) notes that MWT, ESS and MSLT scores are significantly correlated. Also, the MSLT measures only one situational sleep propensity, and a subject's sleep propensity in any one situation is not always closely related to that in a different situation. The ESS has been shown to be more accurate than the MSLT, and about as accurate as the MWT, in distinguishing the sleepiness of narcoleptics from that of normal subjects.

## 1.4 Subjective insufficient sleep

Insufficient sleep is primarily a subjective, rather than objective, matter. That is, insufficient sleep is more than a matter of simple sleep restriction such as not getting 7 or 8 hours sleep on a regular basis – although sometimes these are the only measures available in the literature. Quality as well as quantity are important components of insufficient sleep.

Buysse et al (1989) note that sleep quality represents a complex phenomenon that is difficult to define and measure objectively. It includes quantitative aspects of sleep such as sleep duration, sleep latency and number of arousals. But it also includes subjective aspects such as depth or restfulness of sleep. Moreover, the elements that comprise sleep quality, and their relative importance, vary between individuals. The Pittsburgh Sleep Quality Index is a commonly used tool that examines the range of subjective aspects of sleep quality (Figure 1.3).

**Figure 1.3: The Pittsburgh Sleep Quality Index**

**During the past month,**

1. When have you usually gone to bed? ____________
2. How long (in minutes) has it taken you to fall asleep each night? ____________
3. What time have you usually gotten up in the morning? ____________
4. A. How many hours of actual sleep did you get at night? ____________
   B. How many hours were you in bed? ____________

| 5. During the past month, how often have you had trouble sleeping because you | Not during the past month (0) | Less than once a week (1) | Once or twice a week (2) | Three or more times a week (3) |
|---|---|---|---|---|
| A. Cannot get to sleep within 30 minutes | | | | |
| B. Wake up in the middle of the night or early morning | | | | |
| C. Have to get up to use the bathroom | | | | |
| D. Cannot breathe comfortably | | | | |
| E. Cough or snore loudly | | | | |
| F. Feel too cold | | | | |
| G. Feel too hot | | | | |
| H. Have bad dreams | | | | |
| I. Have pain | | | | |
| J. Other reason (s), please describe, including how often you have had trouble sleeping because of this reason (s): | | | | |
| 6. During the past month, how often have you taken medicine (prescribed or "over the counter") to help you sleep? | | | | |
| 7. During the past month, how often have you had trouble staying awake while driving, eating meals, or engaging in social activity? | | | | |
| 8. During the past month, how much of a problem has it been for you to keep up enthusiasm to get things done? | | | | |
| 9. During the past month, how would you rate your sleep quality overall? | Very good (0) | Fairly good (1) | Fairly bad (2) | Very bad (3) |

Source: University of Pittsburgh, Department of Psychiatry.

There is little apparent correlation between the objective and subjective aspects of sleep quality. Kaplan et al (2017) compared 38 objective sleep, clinical and demographic correlates of sleep quality to assess their explanatory power for predicting subjective sleep quality. However, together these multivariable models explained only 11%–17% of the variance in predicting subjective sleep quality. The authors concluded that "Overall, the commonly obtained measures of polysomnographically-defined sleep contributed little to subjective ratings of prior-night sleep quality."

It also appears that subjective sleep quality may matter more than objective measures. For example, Kang et al (2016) found that quality of life in OSA patients was statistically correlated with their subjective sleep quality (measured by the Pittsburgh Sleep Quality Index) – but had lower correlation with objective AHI scores.

## 1.5 Other causes of inadequate sleep

As noted above, there are three main causes of inadequate sleep:

- intrinsic sleep disorders;
- other health conditions (such as anxiety, depression, obesity and conditions associated with pain or breathlessness); and
- behavioural and lifestyle factors.

As the first two of these causal groups have been discussed in sections 1.2 and 1.3 respectively, this section focuses on behavioural / lifestyle causes of inadequate sleep.

### 1.5.1 Poor sleep hygiene

The Australian Institute of Health and Welfare (AIHW, 2011) reported that "sleep disturbance" was the fourth most common mental health problem for Australians aged between 12 and 24, after depression, anxiety and drug abuse (see Table 1.2). Young people's poor sleeping habits in turn are largely caused by factors such as extensive television watching, video gaming, increased social and recreational demands, and academic pressure (Colten & Altevogt 2006).

**Table 1.2: Most frequent mental health problems for people aged 12-24, 2008-09**

| Problem | Annual GP encounters | Encounters per 100 persons |
|---|---|---|
| Depression | 524,200 | 13.5 |
| Anxiety | 221,700 | 5.7 |
| Drug abuse | 75,900 | 2.0 |
| Sleep disturbance | 71,000 | 1.8 |
| Stress | 67,400 | 1.7 |
| Tobacco abuse | 56,300 | 1.5 |

Source: AIHW (2011).

### 1.5.2 Shift-work / circadian rhythm disruption

There were approximately 1.5 million people working some kind of shift-work in their main occupation in Australia in 2012, according to the Australian Bureau of Statistics (ABS, 2013b). While some of these people would perform shift-work during the day, industries such as the healthcare and mining industry are likely to have a rotating roster of shift-work, which involves night time shifts. Shift-work disrupts the circadian timing system resulting in sleep-wake disturbances. This is known to lead to EDS, impaired function and disturbed sleep in shift-workers (Gumenyuk et al, 2014).

Disruption to the body's circadian rhythms can occur outside of shift-work as well. Another common example of disruption to the normal circadian rhythms is jet lag. Crossing time zones rapidly leads to a mismatch of the internal biological timing with clock time at the destination. This leads to difficulty sleeping during normal sleep hours, and can be exacerbated by shift-work, as can occur in the mining industry where workers may fly-in/fly-out from other time zones.

Furthermore, disruption to sleeping patterns can also include environmental factors outside of shift work such as noise and heat. Muzet (2007 p. 140) notes "the sleep of shift workers is often disturbed by combined influences of ambient factors…" including noise and sleeping during the day. As well as being a primary cause of sleep interruptions, noise is a major cause of shortened sleep (Muzet, 2007).

### 1.5.3 Excessive hours

Excessive work hours can cause inadequate sleep. While this is not limited to a particular industry such as the health sector or transport, these industries can have higher proportions of people working long shifts such as a 12 hour night shift on a ward.

A longitudinal study in the United Kingdom found that long working hours appeared to be a risk factor for difficulties in falling asleep and having shortened sleeping hours (Virtanen et al, 2009). Virtanen et al (2009) found that working more than 55 hours a week was significantly associated with incidental cases of short sleep, difficulty in falling asleep and waking without feeling refreshed when compared with normal working hours. This is also supported elsewhere in the literature. Lockley et al (2007 p. 7) conclude that “the weight of evidence strongly suggests that extended-duration work shifts significantly increase fatigue and impair performance and safety”.

### 1.5.4 Screens and blue light

Long periods spent watching screens has the potential to disrupt their sleep cycles. Olds et al (2010) report that the sleep-promoting hormone melatonin is suppressed more strongly by exposure to blue light. Television and computer screens emit greater proportions of blue light wavelengths and therefore exposure to screens in the evening has the potential to inappropriately reset the body’s internal clock, which increases alertness, decreases the body’s ability to initiate sleep, reduces sleep quality and deregulates sleep/wake rhythms.

The AIHW (2011) indicates that children who spend on average three hours of screen time per day are more likely to experience higher rates of poor sleep, and are more likely to experience poor educational outcomes than children who spend less time in front of screens. Palm et al (2007), in a study of 2,726 upper secondary school students, found the average female student used computers for 19 hours per week. Most of these students reported headache, eyestrain or neck and shoulder symptoms that caused disrupted sleep.

# 2 Prevalence of inadequate sleep in Australia

This chapter outlines the approach taken to estimate the prevalence of inadequate sleep in Australia. This starts with the overall prevalence of sleep disorders, EDS, and insufficient sleep, and then adjusts each of these to the relevant cost categories:

- prevalence of EDS-SD;
- prevalence of other EDS; and
- prevalence of insufficient sleep.

## 2.1 Prevalence of primary and secondary sleep disorders

As noted earlier, two of our previous reports, *Reawakening Australia* (Deloitte Access Economics, 2011) and *Wake Up Australia* (Access Economics, 2004) focused on the prevalence and costs of idiopathic sleep disorders, with emphasis on OSA, primary insomnia and RLS. These reports found a prevalence of such disorders of around 10% of the population.[9]

### 2.1.1 Insomnia

Deloitte Access Economics (2011) estimated that the prevalence of primary insomnia was 3% of the population.

Our literature search was only able to uncover five studies published since Deloitte Access Economics (2011) that reported on the prevalence of primary insomnia (Table 2.1). Two were below the 3% estimate used in that report, two were above it, and one was exactly the same. The study with the same prevalence (Arroll et al, 2012) was conducted in New Zealand, which is demographically similar to Australia. While Chung et al (2014) had a prevalence rate that was twice as high, the subject population were adolescents, who tend to have poorer sleep hygiene.[10]

[9] Primarily these earlier reports reported on idiopathic sleep disorders that are not caused by other conditions such as obesity or depression, which are also known as intrinsic, organic or primary sleep disorders. Therefore the prevalence of sleep disorders in this report is broader, and thus higher.

[10] Interestingly, the ratio of secondary to primary insomnia is around ten to one (Deloitte Access Economics, 2011).

**Table 2.1: Recent prevalence estimates of primary insomnia**

| Study | Year | Prevalence |
|---|---|---|
| Sateia and Buysse | 2016 | 1.0% |
| Ferreira and de Almondes | 2014 | 1.5% |
| Arroll et al | 2012 | 3.0% |
| Samaranayake et al | 2014 | 4.5% |
| Chung et al | 2014 | 7.9% |
| **Average** | | **3.6%** |

The reason for the paucity of recent studies may be because since 2013, the DSM-V no longer divides insomnia into primary and secondary, but now only has a single diagnosis of insomnia disorder.[11]

**Table 2.2: Recent prevalence estimates of total insomnia**

| Study | Year | Prevalence |
|---|---|---|
| Ellis et al | 2012 | 7.9% |
| Komada et al | 2012 | 30.7% |
| Zhang et al | 2012 | 7.1% |
| Fernandez-Mendoza et al | 2012 | 32.3% |
| Vgontzas et al | 2012 | 11.9% |
| Singareddy et al | 2012 | 10.6% |
| Silvertsen et al[12] | 2012 | 5.1% |
| **Mean** | | **15.1%** |

Source: As noted and Deloitte Access Economics calculations.

However, estimates of prevalence for total insomnia vary widely. Morin and Jarrin (2013) note that the variance is partly because of differences in case definitions, assessment procedures, sample characteristics, and length of assessment intervals. For example, if a patient cannot sleep for a week because of an injury, that is still a form of insomnia.[13] Depending on the specific definitions used (i.e. insomnia symptoms vs disorder, sleep dissatisfaction), prevalence rates vary from as low as 5% to as high as 50%. In general, population-based data indicate that about one-third of adults (30%–36%) report at least one nocturnal insomnia symptom (i.e. difficulty initiating or maintaining sleep, nonrestorative sleep), but this rate decreases to between 10% and 15% when daytime consequences (e.g. fatigue) are added to the case definition.

Conversely, the ICD-10 still distinguishes between organic (primary) and inorganic (secondary) forms of insomnia. Other, more stringent diagnostic criteria such as the International Classification of Sleep Disorders (ICSD), or only including insomnia that lasts for

[11] This change is discussed in https://www.psychology.org.au/inpsych/2014/april/bartlett/

[12] Cited in Morin and Jarrin (2013) but not in references.

[13] http://www.sleepdex.org/primary.htm

a month or more – indicate prevalence rates tend to cluster between 6% and 10%[14]. This is similar to the rates reported by Adams et al (2017) for insomnia without comorbidities of 11.3%. In line with these figures, and diagnostic practice that insomnia is classified as primary when not accompanied by comorbidities (Saddichha, 2010) the **prevalence of insomnia of 11.3%** has been used in this report.[15]

### 2.1.2 Restless Legs Syndrome

The literature search uncovered almost no prevalence estimates for primary RLS published since the *Reawakening Australia* report (Deloitte Access Economics, 2011). The two articles identified in the search (Budhiraja et al, 2012 and Park et al 2010) focused on women and/or populations over 40, which are not representative as RLS increases with age and is more prevalent in women.

However, a number of prevalence estimates for overall RLS have been published since 2011. Innes et al (2011) conducted a meta-study of thirty-four papers detailing results of large, population-based studies in 16 North American and Western European countries. Reported general prevalence rates ranged from 4% to 29% of adults, averaging 14.5% across studies. Diagnostic and severity criteria differed considerably among studies, as did inclusion criteria, with corresponding variation in prevalence estimates. Prevalence was higher on average in women and older adults.

The estimate by Adams et al (2017) of 17.6% prevalence falls reasonably close to the midpoint of the estimates in the Innes et al (2011) meta-study. Accordingly, as being both Australian and recent, it was adopted in this report as the prevalence estimate for total RLS.

Primary RLS then needs to be separated out from total RLS. Access Economics (2005) examined data from the REST (RLS Epidemiology, Symptoms and Treatment) study. Out of 15,391 subjects, 9.3% reported RLS symptoms. Around one sixth of this group – 1.4% – reported RLS at least twice a week with moderate or worse symptoms, which was taken to indicate primary RLS. Assuming the same ratio (primary is one sixth of total) applies to total RLS prevalence of 17.6% as reported by Adams et al (2017), then **the estimated prevalence of primary RLS is 2.8%**.[16]

### 2.1.3 Prevalence of OSA

Senaratna et al (2016) recently published a systematic review of OSA prevalence estimates, including 24 studies with a variety of definitions of OSA. The definition adopted in this, and previous (Deloitte) Access Economics reports is an apnoea hypopnoea index (AHI) score of

[14] See for example, Saddichha (2010), American Academy of Sleep Medicine (2015)

[15] Adams et al (2017) estimated total insomnia prevalence to be 20%, which was similarly several times larger than the estimate from Deloitte Access Economics (2011). This may suggest this is mostly secondary insomnia. However, as the DSM-V no longer distinguishes between primary and secondary insomnia, no adjustments are made for this figure – except to distinguish where insomnia is the first reported sleep disorder, rather than secondary to a higher cost group such as OSA. This is consistent with the approach taken in Deloitte Access Economics (2011).

[16] As the largest group in Adams et al (2017) was RLS alone, for comorbidity adjustments, people with primary RLS are assigned to this group.

more than 15 events per hour. The meta-study included four studies using this definition of OSA, including subjects younger than 40 years old and published since 2006.[17] The average across these studies was 9.3% (Table 2.3). As this is very close to Adams et al (2017), which is Australian and recent, Adam's estimate of 8.3% was used in this report.[18]

**Table 2.3: Recent prevalence estimates of OSA**

| Study | Year | Prevalence |
|---|---|---|
| Redline et al | 2014 | 10% |
| Tufik et al | 2010 | 17% |
| Reddy et al | 2009 | 8% |
| Mihaere et al | 2009 | 2% |
| **Mean** | | **9%** |

Source: As noted.

### 2.1.4 Comorbidities of sleep disorders

Comorbidities are extensive across sleep disorders. For example, Adams et al (2017) reported that more people have multiple sleep disorders (8.6%) than who have just OSA (8.3%). Data from Adams et al (2017) were used to address these comorbidities: people with OSA and another disorder are reported under OSA, and people with RLS and insomnia are counted under insomnia. This is consistent with the approach taken by Deloitte Access Economics (2011). **This yields an overall prevalence of sleep disorders of 22.4% of the population.**

**Table 2.4: Prevalence of sleep disorders, adjusted for comorbidity**

| Study | Prevalence |
|---|---|
| OSA | 8.3% |
| Insomnia | 11.3% |
| RLS (primary)* | 2.8% |
| **Total** | **22.4%** |

Notes: OSA includes those who also have insomnia or RLS. Primary RLS derived using ratio of primary to secondary from Access Economics (2006)
Source: Adams et al (2017).

## 2.2 Prevalence of excessive daytime sleepiness (EDS)

EDS is highly prevalent in Australia. Despite daytime sleepiness being well-recognised in public and clinical health settings, there is little information available regarding the

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17 Deloitte Access Economics (2011) did not incorporate any OSA prevalence studies published since Access Economics (2006).

18 This figure is double that used in Access Economics (2004) but obesity, which is a factor cause of OSA, has increased substantially in the intervening decade.

prevalence of EDS in Australia. Studies of EDS prevalence used in this report to generate overall prevalence are listed below.

**Table 2.5: Prevalence estimates of EDS in Western countries**

| Author | Findings |
|---|---|
| Adams et al (2017) | Evaluated 1,011 Australians aged over 18 years old, noting that the consequences of daytime sleepiness are widespread. Based on an ESS score greater than or equal to 11, Adams et al (2017) reported that 19.1% of Australians aged over 18 have EDS. |
| Hayley et al (2014) | Studied a population of 2,050 people between the ages of 20 and 94 in South Eastern Australia. Results from the study indicated that 10.4% of men and 13.6% of women have EDS, measured by a score of 10 or higher on the ESS. |
| John and Hocking (1997) | Using an ESS score of 10 or more to reflect EDS, the prevalence of EDS in Australian workers (n=507) was found to be 10.9%. |
| Pallesen et al (2010) | Administered the ESS to 2,301 adults in Norway. The estimated prevalence of EDS (ESS score of 10 or more) was also higher, at 17.7%. Multiple logistic regression analysis showed that factors significantly related to EDS were: working nights; being young; having symptoms of cataplexy, or periodic limb movement in sleep; having breathing pauses in sleep; and having symptoms of depression. Of note, RLS was not significantly related to EDS in this study. |
| Hillman and Lack (2013) | Conducted a Roy Morgan survey on disrupted sleep and numbers of awakenings. Overall, 19% of the sample population experienced sleepiness that interfered with daily activities at least a few days a week. |

Some of the findings of these studies conflict with each other. For example, some studies (Hillman and Lack, 2013; Adams et al, 2017; Joo et al, 2009 and Pallesen et al, 2010) indicate that EDS decreases with age; others (Hayley et al, 2014; Kao et al, 2008) suggest that EDS increases with age.

The range of EDS prevalence also varies across the studies. Adams et al (2017) and Pallesen et al (2010) report significantly higher prevalence of EDS, which is consistent with Carlton et al (2014) who suggest that the prevalence of EDS is close to 20%. A weighted average across the studies – based on sample size – indicates that the prevalence is approximately 18%.[19]

Since Adams et al (2017) is recent, Australian, and close to the average prevalence of other studies, their prevalence estimate of 19.1% has been used in this report.

[19] While it is not specifically EDS, around one fifth of the studies surveyed by Ohayaon (2008) reported prevalence for "sleep propensity in wakefulness" of between 19% and 26% in Europe and the Americas.

## 2.3 Prevalence of insufficient sleep

Most recent large scale studies find that over a quarter of the population has subjective, self-reported insufficient sleep.

