HCIA

THE SOCIAL AND ECONOMIC COST OF HEARING LOSS IN AUSTRALIA

JUNE 2017

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Contents

Charts

Tables

Figures

Glossary

Acronym	Full name
AABR	automated auditory brainstem response
AAC	augmentative and alternative communication
ABS	Australian Bureau of Statistics
ACCC	Australian Competition and Consumer Commission
ACMA	Australian Communications and Media Authority
ADCET	Australian Disability Clearinghouse on Education and Training
AIHW	Australian Institute of Health and Welfare
ALSA	Australian Longitudinal Study of Ageing
APD	auditory processing disorder
AR-DRG	Australia refined diagnosis related groups
ASSD	Additional Support for Students with Disabilities
AWE	average weekly earnings
BMES	Blue Mountains Eye Study
CHI	centres for the hearing impaired
CI	confidence interval
CPI	consumer price index
CVD	cardiovascular disease
DALY	disability adjusted life year
dB	decibels
DECD	Department for Education and Child Development
DHS	Department of Human Services
DoH	Department of Health
DSP	Disability Support Programme
DSPN	Disability Support Pension
DSS	Department of Social Services
EHIMA	European Hearing Instrument Manufacturers Association
EU	European Union
FTE	full time equivalent
GP	general practitioner
HCIA	Hearing Care Industry Association
HR	hazard ratio
IHPA	Independent Hospital Pricing Authority
ICPC-2	International Classification of Primary Care-2nd edition
kHz	Kilohertz
LOCHI	Longitudinal Outcomes of Children with Hearing Impairment study
3MS	Modified Mini-Mental State Examination

NABS	National Auslan Interpreter Booking & Payment Service
NHANES	National Health and Nutrition Examination Survey
NHMRC	National Health and Medical Research Council
NHS	National Health Survey
NIHL	noise induced hearing loss
NRS	National Relay Service
NSA	Newstart Allowance
OHS	Office of Hearing Services
PCHL	permanent congenital hearing loss
PTA	pure tone average
QALY	quality adjusted life years
RNID	Royal National Institute for Deaf People
SA	Sickness Allowance
SCENIHR	Scientific Committee on Emerging and Newly Identified Health Risks
SDAC	Survey of Disability, Aging and Carers
SNR	signal to noise ratio
SSO	School Support Officer
UK	United Kingdom
UNHS	Universal Neonatal Hearing Screening Program
US	United States
VSL(Y)	value of a statistical life (year)
WHO (HPQ)	World Health Organization (Health Performance Questionnaire)
YLD	years of healthy life lost due to disability
YLL	years of life lost due to premature death

Executive summary

In 2006, Access Economics quantified the impact and estimated impact of both the financial costs and the loss of wellbeing from hearing loss in Australia in 2005. The Hearing Care Industry Association (HCIA) has commissioned Deloitte Access Economics to update this report for 2017, with the intention of raising awareness of the economic cost of hearing impairment in Australia and to inform policy making. Information from research analysis is important to help ensure that available resources are directed towards the most effective preventive and therapeutic interventions.

Key Findings

The prevalence of hearing loss, in the better ear, is estimated to be 3.6 million people in Australia in 2017, which is expected to more than double to 7.8 million by 2060.

Almost half (49%) of childhood hearing loss is preventable, as is over a third (37%) of adult hearing loss.

The financial costs of hearing loss in 2017 were estimated as $15.9 billion, and the value of the lost wellbeing as $17.4 billion, for total costs of $33.3 billion.

Extending the hearing aid voucher program to unemployed people would yield $5.20 in benefits for each dollar spent.

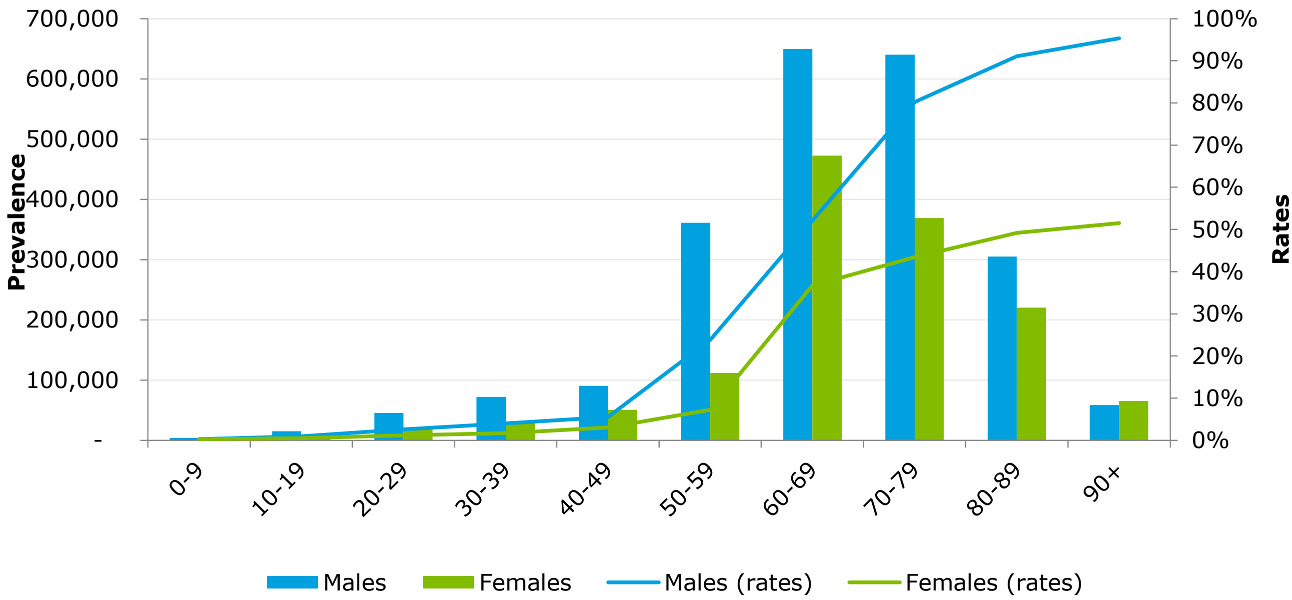
Prevalence of hearing loss

Hearing loss is a relatively common condition that affects approximately one in seven people in Australia. **The prevalence of hearing loss, in the better ear, was estimated to be 3.6 million people in Australia in 2017**,[1] or 14.5% of the population. In 2005, Access Economics (2006) estimated the prevalence of hearing loss to be 2.6 million people, or 12.9% of the 2005 population. This represents a 38.5% increase in estimated prevalence from 2005 to 2017.

Chart i shows the number of cases of hearing loss and the prevalence rates of hearing loss (better ear) by age and gender. In 2017, there are more males (2.2 million) with hearing loss than females (1.4 million). Prevalence rates increase with age, with most men expected to have at least mild hearing loss by the age of 65, and most women by age 90. Chart i shows that the number of cases of hearing loss. The number of cases of hearing loss peaks in the 60-69 age range, then decreases for both males and females. This is primarily driven by the decreasing underlying population.

[1] Measured as 25 decibels (dB) or worse loss in the better hearing ear. In this report, hearing loss refers to loss in the better ear, unless otherwise stated.

Chart i: Number of cases of hearing loss and prevalence rates (better ear), by age and gender, 2017



Source: Deloitte Access Economics calculations

Projections of hearing loss show that prevalence is expected to more than double to 7.8 million by 2060, comprising 4.9 million males and 2.9 million females. This indicates that approximately one in every five people in 2060 will have some form of hearing loss.

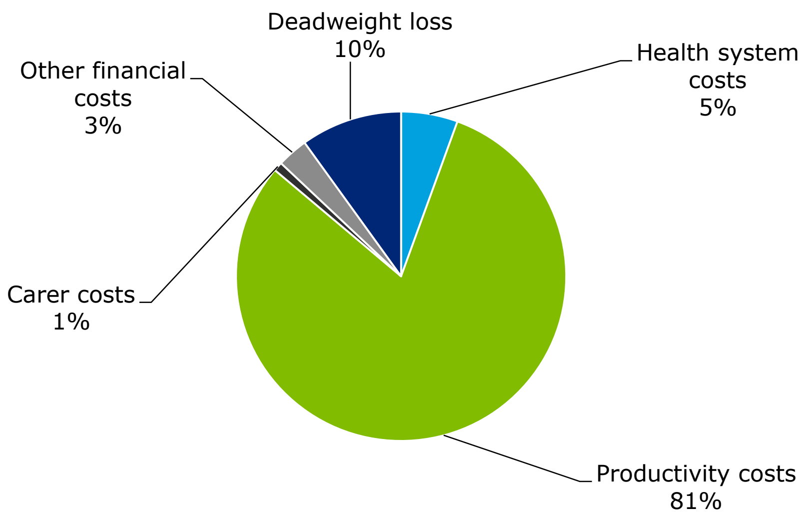
The World Health Organization (2016) estimates that in developed countries, **49% of childhood hearing loss is preventable**. Preventable hearing loss can be caused by meningitis, rubella, ear infection and glue ear, all of which can be prevented through good hygiene and, in some cases, immunisations. **For adults, it was estimated that 37% of hearing loss is due to preventable causes,** primarily noise-induced.

Costs associated with hearing loss

The financial costs of hearing loss in 2017 were estimated as $15.9 billion, comprising:

- health system costs of $881.5 million, or $245 per person with hearing loss. The largest component of health system costs was the cost of the Office of Hearing Services program that is provided by the Australian Government ($521.4 million);
- productivity losses of $12.8 billion, or $3,566 per person with hearing loss, most of which was due to reduced employment of people with hearing loss ($9.3 billion);
- informal care costs of $141.6 million, or $39 per person with hearing loss;
- deadweight losses of $1.6 billion, or $440 per person with hearing loss; and
- other financial costs of $480.3 million, or $134 per person with hearing loss.

Chart ii: Financial costs of hearing loss in Australia, 2017

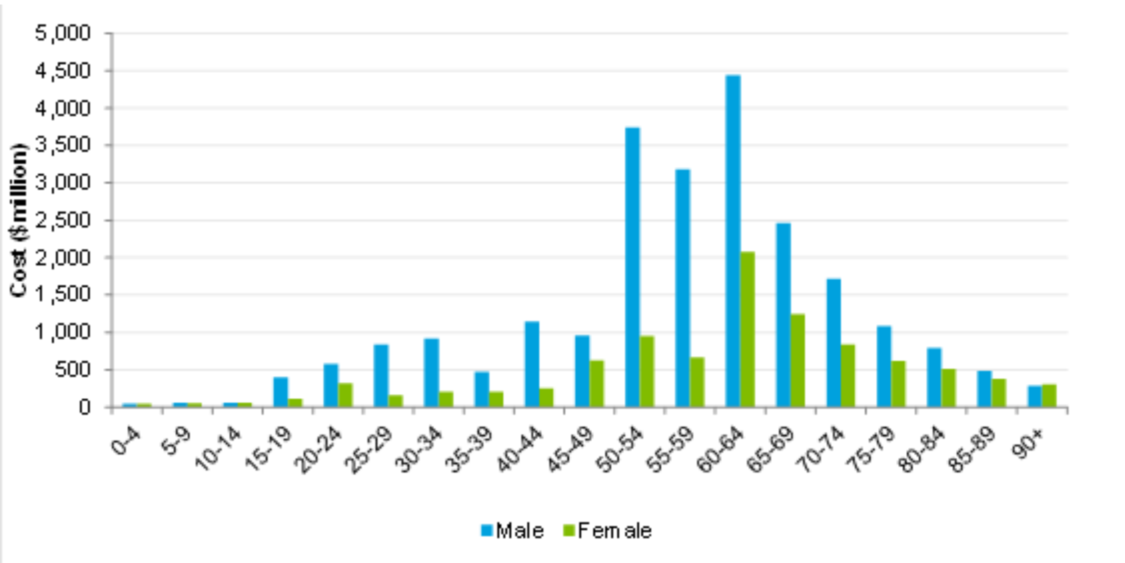


Source: Deloitte Access Economics calculations.

In addition to financial costs, hearing loss imposes a significant reduction of wellbeing, estimated for 2017 as 90,223 disability adjusted life years[2]. **The value of the lost wellbeing was estimated to be $17.4 billion in 2017,** which represents 52% of total costs attributed to hearing loss.

Chart iii shows the total costs of hearing loss in Australia in 2017. Males aged 50-64 bore the highest costs, due to the larger productivity losses and significant underlying prevalence in these cohorts.

Chart iii: Total costs of hearing loss in Australia, by age group and gender, 2017



Source: Deloitte Access Economics calculations

[2] This terminology is globally adopted and understood, so is used in this report although acknowledging that some stakeholders would prefer different semantics.

Impact of potential interventions

Two potential interventions were analysed at the request of HCIA to estimate their possible costs (in the first case) and benefits (in the second case) if introduced in Australia.

1. A free hearing screening program that provides hearing assessments for people aged 50 years and over, as part of a comprehensive 50+ health check program, has the potential to benefit people in achieving timely hearing services for hearing loss (HCIA has made a submission to Government about how this program could be structured). A United Kingdom (UK) based cost benefit analysis found that screening people aged 55 and 65 had strong positive net benefits, and a benefit-to-cost ratio of 8.1 for those aged 55 and 8.2 for those aged 65 (London Economics, 2010). Costs in Australia were calculated assuming people aged 50, 55, 60, 65, 70, 75 and 80 were invited for a hearing assessment. For those aged 50, 55 and 65, it was assumed that 55% of people would take up the invitation, while for those aged 65, 70, 75 and 80, it was assumed that 65% would take it up. The cost of a hearing assessment, as reported by the Office of Hearing Services Fee Schedule for 2016-17, was $136.25 per person (Department of Health, 2016g), leading to an estimated screening cost of $134.3 million in 2017.

2. Free hearing aids are provided to young Australians (people under 26 years of age), older Australians (pensioners and veterans), but not to Australians of working age. Evidence from the UK suggests that extending the hearing aid voucher program to cover low income people of working age would improve the employability of unemployed Australians with hearing loss. The UK example shows that providing free hearing aids could reduce the gap in employment between people with hearing loss and people with hearing by about two thirds. Based on that evidence, extending the hearing aid voucher program to unemployed Australians with hearing loss could represent an estimated additional 48,768 of those people gaining jobs. Assuming that each of these people would receive at least the minimum wage then total benefits would be $1.7 billion. The costs of extending the program were estimated to be $326.4 million. The subsequent cost benefit ratio was calculated to be 5.2. That is, on average, for the average **dollar invested in extending the hearing aid voucher program there is a $5.20 return in benefits**.

1 Study context

1.1 Need for this study

Deloitte Access Economics was commissioned by the Hearing Care Industry Association (HCIA) to update the 2006 Access Economics report *Listen Hear!*. We understand that this report will be used to inform ongoing policy development in relation to hearing health. In the first instance it will be part of a submission into an inquiry being undertaken by the Parliamentary Standing Committee on Health, Aged Care and Sport.

This report has been structured in the following manner:

- **Chapter 2** provides an introduction to this report, including a brief review of the causes of hearing loss, thresholds of hearing loss, comorbidities, and treatment and care pathways;
- **Chapter 3** presents prevalence and mortality estimates for hearing loss, including a review of the available literature;
- **Chapter 4** outlines the costs of hearing loss to the Australian health system by type of cost;
- **Chapter 5** looks at the productivity costs and other financial costs of hearing loss, including education and support services, aids and modifications, and informal care;
- **Chapter 6** estimates the total loss of wellbeing due to hearing loss;
- **Chapter 7** provides an analysis of the cost of an annual screening program and the benefits of free hearing aids to working age Australians with hearing loss; and
- **Chapter 8** summarises the total costs.

2 Background

Hearing is the ability to detect vibrations through the ear and to perceive and understand sound. It is a primary sense, which enables communication, together with vision and touch. A hearing loss essentially limits one's ability to communicate orally, and through this, limits a person's ability to interact with their community, in the absence of appropriate supports such as cochlear implants, hearing aids and sign language.

Hearing loss can be classified in the following ways (Niparko, 2012):

- **conductive hearing loss**, in which lesions in the external auditory canal, tympanic membrane, or middle ear, prevent sound from being conducted to the inner ear;
- **sensorineural hearing loss**, in which hearing loss is caused by lesions of either the inner ear or the auditory nerve; and
- **mixed loss**, which may be caused by severe head injury, chronic infection, genetic disorders, or when a transient conductive hearing loss occurs in conjunction with a sensorineural hearing loss.

2.1 Causes of hearing loss

The aetiology of hearing loss can vary significantly, depending on the affected individual. Hearing loss can be congenital (present at birth) or acquired; progressive or sudden; and temporary or permanent.

Causes of hearing loss can include the following (World Health Organization, 2015):

- **Congenital causes** – hearing loss may be caused by hereditary and non-hereditary genetic factors, prenatal exposure in utero to maternal disease or inappropriate drug use, or during childbirth, such as birth asphyxia, severe jaundice, and low birth weight resulting from premature birth.
- **Noise exposure/Noise-induced hearing loss (NIHL)** – single instances of extreme noise and prolonged exposure to noise can lead, respectively, to sudden or gradual sensorineural hearing loss, as a result of damage to the sensory cells. NIHL is commonly associated with occupational-related noise in industries such as agriculture, manufacturing and construction and may occur with noisy leisure pursuits.
- **Ageing** – age-related hearing loss, also known as presbycusis, can occur progressively with age and involves sensorineural hearing loss as a result of the degeneration of the cochlea and or auditory nerve.
- **Diseases and disorders** – hearing loss can result both directly and indirectly from a variety of different conditions, including autoimmune disorders, chronic ear infections, meningitis, measles, mumps and otitis media. The latter occurs as the result of infection or collection of fluid in the ear and is particularly prevalent among children.
- **Use of particular drugs** – hearing loss may result from the use, or abuse, of particular drugs such as some antibiotic[3] and antimalarial medicines.
- **Physical trauma** – hearing loss can occur as the result of physical trauma, caused by injuries either to the ear itself or to the brain.
- **Cerumen accumulation** – temporary minimal hearing loss may be caused by the build-up of cerumen (earwax) or other foreign bodies in the ear canal, which prevents sound from being effectively conducted.

2.2 Severity of hearing loss

There are a variety of thresholds that are used to define whether a person has hearing loss. Stevens et al (2011)[4] define different hearing loss levels as mild, moderate, moderately severe, severe, profound and complete. Other studies use other categorisations such as mild, moderate and severe. Table 2.1 compares the Stevens thresholds to both the World Health Organization (WHO) definitions (Mathers et al, 2000) and the definitions used in the European Union (EU) (Martini et al, 1996).

[3] Certain chemotherapeutic agents have been found to cause hearing loss (Ryback and Whitworth, 2005).
[4] Stevens et al (2011) is an audiometric study of 29 countries including Australia, the United States and the United Kingdom for the Global Burden of Disease study.

Table 2.1: Different thresholds of hearing loss

	WHO	EU	Stevens et al (2011)
Mild	26-40 dBHL	20-40 dBHL	20-34 dBHL
Moderate	41-60 dBHL	40-70 dBHL	35-49 dBHL
Moderately severe			50-64 dBHL
Severe	61-80 dBHL	70-95 dBHL	65-79 dBHL
Profound	81+ dBHL	95+ dBHL	80-94 dBHL
Complete			95+ dBHL

Source: Mathers et al (2000), Martini et al (1996) and Stevens et al (2011).

This report uses the same Office of Hearing Services (OHS) severity definitions as used in Access Economics (2006):

- mild: 25 – 45 dB;
- moderate: 45 – 65 dB; and
- severe: 65 dB+.

More discussion about the hearing loss severities for this analysis is included within section 3.2.2.

2.3 Treatment and care pathways

Based on the cause of the hearing loss, some specific treatments exist that can be administered to an individual with hearing loss if their impairment is curable (Niparko, 2012). The more common medical and surgical interventions include, in the case of an ear canal obstruction, blockages by matter such as excess cerumen, benign growths or tumours may be addressed through removal of the foreign object(s). Similarly, where hearing loss is caused by fluid build-up in the middle ear, fluid can be drained through a surgical incision, known as a myringotomy, and further fluid build-up prevented with the insertion of a tympanostomy tube, to keep the middle ear aerated. Hearing loss resulting from autoimmune disorders or conditions such as otitis media may be treated through the use of appropriate medications, such as corticosteroids or antibiotics. Structural deformities in the middle ear or the outer ear may be rectified surgically. Where the cause of the hearing loss cannot be cured, care pathways may involve compensating for the hearing loss through the use of the following aids and modifications, and assistive mechanisms:

- **Hearing aids** – hearing aids can help individuals with hearing loss by amplifying sound and facilitating improved communication. Hearing aids can differ in model, completely in the ear canal, in the canal, in the ear and behind the ear, and are prescribed depending on the individual's listening goals, severity of one's hearing loss, and other individual specific medical and social circumstances. As hearing aids have become more sophisticated and smaller, the styles of hearing aid that suit different severities and configurations of hearing loss and address cosmetic concerns have improved. In order to ensure that amplification is as natural and responsive as possible, hearing aids are customised to a person's particular pattern of hearing loss (e.g. selective amplification of relevant frequencies).
- **Cochlear implants** – a cochlear implant is a medical device which is surgically implanted into the cochlear, and worn with an external sound processor. A cochlear implant provides signals to the brain by converting sound to electrical signals that directly stimulate the auditory nerve via multiple electrodes. Unlike hearing aids, which work by magnifying sound to overcome impaired function of the cochlear hair cells, cochlear implants operate by simulating the auditory nerve in the inner ear directly. Cochlear implants are best suited to individuals with severe levels of hearing loss or for individuals who do not benefit from conventional hearing aids, and who have an intact auditory nerve.
- **Bone conduction and middle ear implants** – bone conduction and middle ear implants are surgically implanted to overcome a conductive hearing loss or a single sided deafness. Similar to the cochlear implant, an external sound processor converts sound energy into mechanical energy, and directly stimulates the middle ear, overcoming a conductive hearing loss. These implants can also be used to treat single sided deafness.

- **Brain stem implants** - individuals who have had both acoustic nerves damaged by tumours, disease or trauma may benefit from the use of a brain stem implant, which uses sound-detecting and sound-processing devices to convert sound to electrical signals that are delivered to auditory centres in the brainstem via implanted electrodes.
- **Assistive approaches** – individuals with hearing loss and auditory processing disorders (APDs) can also use a variety of assistive mechanisms to help cope with their hearing loss and disordered sound processing. Special sound systems can help transmit infrared or FM to radio signals to help people hear where there may be excess of conflicting noise, while visual signals or supports, such as lights or subtitles, can assist in place of solely auditory ones. People with hearing loss can also use lip-reading or speech-reading to help discriminate between sounds and might also use sign language to communicate.

2.4 Better ear, worse ear

Hearing loss can differ from one ear to the other (asymmetrical hearing loss). Asymmetrical hearing loss results in problems such as difficulties with the spatial localisation of sound (not being able to tell where a speaker's voice is coming from), and auditory discrimination problems (picking up foreground sounds from background sounds) resulting in practical problems like not being able to function in meetings or social settings especially when people are on the person's 'bad side'. Having better hearing in one ear than the other impacts on the ability to communicate and may lessen the overall effect of the impairment in the worse ear. Given this outcome, disability in epidemiological hearing studies has often been defined on measures of the better ear (Davis, 1989; Wilson et al, 1988). This approach is also adopted in this study. When reporting prevalence rates, better ear measures would provide conservative estimates while worse ear measures may more accurately reflect impairment. This is a little different from visual impairment, where there is very little impairment experienced if vision loss occurs in one eye only.

In this study, the approach has thus been to report hearing loss prevalence for both the better and worse ear, but conservatively to use hearing loss prevalence in the better ear to attribute costs and disease burden. In addition, to distinguish the two, prevalence of hearing loss is used to refer to impairment in the worse ear, while prevalence of hearing disability is used to refer to impairment in the better ear. This aligns with the Australian Institute of Health and Welfare (AIHW) approach, to avoid overstating the burden of disease on the community and adopt a minimum cost burden position.

2.5 Cognitive sequelae of hearing loss

There is reasonably strong evidence of an association between declines in sensory ability, including hearing loss, and cognitive decline in the elderly. However, whether there is a causal connection and, if so, which way it flows, is yet to be demonstrated. There is some evidence that correcting hearing loss (for example through hearing aids) can ameliorate cognitive decline. For example, a link between hearing loss and changes in brain structure has been suggested by a brain imaging study of participants in the Baltimore Longitudinal Study of Aging (Lin et al, 2014). Among a cohort of dementia-free individuals, the mean rate of brain volume reduction over 6.4-years was found to be greater among participants with hearing loss. The size of this effect was approximately equivalent to the average difference seen between people with normal cognition and people with mild cognitive impairment.

Vision, touch, smell, gait and balance have also been found to be involved in neurodegenerative conditions, and their decline has been associated with the progression of cognitive decline (Martini et al, 2015). Wayne and Johnsrude (2015) note that declines in hearing and cognition are functionally interdependent, since there is no sharp division between sensation and perception, and cognition. Humes et al (2013) conducted an experiment where participants had to pass an auditory, visual, and tactile screening procedure in order to reduce the confounding effects of peripheral sensory deficits on performance of cognitive tests. They concluded that declines in sensory function may mediate the relationship between increasing age and declining cognitive function, but that this cannot be attributed only to hearing sensitivity.

2.5.1 Does cognitive decline predict hearing loss?

Kiely et al (2012) report that cognitive decline is a predictor of hearing loss. Their multivariate model was based on Australian longitudinal data, with a total of 3,526 participants with audiometric testing and 366 with cognitive impairment at baseline. Mean age at baseline was 73.6 years. Hearing loss for frequencies important for speech perception declined by an average of 0.91 dB per year. Rates accelerated in older years, with almost all of the oldest cohorts having mild or worse hearing loss. Cognitive impairment at baseline was associated with poorer pure tone average (PTA) thresholds (β=3.9) and faster rates of decline (β=0.4). Both between-person differences and within-person change in cognitive function were identified as risk factors for hearing loss. Apart from cognitive impairment, the only statistically significant predictors of hearing loss were baseline age, sex, and workplace noise exposure. The authors cautioned that no mechanism could be identified from the study, but suggested that the most likely explanation was that a third unidentified variable, such as cerebral microangiopathy, may be responsible for both hearing loss and cognitive impairment. They note that while dementia pathology has been observed in the auditory cortex it is not believed to affect the latter.

2.5.2 Or, does hearing loss predict cognitive decline?

Lin et al (2011) included a cohort of 639 dementia-free older individuals who underwent audiometric pure tone threshold testing in the early 1990s. The participants returned for follow-up every 2 years with a median follow up of over 11 years. Whether the time to all-cause dementia onset depended on the severity of hearing loss was investigated using regression models adjusted for age, sex, race, education, diabetes, smoking, and hypertension. Strikingly, the risk of incident dementia increased by 1.27 times per 10-dB increase in hearing thresholds. Relative to people with normal hearing, the incidence of all-cause dementia was 1.89 times higher in people with mild hearing loss, 3 times higher in people with moderate hearing loss, and 4.94 times higher in people with severe hearing loss.

Lin et al (2013) argue that hearing loss causes cognitive decline. The authors studied 1,984 older adults (average age 77.4 years) over six years. Participants with PTA hearing loss >25 dB had annual rates of decline in cognitive test scores that were 32%-41% greater than individuals with normal hearing. Compared to those with normal hearing, individuals with hearing loss at baseline had a 24% increased risk for incident cognitive impairment. Further, rates of both cognitive decline and risk of incident cognitive impairment were linearly associated with an individual's baseline hearing loss.

On average, individuals with hearing loss would require 7.7 years to decline by 5 points on the Modified Mini-Mental State Examination (or 3MS) which is a commonly accepted level of change indicative of cognitive impairment, compared to 10.9 years in individuals with normal hearing. However, the authors cautioned that further study is needed to determine what the basis of this association is, and whether hearing interventions could affect cognitive decline. The authors speculate that hearing loss may be mechanistically associated with cognitive decline, possibly through social isolation or cognitive load. They note that communication impairments caused by hearing loss can lead to social isolation and loneliness in older adults; epidemiologic and neuroanatomic studies have demonstrated associations between loneliness and cognitive decline or dementia. They also note that under conditions where auditory perception is difficult (i.e. in the case of hearing loss), greater cognitive resources are dedicated to auditory perceptual processing, to the detriment of other cognitive processes. Contrary to other studies, Lin et al (2013) found hearing aid use was associated with slightly attenuated rates of cognitive decline and risk for cognitive impairment (albeit not at statistically significant levels). They note that, contrary to popular perceptions, proper hearing rehabilitative treatment is complex and can vary substantially depending on the treating audiologist.