- Adams et al (2017) conducted a survey of 1,011 Australian adults. The study found that around half (49%) of respondents reported that they usually had adequate sleep.
- Hillman and Lack (2013) reported on a national survey (n=1,512) of sleeping difficulties conducted in Australia by the Sleep Health Foundation in 2010. Around a quarter of respondents (24%) reported that they regularly did not get adequate sleep.
- The Centers for Disease Control and Prevention (2011) examined data from 403,981 participants in the United States Behavioral Risk Factor Surveillance System survey. The study found that that 28% of United States adults had insufficient sleep or rest (<7 hours per night) on a majority of nights over a 30 day survey period.
- Unruh et al (2008) led the Sleep Heart Health Study of 5,407 community dwelling adults in the United States. Choosing the 39 to 49 age bracket as the representative midpoint, the authors found that 31% of women subjectively reported "not enough sleep" as did 41% of men. As the numbers of males and females in the population is essentially equal, this implies an average of 28%.
- Stein et al (2008) utilised data from the German Health Survey (n=4,181) and reported that 35.2% of the German population had insufficient sleep, as measured by the Pittsburgh Sleep Quality Index.[20]

**Table 2.6: Prevalence estimates of insufficient sleep**

| Study | Year | Prevalence |
|---|---|---|
| Adams et al (2017) | 2017 | 51% |
| Hillman and Lack (2013) | 2013 | 24% |
| Centers for Disease Control and Prevention (2011) | 2011 | 28% |
| Unruh et al (2008) | 2008 | 28% |
| Stein et al (2008) | 2008 | 35% |
| **Mean** | | **33%** |

Insufficient sleep is inherently subjective. Furthermore there is significant variability around the average adult sleep requirement of 8 hours. However, while fewer than 5% of adults are natural short sleepers and can function normally on less than 6 hours sleep a night, a higher proportion choose this schedule in an attempt to meet other demands, but at costs to their health and wellbeing (Patel et al, 2010).

Unlike the more objective prevalence estimates for sleep disorders and EDS, Adams et al (2017) is not close to the mid-point of estimates for the prevalence of insufficient sleep.

[20] The Pittsburgh Sleep Quality Index is a self-report questionnaire that assesses sleep quality over a 1-month time interval. The measure consists of 19 individual items, creating 7 components that produce one global score. Clinical studies have found the Pittsburgh Sleep Quality Index to be reliable and valid in the assessment of self-reported inadequate sleep. See http://www.psychiatry.pitt.edu/sites/default/files/page-images/PSQI_Instrument.pdf

**Accordingly, the average of 33.1% from Table 2.6 was used as a basis for the estimates in this report**.

## 2.4 Prevalence of inadequate sleep

Adams et al (2017) found that a considerable proportion of Australians have inadequate sleep – using measures of either EDS or subjective insufficient sleep; however, it is not clear what comorbidity may be present and what cost categories apply to this group.

Adams et al (2017) reported that 51.2% of those with OSA have inadequate sleep, as do 62.9% of those with restless legs. All people with primary insomnia are assumed to have inadequate sleep. Weighted by the sample, approximately 75% of those with a sleep disorder will have inadequate sleep.[21]

It is important to adjust prevalence due to underlying reasons for inadequate sleep, whether that is a sleep disorder, other health conditions or lifestyle reasons. Moreover, it is important to distinguish between EDS that is validated and observed to be higher cost (e.g. Lallukka et al, 2014), and insufficient sleep that may not result in EDS, but would still have observable productivity impacts.

Further clarification was sought from Adams et al (2016, personal communication) to establish odds ratios that could be used to adjust the prevalence estimates of sleep disorders, EDS and insufficient sleep to unique prevalence rates which fit with the cost schema as defined in Figure 1.1.

Three primary sleep disorders were discussed in the results by Adams et al (2017) – being diagnosed OSA, insomnia and RLS.[22] Further clarification was also sought to determine the presence of EDS in each sleep disorder compared to those without a sleep disorder.[23]

Based on data from Adams et al (personal communication, 2016), approximately 26% of those with a sleep disorder also have EDS, while only 17% of those with no disorder (or a possible disorder) do. **This gives an estimated odds ratio of 1.7 for those who have sleep disorders to also have EDS**. Using the methodology in Appendix A, and the prevalence of both sleep disorders (22.4%) and EDS (19.1%) – as in sections 2.1 and 2.2 – **the prevalence of EDS-SD was estimated to be 5.8% and the prevalence of other EDS was estimated to be 13.3%** (= 19.1% - 5.8%).

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[21] That is, EDS and/or insufficient sleep.

[22] Adams et al (2017) also identified the prevalence of probable OSA and snoring, and insomnia and RLS that is secondary to probable OSA or snoring. For the purposes of this analysis, these groups have been classified as a person with no sleep disorder. Primarily, the justification for this is that this group is unlikely to be seeking help for their sleep problem, and are also unlikely to have the same odds of developing associated conditions discussed in this report. Importantly, this does not imply that the costs for this group do not apply, rather, where EDS and insufficient sleep occur due to other reasons, these people are still included under the lower, and likely more relevant, cost group.

[23] As noted before, RLS was adjusted to represent those with RLS who have episodes at least twice a week, with at least moderate symptoms as having primary RLS – as per Access Economics (2005). The remaining people with secondary RLS were classified as not having a sleep disorder.

Finally, the prevalence of insufficient sleep which may impose costs on society was estimated by determining how much would occur with either EDS-SD or other EDS. The total prevalence of insufficient sleep used in the analysis was 33.1% - as in section 2.3. Based on Adams et al (2017), 65% of people who have a sleep disorder also report having insufficient sleep.[24] This was applied to people who have EDS-SD or other EDS (19.1%) to estimate that **20.7% of the population have insufficient sleep which is separate from EDS-SD or other EDS** (=33.1% - 65% * 19.1%).

**Table 2.7: Prevalence of EDS-SD and other EDS**

| | |
|---|---|
| Prevalence of sleep disorders (%) | 22.4 |
| Prevalence of EDS (%) | 19.1 |
| Odds ratio of EDS in people with sleep disorders | 1.7 |
| Estimated prevalence of EDS-SD (%) | 5.8 |
| Estimated prevalence of other EDS (%) | 13.3 |
| Estimated prevalence of insufficient sleep (%) | 20.7 |
| **Total prevalence of inadequate sleep (%)** | **39.8** |

Source: Adams et al (personal communication, 2016) and Deloitte Access Economics calculations.
Note: components may not sum to totals due to rounding.

Based on data from Adams et al (2016, personal communication), the odds ratios of having EDS for people who have OSA, insomnia and RLS was 2.6, 1.6 and 1.5, respectively. Using the methodology in Appendix A and these odds ratios, it was estimated that:

- 45.9% of EDS-SD would be attributed to OSA;
- 43.2% of EDS-SD would be attributed to insomnia; and
- 10.9% of EDS-SD would be attributed to RLS.[25]

Based on the total prevalence of sleep disorders (22.4%), EDS (19.1%) and insufficient sleep (33.1%) outlined in sections 2.1 to 2.3, and using the methodology in Appendix A and these odds ratios, it was estimated that the prevalence of inadequate sleep is broken down as follows. Approximately:

- 5.8% of Australians have EDS-SD, of which 2.7%, 2.5% and 0.6% were estimated to be due to OSA, insomnia and RLS, respectively[26];
- 13.3% of Australians have other EDS;
- 20.7% of Australians have insufficient sleep; and
- 39.8% of Australians have inadequate sleep (the combined total).

[24] This ratio was assumed to hold for people who have EDS-SD and other EDS. The measure used by Adams et al (2017) was "feeling unrefreshed".

[25] This distinction was important to attribute conditions to inadequate sleep due to limitations in available literature. There is a stronger body of evidence for consequences of sleep disorders than there is for inadequate sleep, even though inadequate sleep may be the causal pathway. For this report, it was assumed that people with sleep disorders (but no inadequate sleep) would have a similar odds ratio of having an attributed condition as those with EDS-SD.

[26] 2.7% = 45.9% * 5.8%, 2.5% = 43.2% * 5.8%, 0.6% = 10.9% * 5.8%.

**In total there were estimated to be 7.4 million Australians who will suffer from inadequate sleep in 2016-17** (Table 2.8). Slightly more than half of this (52%) is the 3.8 million people who have insufficient sleep due to behaviours or other reasons. This is closely followed by the 2.5 million people (33%) who have other EDS. Finally the 1.1 million people with EDS-SD account for the remaining 15%.

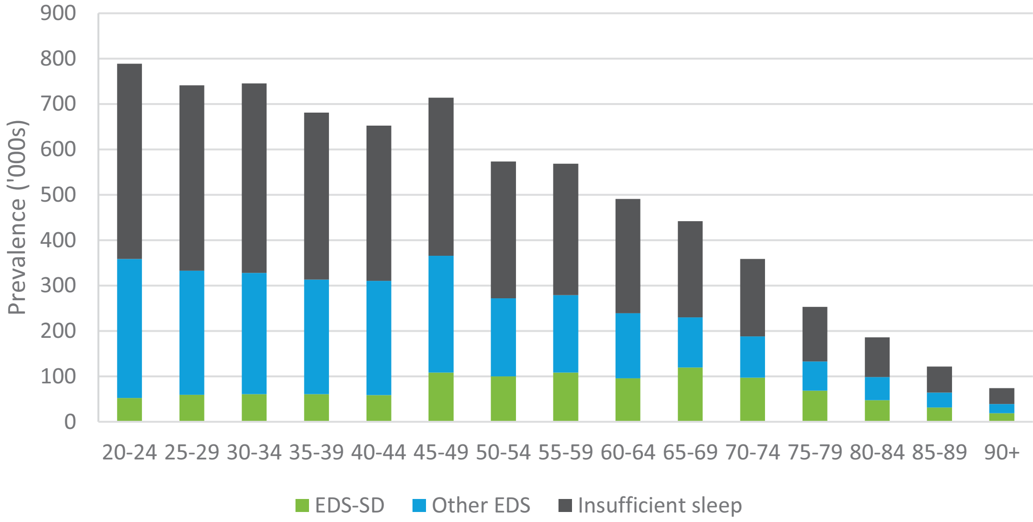
**Table 2.8: Prevalence of inadequate sleep in Australia in 2016-17 (% and '000s)**

| Age/ gender | EDS-SD | Other EDS | Insufficient sleep | EDS-SD | Other EDS | Insufficient sleep | Total |
|---|---|---|---|---|---|---|---|
| *Male* | *%* | *%* | *%* | *('000s)* | *('000s)* | *('000s)* | *('000s)* |
| 20-24 | 3.3 | 15.4 | 23.3 | 28.4 | 131.7 | 199.8 | 360.0 |
| 25-29 | 3.4 | 12.7 | 20.5 | 31.2 | 116.4 | 188.5 | 336.1 |
| 30-34 | 3.4 | 12.5 | 20.5 | 31.7 | 116.7 | 191.8 | 340.2 |
| 35-39 | 3.6 | 12.8 | 19.8 | 30.5 | 108.7 | 169.0 | 308.3 |
| 40-44 | 3.6 | 13.1 | 19.4 | 29.1 | 106.9 | 158.1 | 294.1 |
| 45-49 | 7.9 | 13.1 | 19.2 | 65.5 | 109.2 | 159.3 | 334.1 |
| 50-54 | 7.9 | 10.0 | 18.2 | 60.3 | 76.8 | 139.3 | 276.4 |
| 55-59 | 8.4 | 10.1 | 17.8 | 62.6 | 75.9 | 133.4 | 271.9 |
| 60-64 | 8.4 | 9.6 | 17.3 | 55.4 | 63.4 | 114.4 | 233.1 |
| 65-69 | 10.0 | 8.5 | 16.6 | 58.5 | 49.8 | 96.8 | 205.1 |
| 70-74 | 10.0 | 8.5 | 16.5 | 47.3 | 40.3 | 77.7 | 165.3 |
| 75-79 | 10.0 | 8.5 | 16.5 | 32.7 | 27.8 | 53.7 | 114.2 |
| 80-84 | 10.0 | 10.9 | 17.1 | 21.1 | 23.0 | 36.1 | 80.2 |
| 85-89 | 10.0 | 10.9 | 17.1 | 12.4 | 13.5 | 21.3 | 47.2 |
| 90+ | 10.0 | 10.9 | 17.1 | 6.2 | 6.7 | 10.5 | 23.4 |
| *Female* | | | | | | | |
| 20-24 | 2.9 | 21.3 | 28.1 | 24.1 | 174.6 | 230.1 | 428.8 |
| 25-29 | 3.2 | 17.4 | 24.4 | 28.4 | 156.6 | 220.3 | 405.3 |
| 30-34 | 3.2 | 16.2 | 24.4 | 29.1 | 150.2 | 225.9 | 405.2 |
| 35-39 | 3.6 | 16.9 | 23.5 | 30.5 | 143.4 | 199.3 | 373.1 |
| 40-44 | 3.6 | 17.6 | 22.4 | 29.5 | 144.9 | 183.9 | 358.3 |
| 45-49 | 5.0 | 17.5 | 22.3 | 42.6 | 148.6 | 188.5 | 379.7 |
| 50-54 | 5.0 | 12.2 | 20.8 | 39.4 | 95.4 | 162.5 | 297.3 |
| 55-59 | 5.9 | 12.3 | 20.2 | 45.5 | 94.8 | 156.2 | 296.5 |
| 60-64 | 5.9 | 11.6 | 20.1 | 40.4 | 79.8 | 137.8 | 258.0 |
| 65-69 | 10.1 | 10.0 | 19.2 | 61.0 | 60.5 | 115.5 | 237.0 |
| 70-74 | 10.1 | 10.1 | 18.9 | 50.0 | 50.1 | 93.4 | 193.5 |
| 75-79 | 10.1 | 10.1 | 18.9 | 36.0 | 36.0 | 67.1 | 139.1 |
| 80-84 | 10.1 | 10.7 | 19.4 | 26.6 | 28.1 | 51.0 | 105.7 |
| 85-89 | 10.1 | 10.7 | 19.4 | 18.7 | 19.8 | 36.0 | 74.5 |
| 90+ | 10.1 | 10.7 | 19.4 | 12.8 | 13.5 | 24.6 | 50.9 |
| **Persons** | **5.8** | **13.3** | **20.7** | **1,087.5** | **2,463.2** | **3,841.9** | **7,392.6** |

Source: Adams et al (2017), Hayley et al (2014), Adams et al (2017), John and Hocking (1997), Hillman and Lack (2013), Pallesen et al (2010), Centers for Disease Control and Prevention (2011), Unruh et al (2008), Stein et al (2008), Table 2.6 and Deloitte Access Economics calculations.
Note: components may not sum to totals due to rounding.

Chart 2.1 shows the prevalence of inadequate sleep by age and type of inadequate sleep (EDS-SD, other EDS or insufficient sleep). The overall prevalence generally declines with age, although this is mostly driven by demographics – i.e. the size of the underlying population.

**Chart 2.1: Prevalence of inadequate sleep in Australia in 2016-17, by type ('000s)**




Source: Table 2.8.

# 3 Conditions attributable to inadequate sleep

A range of conditions are attributable to inadequate sleep. To estimate the prevalence of conditions attributed to inadequate sleep, it is necessary to use a population attributable fraction (PAF) approach. PAFs refer to the proportion of one health condition, injury or risk factor that can be directly attributed to another. This section estimates PAFs for EDS-SD, other EDS and insufficient sleep, based on information obtained in the literature review on prevalence and linkages between sleep conditions and other health impacts. The methodology to make these adjustments is explained further in Appendix A.

## 3.1 Conditions attributable to inadequate sleep

This section examines the literature and calculates PAFs for sleep conditions in order to determine whether a causal relationship exists between them and other health conditions. Where a causal relationship is found, odds ratios from relevant studies are presented (where available).[27] An odds ratio indicates the ratio of the probability of experiencing that medical condition for an individual with a sleep condition compared to those without a sleep condition.

A breakdown of PAFs based on the link between each sleep condition and their related health conditions is provided in Table 3.1. These linkages are based on established evidence unearthed throughout the literature review.

**Table 3.1: Linkage between sleep conditions and health conditions**

| Condition | EDS-SD | Other EDS | Insufficient sleep |
|---|---|---|---|
| Congestive heart failure | X | | |
| Coronary artery disease | X | | |
| Stroke | X | X | |
| Diabetes | X | | |
| Depression | X | X | |
| Workplace injuries | X | X | X |
| MVAs | X | X | X |

Sources: see below sections.

[27] Causal relationships were established using prospective or longitudinal studies. There are two types of studies commonly used to investigate the association of sleep conditions with other medical conditions.

- **Co-existence or cross-sectional studies**: look at the prevalence of sleep conditions in people with another medical condition at a particular point in time, after controlling for other confounding factors, such as age. This approach, the more frequently available, does not actually establish a cause and effect relationship between sleep conditions and comorbidities, but rather just establishes the correlation.

- **Prospective or longitudinal studies**: track a group of people known to have a sleep condition to determine the odds ratio of contracting another medical condition (assumed to be associated with the sleep condition). These are preferred to establish causal pathways.

The following subsections are broken down by health conditions and the type of inadequate sleep, where sufficient evidence existed, noting the relationships between:

- sleep disorders and other health conditions were assumed to represent EDS-SD;
- EDS and other health conditions were assumed to represent other EDS; and
- various subjective measures of inadequate sleep were assumed to represent insufficient sleep.

### 3.1.1 Cardiovascular disease

There is an established relationship between cardiovascular disease and sleep conditions. The prevalence of cardiovascular disease was broken down into the following categories: congestive heart failure, coronary artery disease and stroke. The prevalence of each possible attributed condition used in the PAF calculations was as follows:

- **the prevalence of congestive heart failure was 1.9%**, which was based on the National Health Survey (ABS, 2009);
- based on the ABS' 2012 *Survey of Disability, Ageing and Carers*, Deloitte Access Economics (2014b) estimated that **the prevalence of stroke was 1.9% in 2016-17**.
- **the prevalence of coronary artery disease was 4.9%**, which was based on the National Health Survey (ABS, 2009).

#### 3.1.1.1 Cardiovascular disease and EDS-SD

Sleep disorders have been linked to incident cases of cardiovascular disease through prospective studies. Deloitte Access Economics (2011) noted a number of relationships between sleep disorders and cardiovascular diseases. Briefly, the following relationships were found between OSA and cardiovascular disease (Deloitte Access Economics (2011)[28]:

- **OSA has been associated with an increased risk of congestive heart failure.** Gottlieb et al (2010) observed a **hazard ratio of 1.58 for congestive heart failure in people with OSA** after adjusting for confounding factors. OSA was measured using AHI>30.
- OSA has been associated with cases of stroke. Redline et al (2010) found that AHI levels were linearly associated with an increased risk of stroke for men, with each unit increase of AHI increasing stroke risk by 6%. **The adjusted hazard ratio for stroke in people with OSA was 2.86**.
- **OSA has been found to result in 3.17 greater odds of experiencing non-fatal cardiovascular events**, which was defined as either myocardial infarctions, strokes or the need for coronary artery bypass surgery or percutaneous transluminal angiography (Marin et al, 2005). OSA was measured using AHI>30.

Deloitte Access Economics (2011) did not consider the effect of RLS and primary insomnia on cardiovascular disease given uncertainty in the literature about whether RLS and insomnia are related to cardiovascular disease. This assumption has been maintained for the estimates that follow as the scope of this report was inadequate sleep in Australia, rather than from sleep disorders specifically. The PAF calculations for cardiovascular disease attributable to EDS-SD were based on a prevalence of OSA and EDS of 2.7% (as summarised in Section 2.4).

[28] It has been assumed that the odds ratio for sleep disorders applies equally to EDS-SD for all conditions.

**Table 3.2: Cardiovascular disease attributable to EDS-SD**

| Condition | Prevalence (%) | Odds ratio/ relative risk | PAF (%) |
|---|---|---|---|
| Congestive heart failure | 1.9 | 1.6 | 1.5 |
| Coronary artery disease | 4.9 | 3.2 | 4.8 |
| Stroke | 1.9 | 2.9 | 4.8 |

Note: All cardiovascular disease is lower than the sum of the other listed conditions as people can have more than one cardiovascular condition. Source: Marin et al (2005), Gottlieb et al (2010), Redline et al (2010) and Deloitte Access Economics' calculations.

Based on the prevalence of OSA with EDS of 2.7%, the PAFs for congestive heart failure, stroke and coronary artery disease respectively were 1.5%, 4.8% and 4.8%.

#### 3.1.1.2 Cardiovascular disease and other EDS

Qureshi (1997) reported the relationship between daytime somnolence (daytime sleepiness) and sleep duration for a group of 7,844 adults participating in the First National Health and Nutrition Examination Survey Epidemiologic follow up study. Adjusting for confounding factors including age, gender, ethnicity, body mass index and cardiovascular risk factors, daytime somnolence[29] was associated with stroke incidence with a relative risk of 1.4.[30]

Based on the relative risk from Qureshi (1997), and the prevalence of other EDS and stroke being 13.3% and 1.9%, respectively, the PAF for stroke was estimated to be 5.0%.

### 3.1.2 Diabetes

OSA has been linked to the subsequent development of incident cases of type 2 diabetes. The prevalence used in the analysis was derived from Deloitte Access Economics (2014), where it was estimated that approximately **8.9% of individuals over 20 years of age had type 2 diabetes**.

[29] Daytime somnolence was defined as often or almost always being sufficiently sleep to require a nap during the day or evening (Qureshi, 1997).

[30] Davies et al (2003) report a significant relationship between EDS and stroke, with an odds ratio of 3.07, based on an ESS score of greater than or equal to 10. Multiple logistic regression of EDS as a risk factor for stroke reported an odds ratio of 1.09 for a one unit increase in ESS score. This odds ratio was not adjusted for confounding factors and only univariate results were reported, so the findings were not used for calculation purposes.

Additionally, Boden-Albala et al (2012) obtained an ESS for 2,088 community residents. For those that reported significant daytime dozing, there was a significantly increased risk of stroke (odds ratio = 3.0). This study was also not used as the reference group was not comparable with an ESS<10.

#### 3.1.2.1 Diabetes and EDS-SD

OSA is linked to incident cases of type 2 diabetes. This extends not only to sleep disorders, but also to a lack of sleep (Shan et al, 2015), which is likely to stem from sleep disorders themselves.

The meta-analysis by Wang et al (2013) found a **63% greater risk of incident cases of type 2 diabetes for people with OSA defined as AHI>15**. Wang et al (2013) included prospective studies, and had a pooled sample of 5,953 participants with follow up periods between approximately 3 and 16 years. The results from Wang et al (2013) have been used in the subsequent analysis as they represent the most complete analysis identified in the targeted literature review from a range of countries, while being supported by the findings of other recent studies.[31]

> Combining the prevalence of OSA with EDS (2.7% as summarised in section 2.4) and the relative risk of diabetes (1.63), it was estimated that 1.7% of type 2 diabetes cases are attributed to EDS-SD.

### 3.1.3 Depression

The link between depression, sleep disorders and EDS is highlighted below. The prevalence of depression used in the analysis was 6.2% (Tiller, 2012).

#### 3.1.3.1 Depression and EDS-SD

Sleep disorders have been linked to cases of depression through prospective studies and cross-sectional studies. The following relationships were found between sleep disorders and depression (Deloitte Access Economics, 2011):

- Peppard et al (2006) observed statistically significant relationships between OSA and depression, finding those with OSA defined as AHI>15 had 2.6 times greater odds of developing depression than those without OSA.
- Baglioni et al (2011) conducted a meta-analysis of 21 prospective longitudinal studies, finding that the odds of developing depression in people with insomnia was 2.10 times greater than for those without insomnia.
- Winkelman et al (2005) conducted a cross-sectional study on the association between RLS and depression, finding that the odds ratio of a major depressive episode (not caused by another medical condition) was 1.93 times greater than those without RLS.

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[31] Kendzerska et al (2014) observed a 31% increase in the risk of incident cases of type 2 diabetes for people with OSA defined as AHI>30. This was in a retrospective cohort study using clinical health administrative data in Canada. Participants underwent a sleep study between 1994 and 2010 and were followed for incident cases of diabetes until 2011. This was a relatively large sample, with 8,678 patients followed over the period.

Nagayoshi et al (2016) observed a 71% increase in the risk of incident cases of type 2 diabetes for people with OSA defined as AHI>30. This was a prospective study conducted with participants of the Atherosclerosis Risk in Communities Study and the Sleep Heart Study. Patients were followed up for 13 years to determine if there were incident cases of diabetes, which were self-reported. There were 1,453 participants in the study.

**Table 3.3: Depression attributable to EDS-SD**

| Sleep disorder | Prevalence (%) | Odds ratio/ relative risk | PAF (%) |
|---|---|---|---|
| OSA with EDS | 2.7 | 2.6 | 3.6 |
| Insomnia with EDS | 2.5 | 2.1 | 2.4 |
| RLS with EDS | 0.6 | 1.9 | 0.5 |

Source: Adams et al (2016, personal communication), Peppard et al (2006), Baglioni et al (2011), Winkelman et al (2005) and Deloitte Access Economics' calculations.

#### 3.1.3.2 Depression and other EDS

LaGrotte et al (2016) report that EDS is associated with developing cases of depression based on the findings of a longitudinal study. The association of EDS with depression was partially explained by LaGrotte et al (2016) to be a function of premorbid emotional distress. LaGrotte et al (2016) estimated the odds ratio for EDS and depression to be 1.87.

> Based on the odds ratio of 1.87, and the prevalence of other EDS being 13.3% as in Table 2.8, the PAF for depression was calculated to be 9.4%.

### 3.1.4 Injuries and accidents

Inadequate sleep has strong associations with both workplace injuries and MVAs for all types of inadequate sleep. The following sections discuss some of the available literature. The PAF calculations were based on annual rates of workplace-e injuries and MVAs of 1.4% and 1.3%, respectively (Deloitte Access Economics, 2011).

#### 3.1.4.1 Workplace injuries/MVAs and EDS-SD

Sleep disorders have been linked to cases of MVAs, workplace injuries and making more errors at work. Deloitte Access Economics (2011) has previously noted that sleep disorders are associated with an increased likelihood of MVAs and workplace injuries; briefly:

- The results of the meta-analysis by Sassani et al (2004) were used for the basis for the relationship between OSA and MVAs. The pooled odds ratio across six studies was estimated to be 2.52. This is the increased likelihood of MVAs for people with OSA compared to those without.
- Ulfberg et al (2000) observed 1.5 greater odds of having a workplace injury in people with OSA compared to those without when examining accidents retrospectively for a 10 year period.
- Daley et al (2009) found that the odds ratio for those with insomnia experiencing workplace injuries compared to those without insomnia was 2.43.
- No conclusive relationships were found between insomnia or RLS and MVAs. There was also no conclusive evidence for RLS and workplace injuries, despite some literature observing a greater likelihood of reporting having made an error at work. Hence MVAs possibly due to RLS were conservatively excluded from the 2011 study.

Table 3.4 and Table 3.5 estimate the extent of workplace injuries and MVAs attributable to EDS-SD.

**Table 3.4: Workplace injuries attributable to EDS-SD**

| Sleep disorder | Prevalence (%) | Odds ratio/ relative risk | PAF (%) |
|---|---|---|---|
| OSA with EDS | 2.7 | 1.5 | 1.3 |
| Insomnia with EDS | 2.5 | 2.4 | 3.3 |

Source: Adams et al (2016, personal communication), Ulfberg et al (2000), Daley et al (2009), Deloitte Access Economics' calculations.

**Table 3.5: MVAs attributable to EDS-SD**

| Sleep disorder | Prevalence (%) | Odds ratio/ relative risk | PAF (%) |
|---|---|---|---|
| OSA with EDS | 2.7 | 2.5 | 3.8 |

Source: Adams et al (2016, personal communication), Sassani et al (2004), Deloitte Access Economics' calculations.

#### 3.1.4.2 Workplace injuries/MVAs and other EDS

The relationship between EDS, injuries and accidents has been documented throughout the literature, in the form of an increased likelihood of MVAs and workplace injuries. Findings from these studies, measured in odds ratios and relative risk are listed below:

- Melamed (2002) states that after controlling for confounders, EDS is linked to increased risk of workplace injuries in non-shift daytime workers. The odds ratio for sustaining a work injury due to EDS was 2.23.
- In a meta-analysis conducted by Zhang and Chen (2014), the adjusted odds ratio for being involved in a MVA given the presence of EDS was found to be 1.89.

Table 3.6 reports the proportion of MVAs and workplace injuries attributable to other EDS. This was based on an estimated prevalence of other EDS of 13.3% as derived in section 2.4, and the annual rates of MVAs and workplace injuries based on Deloitte Access Economics (2011).

**Table 3.6: MVAs and workplace injuries attributable to other EDS**

| Event type | Annual rate (%) | Odds ratio/ relative risk | PAF (%) |
|---|---|---|---|
| MVAs | 1.3 | 1.9 | 10.3 |
| Workplace injuries | 1.4 | 2.2 | 13.7 |

Source: Deloitte Access Economics (2011), Melamed (2002), Zhang and Chen (2009), Deloitte Access Economics' calculations.

#### 3.1.4.3 Workplace injuries/MVAs and insufficient sleep

As with EDS, self-reported insufficient sleep is a strong risk factor for MVAs and workplace injuries. The relationship between insufficient sleep, injuries and accidents is demonstrated below:

- Kling et al (2010) estimated the odds ratios for individuals reporting trouble going to or staying asleep and having a work injury. A significant relationship was found in both men (odds ratio = 1.25) and women (odds ratio = 1.54). **The average odds ratio for men and women is 1.40**.

- Smith (2016) used a survey of drivers in the United Kingdom to examine the associations between driving when fatigued and MVAs. Smith (2016) measured fatigue using more subjective measures such as driving when tired, driving late/early in the day, or driving after long periods of work. After adjusting for demographics, health, driving and job variables, **the odds ratio of having a MVA that required medical attention for driving when fatigued was estimated to be 1.48**. [32]

Table 3.7 highlights the proportion of MVAs and workplace injuries attributable to insufficient sleep. This was based on an estimated prevalence of insufficient sleep of 14.8% as derived in Table 2.8, and the annual rates of MVAs and workplace injuries based on Deloitte Access Economics (2011).

**Table 3.7: MVAs and workplace injuries attributable to insufficient sleep**

| Event type | Annual rate (%) | Odds ratio/ relative risk | PAF (%) |
|---|---|---|---|
| Workplace injuries | 1.4 | 1.4 | 5.5 |
| MVAs | 1.3 | 1.5 | 11.0 |

Source: Deloitte Access Economics (2011), Kling et al (2010), Smith (2016), Deloitte Access Economics' calculations.

[32] A significant relationship between insufficient sleep and MVAs was found by Zhang and Chan (2014) in a systematic review and meta-analysis of retrospective studies. Zhang and Chan (2014) estimated an odds ratio of 1.85 for those experiencing 'sleepiness' while driving. Studies included in the meta-analysis typically used a measure of acute sleepiness, which has been used as a proxy for insufficient sleep to assess the relationship with MVAs.

The odds ratio for MVAs triangulates reasonably well with a subjective measure reported by Connor et al (2002), which found an adjusted odds ratio of 1.7 of having a MVA that resulted in injury given a score of 2-3 on the Stanford sleepiness scale. This relates to the measures "was functioning at a high level but not at peak" and "felt relaxed, awake but not fully alert, responsive" (Connor et al, 2002). The results from Connor et al (2002) were included in the meta-analysis by Zhang and Chan (2014).

Philip et al (2014) used poor sleep quality in the last three months to assess the impacts of sleepiness as a predictor for MVAs in France. Relative to those with 'very/pretty good' sleep quality in the last three months, people who reported 'neither good nor bad' sleep quality were 2.07 times as likely to have a MVA, after adjusting for demographics and driving related variables.

As there are a wide-range of estimates for the impact of insufficient sleep on MVAs, using various subjective sleep measures, it was conservatively assumed that the odds ratio would be 1.48 as reported by Smith (2016). This choice was made because there is some overlap between those with insufficient sleep and with sleep disorders and/or EDS. Smith (2016) observed a greater odds ratio for people who have multiple sleep problems. This estimate also had benefits of reporting MVAs that require medical attention.

# 3.2 Summary of prevalence and mortality from conditions attributable to inadequate sleep

## 3.2.4 Prevalence of conditions attributable to inadequate sleep

PAFs were calculated for a number of different conditions where there was sufficient evidence of a strong causal link. A breakdown of PAFs based on the link between each sleep condition and their related health conditions is provided in Table 3.8. These linkages are a summary of the relationships presented in the preceding sections.

**Table 3.8: PAFs between sleep conditions and health conditions**

| | Prevalence (%) | PAF (%) | | |
|---|---|---|---|---|
| **Condition** | | **EDS-SD** | **Other EDS** | **Insufficient sleep** |
| Congestive heart failure | 1.9 | 1.5 | - | - |
| Coronary artery disease | 4.9 | 4.8 | - | - |
| Stroke | 1.6 | 4.8 | 5.0 | - |
| Diabetes | 8.9 | 1.7 | - | - |
| Depression | 6.2 | 6.5 | 9.4 | - |
| Workplace injuries | 1.4 | 4.6 | 13.7 | 5.5 |
| MVAs | 1.3 | 3.8 | 10.3 | 11.0 |

Sources: see Section 3.1.1 to Section 3.1.4.

As noted in section 2.4, there were estimated to be 7.4 million Australian adults who will suffer from inadequate sleep and its consequences in 2016-17 (Table 3.9).

A considerable amount of the 7.4 million Australians with inadequate sleep will also experience sequelae due to their inadequate sleep. Based on the PAFs presented in the preceding sections, approximately 6% of Australians with inadequate sleep will experience a secondary health condition (not adjusted for comorbidities), which is most likely to be depression, a MVA or a workplace injury. For those with EDS-SD, this rises to over 17%.

**Table 3.9: Prevalence of inadequate sleep and its consequences in Australia in 2016-17**

| Consequence | EDS-SD | Other EDS | Insufficient sleep | Total |
|---|---|---|---|---|
| Congestive heart failure | 5,271 | - | - | 5,271 |
| Coronary artery disease | 47,552 | - | - | 47,552 |
| Stroke | 13,945 | 14,755 | - | 28,700 |
| Type 2 diabetes | 28,199 | - | - | 28,199 |
| Depression | 74,565 | 108,323 | - | 182,888 |
| Workplace injuries | 11,762 | 34,919 | 19,147 | 65,828 |
| MVAs | 10,971 | 29,821 | 25,608 | 66,400 |
| No attributed conditions | 895,224 | 2,275,398 | 3,797,189 | 6,967,811 |
| **Total** | **1,087,489** | **2,463,216** | **3,841,944** | **7,392,649** |

Source: Deloitte Access Economics calculations based on the PAFs (Tables 3.2 to 3.7) and prevalence rates (Table 3.8).

### 3.2.5 Mortality due to inadequate sleep

Inadequate sleep can result in mortality in Australia through means such as MVAs or workplace injuries, or through conditions that are caused by a lack of sleep. EDS or insufficient sleep are unlikely to increase the risk of mortality on their own.[33] Rather, their sequelae increase the risk of mortality.

Deloitte Access Economics (2011) estimated mortality rates for the sequelae of each of the sleep disorders (Table 3.10). As the underlying aetiologies are unlikely to change, those rates are re-employed in this report for estimating deaths caused by EDS-SD.[34]

A similar methodology was developed for conditions caused directly by EDS and by insufficient sleep (injuries only) by applying PAFs (Table 3.8) to the total number of deaths caused by sequelae, from Deloitte Access Economics (2011).

[33] As discussed at http://www.sleepandhealth.com/sleep-and-mortality-rates/

[34] There would be some obvious caveats to this. For example, it is possible that while the prevalence of falling asleep at the wheel has not changed, cars could have become inherently safer in the intervening six years, which would reduce mortality rates from MVAs. Some new vehicles have automatic braking systems and other advanced safety technologies. However, the number of such vehicles on the road is likely to be too small to make a material difference, and there is no data on any impact the improvements may have made.

**Table 3.10: Mortality rates per 1000, attributed conditions**

| Age/ gender | CHF | CAD | Stroke | Diabetes | Depression | WPI | MVAs |
|---|---|---|---|---|---|---|---|
| *Males* | | | | | | | |
| 20-24 | - | - | - | 0.00 | 0.10 | 0.04 | 0.18 |
| 25-34 | - | 0.03 | 0.01 | 0.01 | 0.08 | 0.02 | 0.11 |
| 35-44 | - | 0.13 | 0.03 | 0.02 | 0.09 | 0.04 | 0.09 |
| 45-54 | - | 0.40 | 0.07 | 0.06 | 0.09 | 0.04 | 0.09 |
| 55-64 | 0.14 | 0.61 | 0.12 | 0.18 | 0.07 | 0.05 | 0.08 |
| 65+ | 1.02 | 7.14 | 2.10 | 1.11 | 0.08 | 0.02 | 0.09 |
| *Females* | | | | | | | |
| 20-24 | - | - | - | 0.00 | 0.10 | 0.04 | 0.18 |
| 25-34 | - | 0.03 | 0.01 | 0.00 | 0.08 | 0.02 | 0.11 |
| 35-44 | - | 0.13 | 0.03 | 0.01 | 0.09 | 0.04 | 0.09 |
| 45-54 | - | 0.40 | 0.07 | 0.03 | 0.09 | 0.04 | 0.09 |
| 55-64 | 0.14 | 0.61 | 0.12 | 0.07 | 0.07 | 0.05 | 0.08 |
| 65+ | 1.02 | 7.14 | 2.10 | 0.91 | 0.08 | 0.02 | 0.09 |

Sources: Deloitte Access Economics (2011, 2014). Note: CHF is congestive heart failure; CAD is coronary artery disease; WPI is workplace injuries.

In total, inadequate sleep and its consequences were estimated to cause 3,017 deaths in 2016-17 (Table 3.11). Perhaps unexpectedly, MVAs only account for a tenth (9.9%) of this total. The great majority of deaths (77.6%) will likely be due to heart conditions (stroke, congestive heart failure and coronary artery disease). Similarly, the majority of deaths (67%) are due to sequelae of inadequate sleep due to OSA. Most of the remainder (27%) is due to sequelae of other EDS (again mostly heart conditions). Inadequate sleep due to RLS and insomnia were estimated to be responsible for less than 2% of deaths.[35]

[35] When considering the mortality estimates, it is important to note that the primary driver of these findings is that prevalence and mortality occur in the same ratios (i.e. the same PAF can be applied to both mortality and prevalence) regardless of the underlying aetiology; this assumption was necessary as there are no detailed data that show the relationship between mortality rates for the specific conditions, when considering whether or not the cohort has had inadequate sleep where the condition was also not present when commencing the study. This may either under- or over- state the mortality due to inadequate sleep for each secondary condition.

**Table 3.11: Number of deaths due to inadequate sleep and its consequences, 2016-17**

| | EDS-SD | Other EDS | Insufficient sleep | Total |
|---|---|---|---|---|
| Congestive heart failure | 61 | - | - | 61 |
| Coronary artery disease | 1,323 | - | - | 1,323 |
| Stroke | 466 | 493 | - | 958 |
| Type 2 diabetes | 65 | - | - | 65 |
| Depression | 88 | 128 | - | 215 |
| Workplace injuries | 17 | 50 | 27 | 94 |
| MVAs | 50 | 135 | 116 | 300 |
| **Total** | **2,069** | **805** | **143** | **3,017** |

Source: Deloitte Access Economics (2011, 2014) and Deloitte Access Economics calculations using PAFs derived from section 3.1.
Note: components may not sum to totals due to rounding.