Gurgel et al (2014) used longitudinal data from 4,463 participants and found hearing loss was an independent predictor of developing dementia (hazard ratio (HR) = 1.27, p=0.026, 95% confidence interval (CI) = 1.03, 1.56). Of those with hearing loss, 16.3% developed dementia, compared to 12.1% of those without hearing loss. The mean time to dementia was 10.3 years in the hearing loss group vs. 11.9 years for non-hearing loss. However, while these results are in support of those from Lin et al (2013), they need to be treated with caution as there was no audiometric testing of hearing loss, as the underlying study did not have hearing loss as a primary focus.

Wayne and Johnsrude (2015) note in their literature review that, although findings by Lin et al (2013) sound substantial, the difference in the total 3MS score is less than 0.2%. They also note that "it is difficult to infer causal relationships on the basis of either cross-sectional or longitudinal correlational designs where parameters of interest are not directly manipulated". They further observe that the link between hearing loss and cognition is not observed at all in several studies, or is only observed to be weak in other investigations. For example in an earlier longitudinal study by Lin et al (2004) after adjusting for age, body mass index, education, smoking, walking speed, handgrip strength, social network and a host of health factors, hearing sensitivity was not significantly associated with decline in 3MS score. Wayne and Johnsrude (2015) conclude that the relationship between hearing loss and cognitive decline appears reliable but weak, accounting for only 1–4% of the total variance.

2.5.3 Meta-analysis

The above studies agree there is a correlation between hearing loss and cognitive decline, but argue for different causation flows. Some resolution can be provided by meta-analysis which provides weights to studies based on factors such as design, size and explanatory power.

Taljaard et al (2016) conducted what they believe to be the first meta-analysis on the link between hearing loss and cognitive decline. The 33 included studies comprised 4,260 individuals with a range of hearing impairment with/without treatment and 176 healthy controls. The results demonstrated that:

> *Cognition is significantly poorer in (i) individuals with untreated hearing and remains poorer in (ii) treated hearing impairment compared to normal hearers. The degree of cognitive deficit is significantly associated with the degree of hearing impairment in both (iii) untreated and (iv) treated hearing impairment. Furthermore, (v) hearing intervention significantly improves cognition.*

However, the authors also concluded "further research is required to understand whether hearing impairment is a *cause* of cognitive deficits, how it confers this risk, and whether hearing intervention mitigates any effects on cognitive function"[5]. Taljaard et al (2016) cautioned that due to diversity within studies, small sample sizes, the failure to control for premorbid and other health factors, this conclusion may be premature. Hearing loss and duration, length of time with treatment, and measures of cognitive decline varied considerably across studies employed. The most powerful assessment of whether intervention improves cognition in hearing impairment would be a blinded, randomised controlled trial, but none of the studies reported were of this kind. Thus, results could potentially be related to practice effects, or other bias.

The overall effects of poorer hearing on cognition were not large, on average explaining just 4.4% of the variance in untreated individuals and 6.6% in treated individuals. In terms of effect sizes, all were small to medium.

- The finding that cognition improved in individuals assessed pre and post treatment was medium (Cohen's d = 0.49), but it was based on just four studies, and there was also evidence of publication bias. Adjusting for population bias rendered the effect size small, but still significant.
- Similarly, the conclusion that there was a difference in cognition between the populations with treated and those with untreated hearing impairment was based on just three studies.

Many studies used cognitive tasks produced and normed for a hearing population, which involve hearing a stimulus and responding in an accurate and timely fashion. When used with hearing impaired individuals, the validity of any results must be questioned. To this end, tasks that have been developed with a visual alternative may be a better test of cognition and may have greater ecological validity for this population. Further, hearing impairment (even when treated) may require greater cognitive resources to complete the tasks well. Thus, the reported differences could be due to the degree to which coping with a hearing impairment uses up processing capacity rather than due to an underlying cognitive difficulty. Many moderator variables that effect cognitive performance such as verbal and non-verbal IQ, oral and manual communication, mood, cognitive reserve, education and the number of health conditions may have also differed across studies, and were unable to be included in the analysis.

2.5.4 Summary

There is reasonably strong evidence that hearing loss is associated with cognitive decline, even if the effect size is weak. There is also some evidence that treating hearing loss can improve cognitive function. However, at this stage the evidence for either hearing loss causing dementia, or hearing interventions delaying cognitive decline are not sufficiently robust to be included as additional costs or benefits in this report.

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[5] Italics in original.

3 Prevalence of hearing loss

This chapter outlines the prevalence, prevalence projections and mortality estimates for hearing loss in Australia. There are a number of sources available that estimate the prevalence of hearing loss in Australia, and a variety of considerations when choosing an appropriate measure. These will be discussed in this chapter. This chapter also outlines the percentage of hearing loss that is preventable for both children and adults.

Key findings:

- The prevalence of hearing loss in Australia (better ear) in 2017 was estimated to be 3.6 million people-2.2 million males and 1.4 million females. This represents 14.5% of the total Australian population.
- In 2060, it is estimated that the prevalence of hearing loss (better ear) will reach up to 7.8 million people - 18.9% of the total population.
- Approximately 49% of child hearing loss was estimated to be preventable, while for adults it is thought that 37% of hearing loss is preventable.

3.1 Audiometric measure versus self-reported prevalence

Hearing loss is a common condition around the world. Despite this, there are a limited number of reliable audiological sources for the prevalence of hearing loss specifically in Australia (as is the situation for most other developed countries). There are many sources of self-reported hearing loss, such as the Australian Institute of Health and Welfare's Burden of Disease Study (AIHW, 2016a), the Australian Bureau of Statistics (ABS) National Health Survey (NHS) 2014-15 (ABS, 2015a) or the ABS Survey of Disability, Ageing and Carers (SDAC) (ABS, 2016). However, self-reported hearing loss is subjective and can poorly estimate total prevalence of hearing loss. For example, Wilson et al (1999) showed that the false positive rate in self-reported studies of hearing loss was 46% and the false negative rate was 17%. This indicates that self-reported hearing loss estimates such as the results from the NHS or the SDAC are poor indicators of true prevalence.

3.2 Prevalence in adults

3.2.1 Data sources

David Wilson at the Behavioural Epidemiology Unit within the South Australian Health Commission conducted a measured study of hearing loss in adults in the mid to late 1990s (Wilson, 1999). This study was based on the methodology of the renowned United Kingdom (UK) National Study of Hearing (Davis, 1989). That is, it was a representative population sample which consisted of a multi-staged, clustered, self-weighting, systematic area sample of people aged 15 years or older. The base sample size was N=9,027 which was double the number of respondents required to meet power requirements at the 95% level for detecting differences in hearing loss.

Wilson's results were similar enough to Davis' that the CIs for both studies overlapped. Population-level audiological studies are not frequent events, and just as the British Hearing Study remains the 'gold standard' in the UK, Wilson's work remains the benchmark in Australia[6]. For this study, just as in Access Economics (2006), the Wilson study was used as the main basis of prevalence estimates, assisting in comparisons of findings over time.

There were two other Australian population studies that have collected audiological data as part of a wider ambit. However, Access Economics (2006), acting on the advice of an eminent expert reference group, did not draw upon these studies for the 2006 *Listen Hear!* report.

1. The Blue Mountains Eye Study or BMES (Gopinath, 2009) is a respected local data source. From 1992 to 1994, 3,654 participants 49 years or older were examined for hearing loss. Surviving baseline

[6] For example, Davis is still used for prevalence estimates by the Royal National Institute for the Deaf, and Wilson was used as a source for the Global Burden of Disease Study 2013 (Stevens et al, 2011)

participants were invited to attend 5- and 10-year follow-up examinations, at which 2,335 and 1,952 participants were re-examined, respectively. During 1997 through 2000, 2,956 persons 50 years or older had audiometric testing performed. However, it was not used in Access Economics (2006) as its focus was limited to older adults. Furthermore, its data no longer appears to be readily available.

2. The Australian Longitudinal Study of Ageing (ALSA) is the centrepiece research activity of the Flinders Centre for Ageing Studies (Flinders University, 2017). The ALSA commenced in 1992 with 2,087 participants aged 65 years or older. At baseline, a comprehensive interview and assessment of neuropsychological and physiological functions was undertaken with each participant, supplemented with self-completed questionnaires, biochemistry, and additional clinical studies of physical function. Self-reported hearing measures were obtained concurrently with audiometric assessments in ALSA waves 1, 3, 6, and 7. The final wave (wave 13) of data collection was carried out in 2014. Due to similar constraints as for the BMES, Access Economics (2006) did not utilise the ALSA data[7].

The literature search undertaken by Deloitte Access Economics for this report did not uncover any Australian population health study which had collected audiometric data in the years subsequent to 2006. The Aspirin in Reducing Events in the Elderly trial currently underway is collecting audiometric data from some 1,200 Australians over the age of 70 years, but results will not be available until 2018 (Lowthian et al, 2016).

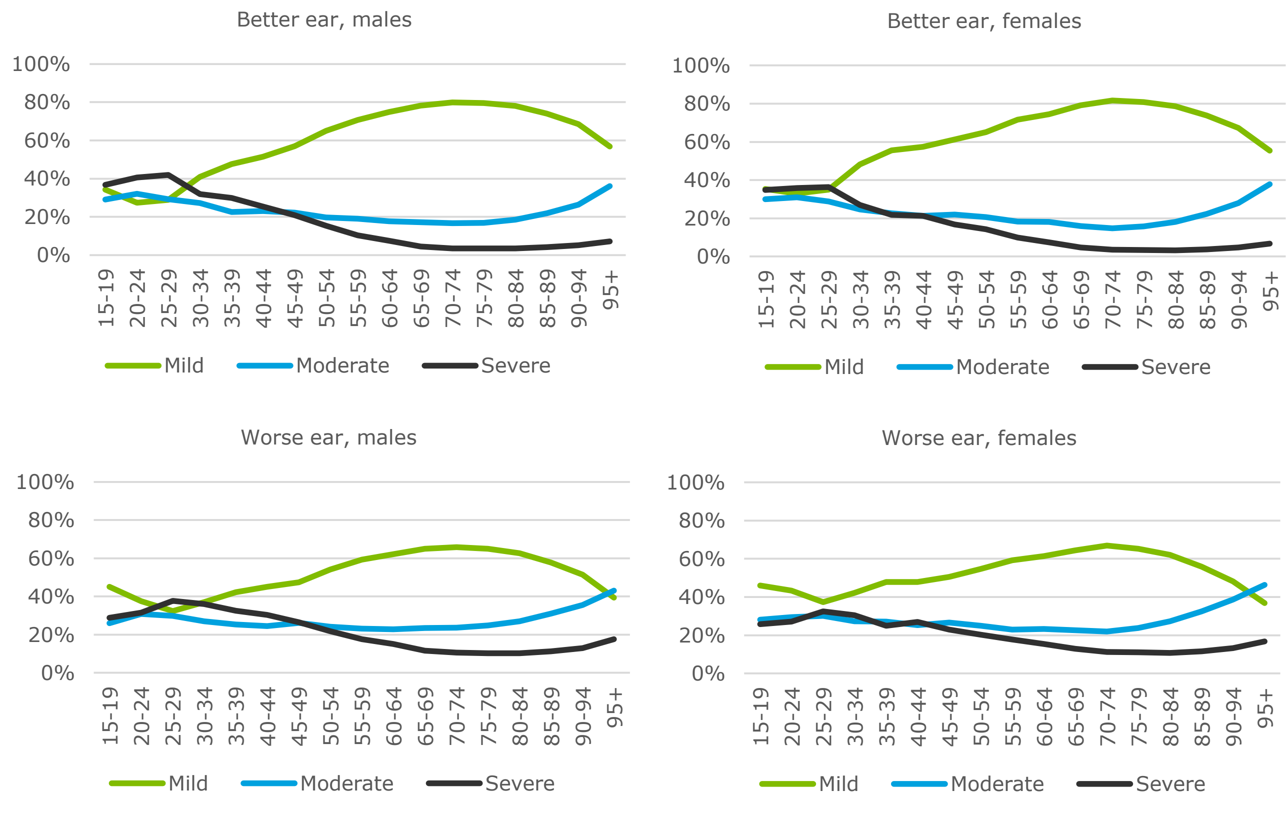
3.2.2 Severity splits for adults

Access Economics (2006) utilised severity split data from Australian Hearing[8]; for this report, severity split information was updated using data from the OHS. The OHS provides services and rebates to eligible people with hearing loss[9]. A special data request was sent to the OHS for the number of people with hearing loss by severity, gender, and age for the 2015-16 financial year.

The proportion of people with hearing loss for better ear and worse ear by severity, age and gender is shown in Chart 3.1. As can been seen, both graphs exhibit the same behaviours across both genders for severity splits; therefore, there appears to be no difference in severity of hearing loss by gender. As people age, moderate and mild hearing loss become more common; this fact, along with the declining proportion of normal hearing loss, indicates that as people age they are likely to have hearing loss. The share of severe hearing loss decreases as people age; this is due to the higher number of cases of mild and moderate hearing loss, which reduces the proportion of severe cases; it is not that the number of cases of severe hearing loss is decreasing.

[7] Deloitte Access Economics has attempted to obtain ALSA data, but may not receive data within the timeframes of this report.
[8] https://www.hearing.com.au/degrees-hearing-loss/
[9] Eligible people include those under the age of 25 years as well as certain concession cardholders.

Chart 3.1: Hearing loss severity, (% of all hearing loss)



Source: OHS 2015-16 program data

3.2.3 Summary of adult prevalence data sources used within this report

As noted in section 3.2.1, the Wilson study was the primary data source for prevalence used in Access Economics (2006) and is the primary source of prevalence for this report. The prevalence rates for hearing loss in the better ear used by Access Economics (2006) are shown in Table 3.1.

Table 3.1: Prevalence rates from Access Economics (2006), better ear

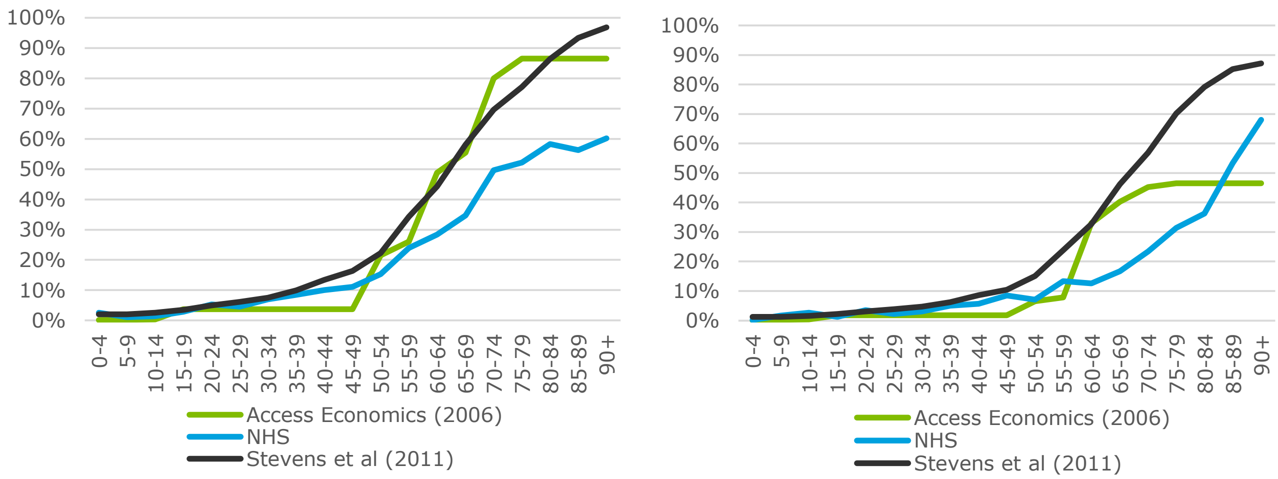
Age/gender	Males	Females	Persons
Males			
0-14	0.26%	0.3%	0.3%
15-50	7.7%	2.5%	5.1%
51-60	42.7%	16.3%	29.5%
61-70	63.8%	53.1%	58.4%
71+	87.7%	63.8%	74.0%
Total	**21.0%**	**13.9%**	**17.4%**

Source: Access Economics (2006)

The prevalence rates from Access Economics (2006) are the same for large age groups, such as the 15-50 age group and the 71+ age group. To provide a more detailed prevalence estimate by five year age groups the age-gender relativities from the NHS 2014-15 (ABS, 2015a) self-reported results were used[10]. As mentioned in section 3.2.1, the NHS is conducted by the ABS and collects information about the health of Australians. The most recent NHS was conducted in 2014-15 and included nearly 19,000 people. Although this is a self-reported survey and results for total prevalence are not appropriate as a prevalence measure for this study, the NHS does provide useful information about how hearing loss changes with age.

By way of comparison, Access Economics (2006) prevalence results, Stevens et al's (2011) averaged results across high-income countries and the NHS 2014-15 (ABS, 2015a) self-reported results are shown in Chart 3.2 for males and females.

Chart 3.2: Comparison of Australian prevalence results, NHS and prevalence estimated in high income countries, males (left) and females (right)



Source: Access Economics (2006), ABS (2015a) and Stevens (2011)

3.3 Children

3.3.1 Newborn hearing screening

All Australian states and territories conduct universal newborn hearing screening programs (Australian Hearing, 2014a). However, data is not centrally collected or publically available in most cases.

The one exception that Deloitte Access Economics found was for Queensland's Healthy Hearing Program in 2012. In that year, 62,774 babies were screened. Of these, 0.18% were found to have permanent congenital hearing loss (PCHL). This would appear to be a representative year, as in the last 12 years the Program had screened "over 660,000 children" and identified 1,350 with PCHL or around 0.20% (Children's Health Queensland Hospital and Health Service, 2016). A breakdown by type (unilateral or bilateral[11]) and severity is provided in Table 3.2.

[10] This methodology was used to calculate prevalence of hearing loss for both better ear and worse ear.
[11] Unilateral hearing loss is where there is one ear with normal hearing and one bad ear with hearing loss. Bilateral hearing loss is where both ears have hearing loss.

Table 3.2: Babies identified with permanent congenital hearing loss in Queensland in 2016.

Type	Degree of loss	Rate per thousand
Bilateral (best ear)	Mild to moderate	0.21
	Moderate or greater	1.04
	Total	**1.25**
Unilateral (worst ear)	Mild to moderate	0.03
	Moderate or greater	0.56
	Total	**0.59**
All types	Mild to moderate	0.24
	Moderate or greater	1.60
	Total	**1.84**

Source: Queensland DoH (2012)

3.3.2 Australian Hearing child data

In 2014, Australian Hearing cared for 13,565 "current and active" aided children under the age of 15, who were fitted with hearing aids or cochlear implants, which represented 0.31% of the then total population (Table 3.3). This figure could be an underestimate, as while children (and young adults up to the age of 25) are eligible for government-funded services (Australian Hearing, 2014b), there would still be children who should have received free hearing aids but have not. Conversely, there may be children whose parents had chosen to purchase hearing aids privately.

Table 3.3: Australian Hearing, aided children, 2014

Age (years)	Number	Percent of total population
0	328	0.11%
1	483	0.15%
2	523	0.17%
3	609	0.20%
4	684	0.22%
5	875	0.29%
6	993	0.33%
7	1,099	0.37%
8	1,129	0.38%
9	1,085	0.38%
10	1,137	0.40%
11	1,175	0.42%
12	1,152	0.41%
13	1,148	0.41%
14	1,145	0.40%
Total	**13,565**	**0.31%**

Source: Australian Hearing (2015)

If a child has unilateral hearing loss they can still receive a free hearing aid or cochlear implant– that is, services are provided on a worst ear basis. Commonwealth guidelines allow for the provision of hearing aids for any ear with a hearing loss of greater than 23 dB (DoH, 2015a)[12]. Australian Hearing collects statistics on the distribution of better ear hearing loss for aided clients.

Table 3.4: Better ear hearing loss by severity in Australian Hearing client under 26 years, 2014.

Loss (dB)	Share
<40	58.7%
41 to 60	20.5%
61 to 90	11.3%
90>	9.5%
Total	**100.0%**

Source: Australian Hearing (2015)

3.3.3 The Longitudinal Outcomes of Children with Hearing Impairment study

The Longitudinal Outcomes of Children with Hearing Impairment (LOCHI) study is a population-based, prospective study that directly compares the outcomes of children with hearing loss who received early or later intervention (National Acoustics Laboratories, 2017). The study includes approximately 450 children with hearing loss born in NSW, Queensland, and Victoria between 2002 and 2007. Depending on the stage of implementation of universal newborn hearing screening (UNHS) programs in the respective states at the time, the hearing loss of children was identified via either UNHS or standard care. All shared the same post-diagnostic expert audiological services from Australian Hearing, which means that the results of children can be fairly compared, whenever and wherever their hearing loss was discovered. This research is being conducted by the National Acoustic Laboratories and its collaborators within the HEARing Cooperative Research Centre (CRC). The research team is currently assessing the LOCHI children at 9 years of age.

The study provided world-first evidence of the benefits at 5 years of age of early hearing-aid fitting by 6 months or cochlear implantation by 12 months of age combined with educational intervention for language development of children. Children with hearing loss discovered via UNHS at birth and who received early intervention had better spoken language abilities than those whose hearing loss was discovered later than this. On average, children fitted with hearing aids before 6 months of age had higher language scores than those fitted later. For children with severe or profound hearing loss, those who received a cochlear implant before 12 months of age had significantly higher language scores than those who received a cochlear implant at an older age[13].

3.3.4 Summary of child prevalence data sources used within this report

For prevalence of hearing loss (better ear) in children the prevalence rates shown in Table 3.2 were utilised for those aged 12 months and younger. For those aged 1-14 years the prevalence rates from Table 3.3 were utilised. The severity split for mild, moderate and severe hearing loss for those aged 0-14 years was taken from Table 3.4. The prevalence for hearing loss in the worse ear was calculated by multiplying the prevalence rates for hearing loss (better ear) by the adult ratio of better ear to worse ear.

3.4 Total prevalence

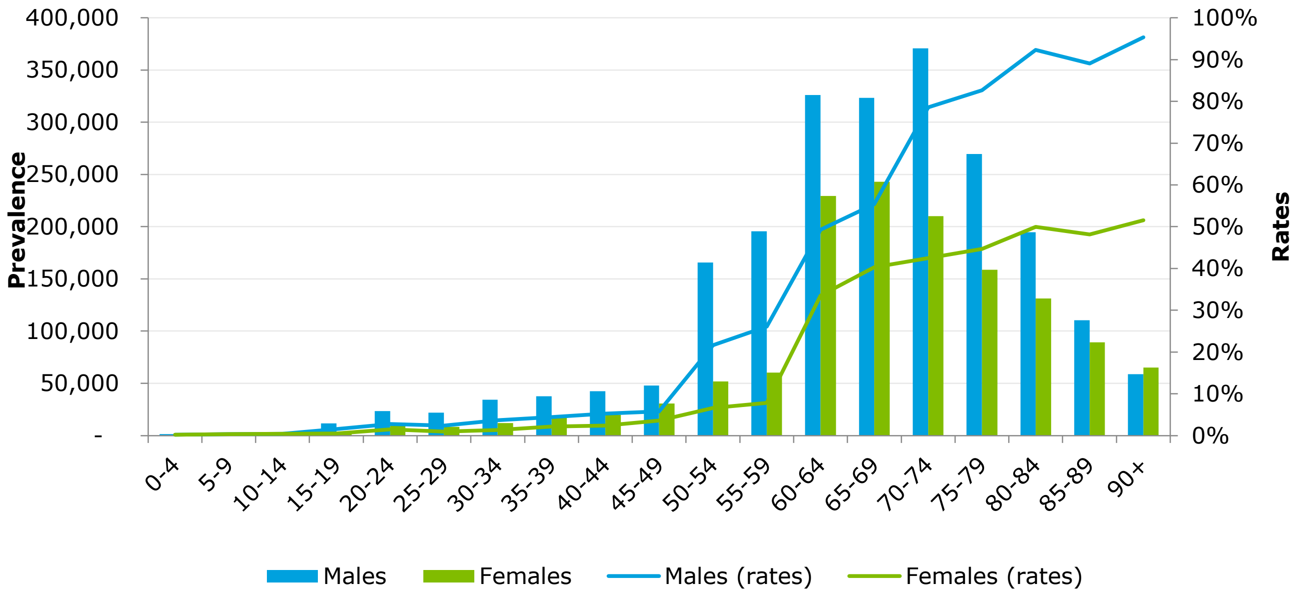
3.4.1 Better ear

There were estimated to be 3.6 million people who have hearing loss in Australia in 2017 – 14.5% of the total population. The prevalence rates and number of people who have hearing loss in Australia in 2017 is shown in Chart 3.3. Hearing loss is more prevalent in people aged over 50 years. Although prevalence rates are increasing as people age, the absolute number of cases of hearing loss decreases after the age of 70-74 for

[12] Defined as a 3 frequency average hearing loss (measured at 0.5, 1 & 2 kHz)
[13] Deloitte Access Economics sought access to this data source, but had not received any data when this report was finalised.

males and 65-69 for females due to the smaller underlying population that the rates are applied to. Of all hearing loss cases in 2017, males comprised 62% and females 38%.

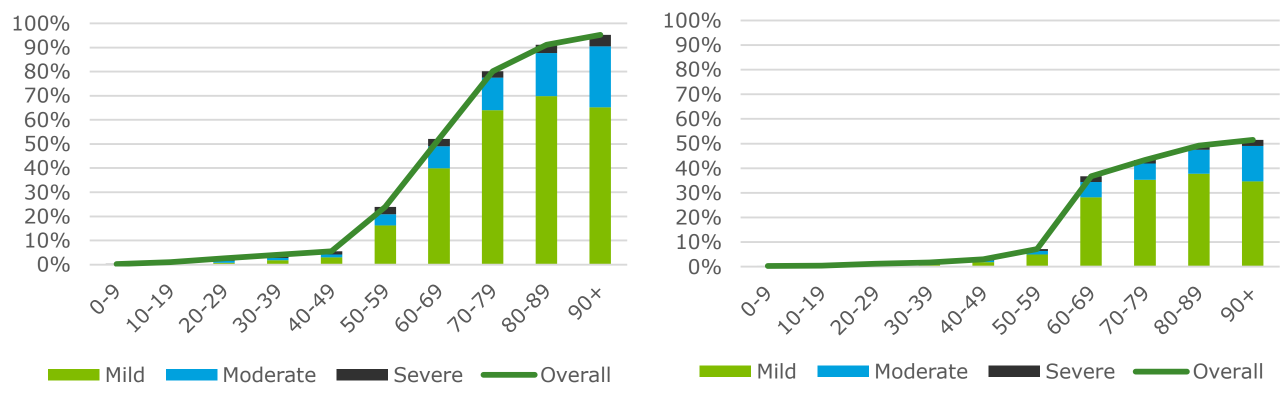
Chart 3.3: People with hearing loss (better ear) in Australia, 2017



Source: Deloitte Access Economics calculations

Chart 3.4 shows the prevalence rates by severity and age for males and females. For males, 18.2% had hearing loss in 2017, with 13.2% mild, 3.4% moderate and 1.5% severe. Hearing loss prevalence increases with age and as males age, they are highly likely to develop hearing loss. For females, 10.9% had hearing loss in 2017, with 8.1% mild, 2.0% moderate and 1.1% severe. Hearing loss prevalence again increases with age.

Chart 3.4: Prevalence rates of hearing loss (better ear) by severity and age, males (left) and females (right)



Source: Deloitte Access Economics calculations

Table 3.5 summarises the number of cases by severity, age and gender of hearing loss (better ear) in Australia in 2017. **There were an estimated 2.2 million males and 1.4 million females with hearing loss in the better ear in 2017.**

Table 3.5: Number of prevalent cases of hearing loss, better ear, 2017

Age/gender	Mild	Moderate	Severe	Overall
Male				
0-9	2,445 (0.1%)	854 (0.1%)	866 (0.1%)	4,165 (0.3%)
10-19	5,806 (0.4%)	4,016 (0.3%)	4,910 (0.3%)	14,732 (1.0%)
20-29	12,755 (0.7%)	13,926 (0.8%)	18,732 (1.1%)	45,413 (2.6%)
30-39	31,918 (1.8%)	17,769 (1.0%)	22,151 (1.2%)	71,837 (4.0%)
40-49	49,260 (3.0%)	20,507 (1.2%)	20,821 (1.3%)	90,588 (5.5%)
50-59	246,062 (16.3%)	69,590 (4.6%)	45,499 (3.0%)	361,150 (23.9%)
60-69	497,100 (39.9%)	113,318 (9.1%)	38,917 (3.1%)	649,335 (52.1%)
70-79	510,925 (64.0%)	107,266 (13.4%)	22,024 (2.8%)	640,215 (80.2%)
80-89	233,737 (69.8%)	60,113 (17.9%)	11,336 (3.4%)	305,187 (91.1%)
90+	40,142 (65.2%)	15,516 (25.2%)	2,980 (4.8%)	58,638 (95.3%)
Male total	1,630,150 (13.2%)	422,873 (3.4%)	188,236 (1.5%)	2,241,259 (18.2%)
Female				
0-9	2,321 (0.1%)	810 (0.1%)	822 (0.1%)	3,953 (0.3%)
10-19	3,050 (0.2%)	1,717 (0.1%)	1,906 (0.1%)	6,673 (0.5%)
20-29	6,936 (0.4%)	6,168 (0.4%)	7,397 (0.4%)	20,501 (1.2%)
30-39	15,981 (0.9%)	7,110 (0.4%)	7,225 (0.4%)	30,316 (1.7%)
40-49	30,143 (1.8%)	10,964 (0.7%)	9,388 (0.6%)	50,494 (3.0%)
50-59	76,831 (4.9%)	21,722 (1.4%)	13,374 (0.9%)	111,928 (7.2%)
60-69	363,282 (28.2%)	80,402 (6.2%)	28,728 (2.2%)	472,412 (36.7%)
70-79	299,804 (35.3%)	56,213 (6.6%)	12,795 (1.5%)	368,812 (43.4%)
80-89	169,023 (37.7%)	43,635 (9.7%)	7,630 (1.7%)	220,288 (49.2%)
90+	43,834 (34.7%)	18,252 (14.4%)	3,110 (2.5%)	65,197 (51.5%)
Female total	1,011,205 (8.1%)	246,994 (2.0%)	92,375 (0.7%)	1,350,574 (10.9%)
Person total	**2,641,355 (10.7%)**	**669,867 (2.7%)**	**280,611 (1.1%)**	**3,591,832 (14.5%)**

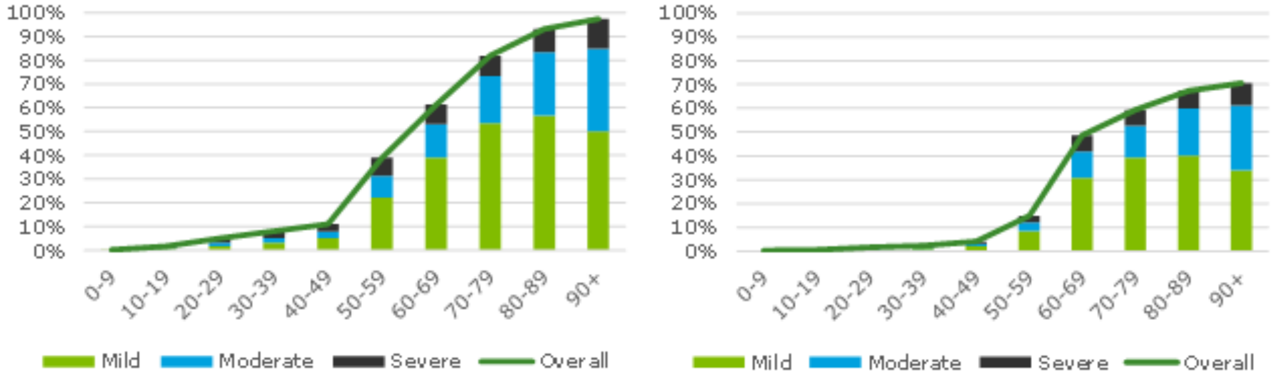
Source: Access Economics (2006) and ABS (2015a)

As was the case with Access Economics (2006), this study conservatively uses hearing loss prevalence in the better ear to attribute costs and disease burden.

3.4.2 Worse ear

Chart 3.5 shows the prevalence rates by severity and age for males and females. For males, total prevalence was estimated to be 23.0% in 2017. Mild, moderate and severe hearing loss was estimated to be 13.5%, 5.7% and 3.8% of the population, respectively. Hearing loss prevalence peaked in the 60-69 age groups and decreased past this point. For females, total prevalence was estimated to be 15.3% in 2017. Mild, moderate and severe hearing loss was estimated to be 9.3%, 3.8% and 2.2% of the population, respectively.

Chart 3.5: Prevalence rates of hearing loss (worse ear) by severity and age, males (left) and females (right)



Source: Deloitte Access Economics calculations

The total number of cases of hearing loss in the worse ear is shown in Table 3.6. **There were an estimated 2.8 million males and 1.9 million females with hearing loss in the worse ear in 2017.**

Table 3.6: Number of prevalent cases of hearing loss, worse ear, 2017

Age/gender	Mild	Moderate	Severe	Overall
Male				
0-9	3,792 (0.2%)	1,117 (0.1%)	586 (0.04%)	5,495 (0.3%)
10-19	13,368 (0.9%)	7,003 (0.5%)	7,252 (0.5%)	27,623 (1.8%)
20-29	32,266 (1.8%)	27,988 (1.6%)	31,698 (1.8%)	91,952 (5.2%)
30-39	57,756 (3.2%)	37,902 (2.1%)	49,797 (2.8%)	145,456 (8.1%)
40-49	84,942 (5.2%)	46,570 (2.8%)	51,910 (3.2%)	183,422 (11.2%)
50-59	335,809 (22.2%)	139,323 (9.2%)	115,655 (7.6%)	590,786 (39%)
60-69	484,636 (38.9%)	176,439 (14.2%)	102,367 (8.2%)	763,441 (61.3%)
70-79	427,655 (53.6%)	157,537 (19.7%)	68,394 (8.6%)	653,586 (81.9%)
80-89	189,718 (56.6%)	88,748 (26.5%)	33,094 (9.9%)	311,560 (93.0%)
90+	30,778 (50.0%)	21,280 (34.6%)	7,804 (12.7%)	59,862 (97.3%)
Male total	1,660,719 (13.5%)	703,908 (5.7%)	468,556 (3.8%)	2,833,182 (23.0%)
Female				
0-9	3,393 (0.2%)	1,196 (0.1%)	627 (0.04%)	5,216 (0.3%)
10-19	4,849 (0.3%)	2,332 (0.2%)	1,760 (0.1%)	8,941 (0.6%)
20-29	11,361 (0.7%)	8,287 (0.5%)	8,152 (0.5%)	27,800 (1.6%)
30-39	18,757 (1.1%)	11,183 (0.6%)	11,170 (0.6%)	41,110 (2.3%)
40-49	33,859 (2.0%)	17,827 (1.1%)	16,786 (1.0%)	68,472 (4.1%)
50-59	132,137 (8.5%)	55,042 (3.5%)	43,719 (2.8%)	230,898 (14.9%)
60-69	395,433 (30.7%)	143,783 (11.2%)	88,565 (6.9%)	627,781 (48.7%)
70-79	333,932 (39.3%)	114,822 (13.5%)	56,169 (6.6%)	504,924 (59.4%)
80-89	179,685 (40.1%)	88,625 (19.8%)	33,276 (7.4%)	301,586 (67.3%)
90+	43,039 (34.0%)	34,467 (27.2%)	11,752 (9.3%)	89,258 (70.6%)
Female total	1,156,446 (9.3%)	477,564 (3.8%)	271,976 (2.2%)	1,905,986 (15.3%)
Person total	**2,817,164 (11.4%)**	**1,181,472 (4.8%)**	**740,532 (3.0%)**	**4,739,168 (19.1%)**

Source: Access Economics (2006) and ABS (2015a)

3.5 Projections

Prevalence projections for the total population of Australia were conducted for the years 2020, 2030, 2040, 2050 and 2060. These prevalence projections were made on the basis of demographic ageing only. They do not take into account possible changes in age-gender prevalence rates in the future due to prevention or interventions that may reduce rates, or other changes that may impact rates.

3.5.1 Projections for children

Prevalence projections for hearing loss in children (those aged ≤ 14 years) are shown in Table 3.7 (better ear) and Table 3.8 (worse ear). **The number of children with hearing loss (better ear) is projected to increase from 14,210 in 2017 to 21,337 in 2060. The number of children with hearing loss (worse ear) is projected to increase from 18,749 in 2017 to 28,153 in 2060.**

Table 3.7: Prevalence projections for children ≤14 years, better ear

	2017	2020	2030	2040	2050	2060
Mild	8,341	8,829	9,917	10,555	11,533	12,525
Moderate	2,913	3,083	3,463	3,686	4,028	4,374
Severe	2,956	3,128	3,514	3,740	4,087	4,438
Total	**14,210**	**15,040**	**16,894**	**17,982**	**19,648**	**21,337**

Source: Deloitte Access Economics calculations

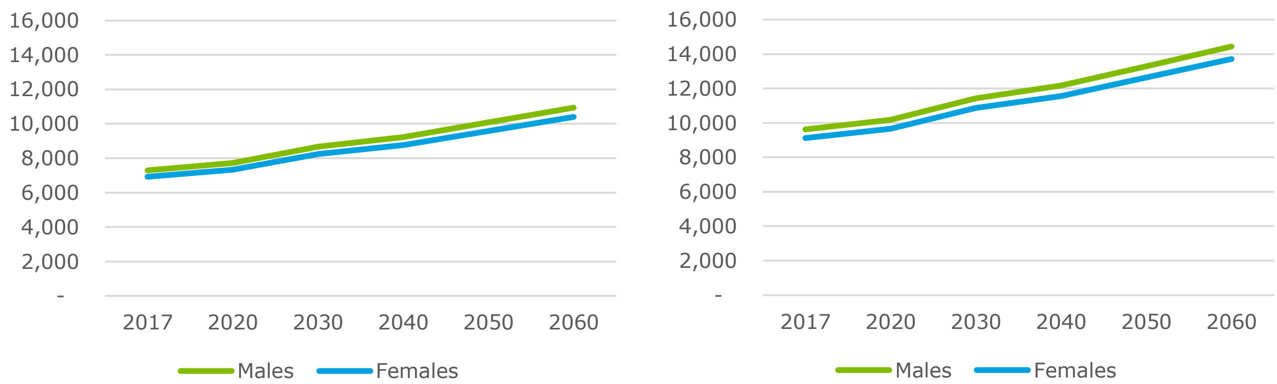
Table 3.8: Prevalence projections for children ≤14 years, worse ear

	2017	2020	2030	2040	2050	2060
Mild	12,484	13,215	14,852	15,801	17,265	18,754
Moderate	4,120	4,361	4,895	5,213	5,696	6,184
Severe	2,145	2,269	2,544	2,712	2,963	3,215
Total	**18,749**	**19,844**	**22,291**	**23,726**	**25,924**	**28,153**

Source: Deloitte Access Economics calculations

Chart 3.6 shows the projected prevalence of child hearing loss by gender for better ear and worse ear. As can be seen, the prevalence of hearing loss among males is higher than females and this trend is expected to continue to 2060.

Chart 3.6: Projected prevalent cases of child hearing loss (≤14 years), by gender, better ear (left) and worse ear (right)



Source: Deloitte Access Economics calculations

3.5.2 Projections for adults

The number of people aged 15 or older with hearing loss (better ear) is projected to more than double to 7.8 million by 2060 (Table 3.9), while those with hearing loss (worse ear) is projected to increase to 9.9 million in 2060 (Table 3.10).

Table 3.9: Prevalence projections for people aged 15+, better ear

	2017	2020	2030	2040	2050	2060
Mild	2,633,014	2,859,326	3,636,083	4,347,853	5,042,564	5,767,590
Moderate	666,953	720,159	910,019	1,101,622	1,285,258	1,466,087
Severe	277,655	294,391	350,329	409,456	466,328	518,167
Total	**3,577,623**	**3,873,877**	**4,896,431**	**5,858,931**	**6,794,150**	**7,751,844**

Source: Deloitte Access Economics calculations

Table 3.10: Prevalence projections for people aged 15+, worse ear

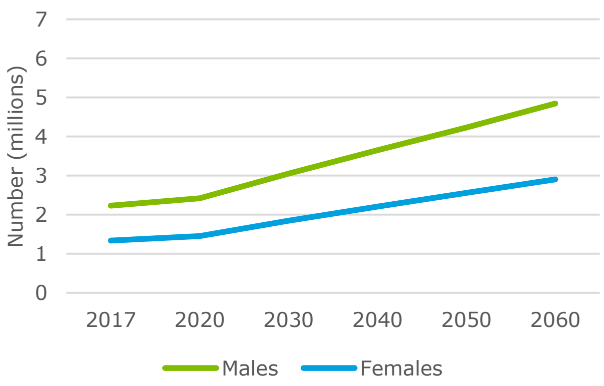
	2017	2020	2030	2040	2050	2060
Mild	2,804,681	3,028,461	3,793,029	4,506,517	5,195,601	5,899,542
Moderate	1,177,351	1,267,736	1,593,325	1,924,581	2,234,663	2,539,484
Severe	738,387	787,281	952,978	1,122,849	1,284,810	1,438,164
Total	**4,720,419**	**5,083,477**	**6,339,333**	**7,553,947**	**8,715,073**	**9,877,189**

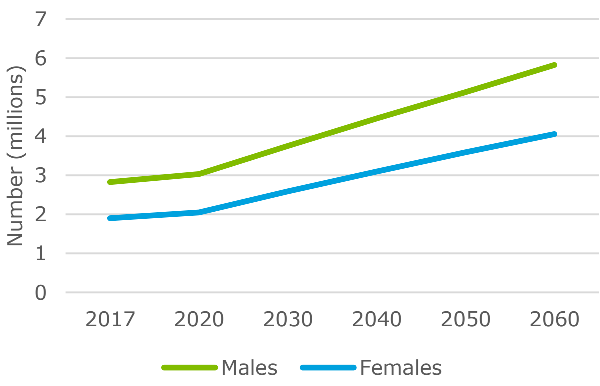
Source: Deloitte Access Economics calculations

Chart 3.7 shows the projected growth in the number of cases of hearing loss by gender for better ear and worse ear.

- The prevalence of hearing loss in adults (defined as 15+) is expected to more than double by 2060 (a 2.2-fold increase for prevalence of hearing loss in the better ear and a 2.1 – fold increase for prevalence of hearing loss in the worse ear).
- The prevalence of hearing loss (better ear) in adult men is projected to increase from 22.5% in 2017 to 28.6% in 2060, while for adult women prevalence increases from 13.2% in 2017 to 16.8% in 2060.
- The prevalence of hearing loss (worse ear) in adult men is projected to increase from 28.4% in 2017 to 34.4% in 2060, while for adult women it increases from 18.7% in 2017 to 23.5% in 2060.

Chart 3.7: Projected growth in hearing loss by gender, better ear (left) and worse ear (right)





Source: Deloitte Access Economics calculations

3.5.3 Total projections

Table 3.11 and Table 3.12 show the projected prevalence of hearing loss in the total population for better ear and worse ear, respectively.

Table 3.11: Projected prevalent cases of hearing loss, 2017 to 2060, better ear

Age/gender	2017	2020	2030	2040	2050	2060
Male						
0-9	4,165	4,364	4,790	5,114	5,641	6,072
10-19	14,732	15,270	18,120	19,808	20,985	22,972
20-29	45,413	46,032	50,062	57,221	61,082	64,624
30-39	71,837	77,613	84,574	90,482	101,894	108,230
40-49	90,588	92,964	113,891	123,204	131,442	146,878
50-59	361,150	371,464	409,125	497,809	538,725	573,926
60-69	649,335	685,944	786,388	868,780	1,059,384	1,147,247
70-79	640,215	726,074	938,665	1,086,849	1,208,945	1,487,573
80-89	305,187	338,840	553,427	731,692	860,793	978,570
90+	58,638	68,915	101,924	180,362	256,357	325,059
Male total	2,241,259	2,427,480	3,060,966	3,661,322	4,245,249	4,861,151
Female						
0-9	3,953	4,144	4,550	4,857	5,357	5,765
10-19	6,673	6,983	8,231	8,918	9,499	10,405
20-29	20,501	20,810	22,723	25,899	27,551	29,170
30-39	30,316	32,850	36,095	38,317	43,061	45,732
40-49	50,494	51,621	61,886	67,451	71,424	79,655
50-59	111,928	115,087	125,963	151,005	163,681	173,711
60-69	472,412	504,108	581,635	637,416	763,162	827,642
70-79	368,812	420,262	557,010	644,110	707,577	852,861
80-89	220,288	234,383	364,934	489,032	568,668	631,628
90+	65,197	71,189	89,334	148,589	208,568	255,462
Female total	1,350,574	1,461,437	1,852,359	2,215,591	2,568,548	2,912,031
Person total	**3,591,832**	**3,888,917**	**4,913,325**	**5,876,913**	**6,813,797**	**7,773,181**

Source: Deloitte Access Economics calculations

Table 3.12: Projected prevalent cases of hearing loss, 2017 to 2060, worse ear

Age/gender	2017	2020	2030	2040	2050	2060
Male						
0-9	5,495	5,758	6,320	6,747	7,443	8,012
10-19	27,623	28,556	33,958	37,211	39,363	43,077
20-29	91,952	93,205	101,365	115,860	123,679	130,851
30-39	145,456	157,151	171,245	183,209	206,315	219,144
40-49	183,422	188,234	230,607	249,464	266,145	297,398
50-59	590,786	607,659	669,264	814,362	881,272	938,877
60-69	763,441	806,626	923,862	1,020,516	1,245,264	1,347,680
70-79	653,586	741,237	958,269	1,109,547	1,234,193	1,518,639
80-89	311,560	345,916	564,985	746,973	878,770	999,006
90+	59,862	70,354	104,052	184,129	261,711	331,847
Male total	2,833,182	3,044,695	3,763,927	4,468,017	5,144,154	5,834,533
Female						
0-9	5,216	5,468	6,004	6,408	7,068	7,607
10-19	8,941	9,352	11,026	11,951	12,726	13,940
20-29	27,800	28,220	30,813	35,120	37,361	39,555
30-39	41,110	44,546	48,947	51,959	58,393	62,015
40-49	68,472	70,000	83,920	91,467	96,854	108,017
50-59	230,898	237,415	259,887	311,372	337,658	358,220
60-69	627,781	669,916	772,603	846,619	1,013,990	1,099,365
70-79	504,924	575,363	762,577	881,822	968,713	1,167,614
80-89	301,586	320,884	499,615	669,512	778,539	864,734
90+	89,258	97,462	122,303	203,426	285,542	349,741
Female total	1,905,986	2,058,627	2,597,696	3,109,656	3,596,843	4,070,809
Person total	**4,739,168**	**5,103,321**	**6,361,624**	**7,577,673**	**8,740,997**	**9,905,342**

Source: Deloitte Access Economics calculations

3.6 Mortality and hearing loss

Hearing loss and associated hearing health conditions have been associated with an increase in mortality in a number of studies. In the past, adjusting for a number of confounding factors generally meant that hearing loss was not significantly associated with an increase in mortality. The confounding factors typically include age, gender, a range of comorbid conditions, and a range of indirect factors such as ability to walk, cognitive impairment and self-rated health. Previous work to cost the impact of hearing loss has typically excluded any mortality aspects and suggested no direct link between mortality and hearing loss – for example, see Access Economics (2006).

However, there are a number of **suggested pathways that may link an increased risk of mortality with hearing loss.** Genther et al (2015) cite studies that report an increased risk of falls and hospitalisations in people with hearing loss – for example, see Lopez et al (2011), which found that hearing loss was significantly associated with an increased risk of falls, and borderline significance for risk of being injured by a fall**.** The **suggested mechanisms include confounding factors with shared conditions (e.g. microvascular conditions), increased brain processing requirements due to degraded auditory signals, and social**

isolation.[14] Genther et al (2015) highlight that these mechanisms are not mutually exclusive, meaning that they can coexist and contribute to reduced functioning in older adults with hearing loss. Finally, it is possible that other conditions which contribute to hearing loss may be the direct cause of death. For example, Sanders et al (2015) identifies a small number of deaths could arise from otitis media in Pacific Island countries due to resultant complications such as abscess, meningitis and thrombosis.

A literature search for studies was conducted to see if recent evidence suggests a direct association between hearing loss and mortality when controlling for confounding factors such as ageing, gender and other conditions. This is commonly measured using a HR which assesses the relative difference in the probability of an event occurring (death) over time between two populations of interest – those with and without hearing loss. Most of the studies identified in the search were prospective observational studies, and generally contained a longitudinal sample or survey linked to national deaths data. A summary of the literature is presented in Appendix A.

The results identified in the literature and the respective population characteristics are shown in Table 3.13. Of the identified literature using audiometric testing, there was approximately a 10% increase in the risk of mortality across the studies, although this was only significant in some of the studies. As such, meta-analysis was undertaken on these results using a fixed effects model as the results were consistent with overlapping ranges. The results of the meta-analysis are reported in Table 3.13 and Figure 3.1.

Table 3.13: Meta-analysis of mortality outcomes

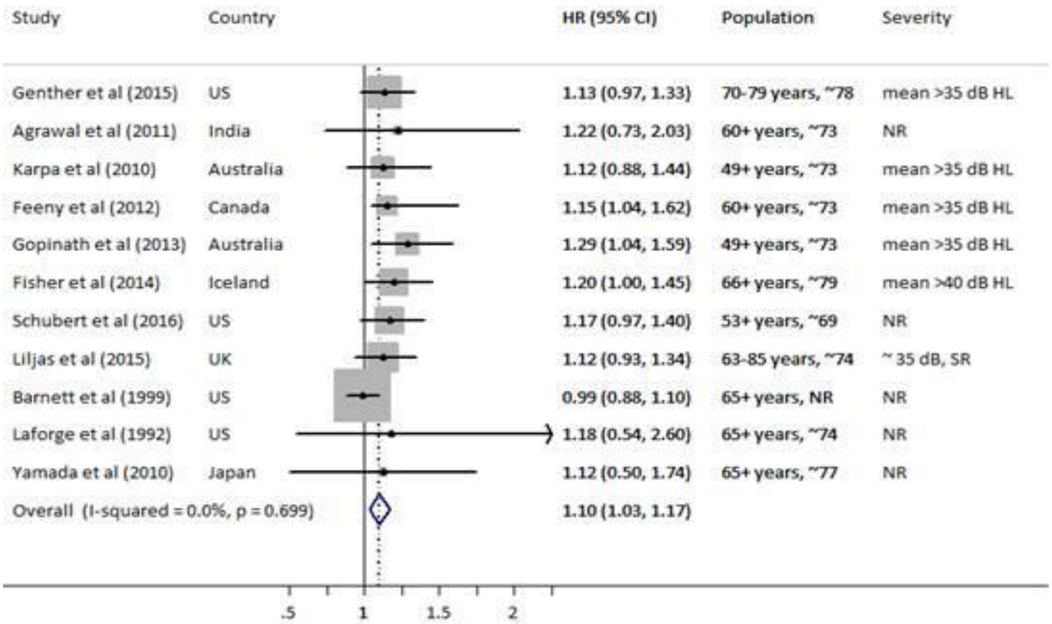
Study	Country	Population age	Mean severity	HR	95% CI
Genther et al (2015)	US*	70-79 years, ~78	>35 dB	1.13	0.97-1.33
Agrawal et al (2011)	India	60+ years, ~73	NR	1.22	0.73-2.03
Karpa et al (2010)	Australia	49+ years, ~73	>35 dB	1.12	0.88-1.44
Feeny et al (2012)	Canada	60+ years, ~73	>35 dB	1.15	1.04-1.62
Gopinath et al (2013)	Australia	49+ years, ~73	>35 dB	1.29	1.04-1.59
Fisher et al (2014)	Iceland	66+ years, ~79	>40 dB	1.20	1.00-1.45
Schubert et al (2016)	US	53+ years, ~ 69	NR	1.17	0.97-1.40
Liljas et al (2015)	UK	63-85 years, ~74	~35 dB, SR	1.12	0.93-1.34
Barnett et al (1999)	US	65+ years, NR	NR	0.99	0.88-1.10
Laforge et al (1992)	US	65+ years, ~74	NR	1.18	0.54-2.60
Yamada et al (2010)	Japan	65+ years, ~77	NR	1.12	0.50-1.74
Pooled result	**-**	**70+ years**	**>35 dB**	**1.10**	**1.03-1.17**

Source: Deloitte Access Economics estimates.

Note: * US=United States. NR=not reported, SR=some reporting

[14] These CVD risk factors (confounding factors) may lead to endogeneity in the sample.

Figure 3.1: Meta-analysis of mortality outcomes



Source: Deloitte Access Economics estimates.

Finally, the results presented above are considered to be plausible given the suggested pathways and mechanisms in the literature. For example, Karpa et al (2010) used structural equation modelling to identify pathways for hearing loss to mortality, and found that both cognitive impairment and disability in walking were significantly associated with mortality for people with hearing loss. They observed that the HR for people with cognitive impairment was 1.45, while for disability in walking it was 1.63. Further, Karpa et al (2010) suggest that these associations may be due to "… increased fear of falling, infirmity caused by declining physical and social activities associated with hearing loss – reflecting a decreased ability to seek professional help for hearing loss – and impaired balance from accompanying decreased vestibular function" (p. 457). If this is the case, then the higher mortality risk is due to systemic issues that are modifiable. Further, there is some evidence an increase in cognitive impairment (which is associated with an increase in mortality) can be "… explained by sensory underload (lack of intellectual stimulation reducing cognitive ability), attentional demands of sensory measurement…, or some common cause (hearing loss and cognitive function are both measures of the physiological architecture of the brain)" (p. 457).

3.6.2 Deaths due to hearing loss

To estimate the number of deaths due to hearing loss, the results from the literature are converted to a population attributable fraction to estimate the number of deaths that may be due to hearing loss[15]. The mortality rates in people with moderate or worse hearing loss and people who are aged 70 years or older were estimated by applying the population attributable fraction to the general population mortality rates for people aged 70 years or older.

General population mortality rates were derived by dividing deaths by total population for each age and gender group, which were both sourced from ABS (2016a). The mortality rates for 2017 were then modelled by applying an exponential curve across each single year age and gender group based on the fata from 1999 to 2015.

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[15] The population attributable fraction (PAF) measures the contribution of a risk factor to a death. This is the proportional reduction in population mortality that would occur if hearing loss did not occur. The population attributable fraction is calculated using the formula:

$$PAF = P_{HL}.\frac{HR_{HL} - 1}{1 + P_{HL}.(HR_{HL} - 1)}$$

Where P_{HL} is the prevalence of hearing loss and HR_{HL} is the HR of mortality.

The literature presented in Table 3.13 suggests that there may be a 10% increase in the risk of mortality in those with hearing loss of moderate or worse severity and over 70 years old. While the literature reported an increased risk of mortality, it is not clear if these studies have appropriately controlled for all confounding factors. Further, if there are shared pathologies between cardiovascular conditions and hearing loss, the including of cardiovascular risk factors may mean that these variables are "endogenous" – meaning they are not independent of hearing loss. This can subsequently bias results in multivariate regression analysis. Furthermore, the latest burden of disease study in Australia does not report any additional deaths due to hearing loss.

For conservatism, the mortality rates were therefore assumed to be the average of the literature and the latest burden of disease study. The mortality rates were estimates to be 0.10% in people with moderate or worse hearing loss over the age of 70 years. The mortality rate was estimated to be higher for males (0.11%) than for females (0.08%).

Table 3.14 shows the estimated number of deaths due to hearing loss by age and gender. Overall, it was estimated that there were 126 deaths due to hearing loss in Australia in 2017. The number of deaths was higher for males (96) than it was for females (30).

Table 3.14: Estimated deaths due to hearing loss, by age and gender

Age/gender	Additional mortality rate	Estimated deaths
Male		
70-74	0.04%	27
75-79	0.04%	22
80-84	0.04%	18
85-89	0.05%	16
90+	0.07%	13
Male total	0.04%	96
Female		
70-74	0.02%	6
75-79	0.02%	5
80-84	0.02%	5
85-89	0.03%	6
90+	0.03%	7
Female total	0.02%	30
Persons	**0.03%**	**126**

Source: Deloitte Access Economics calculations

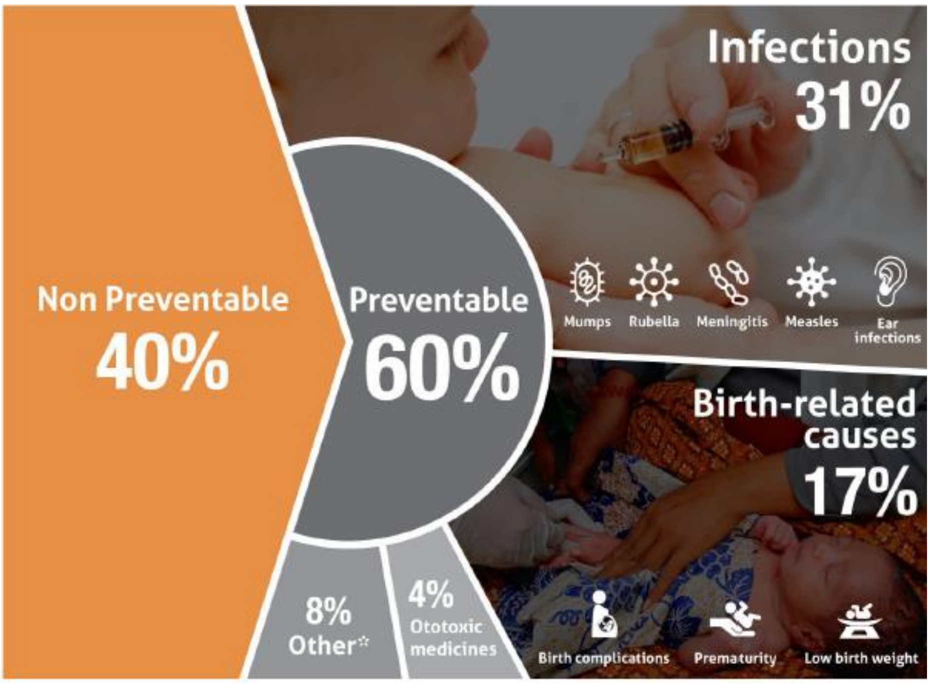
3.7 Preventable hearing loss

While most hearing loss in adults is due to presbycusis (or age-related hearing loss) (Roland, 2015) which is not preventable, the converse applies for children.