# 4 Health system costs

The health system costs attributed to inadequate sleep comprise the cost of treating sleep disorders which cause inadequate sleep and their attributed conditions (EDS-SD), and the cost of treating conditions caused by other EDS or insufficient sleep. The following sections outline the approach taken to estimate health system costs due to inadequate sleep.

## 4.1 Costs of treating conditions attributed to inadequate sleep

Costs related to stroke, coronary artery disease and congestive heart failure were based on the latest AIHW disease expenditure data at the time of writing (AIHW, 2014) for individuals aged over 20 years. Costs for depression were based on total mental health expenditure reported by AIHW (2016), adjusted for the relative share of depression and anxiety for 2004-05 (AIHW, 2010)[36]. Health system costs for diabetes were based on AIHW (2013).[37] All historical health system expenditure was inflated to 2016-17 using the health price index (AIHW, 2016a), which was estimated for 2016-17 using 5-year average historical growth in the index.

For MVAs, workplace injuries and sleep disorders, health system costs were based on Deloitte Access Economics (2011), where the total health system costs of:

- MVAs were estimated to be $5,274 per injury in 2016-17 dollars;
- workplace injuries were estimated to be $9,428 per injury in 2016-17 dollars; and
- sleep disorders were estimated to be $214 per person in 2016-17 dollars.

Finally, the health system costs of other conditions that are attributed to inadequate sleep were calculated by applying the PAFs presented in Chapter 3 to the top down health system expenditure reported for each condition attributed to inadequate sleep[38]. For MVAs, workplace injuries and sleep disorders – which cause inadequate sleep – the cost per injury/person was then applied against the annual number of MVAs and workplace injuries attributed to inadequate sleep, or the number of people with EDS-SD as in Table 3.9 to estimate the total health system costs for these conditions.

- For MVAs, the PAF-adjusted prevalence in 2016-17 was estimated to be 72,392 cases, so the health system costs attributed to inadequate sleep were estimated to be **$350 million in Australia in 2016-17**.

[36] The AIHW does not report on depression alone and treats depression and anxiety as one cost group. For the purposes of this analysis, it was assumed that the PAF for depression applies to the expenditure for depression and anxiety. This is consistent with the approach taken in Deloitte Access Economics (2011).

[37] The AIHW constructs cost estimates using a top-down approach – the AIHW uses total health system expenditure and then allocates it across diseases using information from hospital morbidity records and casemix data, Medicare, the Pharmaceutical Benefits Scheme (PBS), the Pharmacy Guild Survey and the BEACH survey of general practice.

[38] EDS-SD will result in health system costs where individuals seek treatment so that they are able to sleep better. Thus, where inadequate sleep stems from a sleep disorder (EDS-SD), it is also appropriate to count the health system costs of treating the sleep disorder itself.

- For workplace injuries, the PAF-adjusted prevalence in 2016-17 was estimated to be 60,681 cases, so the health system costs attributed to inadequate sleep were estimated to be **$620 million in Australia in 2016-17**.
- For EDS-SD, the PAF-adjusted prevalence in 2016-17 was estimated to be 1.09 million people, so the **total cost of treating EDS-SD was estimated to be $232 million in Australia in 2016-17.**

> The total health system cost attributable to inadequate sleep was estimated to be $1,816 million in Australia in 2016-17 (Table 4.1).

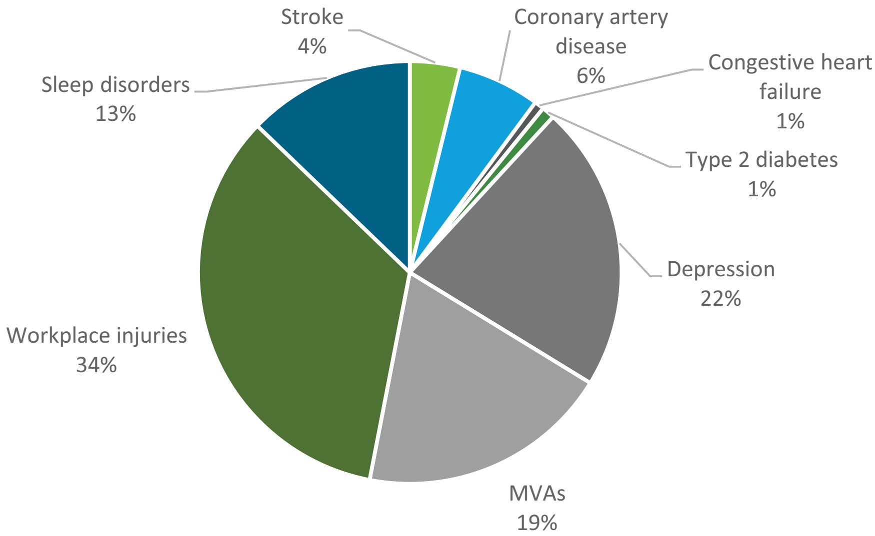
**Table 4.1: Health system costs of sleep disorders and conditions attributed to inadequate sleep, 2016-17**

| Condition | Cost ($m), year of estimate | Cost, 2016-17 ($m) | PAF (%) | Cost attributed to inadequate sleep, 2016-17 ($m) |
|---|---|---|---|---|
| Congestive heart failure | 687.9, 2008-09 | 804.8 | 1.5 | 13.4 |
| Coronary artery disease | 2,028.8, 2008-09 | 2,373.8 | 4.8 | 114.0 |
| Stroke | 607.5, 2008-09 | 710.8 | 4.8 | 69.6 |
| Type 2 diabetes | 917.0, 2008-09 | 1,072.9 | 1.7 | 17.8 |
| Depression | 2,356.5, 2013-14 | 2,510.6 | 15.9 | 398.4 |
| Workplace injuries | - | - | - | 620.6 |
| MVAs | - | - | - | 350.2 |
| Sleep disorders | - | - | - | 232.3 |
| **Total** | **6,597.7** | **7,473.0** | | **1,816.3** |

Source: AIHW (2016; 2014; 2013; 2010), Deloitte Access Economics (2011), and Deloitte Access Economics' calculations. PAFs are from Table 3.8.
Note: components may not sum to totals due to rounding.

Chart 4.1 provides a breakdown of costs attributable to inadequate sleep. Workplace injuries (34%) are expected to comprise the largest share of costs attributable to inadequate sleep, followed by depression (22%) and MVAs (19%).

**Chart 4.1: Health system costs of sleep disorders and conditions attributed to inadequate sleep, by condition, 2016-17**




Source: AIHW (2016; 2014; 2013; 2010), Deloitte Access Economics (2011), Deloitte Access Economics' calculations.

## 4.2 Breakdown of health system costs by type

Health system costs were categorised as: admitted patients, out of hospital medical, pharmaceuticals, and 'other' (predominately community services, public health and research for these conditions). Table 4.2 presents the breakdown of costs attributed to inadequate sleep in Australia in 2016-17 by age and gender groups, and type of health system cost.

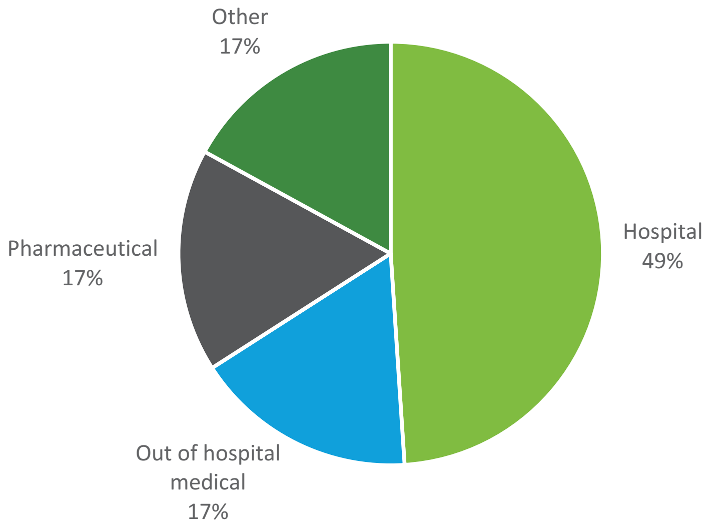
**Table 4.2: Costs attributable to inadequate sleep, by type of cost, age and gender, 2016-17 ($ million)**

| Age group | Admitted hospital | Out of hospital medical | Pharma-ceutical | Other | Total |
|---|---|---|---|---|---|
| *Male* | | | | | |
| 20-29 | 19.2 | 15.2 | 13.4 | 25.2 | 73.1 |
| 30-39 | 11.3 | 7.7 | 6.2 | 11.6 | 36.8 |
| 40-49 | 27.0 | 10.7 | 10.1 | 13.5 | 61.3 |
| 50-59 | 62.6 | 18.7 | 20.5 | 17.0 | 118.8 |
| 60-69 | 111.1 | 28.4 | 31.8 | 22.3 | 193.7 |
| 70-79 | 137.9 | 33.7 | 34.5 | 23.6 | 229.8 |
| 80-89 | 120.0 | 28.0 | 33.6 | 21.9 | 203.5 |
| 90+ | 39.6 | 6.9 | 8.7 | 6.4 | 61.6 |
| *Male total* | *528.8* | *149.3* | *158.9* | *141.5* | *978.5* |
| *Female* | | | | | |
| 20-29 | 19.2 | 16.8 | 14.6 | 27.8 | 78.3 |
| 30-39 | 14.1 | 18.7 | 10.3 | 20.4 | 63.6 |
| 40-49 | 21.5 | 14.3 | 11.2 | 18.5 | 65.5 |
| 50-59 | 34.0 | 19.3 | 16.7 | 20.0 | 89.9 |
| 60-69 | 50.9 | 24.0 | 23.5 | 21.8 | 120.2 |
| 70-79 | 73.9 | 27.9 | 29.9 | 22.9 | 154.7 |
| 80-89 | 93.5 | 27.3 | 32.2 | 25.2 | 178.2 |
| 90+ | 53.2 | 10.3 | 12.8 | 11.0 | 87.4 |
| *Female total* | *360.4* | *158.7* | *151.2* | *167.5* | *837.8* |
| **Total** | **889.2** | **308.0** | **310.1** | **309.0** | **1,816.3** |

Source: AIHW (2016; 2014; 2013; 2010), Deloitte Access Economics (2011), Deloitte Access Economics' calculations.
Note: components may not sum to totals due to rounding.

Chart 4.2 illustrates the proportion of the above costs attributable to inadequate sleep by type of cost. In 2016-17, admitted hospital (49%) while the other three categories (pharmaceuticals, out-of-hospital and other) are all expected to comprise approximately 17% of the total health system cost.

**Chart 4.2: Health system costs attributable to inadequate sleep in Australia, by type of cost, 2016-17 (% of total)**




Source: AIHW (2016; 2014; 2013; 2010), Deloitte Access Economics (2011), Deloitte Access Economics' calculations.

# 5 Other financial costs of inadequate sleep

Financial costs of inadequate sleep 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 workplace injuries, as well as less obvious efficiency losses that result from increased taxation rates. These are outlined in the following sections.

## 5.1 Productivity losses for people with inadequate sleep

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, inadequate sleep 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 EDS-SD, a firm's output may be reduced, resulting in a cost to the firm and to government (through reduced taxes).

A human capital approach is adopted to estimate productivity losses. This involves 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. Productivity losses from premature mortality are estimated in terms of the net present value (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 due to lower capacity while at work; and
- premature mortality, where for a person who dies early due to lack of sleep (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 inadequate sleep in Australia, comprising the productivity impacts of cardiovascular diseases, type 2 diabetes, depression, MVAs and WPIs. Productivity losses were based on the prevalence estimates for attributed conditions and inadequate sleep as in Table 3.9. The attributed cases of each condition were split by age and gender.

There is the potential to double count productivity impacts due to inadequate sleep itself and the conditions that may be caused by inadequate sleep. If a person has a condition attributed to inadequate sleep, 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 inadequate sleep does not compound the probability of productivity impacts for people with an attributed condition.

### 5.1.1 Productivity losses for people who have EDS-SD

This section calculates productivity losses for people with EDS-SD. People who have EDS-SD 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.

#### 5.1.1.1 Reduced employment

The loss of employment was calculated separately for each condition using information on employment rates for each relevant condition. The rates of employment for each type of cardiovascular disease were compared with the employment rate that would be expected in the absence of the disease, based on the probability of employment by age and gender of the Australian population. Deloitte Access Economics (2011) and Deloitte Access Economics (2014) found the following employment rate reductions from the attributed conditions relative to the general population:

- coronary artery disease – 19.0%
- congestive heart failure – 20.7%;
- stroke – 24.8%;
- depression – 12.7%; and
- type 2 diabetes – 3.1%.

These percentage reductions in employment were applied to the general population employment rates and earnings at each age and gender group to determine the resulting productivity loss for people with EDS-SD.

Lost productivity from workplace injuries or MVAs in Deloitte Access Economics (2011) was estimated as the lifetime cost of future lost productivity due to injuries sustained in the base year, as well as short term costs from being temporarily out of work in the base year. Lifetime costs depend on the number of years that any long term disability from an injury or accident continues to affect employment opportunity, until retirement age is reached. Based on the results in Safe Work Australia (2015) and the average annual earnings in 2013 (ABS, 2013) – it was estimated that the productivity impacts per workplace injury due to EDS-SD would be equivalent to 1.22 times the average annual earnings of the general population.[39] This was applied to the number of workplace injuries caused by EDS-SD based on the annual rates of workplace injuries in Deloitte Access Economics (2011), which was estimated to be 11,762 in 2016-17 applied against the current population (as in Table 3.9).

[39] Workplace impacts were reported to be $74,197 per incident after removing medical costs and welfare payments, and the average annual wage was approximately $57,460. Workplace impacts were further adjusted to remove fatalities at work, which increased the weighted estimate by 5.6%. Thus, it was estimated that workplace impacts were $70,256 (excluding medical costs, welfare payments and costs due to fatalities). The impact per injury was therefore estimated to be 1.22 relative to average annual wages. Both figures are in 2012-13 dollars.

To determine the employment impacts of MVAs, it is necessary to know how many cases would not return to work. Based on Deloitte Access Economics (2011), it was estimated that 0.73% of all MVAs result in injury sufficient that the individual does not return to work. This was applied to the lifetime earnings that would have been expected in the absence of the MVA by age and gender group at the time of the accident. All lifetime earnings were estimated in discounted NPV terms using a discount rate of 2.0% - a wage growth rate which adjusts expected long term nominal bond returns (a proxy for positive time preference) by target inflation and expected productivity growth.[40]

The total cost associated with reduced employment was estimated to be $1.9 billion in 2016-17, or $252 per person with inadequate sleep. Table 5.1 shows the estimated productivity impacts by attributed condition.

**Table 5.1: Cost of reduced employment from conditions attributed to EDS-SD, 2016-17**

| Condition | 2016-17 $m | Per person with inadequate sleep ($) |
|---|---|---|
| Congestive heart failure | 19.7 | 3 |
| Coronary artery disease | 221.3 | 30 |
| Stroke | 73.7 | 10 |
| Type 2 diabetes | 21.7 | 3 |
| Depression | 426.6 | 58 |
| Workplace injuries* | 1,019.4 | 138 |
| MVAs* | 81.1 | 11 |
| **Total** | **1,863.4** | **252** |

Source: Deloitte Access Economics calculations.
Note: components may not sum to totals due to rounding. * - costs based on a lifetime estimation approach.

#### 5.1.1.2 Premature mortality

In addition to the productivity losses associated with reduced employment, there is also productivity forgone from premature mortality due to each condition or illness attributed to EDS-SD.

Mortality rates by age and gender for each of the attributed conditions were calculated from Deloitte Access Economics (2011) and were applied to the 2016-17 population to estimate the number of deaths due to each condition. PAFs were applied to the total number of deaths estimated for each condition to determine deaths attributable to EDS-SD.

The productivity lost due to premature deaths was then calculated by multiplying the estimated number of deaths by the expected lifetime earnings (in discounted NPV terms) by age and gender group that would be expected to occur for the general population had the individual not died early.

[40] In the latest Intergenerational report prepared by the Treasury, long term yields over the next 40 years are expected to return to 6%, while productivity growth and inflation are expected to be 1.5% and 2.5%, respectively.

The total cost associated with premature mortality was estimated to be $345.8 million in 2016-17, or $47 per person with inadequate sleep. Table 5.2 shows the estimated productivity impacts by each attributed condition.

**Table 5.2: Premature mortality losses from conditions attributed to EDS-SD, 2016-17**

| Condition | 2016-17 $m | Per person with inadequate sleep ($) |
|---|---|---|
| Congestive heart failure | 3.7 | 0 |
| Coronary artery disease | 129.5 | 18 |
| Stroke | 36.7 | 5 |
| Type 2 diabetes | 7.0 | 1 |
| Depression | 93.2 | 13 |
| Workplace injuries* | 19.5 | 3 |
| MVAs* | 56.3 | 8 |
| **Total** | **345.8** | **47** |

Source: Deloitte Access Economics calculations.
Note: components may not sum to totals due to rounding. * - costs based on a lifetime estimation approach

#### 5.1.1.3 Absenteeism

There are two aspects of absenteeism relevant to this study. Firstly, people with chronic conditions attributed to EDS-SD may take more days off work than the average Australian due to that disease or injury. Secondly, people with EDS-SD may be more likely to take days off work because they are tired.

Absenteeism for chronic conditions attributed to EDS-SD were measured by looking at the number of work days missed by people with chronic conditions relative to the rest of the population. AIHW (2009) found that people with chronic disease, including cardiovascular disease, and depression, 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 was therefore assumed to be 5.5 days per person with a chronic condition attributed to EDS-SD. For type 2 diabetes, Deloitte Access Economics (2014) found that people with type 2 diabetes would be absent from work 2.1 days on average relative to the general population. The cost of a missed day of work for each condition was based on average weekly earnings of the general population, by age and gender.

Temporary absenteeism from MVAs attributed to EDS-SD was based on analysis presented in Deloitte Access Economics (2011). Temporary costs were estimated by multiplying the number of people expected to have returned to employment after a MVA by the weeks temporarily absent and their expected weekly wage. This was based on the severity of injury. It was estimated the people who have had MVAs would be away from work for 9.3 days on average.

No estimates of absenteeism were included here for workplace injuries as they were included in the general productivity losses reported in section 5.1.1.1 (Deloitte Access Economics, 2011).

For those with EDS-SD, but not with any attributed conditions, it was also necessary to estimate the absenteeism impacts due to taking days off work because of being tired. The absenteeism impacts for a person with EDS-SD were estimated to be 2.1 additional days off work compared to those without EDS-SD (see section 5.1.2.3). These absenteeism impacts were only applied to people who do not have an attributed condition to avoid double counting.

The total cost associated with absenteeism due to EDS-SD was estimated to be $534.6 million in 2016-17, or $72 per person with inadequate sleep. Table 5.3 shows the estimated productivity impacts by attributed condition.

**Table 5.3: Absenteeism losses from EDS-SD and attributed conditions, 2016-17**

| Condition | 2016-17 $m | Per person with inadequate sleep ($) |
|---|---|---|
| Congestive heart failure | 3.1 | 0 |
| Coronary artery disease | 28.3 | 4 |
| Stroke | 8.2 | 1 |
| Type 2 diabetes | 8.1 | 1 |
| Depression | 96.4 | 13 |
| Workplace injuries^ | - | - |
| MVAs | 20.4 | 3 |
| EDS-SD with no attributed conditions* | 370.2 | 50 |
| **Total** | **534.6** | **72** |

Source: Deloitte Access Economics calculations.
Note: components may not sum to totals due to rounding. ^ absenteeism due to workplace injuries was included in Table 5.1.