3.7.1 Children

The World Health Organization (WHO, 2016) estimated that most (60%) of childhood hearing loss globally is preventable.

Figure 3.2: Causes of childhood hearing loss

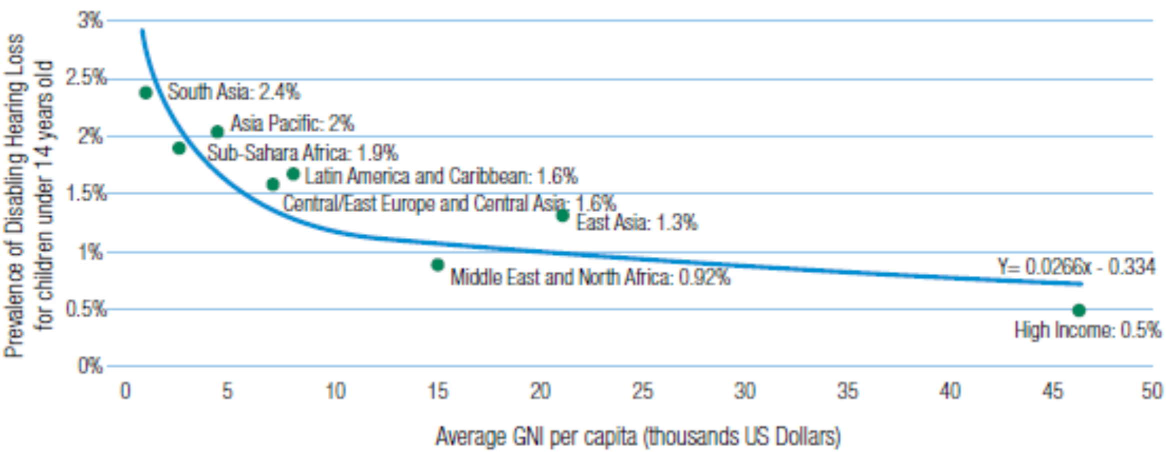


Source: WHO (2016)

Genetic factors account for 40% of childhood hearing loss, but almost everything else is at least potentially preventable. For example, meningitis and rubella account for 19% of childhood hearing loss, but both can be prevented by immunisation and good hygiene. Ear infections and glue ear can be prevented through good ear care and general hygiene, or at least can be reversed by prompt medical and surgical intervention. Complications at birth, such as lack of oxygen, low birthweight, prematurity and jaundice can be prevented through improved maternal and child health practices. Use of ototoxic medicines in pregnant women and children can be avoided through use of other medications.

The proportion of hearing loss due to preventable causes is around 1.5 times higher in middle- and lower-middle-income countries (75%) than in high-income areas (49%). This difference is mostly due to higher occurrence of infections in the middle- and lower-middle-income countries and better maternal and child health care in high-income countries.

Chart 3.8:Prevalence of disabling hearing loss in children, versus gross national income



Source: WHO (2016)

3.7.2 Noise-induced hearing loss in adults

The main form of preventable hearing loss in adults is noise-induced hearing loss (NIHL). Traditionally, this mostly affected adults of working age through occupational NIHL, but recreational NIHL is an increasing risk, particularly from lengthy exposure to loud music in young people.

It can be difficult to distinguish between the effects of NIHL and presbycusis, as they frequently co-exist. The effect of noise is cumulative and can increase susceptibility and accelerate hearing deterioration in later life, even after the exposure has ceased. Hence, cochlear degeneration from early noise exposure can render the ears more vulnerable to the effects of ageing (WHO, 2015b).

Rabinowitz (2012) observed that it is difficult to estimate prevalence of NIHL as definitions vary between countries (and even between US states) including whether to use an absolute approach (a given dB cut-off), relative approaches (shift from a baseline audiogram) or the presence of high frequency notches in audiograms that suggest NIHL rather than presbycusis. Some experts have attempted to use tables of 'expected' hearing loss from ageing and assign the difference to NIHL. However, studies of populations living in the absence of significant noise exposure report only minimal changes in hearing with advancing age.

Audiometrically, noise-induced threshold shifts can usually be observed as a characteristic 'notch' in the 3–6 kHz range on an audiogram. Continued noise exposure can cause the notch to worsen and spread to neighbouring frequencies. In contrast, age-related hearing loss is usually characterised by a progressive threshold shift beginning with the higher frequencies (Safe Work Australia, 2010).

NIHL also may be becoming a relatively larger cause of hearing loss because presbycusis appears to be diminishing on an age-standardised basis. Zhao et al (2010) found that a given age cohort population in the US experiences less age-related loss than did previous generations. After controlling for age, every 5 year increase in birth year lowered the odds of hearing impairment by 6% in women and 13% in men. The authors attribute this to population-wide improvements in medical care, nutrition, and general health.

3.7.2.1 Occupational noise-induced hearing loss

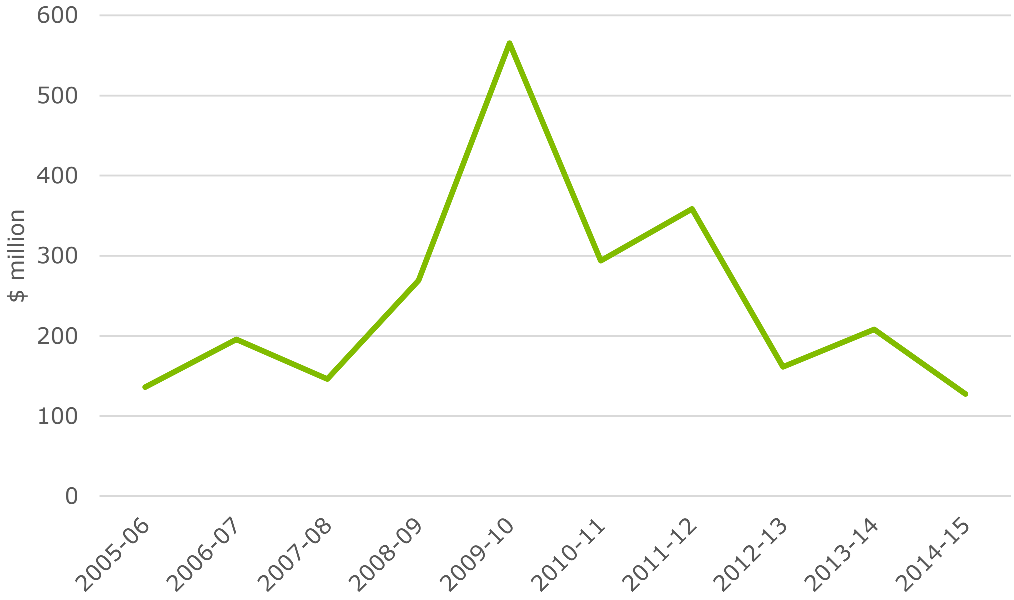
Mahboubi et al (2013) reported that NIHL is the most significant preventable source of hearing loss, and the greatest compensable occupational hazard in the United States.

Safe Work Australia (2010) estimated that around 10-12% of the Australian workforce is exposed to excessive noise. On average, there are around 4,500 workers' compensation claims a year for NIHL, with a median cost of around $47,600 (Safe Work Australia, personal correspondence). However, both the incidence and median cost of such claims have been falling substantially since 2010 (Chart 3.9), resulting in around 3,700 successful workers' compensation claims per year for industrial deafness involving permanent impairment due to noise.

Dobie (2008) estimated that exposure to noise in the workplace accounts for about 10% of the burden of adult hearing loss in western countries, and that a similar proportion is likely to be attributable to non-occupational noise sources such as the environment, entertainment venues and personal music players. Similarly, Nelson et al (2005) estimated that occupational NIHL accounts for 16% of disabling hearing loss in adults.

While both Nelson and Dobie are widely cited, it is possible their figures are conservative; a study of National Health and Nutrition Examination Survey (NHANES) data by Tak and Calvert (2008) estimated that 24% of hearing loss could be attributed to occupational noise, although this was based on questionnaire responses.

Chart 3.9: Total cost of workers' compensation claims for noise-induced hearing loss, Australia, 2005-06 to 2014-15



Note: 2014-15 figures are provisional. Cost is calculated as total claims times median cost per claim, as mean cost per claim is no available
Source: Safe Work Australia National Data Set

3.7.2.2 Recreational noise-induced hearing loss

The WHO (2015) estimated that environmental noise from non-occupational sources such as traffic is also increasing and is responsible for an estimated 1-1.6 million DALYs (disability adjusted life years) in Western European countries, implying an annual loss of 1 million life years in that part of the world.

The WHO (2015) also estimated that 1.1 billion young people (12-35 years old) worldwide could be at risk of hearing loss due to unsafe listening practices. Sliwinska-Kowalska and Davis (2012) reported that **the number of young people with social noise exposure from personal music players in Australia and other Western countries**[16]**, has tripled between 1980 and 2000, from 6%-18%.** The Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR) expected that the 5%-10% of British young people who listen to music for more than an hour a day at 90 dB or more would be likely to develop hearing loss after five years of exposure (SCENIHR, 2008). These rates may have increased since the advent of smartphones. A study of over 1,600 Danish students found that 27% listened to music at 85+dB for an hour a day or more (Vogel et al, 2011) and in a study of Canadian students it was found that 42% did so (Lévesque et al, 2010).

Sliwinska-Kowalska and Davis (2012) estimated that, as a consequence, some 15-20% of young people have audiometric "notches" at 4-6 kHz that may indicate excessive noise exposure. Similarly, a study of audiograms of young adults entering the workforce found that 16% showed evidence of high-frequency hearing loss at noise-sensitive frequencies (Rabinowitz et al, 2006). Another contemporaneous analysis comparing hearing thresholds of adolescents in the 1988–1994 and 2005–2006 NHANES surveys found that the prevalence of hearing loss increased from 14.9% to 19.5%, often involving the higher (noise-sensitive) frequencies (Shargorodsky et al, 2010).

3.7.3 Total preventable hearing loss

Access Economics (2006) estimated that NIHL was responsible for 37% of hearing loss in adults. Although this figure appears high, it is an Australian, audiometric estimate that continues to be cited in peer-reviewed literature. There is evidence that a proportion of presbycusis (age-related hearing loss) may be caused by NIHL (Rabinowitz, 2012). Nelson (2005) estimates that occupational NIHL accounts for around 16% of adult hearing loss, and Dobie (2008) found that recreational NIHL accounted for around the same proportion of

[16] Specifically, Australia, America, Germany and Sweden.

adult hearing loss as did occupational NIHL, which together imply recreational NIHL could have accounted for 16% of hearing loss in the mid-2000s,. Back then only around 10% of young adults displayed hazardous listening behaviour on personal music players (SCENIHR, 2008) whereas the WHO (2015) estimated that that figure is closer to 50% now. (According to the ABS, the average Australian is 35 years old, which is within the WHO's recreational noise at risk group)[17] This may suggest that recreational NIHL could be a greater problem now than occupational NIHL is. However, following Dobbie (2008) this report assumes that occupational NIHL and recreational NIHL are equally responsible for adult hearing loss.

Accordingly this report assumes that 49% of hearing loss in children (up to 15 years old) is due to preventable causes, based on WHO (2016) estimates for developed countries **and 37% of adult hearing loss is due to preventable causes** (as per Access Economics, 2006)**.**

[17] According to the ABS the median Australian was born in 1978 (ABS, 2015c).

4 Health system costs

Health system costs comprise the costs of running hospitals, general practitioner (GP) consultations, other medical specialist and other health professional services[18], the cost of any pharmaceuticals (such as those associated with rehabilitation after cochlear implant surgery) and research. Health system costs are primarily paid for by government, but there are also other sources including substantial out-of-pocket payments, and funding from other parties such as private health insurers (noting insurance is a small source for hearing loss).

Key findings:

- Total health system expenditure attributed to hearing loss in 2017 was estimated to be $881.5 million, or $245 per person with hearing loss.
- The largest component of health system expenditure in 2017 was the OHS program ($521.4 million or $145 per person with hearing loss), followed by expenditure on hearing aids in the private market ($121.0 million or $34 per person with hearing loss).
- The Federal Government bore the majority of health system costs (76%), followed by other parties (13%) and State/Territory Governments (11%).

4.1 Hospital expenditure

There is no hospital expenditure data specifically related to hearing loss in Australia. Ideally, hospital data would separately identify costs with treating hearing loss in specific hearing loss clinics and general public and private hospitals.

4.1.1 Inpatient expenditure

To determine admitted patient expenditure, a weighted average of Australia refined diagnosis related groups (AR-DRG) cost weights relating to hearing loss, as reported by the Independent Hospital Pricing Authority (IHPA, 2016), were applied to the number of hospital separations specifically relating to hearing loss in 2013-14. Hearing loss specific separation statistics were retrieved from the National Hospital Morbidity Database for 2013-14 (AIHW, 2016) for the H90 and H91 ICD-10 codes[19]. T**here were estimated to be 3,769 hearing loss separations in 2017** (3,543 separations in 2013-14 adjusted for demographic changes).

The average cost per separation for hearing loss in 2013-14 was $4,667. Inflated to 2017 (using AIHW (2016) health cost inflations data) this is $4,759. The cost weight for each AR-DRG related to hearing loss is reported in Table 4.1. These AR-DRGs were selected based on their applicability to hearing loss.

[18] "Other health professionals" includes all health professionals apart from doctors.
[19] ICD-10 stands for the International Statistical Classification of Disease and Related Health Problems. The H90 and H91 codes are Conductive and sensorineural hearing loss, and other hearing loss, respectively.

Table 4.1: AR-DRG cost weights for hearing loss related separations, 2013-14

AR-DRG description	Separations	Cost weight ($)
D01Z – cochlear implant	600	30,334
D12A – other ear, nose, mouth and throat procedures with complications	836	11,245
D12B – other ear, nose, mouth and throat procedures without complications	5,405	4,277
D66A – other ear, nose, mouth and throat disorders with complications	1,457	7,798
D66B – other ear, nose, mouth and throat disorders without complications	4,880	3,199
D66C – other ear, nose, mouth and throat disorders sameday	8,405	1,272
D06Z- sinus and complex middle ear procedures	7,094	6,407
Weighted average	**28,677**	**$4,667**

Source: IHPA (2016) and Deloitte Access Economics calculations.

The number of hearing loss separations in 2017 (3,769) was multiplied by the average cost weight ($4,759) to calculate the total admitted patient hospital expenditure. **The total admitted patient hospital expenditure for hearing loss was estimated to be $18.9 million in 2017**.

4.1.2 Outpatient expenditure

To calculate outpatient expenditure, the total number of service events for ear, nose and throat from 2013-14 and the cost unit for these events were sourced from IHPA (2016). Total service events for ear, nose and throat were 161,279 in 2013-14 and the cost unit for each of these events was $251.

To determine the proportion of the ear, nose and throat service events that were hearing loss specific, data from the inpatient section were used. The number of hospital separations that had a primary diagnosis of H90 and H91 (3,543) were compared to the number of ear, nose and throat separations from Table 4.1 (28,677), suggesting 12.4% of ear, nose and throat hospital separations were related to hearing loss. The total number of ear, nose and throat services events from 2013-14 were multiplied by this proportion to give an estimate of the number of hearing loss related service events (19,925). The number of hearing loss service events was then brought forward to 2017 figures using age-gender demographic changes and population growth, while the unit cost from 2013-14 was inflated to 2017 using AIHW (2016) health cost inflation data.

There were estimated to be 20,439 hearing loss outpatient service events in 2017 each at a cost of $267.42. **The total outpatient expenditure on hearing loss was estimated to be $5.5 million in 2017.**

4.2 Aged care

No publicly available information on the number of people with hearing loss requiring aged care was found. A targeted literature search was conducted to identify any additional need for aged care in people with hearing loss. No studies were found, which suggests that people with hearing loss are not substantially more likely to require aged care.

This is similar to the results from Access Economics (2006), which suggested that aged care was less than 1% of all health system costs for hearing loss. As such, no estimates for aged care costs were included in this report. It is worth noting that while no aged care costs are attributed to hearing loss, this naturally does not mean that people with hearing loss do not use aged care services. Rather, it is worth noting, this may reflect a gap in residential aged care services as they may have many residents with hearing loss, without hearing aids and hence they could, in theory, be providing hearing support on top of usual support for daily living.

More research is needed to provide better data in relation to this cost item.

4.3 General practitioners

A publication by Britt et al (2016) analysed GP encounters in Australia from 2015-16. During this year the number of ear related problems managed was approximately 1.9 encounters per every 100 encounters. This figure includes all ear related problems as defined by the International Classification of Primary Care-2nd edition (ICPC-2), apart from excessive ear wax and otitis media/myringitis.

To calculate the number of ear related GP consultations, the number of GP encounters in 2015-16 (DoH, 2017) were multiplied by the rate from Britt et al (2016). This resulted in approximately 2.4 million ear related GP consultations. The average 2017 cost per GP consultation was calculated by adding the rebate for a GP consult ($36.30) and the average patient contribution ($33.38) from Medicare data (DoH, 2017) and inflating using health inflation. The total cost of ear GP consultations was calculated to be $168.4 million.

However, the ICPC-2 code for ear related problems includes a number of items that are not strictly related to hearing loss. For example, "plugged feeling ear" and "concern with appearance of ears" are classified as ear conditions within this code. Therefore, the $168.4 million is an overestimate of the GP expenditure attributed to hearing loss.

To estimate the GP expenditure specifically for hearing loss, the ratio between the number of separations for ICD-10 codes H90 and H91 to the number of hearing loss separations from the National Hospital Morbidity Database for 2013-14 (IHPA, 2016) that was used in section 4.1.2 was used (12.4%). It was assumed that this is the percentage of all ear related GP consultations that are related to hearing loss. **Total GP hearing loss expenditure in 2017 was estimated to be $20.8 million.**

4.4 Cochlear implants

State governments run programs which cover the costs of a set number of cochlear implants each year (Cochlear, 2016). Another source of funding for cochlear implants is private health insurers. Limited information was found on the number of cochlear implants provided by state governments and private health insurers. Instead, other publicly available information was used to calculate the cost of cochlear implants.

A news article from 2013 noted that an additional $7.8 million from Queensland Health would provide 140 people with cochlear implants (Kehren, 2013). These figures indicate that average spending on cochlear implants per person in 2013 was $55,714 (=$7.8 million/140 people). This cost was assumed to take into account the cost of the device, the surgery, and rehabilitation and was inflated to 2017 figures using health inflation. The Access Economics (2006) report received information from Cochlear Ltd about the number of Australians that receive an implant each year. In 2006 this figure was 400, inflating this figure using prevalence growth resulted in an estimate of 547 people in 2017 receiving cochlear implants[20].

Multiplying the 2017 cost per person ($59,942) by the number of people receiving cochlear implants (547), total cochlear implant expenditure was estimated to be $32.8 million.

4.5 Hearing aids

4.5.1 Public providers

Outcome 3 of the DoH's portfolio outcomes is to provide access to cost-effective medical, dental, allied health and hearing services. To fulfil this outcome the DoH provides a Hearing Services Program which is administered by the OHS. This program provides vouchers to eligible people, which allows them to have a hearing aid and have it refunded by the Government.

To be eligible for the services provided under the program a person must hold a concession card, be a member of the Australian Defence Force, or be a National Disability Insurance Scheme participant with hearing needs referred by a planner from the National Disability Insurance Agency. Other groups may be eligible under the Community Service Obligations component of the program which targets the hearing needs of vulnerable populations such as those living in remote areas or Indigenous people aged over 50 (DoH,

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[20] No recent information on the number of cochlear implants sold in 2017 (or most recent year) was sourced. However, estimates from the 2016/17 Cochlear submission into the *Inquiry into the Hearing Health and Well-being of Australia* state that around 100 children older than one year will receive one or two cochlear implants and that around 75-90 babies will receive a cochlear implant each year. If the number of adults receiving a new cochlear implant is similar to the number of children receiving a new cochlear implant, then the estimated 547 people receiving new cochlear implants is a reasonable assumption.

2016c). Eligibility requirements for the OHS program indicate that the primary users of the program would be people under the age of 26 years and people over 65 years, although those aged in between these ages can access the services if they are receiving certain payments from Centrelink, hold a Pensioner Concession Card, are a dependent of a person of either one of the earlier categories or are undergoing an Australian Government funded disability management services and have been referred (DoH 2016d).

The expenditure for the 2015-16 year on the Hearing Services program was $509.2 million (DoH, 2016b). **This figure was inflated using health inflation to result in total 2017 costs related to the Hearing Services Program of $521.4 million.**

4.5.2 Private providers

It was assumed that although the Hearing Services Program would serve some people aged 25-64 years, the majority of people in this age group would have to acquire hearing aids from the private market. According to ABS (2015b), 100,963 people between the ages of 25-64 in 2015 who had hearing loss also had a hearing aid. People with hearing loss may use either one hearing aid (monaural) or two hearing aids (binaural). Data from the OHS from 2015-16 show that of the number of devices fitted, 85% were for people with two hearing aids (DoH, 2016e). Applying this percentage to the number of people aged 25-64 who had a hearing aid in 2015 indicated that there were approximately 186,770 hearing aids in circulation in 2015. This figure was projected to 2017 figures using prevalence growth, to be 197,139. Not all of these hearing aids would need to be replaced or upgraded in 2017; it was assumed that people in the private market would upgrade their hearing aid every five years. Therefore, there were an estimated 39,428 new hearing aids in the private market in 2017.

The average cost of an aid was calculated by taking the average price of hearing aids listed on *The Hearing Care Shop* (Hearing Care Shop, 2017). Multiplying the average cost per aid ($3,069) by the number of new aids (39,428), it was **estimated that private market expenditure on hearing aids was $121.0 million in 2017.** This cost includes only the cost of the hearing aid device and not the costs of the maintenance of existing aids or the hearing assessment and fitting prior to getting a new hearing aid, which are calculated in section 4.6.

4.6 Other health professionals

It was assumed that the OHS total expenditure presented in section 4.5.1 covers all these hearing aid maintenance and fittings and hearing assessments for public patients. Therefore, all costs presented here are for the private market. These costs do not overlap with those presented in section 4.5.2 which only covers the cost of the hearing aid itself. This section also covers the costs associated with people in the private market undergoing hearing aid assessments and the actual cost of fittings.

Deloitte Access Economics (2017a) reported that for every hearing aid sold there were approximately three additional hearing tests. In section 4.5.2 it was estimated that there were approximately 39,428 new hearing aids in the private market in 2017. This was multiplied by three to provide an estimate for the number of hearing tests in 2017 (118,283). The cost of a hearing assessment as reported by the OHS Fee Schedule for 2016-17 was $136.25 (DoH, 2016g). **Multiplying the cost of a hearing assessment by the number of hearing assessments resulted in total expenditure in 2017 of $16.1 million.**

The number of hearing aid fittings was derived by taking the number of people who needed a new hearing aid and multiplying by the cost of fittings. Using the 2015 SDAC (ABS, 2015b) data on the number of people with hearing aids, it was estimated that in 2017 there were 3,199 people who needed a new monaural aid and 18,114 people who needed new binaural aids. According to the OHS Fee Schedule the cost of an initial fitting and rehabilitation of a monaural aid was $422.85 and for binaural aids it was $507.20. Multiplying the number of people who need a new monaural aid and the number of people who need new binaural aids by the respective costs results in the **total cost of hearing aid fittings was estimated to be $10.5 million in 2017.**

Audiologists and audiometrists are also expected to provide maintenance services for hearing aids. It was assumed that all hearing aids that were not new or replaced in 2017 received maintenance. The number of people who required maintenance in 2017 who have one hearing aid was calculated to be 12,798 and those who have two hearing aids was 72,457 (DoH, 2016g). The cost of maintenance and battery supply from the

OHS Fee Schedule was $73.76 for one aid and $195.35 for two aids. **The total cost for hearing aid maintenance in 2017 was estimated to be $15.1 million.**

All other health professionals costs are summarised in Table 4.2. **The total costs of other health professionals was estimated to be $41.8 million.**

Table 4.2: Other health professionals expenditure summary.

Component	Monaural/binaural	Number of people	Cost per person/aid	Total expenditure ($ million)
Assessments*	-	118,283	136	16.1
Fittings	Monaural	3,199	423	1.4
Fittings	Binaural	18,114	507	9.2
Maintenance	Monaural	12,798	74	0.9
Maintenance	Binaural	72,457	195	14.2
Total	**-**	**-**	**-**	**41.8**

Source: Deloitte Access Economics calculations based on ABS (2015b) and DoH (2016g).

Note: *refers to the number of aids and not the number of people.

4.7 Research

Research costs are based on the number of grants provided by the National Health and Medical Research Council (NHMRC) and other sources of research funding. NHMRC data for all grants provided up to 2015 was publicly available. The NHMRC data contains a description of each grant, this description was filtered using the following terms to identify hearing loss related research:

- hearing;
- cochlear;
- auditory; and
- deaf.

To calculate total hearing loss research expenditure in 2017, the average per year funding of grants active in 2015 was calculated and then inflated to 2017 figures using health inflation. **Total NHMRC funding for hearing loss in 2017 was estimated to be $6.6 million.**

Another Commonwealth organisation which provides funding for research is the Australian Research Council. According to a list of funding provided in 2014, four grants related to hearing loss and cochlear implant research were granted (Australian Research Council, 2014). The per year funding for each of these grants was taken and inflated to 2017 figures using health inflation. **In total, the 2017 funding for hearing loss research provided by the Australian Research Council was estimated to be $181,000.**

A source of non-government hearing loss research funding is the Deafness Foundation. In 2014/15 they provided $84,947 worth of grants and in 2015/16 they provided $82,291. The average of these two figures was inflated to 2017 figures using health inflation to provide an estimate of 2017 funding. This calculation resulted in $87,662 worth of research funding in 2017. In addition to these grants, the Deafness Foundation also provides a Peter Howson Clinical Research Fellowship worth $50,000 each year. **The total research funding provided by the Deafness Foundation in 2017 was estimated to be $137,662.**

To provide more information about research costs the annual report for Ear Science Institute Australia was utilised (Ear Science Institute Australia, 2014). Their 2014 annual report reported a number of grants, some from the NHMRC and Australian Research Council, but also grants from other sources such as the Raine Medical Research Foundation and Cochlear Foundation. The per year grant funding was calculated from the annual report, while ensuring that grants provided by the NHMRC and Australian Research Council were excluded to provide an average per year funding of $600,763 in 2014 terms. **This was inflated using health inflation to 2017 figures to be $634,932.**

This exercise demonstrates the various sources of private funding for hearing loss research. To calculate total private research costs is difficult given the lack of publicly available data. Therefore, the costs presented here are an underestimate of the true cost of hearing loss research.

4.8 Other health system costs (pathology and imaging, specialists and pharmaceuticals)

No readily available data were found to provide an estimate for these costs. As such, the Access Economics (2006) per person costs were calculated, inflated to 2017 figures using health inflation and multiplied by the 2017 prevalence to provide an estimate of these costs. Table 4.3 presents the results of these calculations.

Table 4.3: Other health system costs summary

Other health sector	Cost ($ million)	Per person costs (2017$)
Pathology and imaging	0.6	0.18
Medical specialists (other than GPs)	62.4	17
Pharmaceuticals	22.8	6
Total other expenditure	**85.8**	**24**

Source: Deloitte Access Economics calculations based on Access Economics (2006)

Note: Totals may not add due to rounding

Overall, the estimated per person cost of pathology and imaging, specialist visits and pharmaceuticals for people with hearing loss was $26 in 2017. **Applying this cost to the prevalence estimates resulted in total expenditure in 2017 of $85.8 million.**

4.9 Summary of health system costs

Total health system costs associated with hearing loss in Australia were estimated to be $881.5 million in 2017 (Table 4.4 and Chart 4.1). The largest component was the OHS program ($521.4 million), followed by hearing aid expenditure in the private market ($121.4 million). This cost includes items such as capital expenditures, expenditure on community health (excluding mental health), public health programs and health administration. Allowance is made for these components by factoring up for these costs in the manner adopted by the AIHW (AIHW, 2005)[21] where the unallocated component is estimated as 12.5/87.5 or 14.3%

The unallocated component, comprising the administrative and other items detailed above, was thus estimated as 14.2% of the health system costs that do not include hearing aid and cochlear implant expenditure ($180.5 million)[22] or **$25.8 million as the final estimate of unallocated health costs**.

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[21] Australian Institute of Health and Welfare 2005, *Health system expenditure on disease and injury in Australia, 2000–01 Second edition*, Cat. No. HWE 28, Health and Welfare Expenditure Series No 21, Canberra.

[22] AIHW include within their "unallocated" health expenditure the cost of health aids and appliances. Due to hearing loss having a higher than average cost of aids and appliances relative to recurrent spending across all diseases, we calculated the cost of this separately and have not included it within the unallocated component.

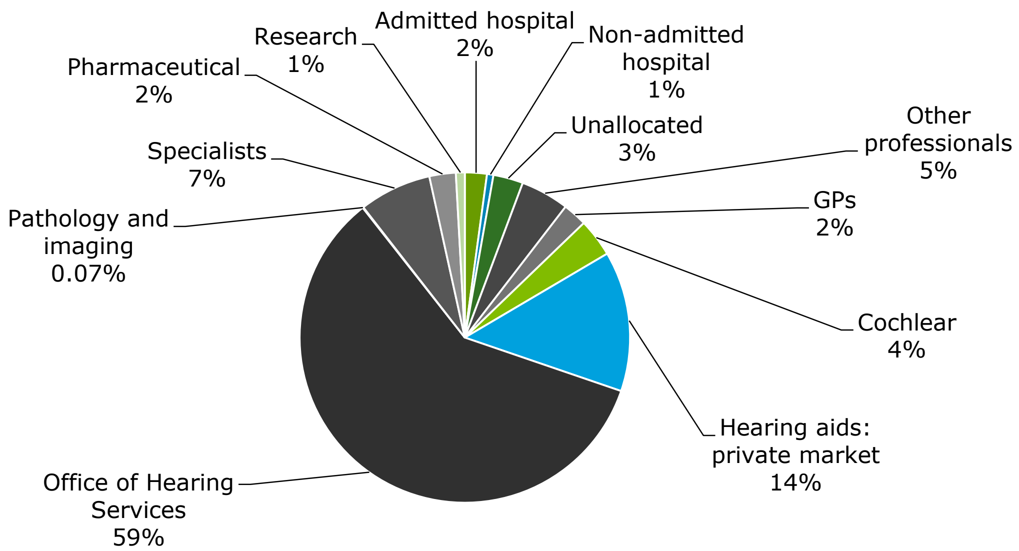
Table 4.4: Health system costs, total and per person, 2017

Health system component	Cost ($ million)	Per person costs ($)
Admitted hospital	18.9	5
Non-admitted hospital	5.5	2
General practitioners	20.8	6
Cochlear implants	32.8	9
OHS	521.4	145
Hearing aids: private providers	121.0	34
Other health professionals (audiologists and audiometrists)	41.8	12
Research	7.7	2
Medical specialists other than GPs	62.4	17
Pharmaceuticals	22.8	6
Pathology and imaging	0.6	0.18
Unallocated	25.8	7
Total	**881.5**	**245**

Note: Per person is total national cost divided by total persons with hearing loss

Source: Deloitte Access Economics calculations.

Chart 4.1: Health system expenditure by component, 2017 (% total)

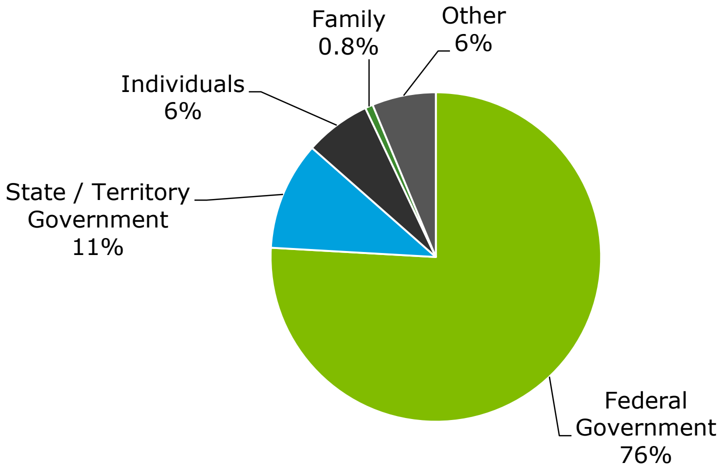


Source: Deloitte Access Economics calculations.

Chart 4.2 presents estimates of the cost for different sectors of society based on data from the AIHW (2016b). In 2017, hearing loss was estimated to cost:

- the Federal Government $669.0 million;
- State/Territory Governments $93.6 million;
- individuals and families $63.7 million; and
- other parties (such as private health insurers) $55.1 million.

Chart 4.2: Health system expenditure by who pays, 2017 (% total)



Source: Deloitte Access Economics calculations.

5 Other financial costs

This chapter describes the approach that was used to estimate productivity costs associated with hearing loss in Australia. Broadly, the costs included here cover lost productivity for people with hearing loss, and lost productivity for people who care for people with hearing loss.

Key findings:

- Total productivity losses attributed to people with hearing loss were estimated to be $12.8 billion, or $3,566 per person with hearing loss in 2017. The majority of these costs were attributed to reduced employment (72%). Individuals bear the majority of these costs (47%), followed by the government through lost taxes (32%).
- Productivity losses due to informal carers' lower employment were estimated to be $141.6 million in 2017, or $39 per person with hearing loss.

5.1 Productivity losses

Hearing loss can have a significant impact on an individual's ability to work. This may include a reduced chance of employment, premature retirement, a greater number of sick days than average, or a diminished capacity to be productive at work due to impaired ability or psychological stresses. As such, hearing loss may incur a range of productivity costs not only to the individual but also to their employers and the economy in general.

We adopt a human capital approach to estimate the productivity losses. Estimating losses due to reduced employment involves calculation of the difference in employment between people with hearing loss and the general population, multiplied by average weekly earnings (AWE) (ABS 2017; ABS 2016b). Productivity losses from premature retirement are estimated in terms of the net present value of the future income streams lost. Costs incurred through absenteeism and/or presenteeism are derived by multiplying the average number of weeks, as converted from the number of days and hours respectively lost, by AWE[23].

5.1.1 Reduced employment

Hearing loss may result in reduced employment either through disadvantages in job-seeking or self-selection out of the labour force. This can lead to significant productivity losses, in the form of wages lost from employment that would otherwise have been gained, in addition to other costs to the individual, such as diminished social engagement. Ruben (2000) notes communication disorders including hearing or speech impairments increasingly impact people's ability to work due to the shift in the 20th century from manual labour to increasingly communication-based jobs. Deloitte Access Economics undertook a literature review in order to assess to what extent hearing loss leads to reduced employment Table 5.1 shows an overview of the findings.

[23] The methodology employed within this section is similar to that used in the Access Economics (2006) report; the only notable difference is for carer numbers, where assumptions had to be made in 2006, but data are now available.

Table 5.1: Summary of results pertaining to the impact of hearing loss on employment

Reference	Country	Relationship
Hogan et al, 2009	Australia	Hearing loss was associated with an increased rate of non-participation in employment of 11.3%-16.6%, and 2.1% when controlling for co-morbidities.
Winn, 2007	Australia	Congenitally deaf males have a 26.9% higher unemployment rate.
Hogan et al, 1999	Australia	Employment rate for people aged 45-64 years with hearing loss was 20.5% lower for males and 16.5% lower for females than for people without hearing loss.
Rydberg et al, 2010	Sweden	Employment gap of 15.0%.
Mohr et al, 2000	US	Labour force participation gap (severe to profound hearing loss) found to be 18% for ages 18-44, 19% for ages 45-64, and 6% for ages 65 and older.
Ruben, 2000	US	Employment gap of 10.4% for people with difficulty hearing and 24.4% for people who are unable to hear.
SDAC, 2015	Australia	Overall, hearing loss is associated with a 13.0% decrease in employment for males and 9.0% in females.

Hogan et al (2009) found that hearing loss was associated with an increased rate of non-participation in employment of between 11.3% and 16.6%, based on analysis of the 2003 SDAC. They also found that co-morbidities and advancing age increased the likelihood of low employment; after controlling for co-morbidities, it was found that hearing loss was associated with a 2.1% higher rate of non-participation in employment. They note that as the SDAC relies on self-reported data for those experiencing disability, the findings are likely to be a conservative estimate of the impact of hearing loss on accessing well-paid employment.

Winn (2007) references a study of 60 congenitally deaf adults in Australia, which found that rates of unemployment for male and female deaf adults were almost equal; however, they were significantly higher than the unemployment rate at the time. Males in the study were found to have an unemployment rate of 37.5%, while the state unemployment rate at the time of the study was 10.6%.

Access Economics (2006) attributed productivity loss due to hearing loss based on the productivity estimates on data from the 1994 South Australia Health Omnibus Study (Hogan et al, 1999). This study found that of people with hearing problems aged 15–64 years, 55.6% reported being in paid work compared with 62.4% of people without hearing problems, a net difference of 6.8%. In examining the data by age group, it was found that there was a significant difference for people aged 45-64 years old. The age-standardised employment rate for males aged 45-64 years with hearing loss was 20.5% lower than that for people without hearing loss and the age-standardised employment rate for females aged 45-64 years with hearing loss was 16.5% lower than that for people without hearing loss.

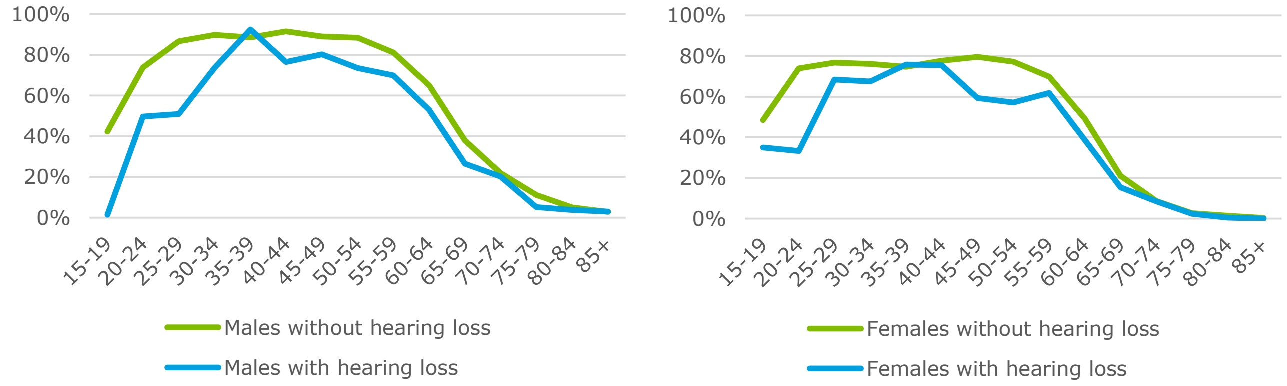
Rydberg et al (2010) compared a population of 2,144 people born from 1941-1980 who attended special education programs for the deaf to 100,000 randomly chosen individuals from the total Swedish population born during the same period. They found that, in the deaf population, 63% were employed compared to 78% of the reference population, resulting in a 15% difference.

In their study on the impact of severe to profound hearing loss on employment outcomes, Mohr et al (2000) identified differences between the labour force participation rates of people with severe to profound hearing loss and the general population for three specified age brackets, with labour force participation gaps ranging from 6% for individuals aged 65 and older to 19% for individuals aged between 45-64.

In his study of the economic impact of communication disorders on the US economy, Ruben (2000) analysed 1997 data from the US Department of Labor and compared employment outcomes between individuals with hearing loss and the general working age population. In comparison to the general working age population, who reported an employment rate of 74.8%, working age individuals who either had difficulty hearing or were unable to hear reported employment rates of 64.4% and 50.4% respectively, i.e. differences of 10.4% to 24.4% respectively.

Analysis of data from the 2015 SDAC (ABS 2015c) found that, overall, for males of working age (15-64) without hearing loss, 80% of the population was employed (full time or part time). The corresponding figure for those with hearing loss was 67%. That is, males with hearing loss were only 84% as likely to be employed as those without hearing loss. For females without hearing loss, 71% were employed, while for those with hearing loss, 56% were employed. That is, females with hearing loss were only 79% as likely to be employed as their hearing counterparts. In both cases, the employment gap was considerably larger for young people under the age of 30. Conversely, in both cases, people with hearing loss in their mid-30s had higher employment rates than their hearing counterparts (Chart 5.1). This is not necessarily counterintuitive; Deloitte Access Economics (2017) found that hearing impaired children who had gone through the First Voice early intervention program had better Year 12 completion rates than the general population. So, different cohorts may be affected by a range of different factors.

Chart 5.1: Employment rates for people with and without hearing loss, Australia, 2015



Note: Employment is a percent of population, not of labour force
Source: ABS (2015c)

Interestingly, the employment gap between those with and without hearing loss and hearing populations does not substantially worsen with higher degrees of disability – except, again, in the young. This is shown in Chart 5.2 where the relationship between employment rate and severity of hearing loss is mapped for both males and females.

Chart 5.2: Relationship between employment and severity of hearing loss, males (left) and females (right).

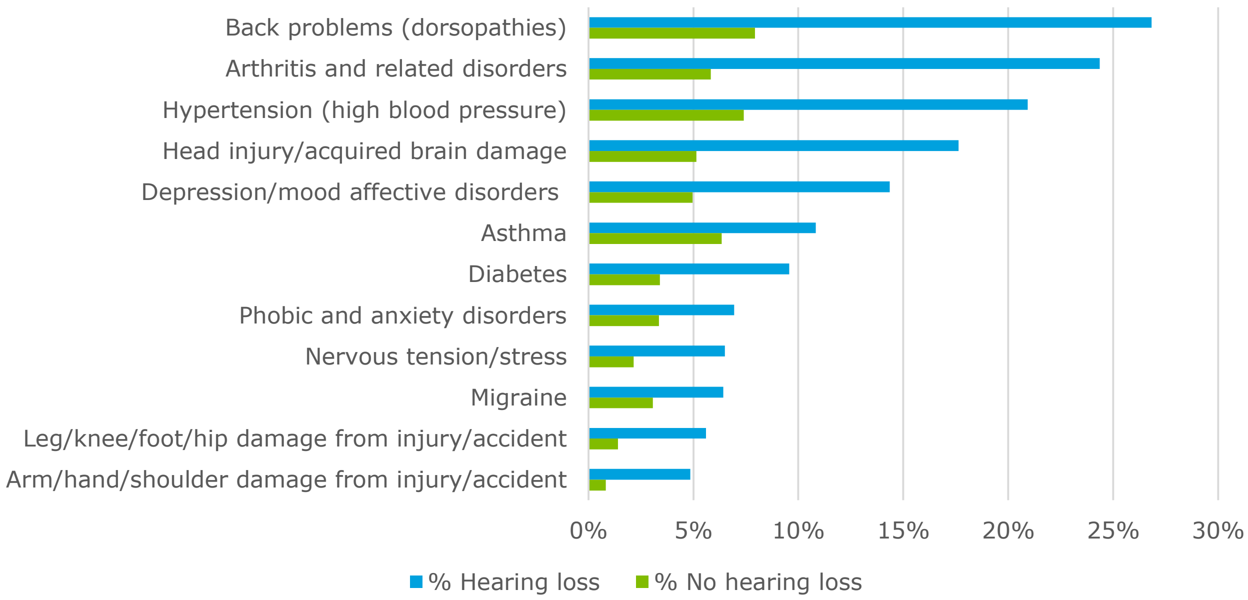
Note: Employment is percent of population, restriction is on employment or study ability
Source: ABS (2015c)

The fact that people with hearing loss have worse employment outcomes than those with full hearing does not necessarily mean that this is directly due to the hearing loss per se. Regression analysis conducted on 2015 SDAC data (ABS, 2015b) suggests that, for the small subset of people with hearing loss and no other conditions, employment outcomes are only about 5% worse than for the small subset of people with no long term health conditions. However, as discussed in section 3.6 hearing loss is associated with considerable physical and mental comorbidity, even to the extent of increased mortality. Further, the more severe a person's hearing loss is, the more comorbidities they have, with longitudinal evidence suggesting that this association is causal (Hogan et al, 2009b). For example, a study by Bartlett et al (2008) found that admitted patients with communication difficulties – most of which were due to hearing loss – were more than three times as likely to have an adverse event in hospital than those without. The great majority of hearing loss is caused by ageing and excessive noise exposure, rather than other health conditions.

The majority of the top twelve most common comorbidities in people with hearing loss appear to have some relation to hearing loss (Chart 5.3). For example, injuries (including back problems) may be caused by not hearing potential threats. Communication problems can lead to mental health issues, which in turn can cause or aggravate physical conditions. Luppino et al (2010) in a meta-analysis of longitudinal studies found that depression is a predictor of obesity, which in turn is a risk factor for diabetes and asthma, while stress is a risk factor for heart diseases such as hypertension.

- There is no apparent causal connection between hearing loss and arthritis; rather, both are correlated with ageing, and the average age of workers with hearing loss is around 13 years higher than those without hearing loss (ABS, 2015c). However, while ageing may explain the generally higher incidence of some comorbidities in the hearing loss population, there remains the question as to why the employment gap between the two populations is greatest in the youngest cohort, which has the fewest comorbidities.

Chart 5.3: Most common comorbidities in people with hearing loss



Source: ABS (2015c)

Research by Kochkin (2010) has shown that, for all but severe hearing loss, the employment gap should disappear with hearing aid use, explored further in section 7.2.2. However, these findings suggest that, even if co-morbidities play a role in decreased employment for people with hearing impairment, the disparity in employment is negated if hearing aids are used. The attribution of the employment gap to hearing loss in the most recent 2015 SDAC data (ABS, 2015b) thus appears to be relatively robust, and hence these data were used to calculate the costs of reduced employment for people with hearing loss. The employment rates for males and females with and without hearing loss from the 2015 SDAC are shown in Table 5.2 and Table 5.3.

Table 5.2: Employment rates for people with and without hearing loss, males

Age/gender	With hearing loss	Without hearing loss	Difference
15-19	42%	1%	**-41%**
20-24	74%	50%	**-24%**
25-29	87%	51%	**-36%**
30-34	90%	74%	**-16%**
35-39	89%	92%	**4%**
40-44	92%	77%	**-15%**
45-49	89%	80%	**-9%**
50-54	88%	74%	**-15%**
55-59	81%	70%	**-11%**
60-64	65%	53%	**-12%**
65-69	38%	26%	**-11%**
70-74	22%	20%	**-2%**

Source: ABS (2015b)

Table 5.3: Employment rates for people with and without hearing loss, females

Age/gender	With hearing loss	Without hearing loss	Difference
15-19	48%	35%	**-13%**
20-24	74%	33%	**-41%**
25-29	77%	68%	**-8%**
30-34	76%	67%	**-9%**
35-39	75%	76%	**1%**
40-44	78%	75%	**-2%**
45-49	80%	59%	**-20%**
50-54	77%	57%	**-20%**
55-59	70%	62%	**-8%**
60-64	49%	39%	**-10%**
65-69	21%	15%	**-6%**
70-74	9%	8%	**-0.2%**

Source: ABS (2015b)

The difference in employment rates for people with hearing loss in the different age categories was applied to the general employment rates in Australia and AWE at different age categories (ABS, 2017; ABS, 2016b). **This resulted in a total cost of $9.3 billion in reduced employment due to hearing loss.**

5.1.2 Absenteeism

Absenteeism is defined in the literature as the average number of days per year that an employee takes off work as a result of hearing loss. This can incur a productivity cost to employers if absenteeism rates for employees with hearing loss are higher than those for their employees without hearing loss.

A literature scan was conducted to find relevant data regarding the relationship between hearing loss and absenteeism. As noted in a systematic literature review by Friberg et al (2012), studies on the impact of hearing loss on absenteeism are limited. While there are a variety of studies on the impacts of different conditions associated with hearing loss, such as otitis media and Ménière's disease, far fewer were identified on the impacts of hearing loss in particular. This may be attributed to the inconspicuous nature of the symptoms associated with hearing loss, which do not require sick leave to manage in the typical fashion that other more acute or episodic conditions do.

However, in their study of supports required by employees with chronic diseases in the workplace, Detaille et al (2003) identified that employees with hearing loss were particularly affected by the psychological toll of their condition. This was reflected in an identified need for more emotional forms of support, such as workplace support and acceptance and awareness of their limitations, in addition to material supports, such as reimbursement for hearing aids. Similarly, in their study of data from the Dutch National Longitudinal Study on Hearing, which included self-reported data on psychological work characteristics, Nachtegaal et al (2009) found a significant association between hearing status and the need for recovery after work. For every dB SNR (signal to noise ratio) worsening hearing status, they identified an increase of 9% in the need for recovery after work. This effect was attributed to the psychological stresses associated with working with hearing loss, such as the extra effort and concentration required to communicate with normally-hearing colleagues, essentially imparting a 'double workload' on hearing-impaired employees.

Three studies that identified the specific impact of hearing loss on absenteeism were found as part of the literature scan, and their results are summarised in Table 5.4.

Table 5.4: Summary of results pertaining to the impact of hearing loss on absenteeism

Reference	Country	Average difference in sick days
Joore et al, 2003	The Netherlands	0 days
Kramer et al, 2006	The Netherlands	20.3 days
Nachtegaal et al, 2012	The Netherlands	3.5 days

Note: Difference in sick days is calculated in the following manner: average number of sick days taken by individuals with hearing loss minus average number of sick days taken by individuals without hearing loss over the course of a year.

Joore et al (2003) studied 84 moderately hearing-impaired first-time hearing aid applicants over 25 weeks in the Netherlands, focusing on the impact of hearing aid fittings on societal and quality of life outcomes. Analysis of the two groups was not controlled for any confounding factors. Analysis of the 10 employed individuals in this sample found no difference between absence from work before and after hearing aid fitting. However, a sample size of 10 is extremely small and not statistically robust.

A study by Kramer et al (2006) of hearing loss in the Netherlands surveyed the work-related outcomes of 150 hearing-impaired employees and 60 normally-hearing employees. While the data were not controlled for any confounding factors, both groups were found to be comparable in terms of age, gender and educational level. They identified a significant difference between the average number of days of sick-leave taken in a year by hearing able individuals (6.0 days) and those with hearing loss (26.3 days). Participants were required to codify their sick leave either as due to "mental distress" (e.g. burnout, stress, fatigue) or to "other reasons" (e.g. an operation, a cold, other illness). While approximately 50% of both populations reported sick leave due to "other reasons", a significantly larger proportion of employees with hearing loss (26%) attributed their sick leave to "mental distress" than that of their hearing able colleagues (7%). As such, the relative difference in average sick days taken between both populations may possibly reflect the number of sick days taken due to stress-related factors associated with hearing loss, in line with the findings in the literature. However, given the significant magnitude of this result and the possible attribution of this effect to a variety of other, omitted factors, the result from Kramer et al (2006) was excluded from our estimates.

In another study situated in the Netherlands, Nachtegaal et al (2012) surveyed 1,295 adults and reported far smaller differences between the amounts of sick leave taken by those with hearing loss and their hearing colleagues. The analysis was adjusted for relevant confounders, including age, gender, educational level, and the presence of other chronic conditions. Of those who were in the "Good" National Hearing test category, employees reported an average of 3.1 days of sick leave in the past four months. Conversely, those in the "Insufficient" and "Poor" categories reported only slightly higher averages of 4.4 and 4.1, respectively, resulting in an average number of sick days for employees with hearing loss of 4.3 days, a difference of one to two days (rounded) over four months or three to five days over a year. The annual estimate overall was 3.5 days absent due to hearing loss.

In order to identify an estimate for the impact of hearing loss on absenteeism, the results of the study by Nachtegaal et al (2012) were used as it was the largest, most representative and well-constructed study. Applying this to the Australian general population employment rates (ABS, 2016b) and average weekly earnings by age and gender (ABS, 2017) **resulted in a total cost from absenteeism due to hearing loss of $1.6 billion.**

5.1.3 Presenteeism

Presenteeism refers to the average number of hours per day that an employee loses to reduced performance or impaired function as the result of their condition. As presenteeism is not as readily apparent as absenteeism, its prevalence and effects may not be as easily discerned. However, presenteeism has the potential to incur significant costs to employers by reducing the quality of work produced by employees or the efficiency with which it is performed. Relative to absenteeism, presenteeism may occur more frequently and have a larger effect (van den Heuvel et al, 2010).

Due to the relative infancy of this area of study in academia, limited data on presenteeism were available. In van den Heuvel et al (2010), logistic regression analysis was used to identify the association between problems with hearing and low performance at work. Analysis produced an odds ratio of 1.17, suggesting that hearing loss was positively associated with presenteeism. Presenteeism was assessed using three questions ("I achieve all objectives of the job", "job-related tasks come easily to me", and "I perform well in my job"), with answers ranked on a 5-point scale and a sum score calculated as a result. Given the relative subjectivity of these answers and an inability to translate these scores into a measure of time, results from van den Heuvel et al (2010) were excluded from our presenteeism estimate.

In Nachtegaal et al (2012), self-reported productivity was collected from the study's survey sample, using the World Health Organization Health Performance Questionnaire (HPQ). Differential work productivity, which measured each employee's perception of their own performance against their perception of the performance of the average employee, was found to be higher for employees in the "Good" National Hearing test category, at an average of 0.32, than for employees in the "Insufficient" and "Poor" categories, who reported averages of 0.18 and 0.04 respectively. Relative productivity was calculated for each of the categories and a weighted average produced for the "Insufficient" and "Poor" categories. In comparison to the "Good" score of 1.04, the average score for relative productivity for "Insufficient" and "Poor" was found to be 1.02.

Based on calculations with data from Nachtegaal et al (2012), it was estimated that hearing loss leads to a small increase in presenteeism, resulting on average in a 2.8% (=1.02/1.04-1) decrease in productivity relative to that of an employee without hearing loss. Applying this to the Australian general population employment rates (ABS, 2016b) and AWE by age and gender (ABS, 2017), the **total cost associated with presenteeism due to hearing loss was estimated to be $2.0 billion in 2017.**

5.1.4 Other productivity costs

As section 3.6 notes, hearing loss and associated hearing health conditions have been associated with an increase in mortality in a number of studies. More detail on the literature on mortality associated with hearing loss can be found in Appendix A. The cost of premature mortality was calculated using the increased mortality rate for males and females aged 75-79[24], and the net present value of expected remaining lifetime earnings. **This resulted in a total cost of $1.1 million due to premature mortality.**

Employers incur administrative costs associated with short run and long run productivity costs. Premature retirement and premature mortality results in increased employee turnover costs, such as search, hiring and training costs. These costs are estimated to be equal to 26 weeks salary of the incumbent worker (Access Economics, 2004). However, this cost is merely 'brought forward' a number of years because there would be some normal turnover of people with dementia in the absence of their condition – approximately 15% per annum (which implies that people change jobs, on average, approximately once every 6.7 years (Access

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[24] This age group was used since it is the only age group that has mortality associated with hearing loss and is also employed.

Economics, 2004)). **Administrative costs were calculated to be $4,990 in 2017.** While this is a tiny figure, it is included for completeness and comparability with other similarly conducted cost burden studies.

5.1.5 Summary of productivity costs

Productivity costs are summarised in Table 5.5. **The total productivity costs for people with hearing loss are estimated to be $12.8 billion.** This is equivalent to $3,566 per person with hearing loss. The majority of productivity costs are associated with reduced employment for people with hearing loss ($9. billion), and reduced productivity while at work ($2.0 billion). This does not include the substantial carer costs associated with informal care (discussed further in section 5.2).