### 5.1.1.4 Presenteeism

Presenteeism refers to attending work despite conditions that result in a lower productivity while at work and reduced work output. For people with a condition attributed to EDS-SD, presenteeism impacts were conservatively assumed to be captured within absenteeism estimates. A person who has cardiovascular diseases as a result of inadequate sleep is likely to take time off work and return to work once they have recovered, or exit the workforce if they still have restrictions.

For people without an attributed condition, **presenteeism impacts were estimated to be 3.4%**. This is based on the research presented in section 5.1.2. The EDS estimates apply to this group as each person with EDS-SD has EDS by definition.

> The total cost associated with presenteeism for people with EDS-SD was estimated to be $1.1 billion in 2016-17, or $145 per person with inadequate sleep.

### 5.1.2 Productivity losses for people who have other EDS

There are many studies demonstrating a robust relationship between EDS and reduced work productivity. This section calculates productivity losses for those with other EDS, and conditions attributed to other EDS. Where conditions were attributed to other EDS, they were assigned the same per unit cost as for EDS-SD (section 5.1.1).

#### 5.1.2.1 Reduced employment and premature mortality

In contrast to absenteeism and presenteeism, there is little in the literature that discusses the impact of EDS on employment. It has been suggested that EDS can undermine motivation, performance and employment opportunities (Hossain and Shapiro, 2002), and while perhaps intuitive, it is not clear to what extent this occurs.

As such, no employment impacts were quantified directly for other EDS. However, other EDS is still able to cause reduced employment and premature mortality productivity losses indirectly through attributed conditions. Deloitte Access Economics (2011) reported that sleep disorders caused high rates of injuries, and that the most severe of these injuries resulted in people being unable to return to work, or even cases of premature death. The impact of other EDS per se on injuries is discussed in Section 3.1.4. Applying the same per person values as for EDS-SD, **it was estimated that the costs of reduced employment or premature mortality caused indirectly by stroke, depression, MVAs and workplace injuries due to other EDS were $4.3 billion in Australia in 2016-17.**

**Table 5.4: Reduced employment from conditions attributed to other EDS, 2016-17**

| Condition | 2016-17 $m | Per person with inadequate sleep ($) |
|---|---|---|
| Stroke | 116.8 | 16 |
| Depression | 755.2 | 102 |
| Workplace injuries* | 3,084.3 | 417 |
| MVAs* | 373.5 | 51 |
| **Total** | **4,329.7** | **586** |

Source: Deloitte Access Economics calculations. Calculations are based on the PAFs described in Chapter 3.
Note: components may not sum to totals due to rounding. * Costs based on a lifetime estimation approach.

#### 5.1.2.2 Absenteeism

The parameters used to calculate absenteeism losses for conditions attributed to other EDS are the same as in section 5.1.1.3. However, productivity losses also occur for people with other EDS but without an attributed condition. EDS has also been shown to contribute to the risk of absence from work in several studies. For example, Swanson et al (2011), using the standard ESS ≥10 test, found that those scoring higher than this threshold had increased odds for absenteeism due to sleepiness (with an odds ratio of 6.06).[41] **For this report it was**

[41] Similarly, Philip et al (2001) studied 1,105 employees of the French National Gas and Electricity Board for a year. The study did not measure EDS per se, but rather “daytime somnolence” using the Basic Nordic Sleep Questionnaire . A strong association was observed between daytime somnolence and sickness-related absence, which remained significant even after adjusting for potential confounding factors (age, sex, employment grade,

**estimated that the average person with EDS would have an additional 2.1 days off work each year.**

- Lallukka et al (2014) investigated insomnia-related symptoms, such as early morning awakenings, being more tired during the daytime than other people of the same age, and EDS as determinants of absence due to sickness. The study population was 1,885 males and 1,875 females in Finland, with seven years of follow-up. After adjusting for age, health, and health behaviours, the ratio of sickness-related absence was 1.13 for those in the high quartile of ESS scores versus those in the lowest quartile – i.e. those with and without EDS.[42]
- In Australia, average absenteeism days are reported to be approximately 9.5 days per employee per annum (Direct Health Solutions, 2016). Applying the ratio of 1.13 from Lallukka et al (2014), it was estimated that **employees with EDS would take an additional 1.2 days off work each year**.
- Based on data from Adams et al (2017), approximately 17% of study participants with a sleep problem or sleep complaint reported taking one to two days off work each month due to that problem or complaint, while around 3.5% reported taking three or more days off work (assumed to be five days). If this applies to EDS equally, the **additional days off per annum could be as high as 5.2 days**.
- As with presenteeism, reduced sleep hours were used to proxy the absenteeism impacts for people with EDS. When looking at the survey results reported by Hafner et al (2015), **no absenteeism impacts were observed due to reduced sleep hours**.

> Absenteeism is measured as the average number of days per year that an employee takes off work due to inadequate sleep. A simple average was taken across the literature found (1.2, 5.2 and 0), estimating the absenteeism impacts for people with EDS as 2.1 days per person per year. The absenteeism impacts of conditions attributed to other EDS were assumed to be the same as for EDS-SD (see section 5.1.1).

**The total cost associated with absenteeism due to other EDS was estimated to be $1.4 billion in 2016-17, or $186 per person with inadequate sleep** (Table 5.5).

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sleep symptoms and self-reported diseases). The odds ratio for absence as a result of sickness, was 2.2 for those experiencing daytime somnolence of three days or more a week. As the actual number of days was not reported, Philip et al (2001) was not included in the modelling.

[42] Interestingly, Lallukka et al (2014) found that if sickness-related absence days among those with EDS could be reduced to the same level as the general population, this would result in a decrease of 4% to total costs of sickness-related absence in Finland.

**Table 5.5: Absenteeism losses due to other EDS and attributed conditions, 2016-17**

| Condition | 2016-17 $m | Per person with inadequate sleep ($) |
|---|---|---|
| Stroke | 8.6 | 1 |
| Depression | 140.0 | 19 |
| Workplace injuries^ | - | - |
| MVAs | 55.3 | 7 |
| Other EDS with no attributed condition | 1,167.7 | 158 |
| **Total** | **1,371.7** | **186** |

Source: Deloitte Access Economics calculations.
Note: components may not sum to totals due to rounding. ^ absenteeism due to workplace injuries was included in Table 5.4.

#### 5.1.2.3 Presenteeism

The parameters used to calculate presenteeism losses for conditions attributed to EDS are the same as in section 5.1.1.4. That is, presenteeism losses were conservatively assumed to be minimal. A person who has a cardiovascular disease as a result of other EDS is likely to take time off work and return to work once they have recovered, or exit the workforce if they still have restrictions. However, productivity losses also occur for people with other EDS but without an attributed condition.

Qualitative impacts of EDS on work productivity are clear[43]. This can include an increased likelihood of making an error while at work, falling asleep while driving, or other less perceivable impacts such as having impaired cognitive functioning while at work, which can lead to lower productivity. This also includes aspects of decreased motivation.

To quantify the presenteeism costs of EDS, it is necessary to compare the productivity of those with EDS to those without. Various work productivity tools have been developed to determine the impacts of EDS, which mostly focus on the Work Limitations Questionnaire and the Work Productivity and Activity Impairment Questionnaire (see for example Hafner et al, 2015; Hafner et al, 2016; Mulgrew et al, 2007). **For this report, it was estimated that the average person with EDS would be 3.4% less productive than someone who does not have EDS**.

[43] Briefly, statistically significant relationships have been observed between EDS and medical error rates such as including drug administration errors, incorrect operation of medical equipment and needlestick injuries (Suzuki et al, 2005). Long work hours have also been observed to lead to increased sleepiness and a fall in professional performance and judgment amongst medical residents, as well as outside of work impacts including falling asleep while driving – increasing the risk of having a MVA (Pikovsky et al, 2013). Impacts are not only linked to health professionals. Hossain et al (2002) observed that shift-workers frequently experience increased sleepiness and decreased alertness and performance on and off the job – estimating a 5% decline in productivity amongst factory workers. EDS has also been associated with decreased school performance for students (Shin et al, 2003).

Moreover, Swanson et al (2011), using the standard ESS ≥10 test, found that those scoring higher than this threshold were at increased odds for difficulty with cognitive tasks at work, including problems with concentration (odds ratio = 2.22) and organisation (odds ratio = 2.78). They were also more likely to report decreased productivity (odds ratio = 3.12).

- Mulgrew et al (2007) demonstrated a clear relationship between excessive sleepiness and decreased work productivity in a population of 498 patients referred for suspected sleep disordered breathing. They found strong associations between EDS (as measured by the ESS) and three of the four scales of work limitation in the Work Limitations Questionnaire. Mulgrew et al (2007) estimated that every 1 point increase on the ESS was associated with an additional 1% of time spent at suboptimal work performance for all scales of work except physical output.
- Suboptimal output means something between 0% and 1% of time would be lost, so the percentage impacts below were halved to estimate output impacts **– i.e. 0.5% less productive for every 1 point increase on the ESS** (Mulgrew et al, 2007). Based on data from Adams et al (2017), around 14.2% of the population have an ESS score of 11 to 15 (inclusive) and approximately 4.8% of the population have an ESS score of 16 or more. Assuming the ESS score in each of the three groups is 7, 13 and 18 on average[44], it was estimated that the (weighted) average ESS score for people with EDS was 14.3. Thus, there is approximately a 7.3 percentage point change in ESS scores between those with EDS and those without. By applying the reduction in productivity from Mulgrew et al (2007), **the estimated productivity reduction was estimated to be 3.7%**.
- It is also possible to quantify the potential productivity reductions based on hours of sleep each night. While this does not directly correspond to EDS, there is likely to be a high amount of correlation between those reporting reduced hours of sleep each night, and those reporting EDS. When looking at survey results reported by Hafner et al (2015) and Hafner et al (2016), the rates of those in the United Kingdom and United States reporting fewer than six hours of sleep per night were similar to the EDS rates reported by Adams et al (2017). Hafner et al (2016) estimated that fewer than six hours of sleep per night **resulted in a 2.4% reduction in productivity** (primarily due to presenteeism). Using a similar approach, Hafner et al (2015) estimated the **presenteeism impacts were likely to be around 4.4% for those suffering from EDS** – as proxied by having fewer than six hours of sleep per night.
- Finally, Rosekind et al (2010) reported mean productivity losses for groups classified as at-risk of insufficient sleep syndrome or insomnia, insufficient sleep syndrome, and those who report no more than one sleep problem (including no inadequate sleep). Again, these measures serve as proxies for EDS, noting that the prevalence of insufficient sleep syndrome is lower than EDS, and may represent greater sleepiness that the definitions used by Adams et al (2017). However, Rosekind et al (2010) **found that the mean productivity loss was 3% more than those with good sleep**.

> Based on the average of the results reported by Mulgrew et al (2007), Hafner et al (2015), Hafner et al (2016) and Rosekind et al (2010), it was estimated that EDS results in presenteeism impacts – reduced productivity while at work – of 3.4%.

The **total cost associated with presenteeism for people with other EDS was estimated to be $3.3 billion in 2016-17, or $441 per person with inadequate sleep.**

[44] 13 is the midpoint of 11 to 15, while 7 and 18 were selected to account for skew in the lowest and highest categories, respectively – recognising that people are less likely to be at the extreme ends of the ESS scale (e.g. see Sanford et al, 2006).

### 5.1.3 Productivity losses for people who have insufficient sleep

There are few studies highlighting the relationship between productivity and insufficient sleep, including fatigue, when discussing subjective measures of insufficient sleep. Instead, it was necessary to rely on proxy measures of reduced productivity for insufficient sleep.

#### 5.1.3.1 Reduced employment and premature mortality

As with EDS, there are also demonstrated links between insufficient sleep and both workplace injuries and MVAs (as shown in Table 3.9 and section 3.1.4). Consequently, there will also be productivity losses associated with these attributed conditions. There were no discernible impacts of insufficient sleep on employment or mortality where no conditions were attributable to insufficient sleep.

Applying the same per person values of workplace injuries and MVAs as for EDS-SD and EDS, **it was estimated that the cost of reduced employment and premature mortality caused by MVAs and workplace injuries due to insufficient sleep was $2.0 billion in Australia in 2016-17**.

**Table 5.6: Costs of reduced employment and premature mortality from conditions attributed to insufficient sleep, 2016-17**

| Condition | 2016-17 $m | Per person with inadequate sleep ($) |
|---|---|---|
| Workplace injuries* | 1,691.2 | 229 |
| MVAs* | 320.7 | 43 |
| **Total** | **2,011.9** | **272** |

Source: Deloitte Access Economics calculations.
Note: components may not sum to totals due to rounding. * Costs based on a lifetime estimation approach.

#### 5.1.3.2 Absenteeism

There is little literature to show absenteeism impacts when discussing subjective measures of insufficient sleep. As such, it was necessary to adopt an approach where a reduction in hours of sleep each night was used as a proxy for the absenteeism impact due to insufficient sleep.

Two studies were found that discussed the absenteeism impacts of a reduction in work hours. Lallukka et al (2014) found that sickness absence days were lowest at approximately 8 hours of sleep each night. Insufficient sleep was largely assumed to occur below this cut off. As with EDS, an approach was taken that roughly approximated the expected prevalence of insufficient sleep, capturing those with fewer than 8 hours of sleep per night. Approximately 50% of Lallukka's sample slept for less than 8 hours per night, so a weighted average was taken over the number of hours of sleep below this cut off. **It was estimated that approximately 0.8 days would be taken off work each year due to insufficient sleep**.

A similar approach was taken for the survey results reported by Hafner et al (2015); however, there was **no discernible impact of insufficient sleep on absenteeism days** (noting that the higher cost groups would already be costed elsewhere).

Taking a simple average of these studies, it was estimated that insufficient sleep would result in 0.4 additional days off work each year per person (average of 0.8 and 0 days above). This only applies to people who do not have a condition attributed to insufficient sleep (i.e. workplace injuries and MVAs).

**The total cost associated with absenteeism due to insufficient sleep was estimated to be $629.1 million in 2016-17, or $85 per person with inadequate sleep.**

**Table 5.7: Absenteeism losses due to insufficient sleep and attributed conditions, 2016-17**

| Condition | 2016-17 $m | Per person with inadequate sleep ($) |
|---|---|---|
| Workplace injuries^ | - | - |
| MVAs | 47.5 | 6 |
| Insufficient sleep with no attributed condition | 581.5 | 79 |
| **Total** | **629.1** | **85** |

Source: Deloitte Access Economics calculations.
Note: components may not sum to totals due to rounding. ^ absenteeism due to workplace injuries was included in Table 5.6.

### 5.1.3.3 Presenteeism

Swanson et al (2011) cited that, independent of sleep duration, poor sleep quality was also associated with impairments at work, including difficulty with concentration and organization, and impatience with co-workers.

The findings by Swanson et al (2011) align with other research findings on the effect of insufficient sleep on productivity. For example, measures of night time awakenings, which can lead to reduced sleep hours and insufficient sleep, have been found to result in greater work impairments (Kobelt et al, 2003). Similarly, sleep deprivation has been found to result in substantial presenteeism impacts (Williamson and Feyer, 2000), and could be seen as a form of insufficient sleep. However, despite the availability of literature for objective measures that may form part of insufficient sleep, there is little literature identifying the impacts of subjective measures of insufficient sleep. **For this report, it was estimated that the average person with insufficient sleep is 1.6% less productivity than someone without insufficient sleep.**

- As with the productivity impacts of EDS, it is possible to quantify the potential productivity reductions based on hours of sleep each night. While this does not directly correspond to insufficient sleep as defined by the prevalence in this report, there is likely to be a high amount of correlation between those reporting reduced hours of sleep each night, and those reporting insufficient sleep. When looking at survey results reported by Hafner et al (2015) and Hafner et al (2016), it is clear that those who report insufficient sleep would be split across a number of sleep hour categories including those who reportedly obtain sufficient sleep, in the range of 7 to 9 hours of sleep per night. As such, a weighted average of the sample sizes in each category was taken.
- For example, in Hafner et al (2016), approximately 4.9% of people sampled reported fewer than 6 hours of sleep, 24.0% reported 6 to 7 hours of sleep and 70.2% reported 7

to 9 hours of sleep. Given that the prevalence of insufficient sleep in this report is approximately 33.1% (including the higher cost categories), 4.2% of those with insufficient sleep were assumed to be in the range of 7 to 9 hours range. As noted, Hafner et al (2016) observed productivity impacts of 2.4% for less than 6 hours of sleep and 1.5% for 6 to 7 hours of sleep. **The weighted productivity impact was calculated to be 1.4%.**[45]

- Hafner et al (2015) reported slightly different hour categories when reporting sleep data, finding that the presenteeism impacts for 6 to 7 hours of sleep was 1.2%, and that there were no presenteeism impacts at 7 to 8 hours of sleep. **The incremental value from 6 to 7 hours relative to 7 to 8 hours (i.e. 1.2%) was taken as a proxy for the presenteeism impact**.
- Finally, Rosekind et al (2010) reported mean productivity losses for groups classified as at-risk of insufficient sleep syndrome or insomnia, insufficient sleep syndrome, and those who report no more than one sleep problem (including no insufficient sleep). Again, these measures serve as proxies for insufficient sleep as for EDS, noting that the prevalence of the at-risk group was slightly higher than insufficient sleep in this report. Based on the differential between the at-risk group and the good sleep group, Rosekind et al (2010) **found that the mean productivity loss was 2.1% more than those with good sleep**, which was used as a proxy for the presenteeism impact of insufficient sleep.

A simple average was taken across the literature found, finding that presenteeism impacts for people with insufficient sleep was 1.6% in terms of lost worker output (the average of 1.4%, 1.2% and 2.1%).

**The total cost associated with presenteeism due to insufficient sleep was estimated to be $2.5 billion in 2016-17, or $333 per person with inadequate sleep**.

### 5.1.4 Summary of productivity costs

**The total productivity losses associated with inadequate sleep in Australia were estimated to be $17.9 billion in 2016-17, or $2,418 per person with inadequate sleep**. Table 5.8 shows the estimated productivity impacts by type of loss and inadequate sleep.

[45] This is calculated as (2.4% * 4.9% + 1.5% * 24.0% + 0.0% * 4.2%)/(4.9% + 24.0% + 4.2%).