Table 5.5: Summary of productivity costs for people with hearing loss

Productivity loss component	Cost ($ million)	Per person ($)
Reduced employment	9,262.2	2,579
Temporary absenteeism from work (including management time)	1,580.2	440
Presenteeism (reduced productivity at work)	1,963.7	547
Mortality and administration	1.1	0.30
Total	**12,807.2**	**3,566**

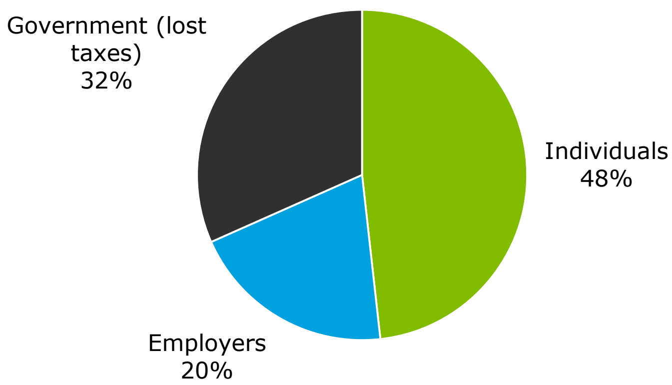
Source; Deloitte Access Economics calculations

The productivity costs are shared between workers, employers, and government (through a reduction in taxable income). Post-tax, the shares of productivity losses are:

- **workers:** the productivity cost of hearing loss borne by workers is $6.2 billion in 2017 – this largely consists of lost earnings as a result of reduced employment;
- **employers:** the productivity cost of hearing loss borne by employers is $2.6 billion in 2017 - this largely consists of reduced productivity while at work (presenteeism) and additional paid days off work (absenteeism); and
- **government:** the productivity cost of hearing loss borne by government is $4.1 billion in 2017 – this is largely the result of reduced employment for people with hearing loss – resulting in lower taxation revenue.

The share of productivity costs borne by each payer are shown in Chart 5.4. Individuals bore the largest share of costs (48%), followed by the government through lost taxes (32%) and then employers (20%).

Chart 5.4: Productivity costs for people with hearing loss by who bears the cost, 2017



Source: Deloitte Access Economics calculations.

5.2 Carers

This section describes the approach that was used to estimate the costs of informal care for people with hearing loss in Australia. Carers are people who provide care to others in need of assistance or support, such as assistance with everyday activities of daily living. An informal carer provides this service free of charge and does so outside 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. As such, many people receive informal care from more than one person. The person who provides the majority of informal care is known as the primary carer.

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 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, an opportunity cost approach was used.[25]

To determine the costs of informal care, a literature search was conducted to determine the number of recipients of care, the average number of hours of informal care provided per person and the demographic characteristics of those who provide care to someone with hearing loss, which is important to ascertain in order to correctly value the carer's opportunity cost of time, which in turn is calculated based on AWE for age and gender groups (ABS, 2017) and the chance of being employed (ABS, 2016b).

5.2.1 Recipients of care

The most recent study to identify how many people with hearing loss receive informal care was the 2015 SDAC (ABS, 2015b). This survey showed that 35,607 people with a main condition of hearing loss in 2015 were reported to need informal assistance with communication. Inflating this number by prevalence growth led to an estimate of the number of people requiring informal care in 2017 of 37,585.

No studies specifically identified the relationships between carers and care recipients. It was assumed that children received informal care from a parent or guardian and that adults received informal care from their

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[25] It is also possible to use the replacement cost method (which measures the cost of 'buying' an equivalent amount of care from the formal sector if the informal care was not supplied), and the self-valuation method (which measures how much carers themselves feel they should be paid for undertaking their responsibilities. However, these methods were not used in this report.

spouse or partner. This resulted in an age distribution similar to the age distribution of people with hearing loss.

5.2.2 Hours of informal care provided

The most recent data source that provided an indication of the additional hours needed to care for someone with hearing loss, compared to someone without hearing loss, was the 2015 SDAC (ABS, 2015b). Data from this survey show that the number of people with hearing loss as a main condition received on average 24.1 hours of care per week, while people who needed care but did not have a long-term health condition received on average 16.1 hours of care per week. The difference between these two figures (8.0 hours) represents the additional number of care hours each week for someone with hearing loss.

5.2.3 Cost of informal care

The cost of informal care was calculated by first multiplying the number of people requiring care by the annual hours of care provided (=8 hours per week*52 weeks*37,585 people). This provided an estimate on the number of hours that are spent in a year caring for people with hearing loss.

The second step in calculating carer cost was to multiply the number of hours of care provided to people with hearing loss by the opportunity cost of carers' time. The opportunity cost of the carers' time was calculated by multiply the AWE (by age and gender) for the carers ($29.09) by the age and gender weighted probability that they were employed (31.1%) (ABS, 2017; ABS, 2016b). Multiplying the opportunity cost of carers' time by the number of hours of informal care provided to people with hearing loss resulted in **the cost of informal care provided to people with hearing loss of $141.6 million in 2017**.

This represents $9.06 per hour of informal care based on an opportunity cost approach. Of the total cost:

- carers (post-tax) bore $92.8 million (65%) in the form of lost income; and
- government bore $48.9 million (35%) in the form of lost taxes.

5.3 Education and support services

Children who are deaf or have hearing loss on average tend to have poorer educational and employment outcomes than children without hearing loss (Deloitte Access Economics, 2017a). However, there is evidence that early intervention and other educational support leads to improved school and post-secondary outcomes for participants.

5.3.1 Early intervention services

While early intervention services vary nationally, a range of audiological and educational services exist for children with hearing loss aged under five years. In 2017, it was estimated that 2,595 children aged 0-4 have hearing loss. There is much evidence that early detection and intervention improves outcomes for babies and infants with hearing loss (Deloitte Access Economics, 2017b). Early intervention services can include:

- neo-natal hearing screening services;
- early intervention programs for children aged less than 3 years, involving individual and/or group interventions and encompassing mode specific (sign/speech) interventions; and
- pre-school education programs either at a specialist centre or visiting services to existing pre-schools.

Universal routine newborn hearing screening also operates across Australia. This typically happens through Oto-Acoustic Emissions technologies or Automated Auditory Brainstem Response (AABR), which measures the automatic reaction of a child's nervous system to a series of sounds or clicks.   **Newborn hearing screening programs are funded by state and territory governments; however, no annual costs were available.**

First Voice is the national voice for member organisations whose primary focus is the provision of listening and spoken language therapy services in Australia and New Zealand. Each member organisation provides early intervention services to develop listening and spoken language skills in children and infants who are deaf or hearing impaired. Early childhood intervention services are offered to children with hearing impairment from birth until the child starts compulsory schooling (typically the age of 5 years). It aims to teach parents how to create and use a listening and learning environment at home and elsewhere so their child can develop spoken language using their 'aided' hearing (First Voice, 2016).

In 2015 terms, the cost of early intervention programs through First Voice were approximately $18,000 per child (Deloitte Access Economics, 2017b). **Inflating this figure using CPI resulted in $18,846 per person in 2017 dollars, or a total value of $48.9 million for all children with hearing loss**

5.3.2 Primary and secondary education services

The *Disability Standards for Education 2005* clarify the obligations of education and training providers and seek to ensure that students with disability can access and participate in education on the same basis as other students. The Standards were formulated under the Disability Discrimination Act 1992 and came into effect in August 2005.

While no national data on the costs of school education for deaf and hearing impaired students was found, there are a range of hearing services available for primary and secondary school children. In South Australia, 26 schools offer an Auslan program in 2017, of which 20 are primary schools (DECD, 2017). Centres for the Hearing Impaired (CHIs) provide services for students with hearing impairments in South Australia. CHIs provide for students with the most significant hearing loss and greatest communication needs, defined as students with a bilateral hearing loss greater than 40 dB. A review of the 6 CHIs in the Adelaide metropolitan area was undertaken in 2015. It found that each centre had an entitlement of an additional 0.4 full time equivalent (FTE) for a coordinator for administrative purposes. Each full-time student enrolled in the CHI accrued 0.25 FTE of a teacher salary. There was also an allocation of 30 hours for a school support officer (SSO) per centre, in addition to 26 hours and 40 minutes of time from the SSO per 1.0 FTE. Finally, CHIs receive an annual grant of between $4,000-$5,500 (DECD, 2015). Table 5.6 shows that in 2016, 84 children were enrolled in a CHI resulting in 28.05 FTE in teacher entitlements and 21.14 FTE in SSO entitlements.

Table 5.6: CHI entitlements 2015

CHI	Enrolment	Teacher entitlement (FTE)	SSO hours per week
Brighton Primary School	14	4.71	136 hours 40 minutes
Elizabeth Park Primary School	7	2.41	83 hours 20 minutes
Hillcrest Primary School	11	3.56	110 hours 00 minutes
Klemzig Primary School	20	6.14	163 hours 20 minutes
Adelaide High School	17	5.54	163 hours 20 minutes
Windsor Gardens Secondary College	15	5.69	136 hours 40 minutes
Total	**84**	**28.05**	**793 hours 20 minutes (21.14 FTE)**

Source: DECD, 2015

Based on the South Australian school teacher's wages effective as of 7/10/2016, an average teacher earnt $80,591 in 2016 (DECD, 2016). The wages of SSO positions range from $45,650 to $107,865, and an average wage of $71,751 was used (DECD, 2016b). This resulted in an expenditure of $3.8 million for the 84 children in the CHI, or $44,960 per person. While some aspects of the CHI changed as a result of the review (including consolidation from 6 into 4 CHI), the review stated that "there would be no changes predicted for the resourcing of the centres". The per child cost for children attending CHI was applied to all young people aged 5-19 with severe hearing loss. **In 2017 there were 7,965 children aged 5-19 with severe hearing loss, resulting in a total cost of $358.1 million.**

5.3.3 Post school education services

Australian and overseas studies note that hearing impaired students with high support needs consume considerable services in higher education (Devlin, 2000). Interpreters and note takers have been identified as comparatively high cost items by Devlin (2000) across a number of western countries including the UK and Canada (Jones, 1994). Students who have a disability have rights under the Disability Discrimination Act and are entitled to ask for accommodations so that they can participate in their chosen course. Many post-secondary education institutions such as TAFE New South Wales and the University of Melbourne provide

Auslan Sign Language Interpreters and note takers where appropriate for deaf or hearing impaired students; however, no national or state based cost estimate was available.

The Disability Support Programme (DSP) helps to remove barriers to access for domestic students with disabilities so they can participate in higher education. In 2011, $6.1 million was made available to higher education providers to support access to and participation in higher education by people with disability. The program consists of three components: Additional Support for Students with Disabilities (ASSD), Performance-based Disability Support funding and the Australian Disability Clearinghouse on Education and Training (ADCET) website. The ASSD component forms the bulk of the program, with 85% of the funds available under the DSP accessed by higher education providers via this component of the program. The ASSD provides funding to eligible higher education providers to assist with the cost of providing educational support services and equipment to high cost students with disability. For example, it reimburses costs for alternative format materials for students with vision impairments such as Braille and audio tapes; sign interpreting services for hearing impaired students; and the purchase of equipment, such as that used for voice recognition (DET, 2014). Performance-based disability support funding aims to further encourage higher education providers to implement strategies to attract and support students with disability. Funding allocations are based on the number of students with disability enrolled at each higher education provider, as well as the retention and success rates of those students (DET, 2014). A review of the DSP found that higher education providers also reported undertaking some innovative activities to help minimise the costs associated with the provision of educational support, including one university which reported that they had built up a pool of Auslan interpreters on staff who could be deployed to assist students, and some higher education providers which pay able bodied students to provide peer note taking services and participation support to students with disabilities (KPMG, 2015).

The review states that the ASSD generally meets about 50%-60% of the costs claimed by higher education providers in any given year and that in 2013, approximately 12% of students had a hearing related disability (KPMG, 2015). In 2013, expenditure on the DSP was $6.8 million (DET, 2014), which was $7.4 million when inflated to 2017 dollars using the consumer price index (CPI). From the funding for the DSP, 85% was attributed to the ASSD, amounting to $6.3 million. **People with hearing disorders were estimated to comprise 12% of the disability types, resulting in a total estimated funding of $0.8 million for hearing disabilities under the ASSD.**

5.3.4 Interpreter services

The National Auslan Interpreter Booking & Payment Service (NABS) provides interpreters anywhere in Australia for people who use sign language. NABS is funded by the Australian Government Department of Social Services (DSS). The national sign language service for Medicare rebate-able medical interpreting services is provided through Wesley Mission Brisbane, under a tender arrangement from DSS.

- The actual costs of this interpreting service could not be obtained, so they were derived on the basis of the Department's request for tender. The Australian Government has published the tender outcomes for 'Interpreting Services' with a contract period from 1 July 2016 – 30 June 2017, awarded to Wesley Mission Brisbane by the Department of Human Services (DHS) for $11,000 (AusTender, 2017).

To calculate the private cost of Auslan services, the number of services provided by Auslan interpreters (taken from Access Economics (2008)) was multiplied by the cost of providing these services. According to Access Economics (2008) there were 269,506 hours of interpreting services supplied in 2007. The number of hours supplied in 2007 was inflated using prevalence growth to provide an estimate for the number of hours that were supplied in 2017. According to Auslan Connections (2017) the hourly rate for a general[26] Auslan interpreting service was $89.00 in 2017.

The number of hours of interpreting (316,350) was multiplied by the cost per hour ($89.00) to provide a total cost figure for interpreting services in 2017. The public cost of providing services was deducted from this cost to avoid double counting. **Therefore, the total private cost of interpreting services in 2017 was estimated to be $28.0 million.**

[26] There are a variety of Auslan services including interpreting in court cases, notetaking, and captioning.

5.3.5 Captioning

Clause 38 of Schedule 4 to the Broadcasting Services Act 1992 requires each commercial television broadcasting licensee and each national broadcaster to provide a captioning service for television programs transmitted during prime viewing hours (6.00–10.30 pm) and for news or current affairs programs transmitted outside prime viewing hours (DBCDE, 2010). The Australian Communications and Media Authority (ACMA) regulates television captioning in Australia. Captions must comply with requirements set out in legislation, industry codes of practice and the Television Captioning Quality Standard. Free-to-air television broadcasters are required to caption all news and current affairs programs and any program screened on their primary or main channels between 6am to midnight, unless the program is music-only or not in English. Subscription television licensees have annual targets on the number of programs that must be captioned. These targets vary depending on the category of the channel (Department of Communications and the Arts, 2017).

As no updated captioning costs were available, the costs from the Access Economics (2006) report were updated using CPI which resulted in a cost of $23.9 million in 2017.

5.4 Communication aids and devices

5.4.1 Communication devices

Other than hearing aids and cochlear implants, which were covered in sections 4.5 and 4.4, respectively, people with hearing loss have available to them other aids and communication devices, including reading or writing aids and speaking aids. Some of the expenditure on these items is covered in section 5.4.2. Table 5.7 shows the number of people with hearing loss as their main condition and the communication aids used.

Table 5.7: Number of people using each type of assistive hearing device, 2015

Communication aid used	Number of people using this aid
Low technology reading or writing aids	2,327
Low technology speaking aids	374
High technology reading or writing aids	2,419
High technology speaking aids	607
Email or internet (households only)	13,936
Reading, writing or speaking aid not specified	5,228
Does not use a communication aid	68,257
Total	**93,148**

Source: SDAC, 2015

Note: The SDAC reports on other hearing devices used by people with hearing loss, such as hearing aids and cochlear implants, which have been calculated earlier in the reports.

The cost of low technology reading or writing aids and low technology speaking aids were included in this analysis. Speaking aids include Augmentative and Alternative Communication (AAC) devices which can speak, after prompts from a picture dashboard or text input. There are free text to speech applications for mobile or tablet users, such as the 'iSpeach' programme. Where this is not suitable, AAC devices with picture dashboards such as the GoTalk 9+ cost approximately $300 in Australia. Reading or writing aids may include smart pens, which enable users to record sound while taking notes with digital assistance. Livescribe Smartpens cost approximately $249 dollars in Australia. The number of people using these aids were multiplied by the average price per aid, **this resulted in a total cost of approximately $2.1 million, incurred by people with hearing loss.**

5.4.2 Telecommunications

The National Relay Service (NRS) is a phone service for people who have a hearing and / or speech impairment or someone who wishes to call someone with a hearing and / or speech impairment. The NRS is provided by eligible telecommunications carriers. In addition to the NRS, an outreach service is also provided to help people use the NRS. The telecommunication providers report to the Department of Communications and the Arts each quarter about the cost of delivering the NRS. The latest report from the Department of

Communications and the Arts (2016) reports the total costs of the NRS for 2015-16 to be $26.3 million. This was inflated to 2017 figures using CPI. It was estimated that the 2017 cost for the NRS will be $27.4 million. Similarly to the Access Economics (2006) report, it was assumed that two thirds of this cost is attributed to people with a hearing loss while the other third is attributed to people with speech impairments. **Therefore, the total 2017 cost of the NRS was calculated to be $18.3 million in 2017.**

5.5 Funeral costs

Premature mortality due to hearing loss results in additional funeral costs for family members. As everyone will die eventually, the additional cost imposed by hearing loss 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 2017 figures, **the discounted value of funeral costs associated with premature deaths was estimated to be $0.4 million**.

5.6 Transfer costs

Transfer payments represent a shift of resources from one economic entity to another, such as raising taxes from the entire population to provide welfare payment to people with hearing loss. The act of taxation and redistribution creates distortions and inefficiencies in the economy, so transfers also involved real net costs to the economy, referred to as deadweight losses.

Transfer costs are important as they allow us to examine the distribution of the costs of hearing loss across different parts of society.

5.6.1 Income support for people with hearing loss

There are currently three forms of support for people with hearing loss:

- the Disability Support Pension (DSPN);
- the Sickness Allowance (SA); and
- the Newstart Allowance (NSA).

The DSPN is an income support payment for people who are unable to work for 15 hours or more per week at or above the relevant minimum wage, independent of a Program of Support, due to permanent physical, intellectual or psychiatric impairment. A DSPN claimant must be aged 16+ and under the age pension age at date of claim. However, once a person is receiving the DSPN they will continue to do so beyond the age pension age (DHS, 2017a). **The SA** is an income support payment for people who are unable to work or study temporarily because of an injury, illness or disability. A SA claimant must be aged 22 years or older, but under age pension age (DHS, 2017b). **The NSA** is an income support payment for people who are looking for work, or participating in approved activities that increases a person's likelihood of finding a job. A NSA claimant must be 22 years or older but under the pension age, prepared to enter a job plan and not involved in industrial action (DHS, 2017c).

A special data request was submitted to DSS to obtain information on the number of people who received either of these income support payments as a result of their hearing loss. This data only captures the number of people who put hearing loss as their first listed medical condition and was recent as of June 2016. Across all people with hearing loss, there were 3,367 receiving the DSPN, 1,313 receiving the NSA and less than 5 receiving the SA. Due to the small number receiving the SA, and its temporary nature, this was not included in the costs.

To determine the total payments made to people with hearing loss, the number of people receiving support was multiplied by the average yearly payments per person. Average yearly payments per person were calculated as total expenditure for the DSPN and the SA, divided by the total number of people receiving each payment. The data were collected from DSS (2016a, 2016b).

There were 781,891 people receiving the DSPN and 732,100 people receiving the NSA during 2015-16 and expenditure was $16.4 billion and $9.9 billion for the DSPN and NSA, respectively. The average annual payments were therefore calculated to be $21,010 per DSPN recipient and $13,473 per NSA recipient. These payments were adjusted to 2017 figures using CPI. Applying the average annual payment to the number of people with hearing loss receiving payments, it was estimated that there were $73.1 million in Disability Support Payments and $18.3 million in NSA payments in 2017.

It is likely that some of these people would have received these payments even in the absence of hearing loss (e.g. due to comorbidities), which must be netted out to estimate the additional welfare payments due to hearing loss. According to Tseng and Wilkins (2002), approximately 13.2% of people receiving the DSPN would receive some welfare in the absence of hearing loss and 12.9% receiving the NSA would receive some welfare assistance in the absence of hearing loss. Netting out general reliance on welfare payments, **it was estimated that $79.3 million in additional DSPN and NSA payments were paid to people with hearing loss in 2017.**

5.6.2 Income support for carers

Carers of people with hearing loss have available to them government support. Two such support payments that are available to carers are:

- **Carer Payment:** is a means-tested income support payment payable to people who cannot work full time because they provide home-based care to an adult or child who has a severe and long-term disability or health condition, or the equivalent amount of care to a number of less disabled people. The person with hearing loss must also be in receipt of an income support payment. The average Carer Payment in 2017 was calculated to be $295.18 per week[27].
- **Carer Allowance:** is a non-means tested income supplement for people who provide daily care to a person with a long-term disability or health condition. The allowance is paid every two weeks and the average cost of this allowance is approximately $62.35 every week (DHS, 2017d).

Information on income support for carers of people with hearing loss was requested from DSS. There was an estimated 1,534 people receiving the Carer Payment in 2017 and 7,891 people receiving the Carer Allowance. Table 5.8 shows the total average weekly payments, the number of recipients and the total cost per annum for each payment. **Total income support for carers of people with hearing loss was calculated to be $49.1 million in 2017.**

Table 5.8: Cost of income support to carers, 2017

	Average weekly payments ($)	Number of recipients	Total cost per annum ($million)
Carer Payment	295	1,534	23.5
Carer Allowance	62	7,891	25.6
Total			**49.1**

Source: DSS special request

5.6.3 Taxation revenue forgone

People with hearing loss and their carers in paid employment, who have left the workforce temporarily due to caring responsibilities, or permanently due to premature retirement, will contribute less tax revenue to the government. As presented in the relevant sections throughout this report:

- people with hearing loss missed out on $9.4 billion in pre-tax wage income due to reduced productivity, unpaid absenteeism and reduced employment;
- carers lost $0.1 billion in pre-tax wage income due to caring for a person with hearing loss; and
- employers lost $3.4 billion in productivity on account of paid absenteeism resulting from hearing loss.

Consistent with Deloitte Access Economics' standard methodology, in terms of allocating these losses to either personal income or company income, only the employer losses were included as lost company revenue, with the remainder allocated as lost personal income in one form or another. In 2017, the average personal

[27] This figure was taken from Deloitte Access Economics (2015). It was provided to Deloitte Access Economics through a previous special request to the DSS. The 2017 figure reported here is the 2015 figure from this report and inflated by CPI.

income tax rate, average indirect tax rate and company tax rate were taken from the Australian Taxation Office's taxation statistics 2013-14 and assumed to be the same in 2017 (Australian Taxation Office, 2016). In 2017 the average personal income tax rate is 22.4%, the average indirect tax rate is 12.1% and the company tax rate is 23.7%.

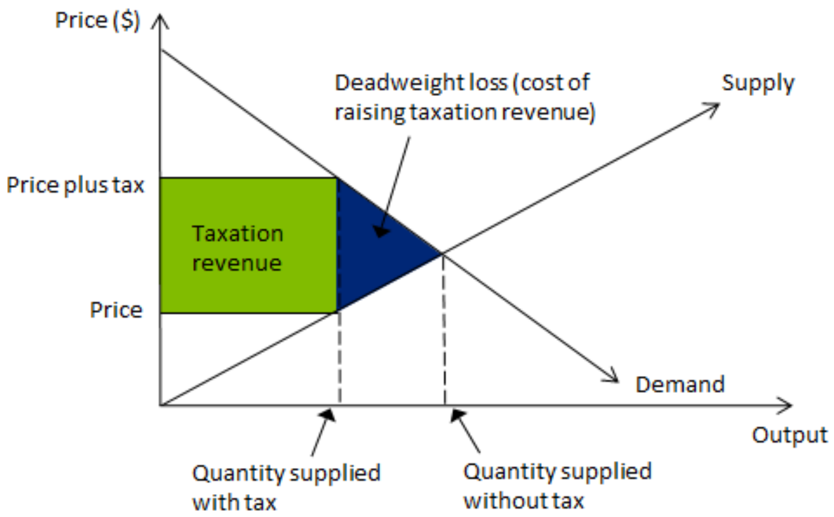
By applying the total lost wage income or business output to the marginal income tax and indirect tax rate and the total lost business output to the company tax rate, the total loss of tax revenue was estimated to be $4.2 billion in 2017. This represents taxation revenue that, to maintain fiscal balance, must be collected from other parts of the economy (e.g those that remain in the workforce) given a "no change in expenditure" assumption.

5.6.4 Deadweight loss of taxation payments and administration

Transfer payments (government payments and taxes) are not a net cost to society as they represent a shift of consumption power from one group of individuals to another in society. If the act of taxation did not create distortions and inefficiencies in the economy, then transfers could be made without a net cost to society. However, these distortions do impose a deadweight loss on the economy.

A deadweight loss is the loss of consumer and producer surplus, as a result of the imposition of a distortion to the equilibrium (society preferred) level of output and prices Figure 5.1. Taxes alter the price and quantity of goods sold compared to what they would be if the market were not distorted, and thus lead to some diminution in the value of trade between buyers and sellers that would otherwise be enjoyed. The principal mechanism by which deadweight losses occur is the price induced reduction in output, removing potential trades that would benefit both buyers and sellers. In a practical sense, this distortion reveals itself as a loss of efficiency in the economy, which means that raising $100 of revenue requires consumers and producers to give up more than $100 of value.

Figure 5.1: Deadweight loss of taxation



Source: Deloitte Access Economics.

To estimate the deadweight loss due to this lost 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; and

- 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, 2016c).

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% deadweight loss;
- reduced income for employers results in a 50.8% deadweight loss;
- welfare payments and Commonwealth health expenditure result in a 29.5% deadweight loss; and
- state health expenditure results in a 45.0% deadweight loss.

Table 5.9 shows the estimated reduced income, transfer payments, and health expenditure payments, the applied deadweight loss of raising taxation, and the resulting deadweight losses associated with hearing loss in Australia in 2017. All rates of deadweight loss include 0.8% administrative loss which covers expenses of administering taxation (Australian Taxation Office, 2016). **The total deadweight losses associated with hearing loss were estimated to be $1.6 billion in Australia in 2017.**

Table 5.9: Deadweight losses due to hearing loss in Australia, 2017

Cost component	Cost ($ million)	Rate of deadweight loss	Resulting deadweight loss ($ million)
Commonwealth health expenditure	669.0	29.5%	197.4
State health expenditure	93.6	37.9%	35.4
Welfare payments	128.5	29.5%	37.9
Lost consumer taxes	3,254.9	23.7%	772.3
Lost company taxes	798.5	50.8%	405.9
Lost carer taxes	48.9	23.7%	11.6
Other government programs	401.0	29.5%	118.3
Total	**5,394.3**	**-**	**1,579.0**

Source: Deloitte Access Economics calculations.

Note: Components may not sum to total due to rounding

5.7 Summary of other financial costs

Table 5.10 summarises the total other financial costs attributed to hearing loss in 2017. The largest component of other financial costs is productivity losses from people with hearing loss ($12,807.2 million), followed by deadweight losses ($1579.0 million), education and support services ($459.6 million) and then productivity losses due to informal care ($141.6 million).

Table 5.10: Total other financial costs attributed to hearing loss, 2017

	Cost ($ million)	Per person ($)
Productivity losses	12,807.2	3,566
Carers	141.6	39
Education and support services	459.6	128
Communication aids and devices	2.1	1
NRS	18.3	5
Funeral	0.3	0.09
Deadweight loss	1,579.0	440
Total	**15,008.1**	**4,178**

Source: Deloitte Access Economics calculations.

Note: Components may not sum to total due to rounding

6 Loss of wellbeing

Beyond financial costs, people's suffering and premature death from hearing impairment can be quantified as costs in terms of diminished quality of life. Loss of wellbeing or burden of disease was developed in the 1990s by the World Health Organization, World Bank and Harvard University (Murray and Lopez, 1996), where pain, suffering and premature mortality are measured in terms of disability adjusted life years (DALYs), with disability weights where 0 represents a year of perfect health and 1 represents death (the converse of a QALY or "quality-adjusted life year" where 1 represents perfect health).

Key finding:

- Total lost wellbeing due to hearing loss in Australia in 2017 was estimated to cost $17.4 billion.

6.1 Valuing life and health

The DALY approach has been adopted and applied in many countries, including Australia. Mathers et al (1999) separately identify the premature mortality (years of life lost due to premature death - YLLs) and morbidity (years of healthy life lost due to disability - YLDs) associated with disability due to a condition:

$$DALY = YLLs + YLDs$$

YLDs are calculated by multiplying the number of people with a condition by a disability weight that applies to them. In any year, the disability weight of a health condition reflects a relative health state. For example, the disability weight for a broken wrist is 0.18, which represents losing 18% of a year of healthy life because of the injury, for the duration of the condition. **YLLs** are calculated based on the life expectancy according to the age and gender of people who died from a condition.

The loss of wellbeing as measured in DALYs can be converted into a dollar figure using the concept of the **value of a statistical life (VSL).** The VSL is an estimate of the value society places on an anonymous life. As DALYs are enumerated in years of life rather than in whole lives it is necessary to calculate the **value of a statistical life year (VSLY)** based on the VSL. This is done using the formula:[28]

$$VSLY = VSL / \Sigma_{i=0,\dots,n-1}(1+r)^n$$

Where: n = years of remaining life, and
r = discount rate

The Department of Prime Minister and Cabinet (2014) provided an estimate of the 'net' VSLY (that is, subtracting financial costs borne by individuals). In this report, a VSLY of $193,821 for 2017 was used based on the Department of Prime Minister and Cabinet (2014) estimate updated for inflation[29].

6.2 Estimating the lost wellbeing from hearing loss

To estimate the lost wellbeing from hearing loss, it was necessary to determine an appropriate disability weight given the severity of hearing loss. In Australia, the current updated source for disability weights is the AIHW (2016a), which uses disability weights from the Global Burden of Disease publication (Salomon et al, 2015). YLDs are estimated using the disability weights for mild, moderate and severe hearing loss multiplied

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[28] The formula is derived from the definition:
$VSL = \Sigma VSLYi/(1+r)^i$ where i=0,1,2….n
where VSLY is assumed to be constant (i.e. no variation with age).

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

by the number of people with each level of hearing loss as estimated in 3.4.1. The disability weights used in this analysis are:

- 0.010 for mild hearing loss;
- 0.027 for moderate hearing loss; and
- 0.158 for severe hearing loss.

The YLLs are based on the number of deaths from hearing loss (section 3.6.2), and the years of expected remaining life at the age of death from standard life tables published by the Institute of Health Metrics and Evaluation in their Global Burden of Disease publication (Salomon et al, 2015). A discount rate of 3% has been applied to the calculations (a standard rate in discounting life) although no age weighting or discount was applied to the estimates of YLLs or YLDs – consistent with the methodology employed by the Global Burden of Disease study[30].

Table 6.1 shows total DALYs by severity, age and gender. Males have a higher loss of wellbeing compared to females, which is mostly the result of higher prevalence in males. As people age, the loss of wellbeing increases in line with prevalence – hearing loss and severity of hearing loss both progress with ageing. Overall, people with hearing loss are estimated to incur 90,223 DALYs in 2017.

[30] When estimating DALYs the Global Burden of Disease study does not apply age-weighting or discounting. This has been their preferred approach since the 2010 Global Burden of Disease study (Murray et al, 2012) to quantify the value of lost life, rather than the social value of loss of health. The Global Burden of Disease does not estimate the value of lost life in dollar terms, and so makes no recommendations about whether to apply discounting to the dollar terms. We maintained discounting of the dollar value of burden of disease (i.e. VSLY in future years). This still reflects a social preference for healthy life today rather than in the future.

Table 6.1: DALYs due to hearing loss in Australia in 2017, by age and gender.

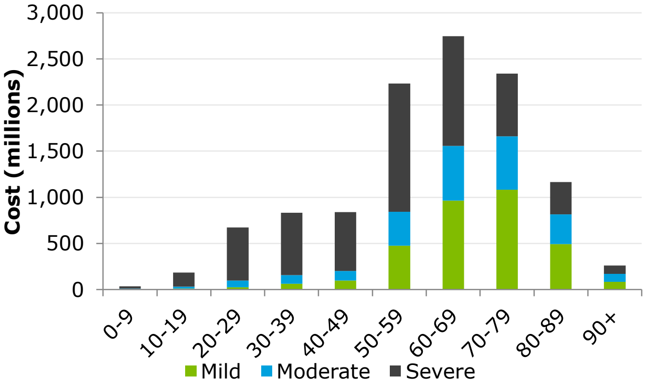
Age/gender	YLDs	YLLs	DALYs	DALYs ($m)
Male				
0-9	184	0	184	36
10-19	942	0	942	183
20-29	3,463	0	3,463	671
30-39	4,299	0	4,299	833
40-49	4,336	0	4,336	840
50-59	11,528	0	11,528	2,234
60-69	14,179	0	14,179	2,748
70-79	11,485	745	12,230	2,341
80-89	5,752	290	6,042	1,164
90+	1,291	55	1,346	260
Male total	57,460	1,090	58,550	11,312
Female				
0-9	175	0	175	34
10-19	378	0	378	73
20-29	1,405	0	1,405	272
30-39	1,493	0	1,493	289
40-49	2,081	0	2,081	403
50-59	3,468	0	3,468	672
60-69	10,343	0	10,343	2,005
70-79	6,537	171	6,708	1,294
80-89	4,074	95	4,169	806
90+	1,423	31	1,453	281
Female total	31,376	296	31,673	6,130
Person total	**88,836**	**1,386**	**90,223**	**17,441**

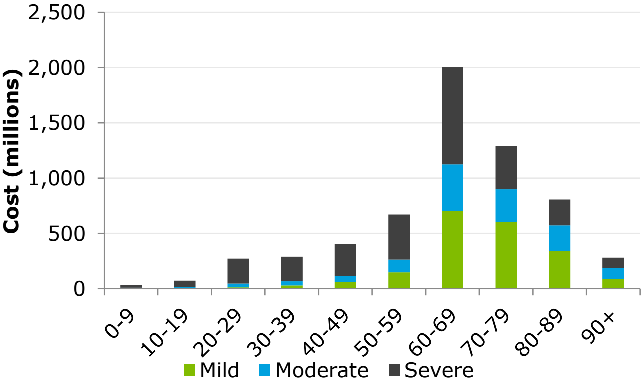
Source: Deloitte Access Economics calculations based on Table 3.5 and Table 3.14.

Note: Numbers do not multiply out exactly to totals due to discounting applied to the value of YLLs.

The loss of wellbeing by severity is shown in Chart 6.1 for males and females. Loss of wellbeing increases with age for both males and females, reflecting both increasing prevalence and severity with age. The loss of wellbeing starts to decline in older age groups due to a smaller underlying population.

Chart 6.1: Loss of wellbeing by age and severity, 2017, males (left) and females (right), $ million





Source: Deloitte Access Economics calculations

7 Costs and benefits of potential interventions

This section analyses two potential interventions: the cost of providing annual hearing screening for people over the age of 50 years, and the benefits of extending the hearing aid voucher program to cover low income people of working age. These interventions have been advocated by HCIA for some time. Although the exact form of the interventions that HCIA have been advocating for may differ from examples used in this section, the examples can nonetheless provide an insight into the potential cost of providing annual hearing screening for people over the age of 50 years, and implications of extending the hearing aid voucher program.

- Providing annual hearing screening for people over the age of 50 years was chosen as an intervention as there is evidence that there is a significant delay between people first getting hearing loss and accessing services and rehabilitation. Free hearing assessments could therefore be valuable in removing barriers to services and encouraging earlier adoption of rehabilitation, with positive impacts on quality of life.
- The benefits of extending the hearing aid voucher program to cover low income people of working age was selected as it is possible that currently low income people of working age face barriers in gaining hearing aids. Hearing aids have the potential to not only improve the quality of life of people with hearing disorders, but also improve their employment rates.

Key findings:

- The total cost of providing a hearing assessments in 2017 was estimated to be $134.3 million.
- By extending the hearing aid voucher program more people in the low income group will be provided with hearing aids. The primary benefit of providing hearing aids to people is that more people are likely to be employed. Deloitte Access Economics estimated that 53,453 people with hearing loss may potentially be employed if this program were extended universally.

7.1 Costs of providing annual hearing screening for people aged 50 years and over

Hearing checks are a simple test to see what sounds people can or can't hear, measured in intensity (decibels) and pitch or frequency (hertz). If a hearing check indicates hearing loss may be present, a full hearing assessment is recommended. The purpose of this assessment is to determine the nature and degree of the hearing loss and the best treatment options. A free hearing screening program which provides hearing assessments for people aged 50 years and over as part of a 50 plus comprehensive health check program has the potential to benefit people in achieving timely hearing services for hearing loss. There is evidence that there is significant delay between people starting to experience hearing loss and receiving hearing services. Action on Hearing Loss in the UK estimated that there are an estimated four million people in the UK with unaddressed hearing loss, and that on average there is a 10-year delay between people identifying that they may have hearing loss and seeking help (RNID, 2013). As a result, the Royal National Institute for Deaf People (RNID) estimated that while approximately two million people in the UK have hearing aids, at least an additional five million others would benefit from having a hearing aid (London Economics, 2010).

Rolfe and Gardner (2016) undertook a study on support-seeking experiences among a sample of UK adults with hearing loss aged 66-88, and their views towards potential strategies to increase rehabilitation support uptake. They found that in the UK, participants predominantly reported that their receiving support was delayed by failure to accurately appraise symptoms, rather than healthcare system factors (Rolfe and Gardner, 2016). Delay in participants recognising hearing loss and seeking support was partially due to their ability to mitigate symptoms or misattribute them to external factors, and participants found that interventions aimed at increasing realisation were acceptable. Rolfe and Gardner (2016) concluded that a national screening programme that would objectively verify hearing loss and direct people towards specialist support was welcomed by the participants (Rolfe and Gardner, 2016). Chou et al (2011) also found that there are a range of individuals who may not realise that they have hearing loss or may not seek services, including that symptoms are relatively mild or slowly progressive, they may perceive hearing loss but not seek evaluation for it, or they may have difficulty recognising or reporting hearing loss due to comorbid conditions, such as cognitive impairment. They concluded that screening could identify individuals with hearing loss who could benefit from the use of hearing aids or other therapies to address hearing loss. In addition, there is a stigma associated with hearing loss that may deter people from seeking testing or assessments and using services. Wallhagen (2009) stated that stigma was influencing decision-making process for people with hearing loss due to its association with ageing.

The RNID advocates for national hearing screening in the UK for all people at the age of 65. A cost benefit analysis of hearing screening for people aged 55 and 65 in the UK found that this was supported by a strong positive net benefit and a benefit to cost ratio of 8.1 if screening were to be at 55 years old and 8.2 at 65 years old (London Economics, 2010). Based on expert advice from the RNID, the cost benefit analysis was based on the assumption that approximately 55% of 55 year olds and 65% of 65 year olds will take-up the invitation to be screened, taking into account that approximately 3% of 55 year olds and 6% of 65 year olds in the UK already use a hearing aid and therefore would not partake in screening. This is more or less in line with the 1.9% of 55-59 year olds and 7.8% of 65-69 year olds in Australia who are estimated to already use a hearing aid according to SDAC (2015). The screening program on which the cost benefit analysis was based involved each member of the general population in the UK being sent a letter from their GP on the occasion of their 55th/65th birthday inviting them to arrange an appointment to attend their local GP surgery for a free hearing screen. The above estimated rates of screening participation are roughly in line with other screening programs in Australia. In 2013-14, the National Cervical Cancer Screening Program rates were on average 60% for women aged 50-64 (AIHW, 2016c). For the National Bowel Cancer Screening Program, 37% participated in 2013-14 (AIHW, 2016d), and 54% of women took part in BreastScreen Australia in 2014-15.

Accordingly, the costs in Australia in this study were calculated based on the assumption that in 2017 all people aged 50, 55, 60, 65, 70, 75 and 80 were to be invited for hearing assessment. At 50, 55 and 65, 55% of people are assumed to participate in screening. At 65, 70, 75 and 80, 65% of people are assumed to participate in screening. As noted in section 4.6, the cost of a hearing assessment as reported by the OHS Fee Schedule for 2016-17 was $136.25 per person (DoH, 2016g). **This resulted in a total cost of $134.3 million in 2017.**

- The above modelling is based on five yearly invitations as it was considered unlikely that the Australian Government would provide annual free hearing assessments. However, providing annual invitations would probably not materially change costs. Evidence from EHIMA (2015) shows that in the UK – where hearing tests are free – only 11% of people have had a test in the past year. If the same results held in Australia, 11% of eligible people taking a free test each year would still add up to 55% over five years, as currently modelled.

7.2 Benefits of extending the hearing aid voucher program to cover low income people of working age

This section looks at whether extending the hearing aid voucher program to cover low income people of working age would improve the employability of unemployed Australians with hearing loss. In Australia, free hearing aids are provided to the young (under 26) and the old (pensioners and veterans) but not to those of working age. Conversely, in the UK, hearing aids are provided free to people of all ages (RNID, 2012). Use of hearing aids by working age people with hearing loss is higher in the UK than it is in Australia, as are employment rates among those with hearing loss. Evidence from the US shows that while unaided people with hearing loss have higher unemployment rates than the normal hearing population, this is not the case for those who use hearing aids. That is, if unemployed people could afford hearing aids, they may no longer be unemployed. This section assesses the costs and benefits of supplying hearing aids to Australians who are unemployed and / or who have income low enough to receive Health Care Cards.[31]

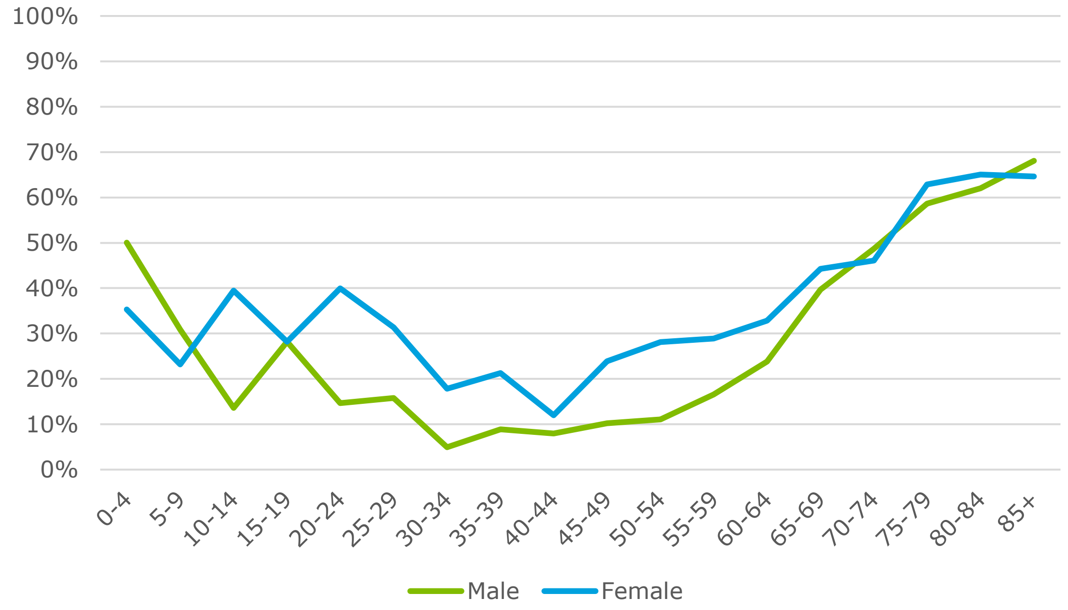
[31] This threshold was chosen as health care cards entitle recipients to subsidised or free treatment for health conditions, which could be extended to hearing aids. The income threshold is also about the same as unemployment benefits, see https://www.humanservices.gov.au/customer/enablers/income-test-low-income-health-care-card, and https://www.humanservices.gov.au/customer/services/centrelink/newstart-allowance/how-much-you-can-get).

If hearing aids were provided for free to low income people of working age in Australia, Deloitte Access Economics estimates that there would be almost 50,000 more of them in employment than there are currently. The detailed calculations underlying this estimation are set out in the sections below.

7.2.1 Comparative use of hearing aids by working age people in the UK and Australia.

As hearing aids are not provided to working age people in Australia, nearly everyone who is in the regular labour market in Australia has to buy their own hearing aids if they need them[32]. The cost of hearing aids and associated services (section 4.5), means that many members of the workforce do not have the hearing aids they need. As Chart 7.1 shows, it is only among the subsidised young and old that the majority of people with hearing loss actually use hearing aids. Indeed for men between the age of 25 (when the OHS voucher eligibility ceases) and 55 (the traditional age of retirement) only 10% of those with hearing loss use hearing aids[33].

Chart 7.1: Proportion of people with hearing loss who use hearing aids, by age and gender, Australia, 2015



Source: ABS (2015b)

In the UK, hearing aids are supplied to everyone who needs them, free of charge (RNID, 2012). Even so, there are still a lot of people who would benefit from hearing aids but do not use them. According to the European Hearing Instrument Manufacturers Association (EHIMA, 2015), 54% of the people with moderate hearing loss in the UK do not use hearing aids. Similarly, the US based Better Hearing Institute reports that 30% of US employees suspect they have a hearing problem but have not sought treatment and that those who do receive treatment have been aware of their hearing loss for 15 years on average before doing so (BHI, 2014). Possible reasons for this lack of take up are denial, stigma, and bad experiences of friends and family with hearing aids. As most people who should have hearing aids do not get them,[34] it is reasonable to assume that, were hearing aids provided for free in Australia, take up rates would be no higher than they are in the UK. In the UK only 32% of working age people with hearing loss use hearing aids, but that is 50% higher than the 21% who do so in Australia (Chart 7.2).

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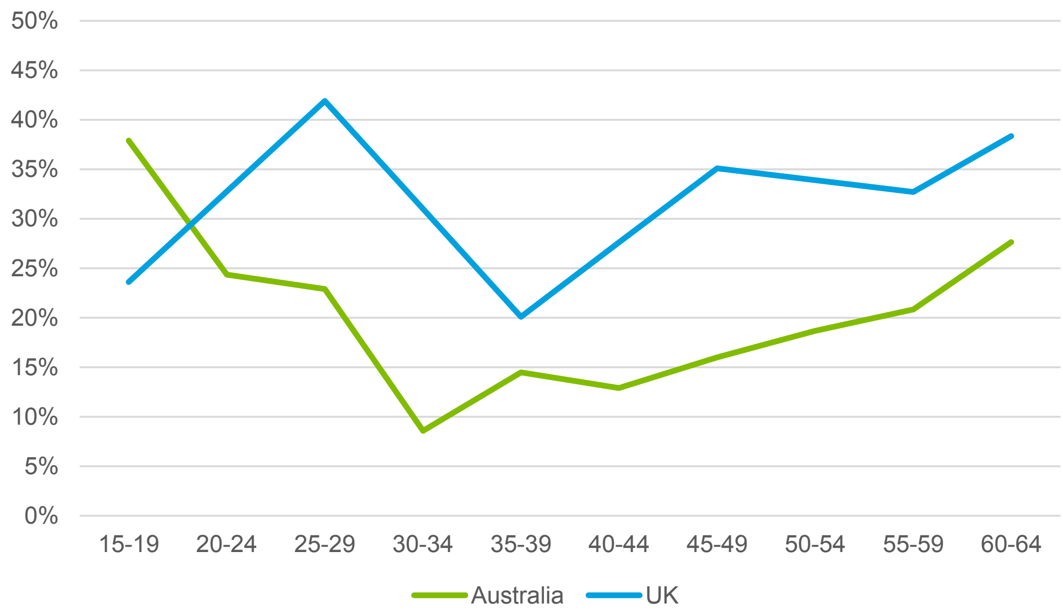
[32] With some minor exceptions, as outlined in Section 4.5.1

[33] Note: these data come from the 2015 SDAC (ABS, 2015c). As this is a subjective survey, it is possible that some people in the ABS category "810: deafness / hearing loss" may have hearing loss less than the 25 dB cut off for OHS voucher eligibility. However, this is not material to the analysis in this chapter, which compares hearing loss and employment outcomes against a similarly subjective hearing loss and consequences survey in the UK.

[34] The SDAC (ABS, 2015a) reports that 44% of the total population with hearing loss have hearing aids.

Chart 7.2: Hearing aid usage rates, Australia and the UK, 2015

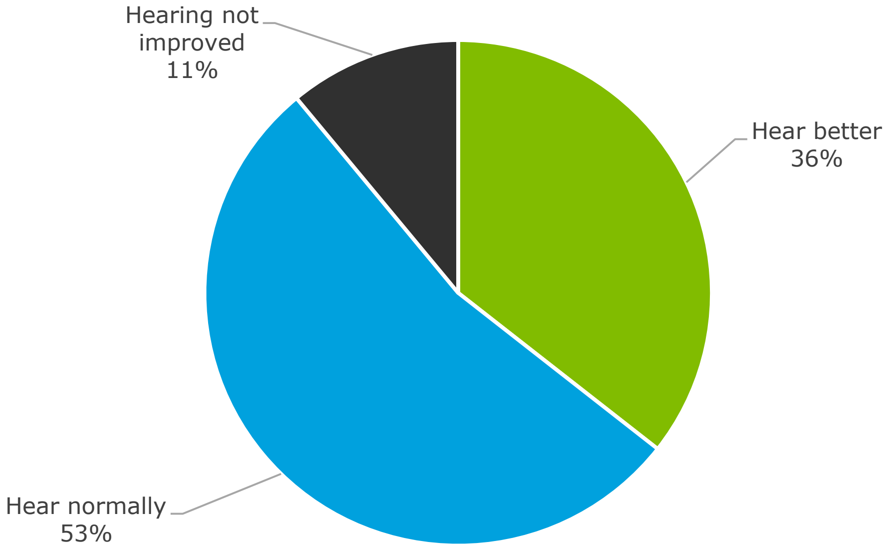


Source: ABS (2015c), EHIMA (2015)

7.2.2 Impact of hearing aid use on employment

There are several theoretical reasons why hearing aids should improve employability. For most people (53%) of working age with hearing loss, hearing aids enable them to hear normally, and for nearly all of them (89%) hearing aids at least enable them to hear better (Chart 7.3). The survey by EHIMA (2015) found that 81% of working hearing aid owners considered that their hearing aids were useful on the job. Moreover, the survey also found that people with hearing aids consider that they "increase the chance of hearing impaired people to get promoted, to get the right job and to get more salary". Also, as discussed in Section 2.5.3 the use of hearing aids can reverse cognitive decline associated with poor hearing, which should also assist with employability.

Chart 7.3: Impact of hearing aids on ability to hear, Australian working age population with hearing loss, 2015



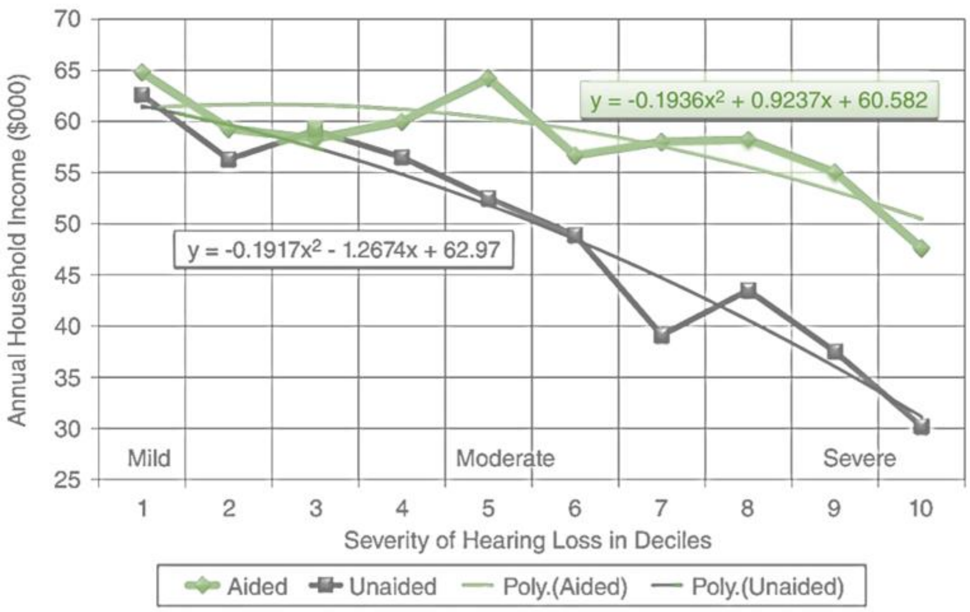
Source: ABS (2015c)

In practice, there is a strong link between hearing aid use and employment outcomes. Kochkin (2010) conducted an extensive analysis of the relationships between employment, income, hearing loss, and use of hearing aids in the US. He used a survey of 46,843 subjects, matched to the US Census characteristics, including 14,623 people with hearing loss and 3,789 hearing aid users. Key findings included:

- As a group people who do not use hearing aids (the "unaided") have substantially lower household incomes than those who do (the "aided"). For moderate hearing loss, this was US$14,100 per year, while for severe hearing loss it was US$30,000.
- While people with hearing loss have lower household incomes than the hearing population, hearing aids mitigate the impact of this by 90%-100% for those with milder hearing losses and from 65%-77% for those with moderate to severe hearing loss.
- There was a strong relationship ($p<0.0003$) between degree of hearing loss and unemployment for the unaided. However, unemployment for the aided was not significantly related to degree of hearing loss.
- Unaided subjects in quintile 1 (lower 20% of hearing loss population) had an unemployment rate of 4.9%, while those in quintile 5 (highest 20% of hearing loss) had an unemployment rate of 15.6%. This was nearly double that of their aided peers in the same quintile (8.3%) who, in turn, did not have appreciably higher unemployment than the hearing population (7.8%).
- For those with jobs, there was no significant relationship between the aided and the hearing regarding perceptions of being passed over for a promotion. Similarly, with respect to perceptions of salary equity for most ages there was no significant difference in responses.
- However, unaided subjects were more likely to report being paid less than their hearing or aided peers.

Kochkin (2010) also constructed a regression that found a strong correlation between hearing aid use and household income among the hearing impaired (Figure 7.1). Given there was little or no reported difference in salaries among those employed between the hearing and the aided, the lower household incomes reported by the aided with more severe hearing loss is most likely due to higher unemployment.

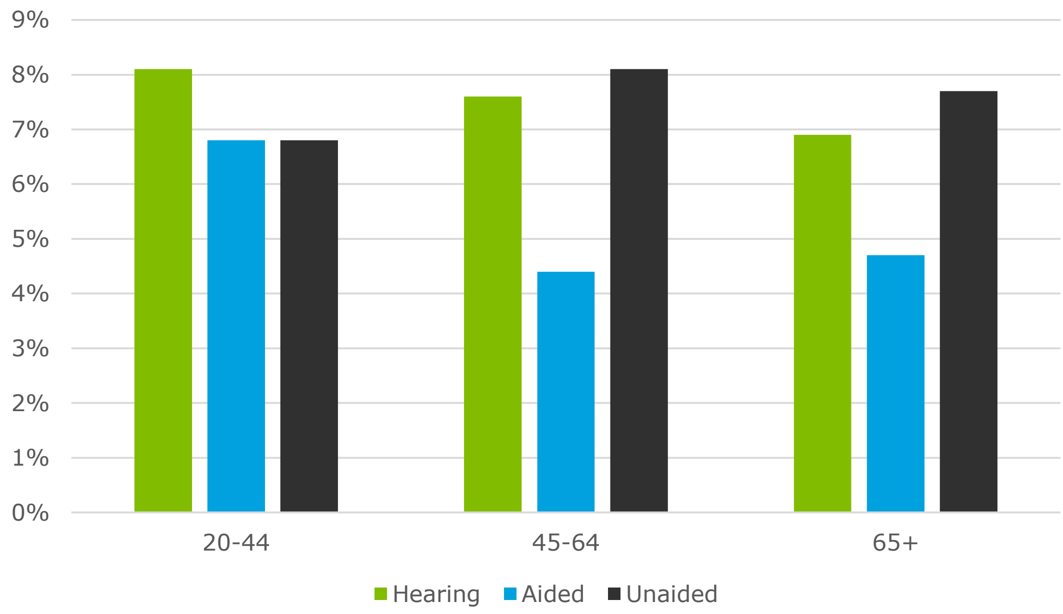
Figure 7.1: Relationship between household income and use of hearing aids, United States, 2010



Source: Kochkin (2010)

Another interesting finding from Kochkin's survey was that people who used hearing aids consistently had lower unemployment rates than their normal hearing peers. As this was a very large survey, and the age bands were broad, this is unlikely to be a small number issue. Conversely, as expected, people with hearing loss who did not use hearing aids had higher unemployment rates than their normal hearing peers (Chart 7.4).

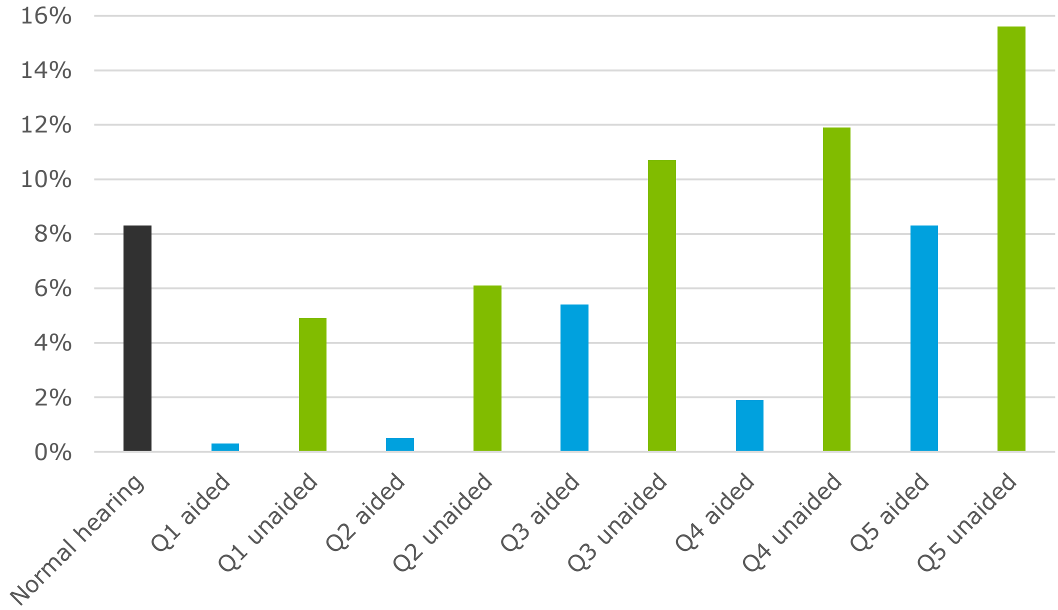
Chart 7.4: Unemployment rates, by age and hearing attributes, United States, 2010



Source: Kochkin (2010)

This result held for most degrees of severity. Only in the most severe quintile (Q5) do unemployment rates for the aided exceed those with normal hearing. Somewhat unexpectedly, the mildest two quintiles of unaided hearing loss also have lower unemployment rates than the hearing population (Chart 7.5). This may imply that for the mildest 40% of the hearing loss population, their hearing loss is not sufficient to alter their employability and they may have personal characteristics sometimes associated with living with disability, such as persistence and resilience, that distinguish them from those without hearing loss.