**Table 5.8: Summary of total productivity costs due to inadequate sleep in Australia in 2016-17**

| Source of productivity loss | EDS-SD | Other EDS | Insufficient Sleep | Total |
|---|---|---|---|---|
| *Reduced employment* | | | | |
| Congestive heart | 19.7 | - | - | 19.7 |
| Coronary artery | 221.3 | - | - | 221.3 |
| Stroke | 73.7 | 78.0 | - | 151.7 |
| Type 2 diabetes | 21.7 | - | - | 21.7 |
| Depression | 426.6 | 619.8 | - | 1,046.4 |
| Workplace injuries | 1,019.4 | 3,026.4 | 1,659.5 | 5,705.2 |
| MVAs | 81.1 | 220.5 | 189.4 | 491.1 |
| *Total* | *1,863.4* | *3,944.7* | *1,848.9* | *7,657.0* |
| *Premature mortality* | | | | |
| Congestive heart | 3.7 | - | - | 3.7 |
| Coronary artery | 129.5 | - | - | 129.5 |
| Stroke | 36.7 | 38.8 | - | 75.5 |
| Type 2 diabetes | 7.0 | - | - | 7.0 |
| Depression | 93.2 | 135.4 | - | 228.6 |
| Workplace injuries | 19.5 | 57.9 | 31.8 | 109.2 |
| MVAs | 56.3 | 152.9 | 131.3 | 340.5 |
| *Total* | *345.8* | *385.0* | *163.1* | *893.8* |
| *Absenteeism* | | | | |
| Congestive heart | 3.1 | - | - | 3.1 |
| Coronary artery | 28.3 | - | - | 28.3 |
| Stroke | 8.2 | 8.6 | - | 16.8 |
| Type 2 diabetes | 8.1 | - | - | 8.1 |
| Depression | 96.4 | 140.0 | - | 236.4 |
| Workplace injuries^ | - | - | - | - |
| MVAs | 20.4 | 55.3 | 47.5 | 123.2 |
| No attributed conditions | 370.2 | 1,167.7 | 581.5 | 2,119.4 |
| *Total* | *534.6* | *1,371.7* | *629.1* | *2,535.3* |
| *Presenteeism* | | | | |
| No attributed conditions | 1,072.4 | 3,259.8 | 2,458.7 | 6,790.9 |
| *Total* | *1,072.4* | *3,259.8* | *2,458.7* | *6,790.9* |
| **Total** | **3,816.2** | **8,961.2** | **5,099.7** | **17,877.1** |

Source: Deloitte Access Economics' calculations as outlined in sections 5.1.1, 5.1.2 and 5.1.3.
Note: components may not sum to totals due to rounding. ^absenteeism costs for workplace injuries were included under costs of reduced employment.

Presenteeism and reduced employment costs were estimated to constitute the largest component of productivity costs due to inadequate sleep. The productivity costs are divided between individuals, employers and government (through a reduction in taxable income). Post-tax, the shares of productivity losses borne by individuals was estimated to be approximately 32%, while 39% and 29% are expected to be borne by employers and government, respectively (Table 5.9).

**Table 5.9: Productivity losses due to inadequate sleep in Australia, by payer, 2016-17**

| Payer | Cost ($m) | Proportion (%) |
|---|---|---|
| Individuals | 5,774.9 | 32 |
| Employers | 6,916.1 | 39 |
| Government | 5,186.1 | 29 |
| **Total** | **17,877.1** | **100** |

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

Individual costs include lost earnings as a result of reduced employment, including small costs associated with unpaid days off work. Employer costs include costs of reduced productivity while at work (presenteeism)[46] and additional paid days off work (absenteeism). The productivity cost to the government is largely the result of reduced employment for people with inadequate sleep (through attributed conditions), resulting in lower taxation revenue.

## 5.2 Informal care

Carers are people who provide care to others in need of assistance or support. An informal carer provides this service free of charge and does so outside of the formal care sector. An informal carer will typically be a family member or friend of the person receiving care, and usually lives in the same household as the recipient of care. People can receive informal care from more than one person.

While informal carers are not paid for providing this care, informal care is not free in an economic sense. Time spent caring involves forfeiting time that could have been spent on paid work or undertaking leisure time activities. As such, informal care can be valued as the opportunity cost associated with the loss of economic resources (labour) and the loss in leisure time valued by the carer. To estimate the dollar value of informal care, the opportunity cost method measures the formal sector productivity losses associated with caring, as time devoted to caring responsibilities is time which cannot be spent in the paid workforce.

The following sections discuss the care requirements of conditions that are due to inadequate sleep. As with Deloitte Access Economics (2011), **it has been assumed that there would be no care requirements due to inadequate sleep itself** – i.e. only conditions attributed to inadequate sleep result in increased care needs such as personal care, housekeeping or other tasks.

The age and gender adjusted average weekly earnings of primary carers in Australia was used to estimate the total cost to society of informal care. The age and gender distribution was assumed to be the same as the age and gender distribution of the general population, so the average weekly earnings (adjusted for the employment opportunity) of the general population represents the opportunity cost of a primary carer's time. This was multiplied by the annual hours of care provided to people with any condition due to inadequate sleep.

[46] In the long run it is likely that employers will be able to pass this on to individuals, through lower wages.

### 5.2.1 EDS-SD

Evidence is clear that people living with consequences of cardiovascular disease, type 2 diabetes, depression, MVAs or workplace injuries can have substantial care requirements. Deloitte Access Economics (2011) quantified the care requirements of conditions associated with sleep disorders as follows:

- People with a profound, severe, or moderate disability following a MVA would require 105, 28.5, or 9 hours of informal care per week, respectively. On average, this was estimated to be 45 hours of care per week. Approximately 0.7% of those who have had a MVA due to sleep disorders require care. The care requirements were assumed to be maintained for the remaining expected life of the individual.
- It was estimated that people who have had a workplace injury would require 3.7 hours of care per week, on average.
- Cases of cardiovascular disease due to sleep disorders (stroke, coronary artery disease and congestive heart failure) were estimated to require 1.1 hours of care per week, on average.
- Type 2 diabetes was estimated to require 0.1 hours of care per week, on average (Deloitte Access Economics, 2014).

Applying these estimates to the prevalence in Table 3.9, **informal care provided to people with a condition attributed to EDS-SD was estimated to cost the economy around $162 million in 2016-17**. Of the total cost:

- carers (post-tax) will be expected to have borne around $106 million in the form of lost income; and
- governments will be expected to have borne around $56 million in the form of lost taxes.

### 5.2.2 Other EDS

There is substantial evidence to suggest that EDS can cause cases of both depression and stroke, as discussed in section 3.1. As per Deloitte Access Economics (2011):

- care needs for MVAs and workplace injuries were assumed to be the same as for EDS-SD;
- no informal care requirements were estimated for depression due to a lack of available data; and
- each case of stroke due to EDS was assumed to require 1.1 hours of care each week, on average.

Applying these estimates to the prevalence of conditions attributed to other EDS in Table 3.9, **informal care provided to people with a condition attributed to other EDS was estimated to cost the economy around $267 million in 2016-17**. Of the total cost:

- carers (post-tax) will be expected to have borne around $175 million in the form of lost income; and
- government will be expected to have borne around $92 million in the form of lost taxes.

### 5.2.3 Insufficient sleep

For insufficient sleep, care needs for people who have had MVAs and workplace injuries were assumed to be the same as care needs for EDS-SD that contributes to MVAs or workplace injuries (section 5.2.1) – i.e. the severity of injury/accident does not depend on the underlying sleep cause.[47] Applying the estimated hours of care to the annual number of workplace injuries and MVAs attributed to insufficient sleep (Table 3.9), **informal care provided to people with MVAs or workplace injuries due to insufficient sleep was estimated to cost the economy around $177 million in 2016-17**. Of the total cost:

- carers (post-tax) will be expected to have borne around $116 million in the form of lost income; and
- government will be expected to have borne around $61 million in the form of lost taxes.

### 5.2.4 Informal care costs due to inadequate sleep

The total cost of informal care due to inadequate sleep was estimated to be $606 million in 2016-17 (Table 5.10). The majority of this cost was attributable to workplace injuries and MVAs (85%).

**Table 5.10: Cost of informal care due to inadequate sleep, 2016-17**

| Condition | Cost ($m) |
|---|---|
| Congestive heart failure | 5.6 |
| Coronary artery disease | 50.1 |
| Stroke | 30.3 |
| Type 2 diabetes | 2.7 |
| Depression[(a)] | - |
| Workplace injuries | 233.4 |
| MVAs | 283.6 |
| **Total** | **605.7** |

Source: Deloitte Access Economics' estimates.
Note: (a) No data were available on the cost of informal care for depression. Components may not sum to totals due to rounding.

## 5.3 Other costs

Other costs of inadequate sleep include costs associated with MVAs and workplace injuries attributable to inadequate sleep. This can include aids and modifications to the home, respite programs, therapy and specialist services, costs of repairing vehicles and travel costs.

### 5.3.1 Other costs of MVAs and workplace injuries

There are a number of other costs associated with workplace injuries and MVAs, including legal costs, costs of investigation, premature funeral costs, aids and equipment, travel delays and vehicle repair costs and the like. These costs apply to the number of accidents due to inadequate sleep from any cause.

[47] Note, while the severity of injuries/accidents was not altered, the rate at which severe injuries/accidents occurs does as outlined in section 3.2.

To estimate the number of workplace injuries and MVAs expected to be attributable to inadequate sleep in Australia, the PAFs due EDS-SD, other EDS, and insufficient sleep were multiplied against the estimated total annual cases of workplace injuries and MVAs in Australia in 2016-17 (Table 2.8).

**Table 5.11: Workplace injuries and MVAs due to inadequate sleep in Australia in 2016-17**

| Condition | PAF for MVAs | PAF for workplace injuries |
|---|---|---|
| EDS-SD | 3.8% | 4.6% |
| Other EDS | 10.3% | 13.7% |
| Insufficient sleep | 8.9% | 7.5% |
| **Total** | **23.0%** | **25.8%** |

Source: Deloitte Access Economics' estimates.

Against the estimated cases of workplace injuries and MVAs in Australia, it was estimated that approximately 66,400 MVAs will be the result of inadequate sleep in 2016-17, and approximately 65,828 workplace injuries would be the result of inadequate sleep in 2016-17 (Table 3.9).

The unit costs of workplace injuries – inflated to 2016-17 dollars using the Consumer Price Index (CPI) (ABS, 2016c) – were estimated to be $1,890 for legal costs, $1,299 for investigations and $1,947 for travel costs, and $1,331 for aids and modifications based on Deloitte Access Economics (2011). **Applying these unit costs to the total number of workplace injuries, it was estimated other costs of workplace injuries due to inadequate sleep would be approximately $425.7 million in Australian in 2016-17**.

Similarly, 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. These costs were estimated to be $48,339 per injury due to a MVA based on findings by Deloitte Access Economics (2011) inflated to 2016-17 using CPI. Applying these unit costs to the total number of MVAs attributable to inadequate sleep (72,392), **it was estimated other costs of MVAs due to inadequate sleep would be approximately $3.2 billion in Australia in 2016-17**.

### 5.3.2 Funeral costs due to premature mortality

Premature mortality due to inadequate sleep through associated MVAs, workplace injuries, and other attributable conditions results in additional funeral costs for family members. As everyone will die eventually, the additional cost imposed by inadequate sleep is the brought forward funeral cost adjusted for the likelihood of dying anyway. The Australian Securities and Investment Commission (2016) reports that the average funeral costs likely range between $4,000 and $15,000 in Australia. Taking the midpoint value ($9,500) and inflating this to 2016-17, the **discounted value of funeral costs associated with premature deaths was estimated to be $12.9 million due to inadequate sleep in Australia in 2016-17**.

## 5.4 Deadweight loss

Transfer payments represent a shift of resources from one economic entity to another, such as raising taxes from the entire population to provide welfare payments to people with a chronic condition due to inadequate sleep. Transfer costs are important when adopting a whole-of-government approach to policy formulation and budgeting. Publically funding costs means the government must effectively increase tax revenue to achieve a budget neutral position. Alternatively, if all inadequate sleep (and its consequences) could be avoided, the government would not need to raise as much tax revenue.

The act of taxation and redistribution creates distortions and inefficiencies in the economy, so transfers also involve real net costs to the economy, known as deadweight losses. 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. Similarly businesses may be discouraged from operating in Australia if company tax rates were too high.

So, although transfer payments are not real costs of themselves they have been estimated, along with public funding of health care to calculate the cost associated with a loss in allocative efficiency. The following sections outline the various transfer payments, and reduced taxation.

### 5.4.1 Welfare payments

Transfer payments include the Disability Support Pension, Pension Supplement and Rent Assistance. Costs of transfer payments in 2016-17 were estimated to range between $84 and $276 per person with a condition or long term injury associated with inadequate sleep based on rates reported in Deloitte Access Economics (2011)[48]. On average, transfer payments represented $10 per person with inadequate sleep. Applied against the prevalence of a chronic condition or long term injury due to inadequate sleep (Table 2.8), **welfare transfer payments were estimated to be $70.5 million in Australia in 2016-17**.

### 5.4.2 Taxation revenue

Reduced earnings from lower employment participation and lower output result in reduced taxation revenue collected by the Government. As well as forgone 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 2013-14, the latest statistics published by the Australian Taxation Office at the time of writing. The average rates were derived by dividing net income tax and net indirect tax by the taxable income. It is also necessary to estimate the average company tax rate, and apply this to lost company earnings (through reduced output). Again, net tax for companies was divided by the total taxable income for companies. The respective tax rates used in the calculation of deadweight losses were:

[48] The Department of Human Services was unable to provide any data on welfare payments for sleep disorders per se.

- 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 was estimated to be $2.7 billion (including lost carer taxes), while the total lost company revenue was estimated to be $2.0 billion in Australia in 2016-17.

### 5.4.3 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 has been estimated to impose a burden of $0.25 for every $1 raised;
- company tax has been estimated to impose a burden of $0.50 for every $1 raised;
- goods and services tax has been 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 state taxes because states 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. Weighted by the revenue raised:

- 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 45.0% efficiency loss.

Table 4.10 shows the estimated reduced income, transfer payments, and health expenditure payments, the applied efficiency loss of raising taxation, and the resulting deadweight losses associated with inadequate sleep in Australia in 2016-17. 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 inadequate sleep were estimated to be $2.3 billion in Australia in 2016-17.**

**Table 5.12: Deadweight losses due to inadequate sleep in Australia, 2016-17**

| Cost component | Total cost ($m) | Rate of efficiency loss | Resulting deadweight loss ($m) |
|---|---|---|---|
| Commonwealth health expenditure | 744.7 | 29.5% | 219.8 |
| State health expenditure | 472.2 | 45.0% | 178.8 |
| Welfare payments | 70.5 | 29.5% | 20.8 |
| Lost consumer taxes | 3,043.1 | 23.7% | 722.1 |
| Lost company taxes | 2,142.9 | 50.8% | 1,089.5 |
| Lost carer taxes | 209.0 | 23.7% | 49.6 |
| **Total** | **6,682.5** | **-** | **2,280.5** |

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

## 5.5 Summary of non-health system costs

Overall, the total cost of inadequate sleep outside the health system was estimated to be $24.4 billion in Australia in 2016-17, or $3,302 per person with inadequate sleep.

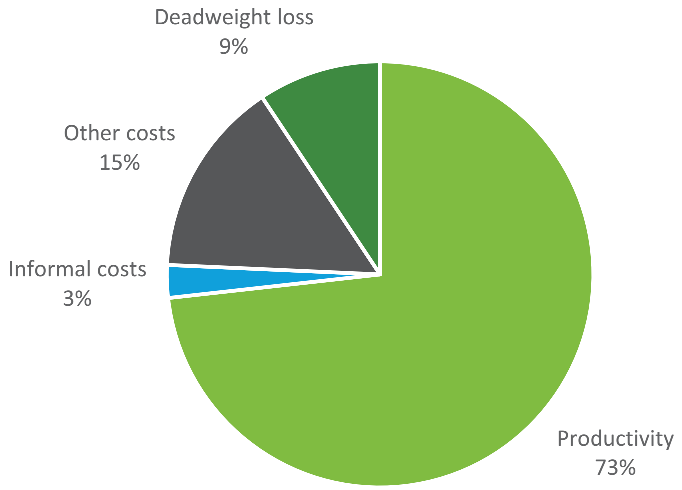
**Table 5.13: Productivity and other costs of inadequate sleep in Australia, by cost component, 2016-17**

| Condition | Cost ($ million) | Per person with inadequate sleep($) |
|---|---|---|
| Productivity | 17,877.1 | 2,418 |
| Informal costs | 605.7 | 82 |
| Other costs | 3,648.3 | 494 |
| Deadweight loss | 2,280.5 | 308 |
| **Total** | **24,411.6** | **3,302** |

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

Chart 5.1 illustrates a breakdown of total financial costs outside the health system by type of cost. Productivity losses comprise the majority of costs (73%), followed by other financial costs associated with workplace injuries and MVAs (15%).

**Chart 5.1: Productivity and other costs of inadequate sleep in Australia, by cost component**




Source: Deloitte Access Economics' calculations.

# 6 Loss of wellbeing

For those experiencing inadequate sleep, less tangible costs such as the loss of quality of life, loss of leisure and physical pain are often as or more important than the health system costs or other financial costs of inadequate sleep.

This chapter presents a quantitative analysis of the loss of wellbeing and premature death both from inadequate sleep and other attributed health conditions. A disability adjusted life year (DALY) approach was taken to measuring the loss in the stock of health capital as a result of inadequate sleep.

## 6.1 Methodology

The 'burden of disease' methodology developed by the World Health Organization is a comprehensive measure of mortality and disability from diseases, injuries and risk factors for populations around the world[49]. It uses a non-financial approach, where pain, suffering and premature mortality are measured in terms of DALYs.

DALYs are a measurement unit that quantify the morbidity aspect and premature death associated with various diseases and injuries. DALY weights are measured on a scale of zero to one, where a zero represents a year of perfect health and a one represents death. Other health states are given a weight between zero and one to reflect the quality of life that is lost due to a particular condition. For example, a disability weight of 0.2 is interpreted as a 20% loss in the quality of life relative to perfect health.

YLDs were only estimated for EDS-SD and for conditions attributed to inadequate sleep. The sources used for disability weights were:

- In relation to sleep disorders with inadequate sleep (EDS-SD), primary insomnia was given a disability weight of 0.100 as per the Global Burden of Disease Study (Salomon et al, 2015). Disability weights for OSA and RLS were 0.105 and 0.120 as per Deloitte Access Economics (2011).
- The disability weights for type 2 diabetes and injuries due to MVAs were sourced from Begg et al (2007), while for workplace injuries the weighted average disability weight by severity from Access Economics (2004b) was used[50].

[49] http://www.who.int/topics/global_burden_of_disease/en/

[50] While Safe Work Australia regularly updates the costs of workplace injuries using the methodology employed in Access Economics (2004) it has not incorporated disability weights since the 2004 publication.

**Table 6.1: Disability weights for individual conditions**

| Condition | Weight | Source |
|---|---|---|
| OSA | 0.105 | Deloitte Access Economics (2011) |
| Insomnia | 0.100 | Deloitte Access Economics (2011) |
| RLS | 0.120 | Deloitte Access Economics (2011) |
| Congestive heart failure | 0.066 | Salomon et al (2015) |
| Coronary artery disease | 0.079 | Salomon et al (2015) |
| Stroke | 0.146 | Salomon et al (2015) |
| Type 2 diabetes | 0.07 | Begg et al (2007) |
| Depression | 0.178 | Salomon et al (2015) |
| Workplace injuries | 0.08 | Access Economics (2004) |
| MVAs | 0.049 | Salomon et al (2015) |

Source: as noted.

Disability weights for the combined burden of having EDS-SD and the associated condition were estimated using a simple multiplicative model which constrained the total possible disability weight to less than one. The formula is:

*DW (condition A and condition B) = 1 - (1 - DW condition A) * (1 - DW condition B)*
*where DW = disability weight*

For conditions attributed to other EDS or insufficient sleep, the disability weight is simply equal to that of the attributed condition.

**Table 6.2: Disability weights for comorbid conditions**

| Disorder and comorbid condition | Disability weight |
|---|---|
| **OSA and** | |
| Congestive heart failure | 0.16 |
| Coronary artery disease | 0.18 |
| Stroke | 0.24 |
| Type 2 diabetes | 0.17 |
| Depression | 0.26 |
| Workplace injuries | 0.18 |
| MVAs | 0.15 |
| **Insomnia and** | |
| Depression | 0.26 |
| Workplace injuries | 0.17 |
| **RLS and** | |
| Depression | 0.28 |

Source: Deloitte Access Economics calculations.

## 6.2 DALYs due to inadequate sleep

YLDs are then calculated by multiplying the prevalence of the various individual and comorbid conditions by their disability weights, from Table 6.1 and Table 6.2. **It was estimated that 162,598 YLDs were attributable to inadequate sleep in Australia in 2016-17.**

**Table 6.3: YLDs from inadequate sleep in Australia, 2016-17**

| Consequences | EDS-SD | Other EDS | Insufficient sleep | Total |
|---|---|---|---|---|
| Congestive heart failure | 865 | - | - | 865 |
| Coronary artery disease | 8,355 | - | - | 8,355 |
| Stroke | 3,286 | 2,154 | - | 5,441 |
| Type 2 diabetes | 4,728 | - | - | 4,728 |
| Depression | 19,714 | 19,281 | - | 38,995 |
| Workplace injuries | 2,030 | 2,794 | 1,532 | 6,355 |
| MVA | 1,633 | 1,461 | 1,255 | 4,349 |
| Inadequate sleep with no attributed condition | 93,510 | - | - | 93,510 |
| **Total** | **134,121** | **25,690** | **2,787** | **162,598** |

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

YLLs are derived from age-gender mortality rates, as discussed in Section 3.2, multiplied by expected years of life remaining for each age-gender group, using life expectancy tables from AIHW (2016b). No YLLs were calculated directly for EDS-SD, other EDS or insufficient sleep without attributed conditions, since these conditions have not been shown to contribute directly to premature mortality. The contribution of inadequate sleep to YLL occurs through the impact on other attributable health conditions. **It was estimated that 65,564 YLLs were attributable to inadequate sleep in Australia in 2016-17**.

**Table 6.4: YLLs from inadequate sleep in Australia, 2016-17**

| Consequences | EDS-SD | Other EDS | Insufficient sleep | Total |
|---|---|---|---|---|
| Congestive heart failure | 993 | - | - | 993 |
| Coronary artery disease | 22,478 | - | - | 22,478 |
| Stroke | 7,784 | 8,236 | - | 16,020 |
| Type 2 diabetes | 961 | - | - | 961 |
| Depression | 3,657 | 5,313 | - | 8,971 |
| Workplace injuries | 672 | 1,996 | 1,094 | 3,763 |
| MVA | 2,045 | 5,560 | 4,774 | 12,379 |
| **Total** | **38,591** | **21,105** | **5,869** | **65,564** |

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

Estimating DALYs caused by inadequate sleep represents the combination of YLDs from Table 6.3 with the YLLs from Table 6.4. Overall, it was estimated that **228,162 DALYs were attributable to inadequate sleep in Australia in 2016-17** (Table 6.5).

**Table 6.5: DALYs from inadequate sleep in Australia, 2016-17**

| Consequences | EDS-SD | Other EDS | Insufficient sleep | Total |
|---|---|---|---|---|
| Congestive heart failure | 1,858 | - | - | 1,858 |
| Coronary artery disease | 30,833 | - | - | 30,833 |
| Stroke | 11,070 | 10,390 | - | 21,460 |
| Type 2 diabetes | 5,688 | - | - | 5,688 |
| Depression | 23,371 | 24,595 | - | 47,966 |
| Workplace injuries | 2,702 | 4,790 | 2,626 | 10,118 |
| MVA | 3,679 | 7,021 | 6,029 | 16,729 |
| Inadequate sleep with no attributed condition | 93,510 | - | - | 93,510 |
| **Total** | **172,712** | **46,795** | **8,655** | **228,162** |

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

## 6.3 Monetary value of DALYs incurred

The DALY approach is not financial. A monetary conversion involves applying the value of a statistical life year (VSLY) for someone without health conditions to the total number of DALYs estimated for a particular condition.

Typically, a VSLY is derived from estimates of an individual's willingness to pay for a reduction in the risk of physical harm, based on market transactions. Examples include how much more people will pay to fly on safer airlines, or how much more compensation they demand to work in dangerous industries. The VSLY essentially estimates how much society is willing to pay to reduce the risk of premature death or purchase healthy life, expressed in terms of a saving a statistical healthy life year. In this report, a VSLY of $193,821 for 2016-17 was used based on Department of Prime Minister and Cabinet 2014 estimates updated for inflation.[51]

> Multiplying the VSLY by estimated DALYs, the total cost was estimated to be $40.1 billion in 2016-17. This is not a monetary cost to the economy in the traditional sense (i.e. a loss in national income). It is the value of a loss in the stock of health capital.

**Table 6.6: Cost of healthy life lost from inadequate sleep in Australia, 2016-17 ($m)**

| Consequences | EDS-SD | Other EDS | Insufficient sleep | Total |
|---|---|---|---|---|
| Congestive heart failure | 316 | - | - | 316 |
| Coronary artery disease | 4,903 | - | - | 4,903 |
| Stroke | 1,778 | 1,625 | - | 3,404 |
| Type 2 diabetes | 1,057 | - | - | 1,057 |
| Depression | 4,204 | 4,294 | - | 8,498 |
| Workplace injuries | 466 | 756 | 415 | 1,637 |
| MVA | 530 | 862 | 740 | 2,132 |
| Inadequate sleep with no attributed conditions | 18,124 | - | - | 18,124 |
| **Total** | **31,378** | **7,538** | **1,155** | **40,071** |

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

[51] https://www.dpmc.gov.au/sites/default/files/publications/Value_of_Statistical_Life_guidance_note.pdf .

# 7 Inadequate sleep cost summary

This chapter summarises the total costs of inadequate sleep.

**Key findings:** The total cost of inadequate sleep in Australia was estimated to be $66.3 billion in 2016-17, comprising $26.2 billion in financial costs and $40.1 billion in the loss of wellbeing. This equates to approximately $8,968 per person affected in both financial and wellbeing costs.

## 7.1 Total costs of inadequate sleep

The estimated components of financial costs are:

- health system costs of $1.8 billion, or $246 per person with inadequate sleep;
- productivity losses of $17.9 billion, or $2,418 per person with inadequate sleep;
- informal care costs of $0.6 billion, or $82 per person with inadequate sleep;
- other financial costs (including deadweight losses) of $5.9 billion, or $802 per person with inadequate sleep; and
- loss of wellbeing of $40.1 billion, or $5,420 per person with inadequate sleep.

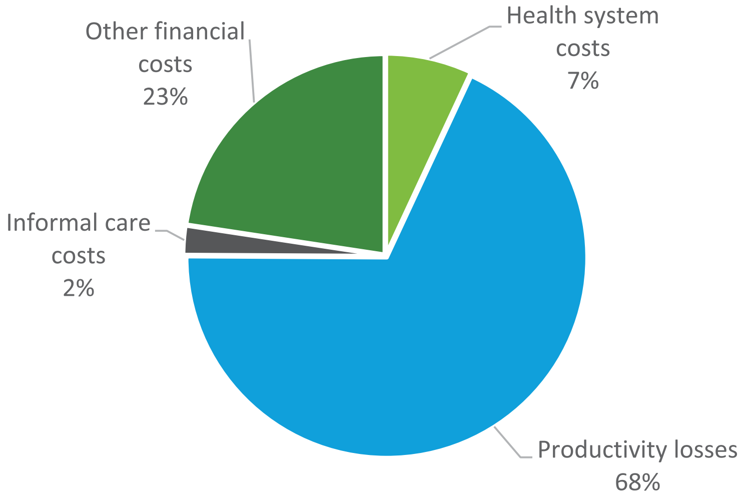
**Table 7.1: Total costs of inadequate sleep, 2016-17**

| Component | Value ($ billion) | Per person ($) |
|---|---|---|
| Health system costs | 1.8 | 246 |
| Productivity losses | 17.9 | 2,418 |
| Informal care costs | 0.6 | 82 |
| Other financial costs | 5.9 | 802 |
| *Total financial costs* | *26.2* | *3,548* |
| *Total loss of wellbeing costs* | *40.1* | *5,420* |
| **Total costs** | **66.3** | **8,968** |

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

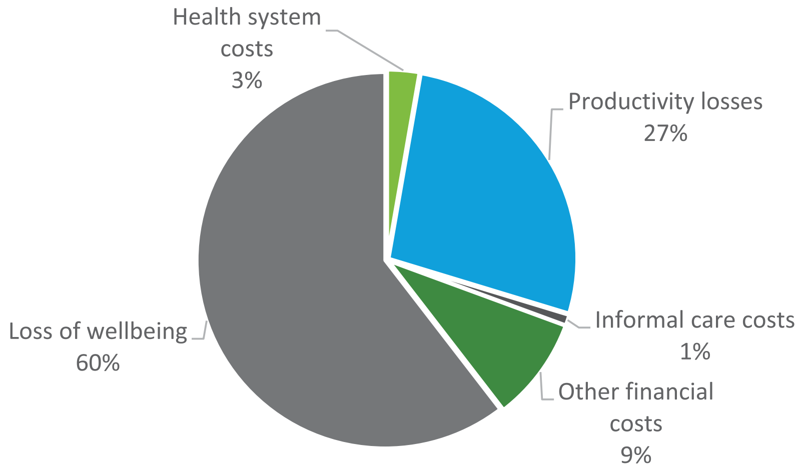
Chart 7.1 illustrates the financial costs associated with inadequate sleep in Australia for 2016-17. Overall, the majority of financial costs are expected to be associated with productivity costs (68%), followed by other financial costs (23%), health system costs (7%) and informal care costs (2%). Total costs reflect financial and wellbeing costs, of which lost wellbeing is expected to account for 60% in 2016-17 (Chart 7.2).

**Chart 7.1: Financial costs associated with inadequate sleep in Australia, 2016-17**




Source: Deloitte Access Economics calculations.

**Chart 7.2: Total costs associated with inadequate sleep in Australia, 2016-17**




Source: Deloitte Access Economics calculations.

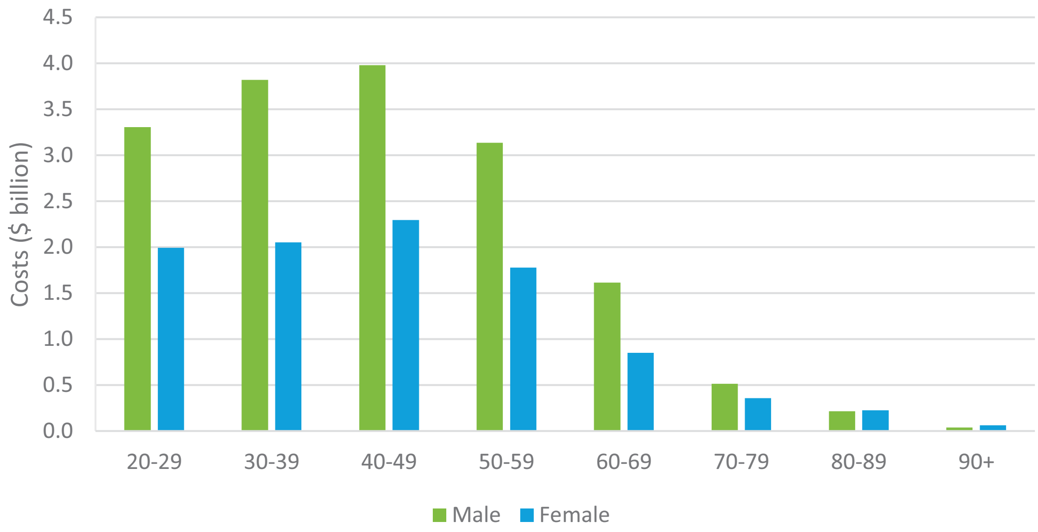
Table 7.2 shows the total estimated costs by age and gender. It is evident that males, particularly in the 30-69 age group, experience significantly higher financial costs in the form of lost productivity and participation in the workforce. The general trend is that men are expected to incur higher costs due to inadequate sleep, particularly before the age of 70, largely as a result of the larger productivity burden due to workplace injuries and MVAs in males of working age. These trends are illustrated in Chart 7.3 and Chart 7.4.

**Table 7.2: Total costs associated with inadequate sleep by age and gender, 2016-17 $ million**

| Age/ gender | Financial cost ($m) | Loss of wellbeing ($m) | Total cost ($m) |
|---|---|---|---|
| **Male** | | | |
| 20-29 | 3,306.3 | 2,549.8 | 5,856.2 |
| 30-39 | 3,817.3 | 2,688.3 | 6,505.6 |
| 40-49 | 3,979.5 | 3,323.0 | 7,302.4 |
| 50-59 | 3,135.3 | 3,682.5 | 6,817.8 |
| 60-69 | 1,612.5 | 4,153.5 | 5,766.0 |
| 70-79 | 512.8 | 3,189.1 | 3,701.8 |
| 80-89 | 215.4 | 1,151.3 | 1,366.7 |
| 90+ | 37.3 | 187.5 | 224.8 |
| *Male* | *16,616.3* | *20,925.1* | *37,541.4* |
| **Female** | | | |
| 20-29 | 1,990.8 | 2,228.9 | 4,219.7 |
| 30-39 | 2,051.2 | 2,427.1 | 4,478.3 |
| 40-49 | 2,295.1 | 2,615.6 | 4,910.6 |
| 50-59 | 1,777.7 | 2,720.8 | 4,498.5 |
| 60-69 | 850.5 | 3,854.1 | 4,704.6 |
| 70-79 | 358.5 | 3,379.3 | 3,737.7 |
| 80-89 | 225.2 | 1,533.3 | 1,758.5 |
| 90+ | 62.8 | 387.1 | 450.0 |
| *Female* | *9,611.6* | *19,146.3* | *28,757.9* |
| **Persons** | **26,227.9** | **40,071.3** | **66,299.2** |

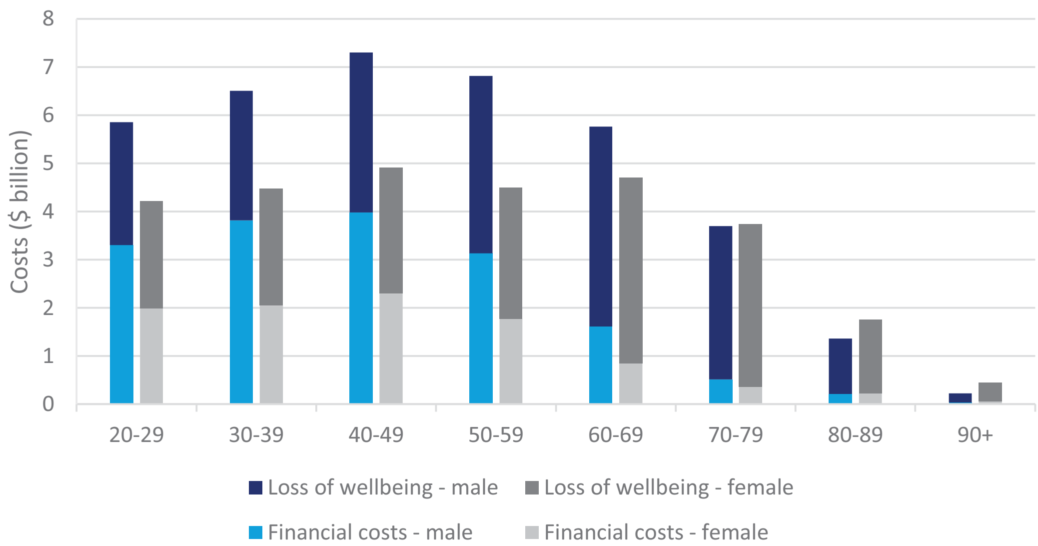
Source: Deloitte Access Economics calculations. Calculated as the sum of total loss of wellbeing, health system costs, productivity losses, informal care costs and other financial costs.
Note: components may not sum to totals due to rounding.

**Chart 7.3: Total financial costs associated with inadequate sleep by age and gender, 2016-17**




Source: Deloitte Access Economics calculations.

**Chart 7.4: Total cost associated with inadequate sleep by age and gender, 2016-17**




Source: Deloitte Access Economics calculations.

Finally, Table 7.3 presents the total costs by type of inadequate sleep in 2016-17. Other EDS was estimated to account for almost half (49%) of total costs, and half of productivity costs. Insufficient sleep was the next largest cost group – largely because of the large number of workplace injuries and MVAs that were attributed to insufficient sleep. EDS-SD was a smaller share of the total, but the cost per person was highest in this group - $5,417 compared with $5,181 and $1,972 for other EDS and insufficient sleep, respectively.

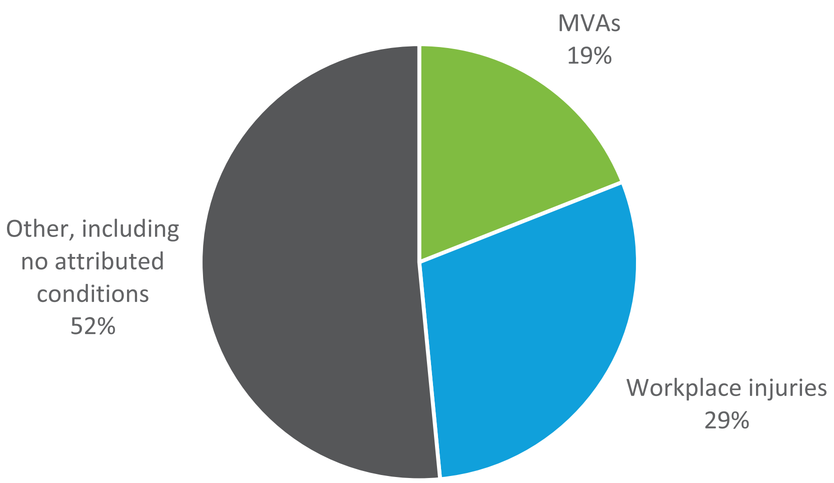
**Table 7.3: Total financial costs of inadequate sleep by cause and type, $ million**

| Cost | EDS-SD | Other EDS | Insufficient sleep | Total |
|---|---|---|---|---|
| Health system | 742.5 | 758.2 | 315.6 | 1,816.3 |
| Productivity | 3,977.9 | 9,228.0 | 5,277.0 | 18,482.8 |
| Other financial | 1,170.4 | 2,775.6 | 1,982.8 | 5,928.8 |
| **Total** | **5,890.8** | **12,761.8** | **7,575.4** | **26,227.9** |

Source: Deloitte Access Economics calculations.

As noted, workplace injuries and MVAs contribute substantially to financial costs and the loss of wellbeing attributable to inadequate sleep in Australia in 2016-17. Chart 7.5 shows that workplace injuries and MVAs combined account for almost half of total costs due to inadequate sleep in Australia – despite the large productivity costs of inadequate sleep without any attributed conditions.

**Chart 7.5: Breakdown of total costs attributed to inadequate sleep, by selected condition**




Source: Deloitte Access Economics calculations.

# 8 Recommendations

Inadequate sleep is a 26.2 billion dollar problem in financial terms (Table 7.3). However, aside from policy to manage the risk of fatigue such as through Safe Work Australia, it does not appear to receive much policy attention in Australia. For example, in the AIHW's (2016c) landmark Australian Burden of Disease Study, sleep issues are only included once, in a single sentence where sleep disorders are simply mentioned as being part of a group of other mental and substance use disorders[52]. The policy implications for each of the main causes of inadequate sleep are discussed below.

Essentially, there are two causes of inadequate sleep: that caused by sleep disorders and other health conditions, and that caused by lifestyle and behavioural factors. Most of the recommendations in this chapter focus on the latter, as policy can impact on people's decisions that affect their sleep. On the other hand, pre-existing health conditions are not so amenable to policy influence apart from enhancing existing efforts to identify and treat them.

## 8.1 Inadequate sleep caused by health conditions

Inadequate sleep from health conditions includes:

- primary sleep disorders;
- secondary sleep disorders; and
- EDS caused by conditions such as depression or diabetes.

### 8.1.1 Sleep disorders

Sleep disorders affect a significant proportion of the Australian population. This report estimated the joint prevalence (adjusted for comorbidity) of OSA, RLS and insomnia to be 22.4% of the Australian population. The majority of these people have inadequate sleep (section 2.4).

Given sleep disorders affect such a large portion of the population, this aspect of inadequate sleep is of particular interest to policy makers trying to improve the overall health of the population. Sleep disorders and its associated inadequate sleep put people at higher risk of cardiovascular diseases, type 2 diabetes, depression, MVAs and workplace injuries. If the prevalence of sleep disorders can be reduced, this can flow on to have multiple benefits, in the form of improved health and wellbeing for individuals and reduced costs borne by individuals, families, government, businesses and others in society.

EDS-SD and attributed conditions were found to significantly reduce employment or act as the trigger for early workforce separation. These productivity costs were estimated to be $4.0 billion in 2017, along with health system costs of $0.7 billion (Table 7.3).

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[52] Similarly, in the cumulative 1,000 plus pages of the latest Department of Health Annual Report, Corporate Plan and Portfolio Budget Statement, there is not a single mention of sleep or any s l condition.

It is a concern that we still know little about the causes of some primary sleep disorders, especially given the magnitude of the economic and social problems they precipitate. This presents a compelling argument to devote more research effort to discover the underlying aetiologies, and hopefully thereby effective methods of treatment and prevention.

### 8.1.2 Other EDS due to health conditions

In addition to the impacts of primary sleep disorders, other EDS can also contribute to a wide range of attributed conditions. Considerable effort is already devoted by Australian governments to tackling these chronic conditions, but to date it is likely that allocation of such effort has not adequately taken into account the relationships between these conditions and sleepiness. For example, the productivity costs from other EDS ($9.2 billion) are almost as large as those of EDS-SD and those from insufficient sleep put together, and health system costs are over three quarters of a billion dollars (Table 7.3). This argues for greater attention on lifestyle related causes of EDS such as smoking and obesity (Bixler et al, 2005).

## 8.2 Inadequate sleep caused by behaviours and other reasons

Around half (52%) of inadequate sleep in Australia is not due to medical conditions, but due to insufficient sleep from factors that in most cases people have control over (Table 2.8) – even if that might mean quitting their current job. The total productivity impacts of insufficient sleep are around 33% greater than productivity impacts of unavoidable EDS-SD causes ($5.3 billion as in Table 7.3). In addition, a substantial proportion of other EDS is caused by behavioural factors rather than by health conditions.

The main issues associated with inadequate sleep revolve around: lifestyle choice, unsafe or disruptive work hours, and the impacts of lighting and technology on sleep and sleepiness.

### 8.2.4 Lifestyle choices

Some individuals may choose to receive less than the required amount of sleep due to perceived better trade-offs from doing so. For instance, individuals may perceive the benefit of watching television late at night to be greater than receiving a proper amount of sleep.

To combat the choice to reduce overall sleep, effective policy should focus on increasing awareness and education of sleep and sleep hygiene. Awareness and education should focus on the short, medium and long term consequences of poor sleep on an individual. These may include: reduced productivity, dozing off at the wheel, or the development of a more serious medical condition. Bakotić et al (2009) performed an intervention study where students aged 15-18 years in the intervention group were provided with an education leaflet on proper sleep practices. Students in the control group did not receive a leaflet. The study found a positive effect of the leaflet in students aged 15-17 years old where these students reported improved sleep practices.

Another significant lifestyle choice affecting individuals is the introduction of the internet, and the ability for individuals to be constantly available for work related activities at home through technology, beyond standard working hours. This 24/7 society impacts on the ability of individuals to fully 'disconnect' from society and obtain proper rest. Bringing work into the home environment may also impact on a worker's circadian adaptation, particularly in a shift work environment.

Poor sleep hygiene likewise impairs an individual's ability to receive the required amount of sleep. Sleep hygiene involves ensuring a consistent sleep-wake schedule and a sleeping environment that is cool, dark, and quiet. It also entails promoting other good sleep behaviours, such as limiting substantial food intake, caffeine and alcohol consumption prior to bedtime (Wright et al, 2013).

### 8.2.5 Circadian rhythm disruption /shift work

Shift schedules that have been shown to increase safety risks include slow rotating, long duration and short breaks (Rajaratnam et al, 2013). Generally, it is recommended that the employer or person in the organisation responsible should consider circadian principles when designing shift work schedules (Kilpatrick et al, 2006). Another important consideration with a growing body of evidence indicates that employee choices in relation to their working schedules can mitigate some of the negative consequences of shift work (Eriksen et al, 2007).

Shift work has been identified as a significant factor affecting the likelihood of an individual injuring themselves on the road or in the workplace. In Australia, there are approximately 1.5 million employees who usually work in a shift work arrangement in their main job, representing 16% of the 9.3 million person workforce (ABS, 2013). The most common type of shift work is a rotating shift, whereby employees work one set of hours for a period and then rotate to a different set of hours. It has been estimated that 45% of those who work shift work do so on a rotating shift basis (ABS, 2013). Males are more likely than females to usually work shift work (18% compared to 14% for females) (ABS, 2013). For males, the industries with the highest proportion of shift workers are mining (47%) and accommodation and food services (44%), while for females it is accommodation and food services (33%) and health care and social assistance (30%) (ABS, 2013).

Shift work, including night shift and rotating or extended-duration shifts involve working at the time when the propensity for sleep is highest and consequently alertness is substantially impaired (Rajaratnam et al, 2013). The imposed sleep–wake cycle from shift work disrupts the body's natural circadian rhythm, which has a range of health and other consequences for shift workers. Even in permanent night shift workers, complete circadian adaptation does not occur and, as a result, many shift workers experience misalignment of their circadian pacemaker (Rajaratnam and Arendt, 2001, 2001).

Shift work is associated with reduced duration of sleep, impaired daytime sleep quality, and reduced alertness during night shifts (Akerstedt et al, 2008; Morgenthaler et al, 2007). The most immediate consequence of shift work is impaired mental alertness, which has widespread effects, including on reaction time, decision making, information processing and the ability to maintain attention (Rajaratnam et al, 2013). This impaired alertness leads to preventable errors, accidents, and injuries, especially in high-risk environments. Risks for errors and accidents are significantly elevated in shift workers, including those in safety-critical industries such as health care, law enforcement and commercial driving (Wright et al, 2013). Compared with day workers, shift workers appear to have a nearly three-fold increased risk of occupational accidents (Swanson et al, 2011). The risk of occupational accidents is increased (relative risk of 1.6) when working outside regular daytime hours

(Akerstedt et al, 2002). Sleep-related accidents occur most commonly during night shifts in transportation fields, with a peak occurring towards the end of the shift (Wright et al, 2013).

Other safety-related consequences of shift work include fatigue-related driving accidents. Shift workers have impaired driving performance and have been reported to have a two to four times greater risk of crashing during their commute to and from work (Barger et al, 2009). In addition to personal and public safety risks, productivity is impaired, with frequent workplace errors and increased absenteeism (Wright et al, 2013). Shift work has a range of health and safety-related impacts that can affect the worker and others, as well as reducing productivity of shift workers.

In light of this, policy changes should focus on the following key areas:

- promoting circadian adaptation in permanent shift workers;
- facilitating restorative sleep when sleep is required; and
- promoting sustained alertness during wake episodes, particularly when working.

### 8.2.6 Excessive work hours

Unsafe hours of work resulting in inadequate sleep can have a range of negative consequences. This is particularly relevant in work sectors where sleep is irregular but responsibility is high, such as the defence, transport or medical sector. In the medical sector, there is much evidence that fatigue leads to accidents and injuries which may include sharps and needle stick injuries, exposure to blood, bodily fluids or pathogens, errors in drug administration or patient identification, and incorrect machine operation. Zhao et al (2010) conducted a meta-study on shift-work and injury rates in health workers. Among the seven studies examining the association between shift-work and blood or body fluid exposure, six studies indicated that shift-work was associated with higher risk of blood or body fluid exposure. The different kinds of shift-work impacting on higher risk of blood or body fluid exposure included long working schedules (over eight hours), rotating shifts, and night shift. An intervention study by Landrigan et al (2004) found that interns in a large academic hospital in Boston made 35.9% more serious medical errors during their traditional schedule than during an intervention schedule which eliminated extended work shifts (24 hours or more) and reduced the number of weekly scheduled hours of work.

In addition to medical and patient safety risks for the patients and interns, risks of fatigue continue once staff leave the work place. Barger et al (2005) found that the odds of medical interns in the United States reporting to have been involved in a motor vehicle crash or near-miss accident after an extended work shift (more than 24 hours) was almost double compared to after shorter shifts. They concluded that "every extended work shift that was scheduled in a month increased the monthly risk of a motor vehicle crash by 9.1% and increased the monthly risk of a crash during the commute from work by 16.2%" (Barger et al, 2005, p.125).

In contrast to other countries, working hours in Australia are not specifically regulated and are instead determined by industrial instruments and within the general obligations imposed by occupational health and safety legislation (AMA, 2012)[53]. The Australian Medical Association (AMA) has developed a voluntary code that provides practical guidance on how

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[53] See for example, Safe Work Australia (2013).

to manage fatigue and eliminate or minimise the risks associated with shift work and extended working hours (AMA, 2016). This code does not provide absolute and enforceable limits, such as the maximum length of a safe shift or the break required between episodes of work; however, it does provide a Risk Assessment Guide and a Risk Assessment Checklist to help assess the risk level of an individual's working hours (AMA, 2016).

Using the risk assessment tools, the AMA audits the work patterns of doctors every five years. The 2011 audit found that 53% of hospital doctors fell into the significant and higher fatigue risk categories. While this was an improvement from the 2006 survey when it was 62% and from the 2001 survey when it was 78%, this is none-the-less evidence that there are still many practitioners who are at risk of fatigue. The 2011 audit also found that while the overall trend improved, certain aspects had become worse. For example, the longest recorded shift increased from 39 hours in 2006 to 43 hours in 2011 and the maximum total number of hours worked during the audit week went up from 113 in 2006 to 120 in 2011. The average of total hours worked in the 2011 audit week for all hospital doctors was 55.1 hours (AMA, 2012).

Fatigue due to long hours is not only limited to the medical sector. In the transport sector, long shifts of driving can have serious consequences. The United States National Transportation Safety Board estimates that fatigue is a contributing factor for 30 to 40% of all heavy truck accidents (National Transportation Safety Board, 2016). Melamed et al (2002) assessed the impact of EDS in 532 non-shift daytime workers. Of the workers studied, 22.6% had EDS, and logistic regression analysis indicated that, during the two-year period prior to the procedure, EDS was associated with an increased risk of sustaining a work injury (odds ratio = 2.23), even after controlling for possible confounders, including factory category, job and environmental conditions. Due to the nature of the work, military workers may occasionally work for long periods of time, and resulting fatigue can have a significant impact on operations including reduced communication, misinterpretation, a tendency to abbreviate or skip routine checks, as well as resulting in a low morale (Department of Defence, 2002).

This evidence has a range of potential policy implications, and the responsibility for reducing fatigue must be shared amongst government, industry, the work force, the public and the scientific community (Åkerstedt 2000). From a public policy perspective, Åkerstedt (2000) and Hafner et al (2016) recommended educating people and raising awareness of the benefits of sleep, as well as supporting further research and monitoring in the area of sleep in order to establish an evidence base for potential regulation, practice and policy regarding fatigue, sleep and accident risk.

Policies providing encouragement and support for health professionals in providing sleep-related help may also be valuable in identification and treatment of sleep related issues. For workplaces, there is evidence that workspaces with natural light may promote sleep health, and it is imperative that remuneration does not encourage unsafe work practices. Conducting analyses as to why strategies designed to prevent fatigue-related accidents are not implemented can contribute to ensuring that these barriers are overcome (Åkerstedt 2000).

In hospital settings, the AMA lobbies for improvements in the management of fatigue as a key patient safety issue. The AMA Safe Hours Audit 2011 states that evidence suggests that cutting work hours does not have a detrimental effect on patient safety or the learning outcomes of doctors in training; however, they also state that there is no conclusive evidence that reduced working hours, in isolation, have a positive effect on patient safety and that reduced working hours must be supported by other changes including better staffing levels and dedicated patient handover arrangements (AMA, 2012). In the defence field, Giam (1997) suggests personnel should be enabled to sleep the recommended 7-8 hours per 24 hours in the week before an operation where they are likely to sleep less, and that during operations sleep management plans should attempt to avoid situations where all personnel are exhausted at the same time. The Department of Defence also provides guides for preventing fatigue, including imposing sensible work demands, fostering morale and whenever possible reducing 'sleep debt' (the cumulative loss of sleep over time sometimes expressed as the amount of sleep required to restore performance levels). These factors may also be applicable to other fields of work.

### 8.2.7 Impact of lighting and technology on sleep and sleepiness

Melatonin is a hormone made in the pineal gland of people's brains, which plays a role in regulating sleep cycles. The pineal gland will normally produce melatonin when the sun goes down and there is a lower exposure to light, usually at around 9pm (Schlangen, 2014). Naturally, the body has an internal clock which typically runs with an average period of 24 hours and 15 to 30 minutes. As this is slightly longer than the conventional 24 hour clock, this means a natural shift occurs each day which without intervention would make people more dependent on alarm clocks each day (Schlangen, 2014). Light plays a vital role in the adjustment of people's internal clocks, or 'circadian rhythm'. There is a significant amount of evidence that exposure to light has the potential to influence people's biological clocks, and that light exposure before going to sleep can lower a person's production of melatonin and decrease the body's ability to initiate sleep, deregulating sleep/wake rhythms (Olds et al, 2010; Santhi et al, 2011; Schlangen, 2014).

Many studies have found that in in addition to presence and brightness of light, the type of light is also a factor in melatonin production (Santhi et al, 2011; Giménez et al, 2014, Schlangen, 2014). Blue or short-wavelength light, which tends to be emitted by electronic devices, has been found to be more disruptive to melatonin production than long-wavelength light yellow or orange light. The issue of light exposure before going to bed has become more relevant with the introduction of electronics into everyday use, such as smart phones, laptops, tables, and televisions. The AIHW (2011) indicates that children who spend on average three hours of screen time a day are more likely to experience higher rates of poor sleep experience and worse educational outcomes than children who spend less time in front of screens.

While exposure to light shortly before attempting to sleep can be disruptive, exposure to morning and day light plays a vital role in adjusting of the internal circadian clock (Brown and Robinson 2008). For non-shift workers, a study by Boubekri et al (2014) found that workers in windowless environments with little access to natural daylight reported more physical problems and sleep disturbances and poorer vitality and overall sleep quality than workers with windows. For night shift workers, Horowitz et al (2001) found that subjects receiving bright light throughout the shift in combination with sleep/darkness scheduling was effective in shifting of sleep cycles.

An implication of this is the use of melatonin supplements, either as a sedative or to reset the internal body clock to a different time, for people who struggle to sleep. Light therapy through exposure to dim light before attempting to sleep and bright light upon waking up may also be effective in order to encourage adjustment of the body's circadian rhythm. Disruption of sleep cycles could in some cases be decreased through abstaining from using electronic devices and bright lights several hours before preparing to go to sleep, and the spectral composition of artificial light could be modified to minimise their disruptive effect on sleep (e.g. programming devices to emit less blue/short wave length light at night). These implications may be relevant to policy in terms of raising public awareness and creating work environments which take these factors into account. Potential workplace interventions that have the potential to improve the sleep health of employees may therefore include placing employee workstations close to windows during the day in order to enable exposure to natural light, and in offices with few or no windows creating outdoor break spaces or otherwise incorporating natural sunlight, particularly in the morning. For shift workers, light quantity and type can also be used in order to induce adjustment of sleep cycles and improve alertness during the shift.

## 8.3 Conclusion

Improving the nation's sleep health requires encouraging and enabling behavioural change and increased awareness of adequate sleep practices and sleep disorders. A concerted national approach is required where inadequate sleep is seen as the vast, varied and costly problem that it is, and addressed by influencing behavioural change and increasing awareness of sleep conditions and their treatment.

Specifically, this report recommends increased policy effort be devoted to:

- research on the causes of primary sleep disorders;
- encouraging prevention and early detection;
- enhancing development and implementation of cost-effective treatment for sleep problems;
- reducing smoking, obesity and other lifestyle causes of EDS;
- raising awareness of the importance of sleep hygiene;
- occupational health and safety regulations that reduce circadian rhythm disruption from shift work and fatigue from excessive work hours - possibly including restrictions on driving without adequate sleep beforehand;
- building design standards that increase natural light; and
- education about the benefits of switching away from blue light on screens at night.

In Australia in 2016-17, inadequate sleep imposed financial losses of $26.2 billion, and loss of wellbeing valued to be $40.1 billion. Creating effective change in the nation's sleep health will take time, but in combination these recommendations will help to reduce the burden of inadequate sleep in Australia.

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# Appendix A: Supplementary methodology

## 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:

$$q1.s1 + q2.s2 = p1 \quad (1)$$

$$q1/(1 - q1)/(q2/(1 - q2)) = OR \quad (2)$$

where:

*q1 = probability of having the particular condition given that an individual has a sleep condition*
*q2 = probability of having the particular condition given that an individual does not have a sleep condition*
*s1 = share of people with a sleep condition = probability of having a sleep condition*
*s2 = share of people without a sleep condition = probability of not having a sleep condition*
*p1 = probability of having the particular health condition*
*OR = odds ratio for that particular condition for individuals with a sleep condition*

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

$$PAF = \frac{(q1 - q2).s1}{p1} \quad (3)$$

Equation (3) was used to determine the PAF for each condition due to EDS-SD, other EDS, and insufficient sleep. Where epidemiological studies reported relationships in terms of a hazard ratio, the hazard ratios were assumed to be roughly equivalent to relative risk ratios.[54] The PAF was calculated using the following equation, taken from Eide and Heuch (2001).

$$PAF = \frac{s1.(RR - 1)}{s1.(RR - 1) + 1} \quad (4)$$

where:
*s1 = share of people with sleep condition = probability of having a sleep condition*
*RR = relative risk ratio*

[54] Choi et al (2010) show that where the risk of an event is rare, relative risk ratios are numerically quite similar to hazard ratios.

# 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 costs of inadequate sleep in Australia. You should not refer to or use our name or the advice for any other purpose.

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- Ageing and Sleep
- Anaesthesia, Sleep and Sleep Apnea
- Anxiety and Sleep
- Bedwetting
- Behavioural Sleep Problems in School Aged Children
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- Menstrual Cycle and Sleep
- Napping
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- Nightmares
- Obstructive Sleep Apnea
- Oral Appliances to Treat Snoring and Obstructive Sleep Apnea
- Periodic Limb Movements of Sleep (PMLS)
- Post Traumatic Stress Disorder
- Pregnancy and Sleep
- REM Sleep Behaviour Disorder
- Restless Legs Syndrome
- Schizophrenia and Sleep
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- Sleep Myths
- Sleep Problems and Sleep Disorders in School Aged Children
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- Sleep Study
- Sleep Terrors
- Sleep Tips for Children
- Sleep Tips for New Mothers
- Sleep Tracker Technology
- Sleeping Better in Your Hotel
- Sleeping Tablets
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- Snoring
- Surgery for Obstructive Sleep Apnea (OSA)
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- Teenage Sleep
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- Ten Tips for a Good Night Sleep
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