Chart 7.5: Unemployment rates by hearing severity and use of hearing aids, US, 2010



Note: Q = Hearing loss quintile. Q1 is mild, Q5 is most severe.

Source: Kochkin (2010)

7.2.3 Employment rates for people with hearing loss in the UK and Australia

Having thus established that hearing aids do improve employability, the next aspect is to examine the difference in employment outcomes between the UK with high hearing aid adoption, and Australia with low adoption[35].

7.2.3.1 Australia

As discussed in section 5.1.1, overall in Australia, people with hearing loss are about one-fifth less likely to be employed than their hearing counterparts. The SDAC (ABS 2015c) showed that overall for males of working age (15 to 64) without hearing loss, 80% of the population was employed (full time or part time). The corresponding figure for those with hearing loss was 67%. That is, males with hearing loss were only 83% as likely to be employed as those without hearing loss. Similarly, for females without hearing loss, 71% were employed, while for those with hearing loss, 56% were employed, so females with hearing loss were only 79% as likely to be employed as their hearing counterparts.

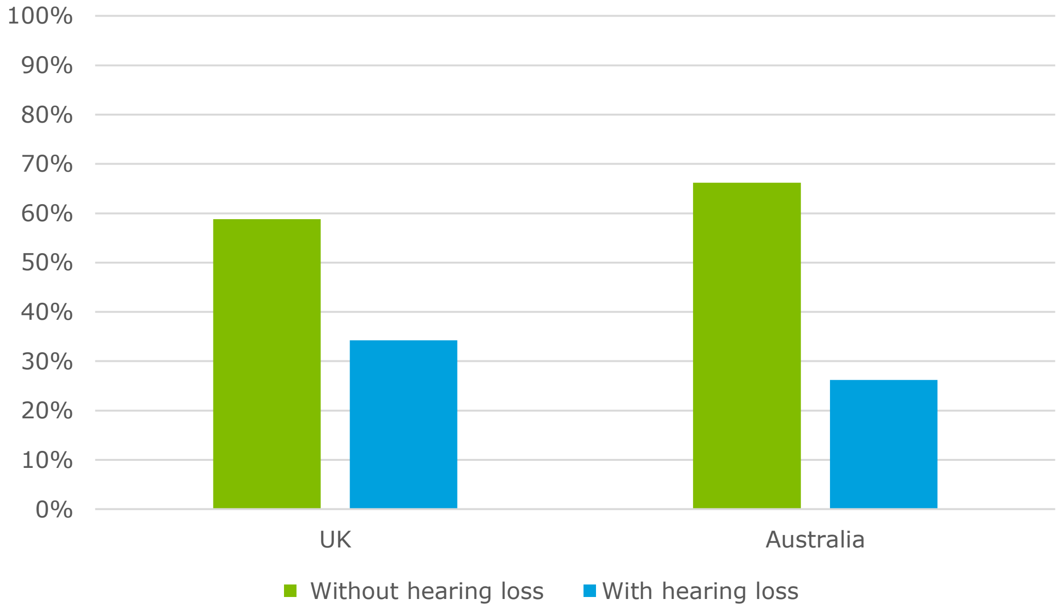
Employment rates for the hearing population are similar in the UK and Australia. EHIMA's (2015) survey of 14,473 Britons reported that 59% of the adult hearing population were employed, which compares closely with the SDAC (ABS, 2015c) results of 66% for Australia.

Conversely, employment among the hearing impaired adult population in the UK is higher than in Australia, both in an absolute sense (34% vs 24% respectively) and in a relative sense (hearing population 1.7 times as likely to employed as hearing impaired in UK, versus 2.7 times as likely in Australia).[36]

[35] Adoption here refers to whether people with hearing loss obtain hearing aids. Whether or not they then use them is a separate matter. Access Economics (2006) reported that 38% of Australian hearing aid owners regularly used their aid. EHIMA (2015) reports that 70% of UK hearing aid owners use their aids for at least an hour a day.

[36] Note, EHIMA's figures are number of employed people against total adult population, not just population of working age. The proportion of hearing impaired Australians working age who are employed is much higher (68%), and the difference in employment rates between them and the hearing population is considerably smaller (19%). This stands to reason as hearing loss gets more severe with age. In order to estimate the ratio of comparative employability, perforce SDAC figures for all adult Australians with hearing loss are compared to EHIMA's figures for all adult Britons with hearing loss. This implicitly assumes that the relative employability gap between the two countries is the same for working age and pension age populations. This is not unreasonable, as while pension aged people do have more severe hearing loss Kochin (2010) has shown that even severe hearing loss is not a barrier to employment for those who use hearing aids.

Chart 7.6: Employment outcomes, hearing vs hearing impaired populations, Australia and the UK, 2015



Source: EHIMA (2015) ABS (2015c)

7.2.4 Employment benefits

Effectively, the 'gap' between employment outcomes between the hearing and the hearing impaired is 1.5 times bigger in Australia than in the UK where people of working age can get free hearing aids. Assuming that provision of free hearing aids would reduce the employment 'gap' between those with and without hearing loss in Australia to the same proportional size as in the UK, this could be modelled by reducing the current Australian gap for each age-gender cohort by two thirds (= 1/ 1.5). For working age Australian men with hearing loss, this would increase employment from 67% to 71% - compared to the same rate for men without hearing loss of 80% (Table 7.1). For women, the corresponding figures would increase from 56% to 61%, as compared to 71% for those without hearing loss (Table 7.2).

- Unfortunately, data are not available for hearing / hearing loss employment splits by age and gender for the UK, so the overall average difference is assumed to apply to each cohort.
- This methodology is conservative to the extent that it still results in a larger employment gap in Australia than in the UK.

Overall, the provision of free hearing aids to people of working age should result in a similar gap in employment outcomes vis a vis the hearing population as to the UK, with employment in the hearing impaired population increasing by 4.2% (from 64% to 68%). Against the 2017 population that would represent an **extra 48,768 people with hearing loss who become employed** (34,055 males and 14,713 females as shown in Table 7.1 and Table 7.2).

Table 7.1: Potential employment gains from free hearing aids, males 2017

Age	Current HL population	Current employment rate	Employment rate with free hearing aids	Gain in HL employment
25-29	21,869	51%	63%	2,423
30-34	34,220	74%	79%	1,696
35-39*	37,617	92%	92%	0
40-44	42,591	77%	82%	1,990
45-49	47,997	80%	83%	1,310
50-54	165,680	74%	79%	7,625
55-59	195,470	70%	74%	6,820
60-64	326,100	53%	57%	12,192
Total	**573,289**	**67%**	**71%**	**34,055**

*Note: for this group, there is currently no gap compared to the hearing population. Ages 15 to 24 excluded as already eligible for free hearing aids in Australia. HL=hearing loss
Source: EHIMA (2015), ABS (2015c), Table 3.5 (Deloitte Access Economics calculations).

Table 7.2: Potential employment gains from free hearing aids, females 2017

Age	Current HL population	Current employment rate	Employment rate with free hearing aids	Gain in HL employment
25-29	8,366	68%	71%	322
30-34	12,078	67%	70%	0
35-39*	18,238	76%	76%	137
40-44	19,861	75%	76%	1,927
45-49	30,633	59%	66%	3,219
50-54	51,750	57%	64%	1,493
55-59	60,178	62%	64%	7,403
60-64	229,555	39%	42%	322
Total	**446,503**	**56%**	**61%**	**14,713**

*Note: for this group, there is currently no gap compared to the hearing population. Ages 15 to 24 excluded as already eligible for free hearing aids in Australia. HL=hearing loss
Source: EHIMA (2015), ABS (2015c), Table 3.5 (Deloitte Access Economics calculations).

7.2.5 Costs of supplying hearing aids to low income people of working age

The cost to the Commonwealth to provide a pair of basic hearing aids, including associated services, is close to $2,000 (Table 7.3).

Table 7.3: Cost of public provision of a pair of hearing aids and associated services

Age	Cost ($)
Hearing aid	$461.85
Second aid	$461.85
First assessment	$136.25
Audiological case management	$43.25
Initial fitting and rehabilitation- Binaural	$435.40
Maintenance and battery supply - Binaural	$195.35
Client Review / Aid Adjustment - Binaural	$119.00
Minor Repairs - Binaural	$108.30
Total	**$1,961.25**

Source: DoH (2016g)

It is a fairly straightforward matter to cost hearing aids for the 48,768 people who could move from welfare to work through receiving free hearing aids. However, there would also be other people who received free hearing aids but stayed on welfare, who also need to be costed. As noted above, in the UK where hearing aids are free to all, hearing aid ownership is around 1.5 times higher than it is in Australia among the working age population (32% compared to 21%). If hearing impaired Australians between the ages of 25 and 65 owned hearing aids at the same rates as their UK peers, there would be around 166,000 more hearing aid users here (Table 7.4).

Table 7.4: Expected increases in ownership if hearing aids were free

Age	Australian HA ownership	UK HA ownership	Australian HL population	Expected additional HAs
25-29	23%	42%	30,235	5,749
30-34	9%	31%	46,298	10,383
35-39	14%	20%	55,855	3,141
40-44	13%	28%	62,451	9,181
45-49	16%	35%	78,631	15,015
50-54	19%	34%	217,430	33,147
55-59	21%	33%	255,648	30,326
60-64	28%	38%	555,655	59,492
Total			**1,302,203**	**166,434**

Note: 15 to 24 year olds not included, as they already receive free hearing aids in Australia. HL = hearing loss, HA= hearing aid.

Source: EHIMA (2015), ABS (2015c), Deloitte Access Economics calculations.

Perforce, the increased employment numbers in the UK due to free hearing aids would have had to have come from the ranks of the unemployed. In this analysis, any increase in Australian hearing aid ownership would also accrue to those who are unemployed, because they are the only ones who would be getting free hearing aids.

- While the majority of people who could benefit from free hearing aids in the UK still choose not to acquire them, they at least have that choice.
- Unemployed people in Australia who could benefit from hearing aids would not be in a position to find $2,000 to fund them.

This is a conservative approach as it assumes that 3.4 unemployed people would have to be given free hearing aids for every one person who then becomes employed (=116,434 new aid users to 48,768 newly employed). To the extent that in the UK some of the additional hearing aid usage accrued to those already employed, rather than the unemployed, this would reduce the ratio of the number of unemployed people who would need to be given aids to result in one person becoming employed.

Thus, the cost of providing free hearing aids to unemployed Australians with hearing loss who would choose to use them would be $326.4 million (= 116,434 times $1,961 for a pair of hearing aids).

7.2.6 Cost benefit ratio

Having established the costs of the intervention, it is then necessary to convert the extra 48,768 jobs into dollar terms to compare the two. From a societal perspective, the value of a job is what the employer is prepared to pay for it – that is the wages (which in turn ultimately derives from the value consumers are willing to pay for the employer's product).

For this purpose, average Australian wages could be utilised. However, people who have been on welfare probably would not step immediately into average wages, as the average worker has taken many years to build up their skills and experience and are remunerated accordingly. Hence, this analysis conservatively assumed that people transitioning from welfare move into jobs paying the minimum wage[37]. As the minimum wage is currently $34,980 a year (Fair Work Commission, 2016), this resulted in a productivity gain to the economy of $1.7 billion (= $34,980 times 48,768 new jobs). **The benefit to cost ratio of the intervention would be 5.2 to 1** (=$1.7 billion / $326.4 million for new hearing aids)**.** Therefore, on average, for every dollar invested in extending the hearing aid voucher program there is a $5.20 return in benefits.

While this is a high benefit to cost ratio, in the current environment of fiscal constraint, the Commonwealth Government may not be inclined to incur an outlay as large as $300 million. However, the intervention would also result in a similar benefit to cost ratio from a budget perspective. The average person on unemployment benefits costs the budget $27,851 in welfare outlays (DHS, 2017c). Thus, anyone who moves from welfare to work improves the bottom line by this amount. There is also an additional budget benefit in that someone on the minimum wage also pays taxes of $3,188 a year (ATO, 2017). Therefore, each person who moves from being unemployed to full time employment on the minimum wage improves the net budget position by $31,039. Multiplying each person moving from welfare to employment by this figures results in an estimated $1.5 billion total benefits. This yields a cost benefit ratio from the Commonwealth perspective of 4.6 to 1 (=$326 million on hearing aids / $1.5 billion in budget repair).

From an alternative break-even analysis, it would require only one person in every fifteen given new aids to move to the equivalent of a full time minimum wage position to have a positive budget impact (=$31,039 welfare reduction and taxation increase / $1,961 per pair of hearing aids).

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[37] To the extent that people move into higher paying jobs, the benefits would be greater. Conversely, if people only moved into part-time jobs, the productivity benefits could be lower (even if hourly wages were higher than minimum rates).

8 Conclusions

Summary of costs
This chapter summarises the total costs of hearing loss.

Key finding:
The total cost of hearing loss in Australia in 2017 was $33.3 billion, or $9,280 per person with hearing loss. Of this total figure, 48% is financial costs ($15.9 billion) and the remaining 52% is lost wellbeing ($17.4 billion).

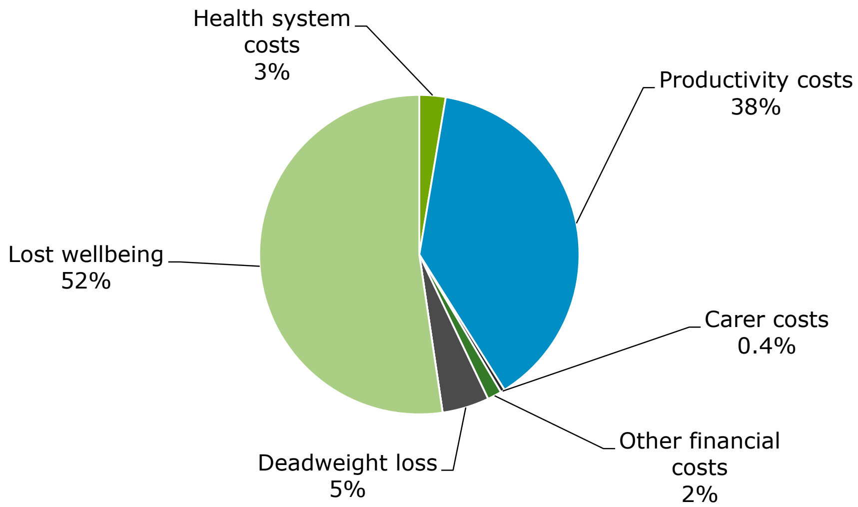
The components of financial costs for 2017 are:

- health system costs of $881.5 million, or $245 per person with hearing loss, the largest component of health system costs was the OHS program that is provided by the Australian Government ($521.4 million);
- productivity losses of $12.8 billion, or $3,566 per person with hearing loss, most of which was due to reduced employment of people with hearing loss;
- informal care costs of $141.6 million, or $39 per person with hearing loss;
- deadweight losses of $1.6 billion, or $440 per person with hearing loss; and
- other financial costs of $480.3 million, or $134 per person with hearing loss.

By way of comparison, Access Economics (2006) estimated costs were:
- health system costs of $674 million;
- productivity costs of $6.7 billion;
- informal care costs of $3.17 billion[38]; and
- other financial costs of $191 million.

Chart 8.1 shows the total cost of hearing loss in Australia. The majority of costs were associated with lost wellbeing (52%), followed by productivity costs (38%).

Chart 8.1: Total costs associated with hearing loss in Australia, 2017



Source: Deloitte Access Economics calculations

[38] In the absence of other data Access Economics assumed that most people with moderate or worse hearing loss would require care, whereas for this report actual carer data were available from the SDAC (ABS, 2015b). Such methodological differences render it difficult to compare costs on a like for like basis.

Table 8.2 depicts total financial costs and total loss of wellbeing costs by age and gender. It is evident that males, particularly the 40-69 age group, experience significantly higher costs in the form of lost productivity and participation in the workforce. This is a similar trend for women who have hearing loss, but not to the same magnitude as men who have hearing loss.

Table 8.2: Total costs associated with hearing loss by age and gender, $ million

Age/gender	Financial cost	Lost wellbeing	Total
Male			
0-9	72.1	35.7	107.8
10-19	276.2	182.6	458.8
20-29	746.3	671.2	1,417.5
30-39	558.5	833.2	1,391.7
40-49	1,264.7	840.4	2,105.1
50-59	4,690.0	2,234.4	6,924.4
60-69	4,157.5	2,748.3	6,905.7
70-79	467.4	2,341.2	2,808.6
80-89	119.1	1,164.4	1,283.5
90+	23.1	260.2	283.3
Male total	12,374.7	11,311.7	23,686.4
Female			
0-9	64.9	33.9	98.8
10-19	97.3	73.3	170.6
20-29	205.6	272.2	477.8
30-39	121.0	289.4	410.4
40-49	473.0	403.3	876.3
50-59	946.8	672.2	1,619.0
60-69	1,323.4	2,004.6	3,328.1
70-79	164.5	1,293.5	1,458.1
80-89	90.3	805.8	896.2
90+	27.9	281.3	309.2
Female total	3,514.8	6,129.6	9,644.4
Person total	**15,889.5**	**17,441.3**	**33,330.8**

Source: Deloitte Access Economics calculations.

Impact of potential interventions
The impact of two potential interventions were analysed in this report: the costs of providing annual hearing screening for people over the age of 50, and extending the hearing aid voucher program to low income people of working age. **The total cost of providing a hearing assessments in 2017 was estimated to be $134.3 million based on five yearly hearing assessments.**

The primary benefit of providing hearing aids to low income people of working age would be that more people would be employed. Deloitte Access Economics estimated that 48,768 people with hearing loss would be employed thereby, resulting in benefits of $1.7 billion. The cost of thus extending the voucher program was estimated to be $326.4 million. Comparison of the cost and benefit resulted in a benefit cost ratio of 5.2 to 1.

Appendix A: Hearing loss and mortality

A literature search for studies was conducted to see if recent evidence suggests a direct association between hearing loss and mortality when controlling for confounding factors such as ageing, gender and other conditions. This is commonly measured using a HR, which assesses the relative difference in the probability of an event occurring (death) over time between two populations of interest– those with and without hearing loss. Most of the studies identified in the search were prospective observational studies, and generally contained a longitudinal sample or survey linked to national deaths data. A summary of the literature is presented below.

Genther et al (2015) assessed the association between hearing loss and mortality in community dwelling older adults in the United States. There were 1,146 participants with hearing loss, of whom 492 died during the study period – representing 42.9% of the sample with hearing loss. For those with normal hearing, 31.4% died during the study period. Hearing was assessed using audiometric testing and the threshold was defined as greater than 25 dB. Genther et al (2015) found that hearing was associated with a 13% increase in mortality risk compared with those with normal hearing in their fully adjusted model. The model adjusted for age, gender, race, education, study site, cardiovascular risk factors[39], hearing aid use, and cognitive impairment. Interestingly, Genther et al (2015) observed a nonlinear relationship, with the risk of mortality increasing with severity, and with the increase in mortality only occurring from around >35 dB. The sample characteristics were representative of those over the age of 70 with moderate or worse hearing loss.

Agrawal et al (2011) assessed the association between hearing loss and mortality in a random sample of 1,422 elderly persons (aged 60 years and over) living in rural villages in India. Hearing loss was assessed using audiometric testing. After adjusting for age gender, literacy and a range of comorbid conditions, orthopaedic impairment, and scores for dressing, feeding and self-rated health, Agrawal et al (2011) did not find a significant association between increased mortality and hearing loss in their sample. However, hearing loss was associated with an increased risk of mortality for those aged 70 years or older when subgroup analysis was conducted. For the overall sample, the HR was 1.22 with a CI of 0.73-2.03. No measure of mean severity was reported for this study. Although it controls well for confounding factors, there are significant differences in the setting of rural India compared to New Zealand.

Karpa et al (2010) assessed the association between hearing loss and mortality risk in 2,956 older persons (aged 49 years and over) in the Blue Mountains Hearing Study in Australia. After adjusting for age, history of acute myocardial infarction, stroke, angina, hypertension, current smoking status, body mass index, cancer, diabetes, walking disability, high serum urate, alcohol consumption, cognitive impairment, depression and self-rated health, the HR was 1.12, although this was not significant – the CI was 0.88 to 1.44. The sample characteristics were representative of those over the age of 70 with moderate or worse hearing loss, as assessed with audiometric testing.

Gopinath et al (2013) also assessed the association between hearing loss and mortality risk in a sample of 2,812 older persons (aged 55 years and over) in the Blue Mountains, but the sample was drawn from the BMES. The sample characteristics were very similar to those in the Hearing Study reported in Karpa et al (2010), although the results were presented as those without visual impairment when vision was corrected with appropriate prescriptions. Overall, Gopinath et al (2013) found that hearing loss was significantly associated with a 29% increase in the risk of mortality – the CI was 1.04-1.59. The analysis by Gopinath et al (2013) adjusted for age, gender, body mass index, systolic blood pressure, current smoking status, self-rated

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[39] The study did not control for family size or presence of a carer compared to living alone. Moreover, as with Genther et al (2015), CVD risk factors (confounding factors) may lead to endogeneity in the sample.

health, walking disability, presence of hypertension and/or diabetes, history of cancer, angina, stroke, acute myocardial infarction and cognitive impairment.

Feeny et al (2012), in a Canadian longitudinal study of 12,375 women and men over the age of 18 years, found that hearing loss was significantly associated with an increased risk of mortality. When considering the sample over 60 years old, the HR for mortality was 0.14 with a CI of 0.04-0.48. This was expressed in logarithm terms, where the HR of less than 0 indicates a reduction in mortality and above 0 indicates an increased risk of mortality. Adjusting this by taking the exponential values for consistency with the other identified studies, the HR was 1.15 with a CI of 1.04-1.62. The sample was mostly representative of those over the age of 70 years and a severity of moderate or worse. Feeny et al (2012) adjusted for a range of factors, including age, gender, marital status, education, income, chronic health conditions, smoking, physical activity, body mass index, alcohol use and subjective measures of stress, coherence and social support.

Fisher et al (2014) used a longitudinal cohort study of 4,926 participants aged 66 years and above in Iceland to identify any associations between hearing loss and mortality. Hearing loss was assessed using audiometric testing and participants were only classified as having hearing loss if the impairment was moderate or greater. After adjusting for a range of confounding factors, including self-reported status, cognitive status, hearing aid use and established mortality risk factors including body mass index, hypertension, diabetes, history of falls, cholesterol, and CVD history, Fisher et al (2014) found that hearing loss was borderline associated with a 20% increased risk of mortality – the CI was 1.00-1.45. The sample was again representative of those aged over 70 years and severity was moderate or worse.

Even though these studies mostly control for other chronic conditions, there could still be endogeneity issues if conditions such as CVD, hypertension or diabetes which increase mortality also increase hearing loss. For example, Yamasoba et al (2013) report that diabetes, cerebrovascular disease and CVD are statistically associated with increased hearing loss. On the other hand, Oh et al (2014) in a study of over 37,000 individuals, found no statistically significant association with hearing loss and hypertension.

Yamada et al (2010) discusses outcomes of dependence in activities of daily living (ADL) and death with hearing difficulty. A total of 1,364 participants aged over 65 years (average 77 years of age) self-reported their hearing difficulty based on a range of: "no difficulty", "a little difficulty", and "a lot of difficulty". Potential major confounding factors were adjusted for in the study's multivariate regression model, including Yamada et al (2010) estimated a HR of 1.12 with a confidence ratio of 0.50–1.74. Overall, a strong association between adverse health outcomes and advanced hearing difficulty was observed however the result was not statistically significant for individuals with moderate hearing difficulty.

A longitudinal analysis evaluating the risk of dying was performed by Laforge et al (1992). Overall, 1408 participants aged over 65 years (average age 74 years) self-reported their level of hearing based on the following categories: excellent, good, fair, poor and blind/deaf. The relationship between hearing loss and one-year mortality and functional decline was evaluated to generate a HR of 1.18 with a CI of 0.54 – 2.60. Using bivariate and multiple logistic regression modelling, hearing loss was found to have a statistically significant risk factor for functional decline, which is a possible risk factor for death (Karpa et al, 2010).

Furthermore, a study performed by Liljas (2015) used logistic regression to assess the association of hearing loss with mortality. A group of 1074 community-dwelling men aged 63-85 (average age 74) were followed up for all-cause mortality after 10 years as a part of the British Regional Heart Study. From this, 27% of men reported having a hearing loss with severity being self-reported on a scale of: "can hear with no aid", "can hear using an aid", "cannot hear with no aid" and "cannot hear and used aid". The regression model was adjusted for confounding factors. Men who could not hear and did not use a hearing aid were found to have a higher risk of all-cause mortality compared to their hearing counterparts. The HR for mortality was 1.12 with a CI of 0.93 – 1.34. However, after adjusting for comorbidities, social class, and lifestyle factors the result was attenuated. It is possible that residual confounding factors existed in the form of unmeasured cognitive functioning.

The relationship between mortality and hearing loss was also discussed in Schubert et al (2016). Overall, a sample of 2,418 individuals aged 53-97 (average age 69) undertook audiometric testing to test for hearing loss. This study evaluated hearing, visual and olfactory impairments together as this is perceived to provide an enhanced understanding of mortality, particularly as these conditions are likely to co-occur. Other confounding factors including atherosclerosis and inflammation were included in the study. A HR of 1.17 with a CI of 0.97–1.40 was estimated for hearing loss. It was found that hearing loss is not linked to any increased risk of mortality, although this was approaching significance. Schubert et al (2016) did not report sufficient data to estimate severity.

Barnett and Franks (1999) utilised national health interview survey data from 1990-1991 in the United States to conduct a multivariate analysis that examined the association between age at onset of deafness, and mortality. A total of 1,565 participants aged over 65 years self-reported their level of hearing loss based on a scale of "good" (1) to "deaf" (4). The analysis was adjusted for sociodemographic factors and stratified by age. The HR for mortality was found to be 0.99 with a CI of 0.88–1.10. Overall, it was found that adults presenting with post-lingual deafness were more likely to die than their hearing counterparts over the given timeframe

References

Acar B, Yurekli MF, Babademez MA, Karabulut H and Karasen RM, 2011, 'Effects of hearing aids on cognitive functions and depressive signs in elderly people'. *Archives of gerontology and geriatrics*, 52(3):250-252.

Access Economics 2008, *Auslan interpreter services in Australia: supply and demand,* Report for the Victorian Deaf Society.

2006, *Listen Hear! The economic impact and cost of hearing loss in Australia*, Report for the Cooperative Research Centre for Cochlear Implant and Hearing Aid Innovation and the Victorian Deaf Society.

2004, *Costs of Workplace Injury and Illness to the Australian Economy: Reviewing the Estimation Methodology and Estimates of the Level and Distribution of Costs*, Report for the National Occupational Health and Safety Commission.

Agrawal N, Kalaivani M, Gupta S, Misra P, Anand K and Pandav C 2011, 'Association of blindness and hearing impairment with mortality in a cohort of elderly persons in a rural area, Indian J Community Med, 36:208-12.

Auslan Connections 2017, *Schedule of Rates – Victoria,* http://auslanconnections.com.au/fee-agreements/, accessed March 2017.

Australian Bureau of Statistics 2017*, Average Weekly Earnings, Australia, Nov 2016*, Cat.No.6302.0, Commonwealth Government, Canberra.

2016a, *Deaths, Australia,* Cat.No.3302.0, Commonwealth Government, Canberra.

2016b, *Labour Force, Australia, Detailed, Quarterly, Nov 2016,* Cat.No.6291, Commonwealth Government Canberra.

2016c, *Taxation Revenue, 2014-15*, Cat. No. 5506DO001.

2015a, *National Health Survey: First Results*, 2014-15, Cat. No. 4364.0, Commonwealth Government, Canberra.

2015b*, Disability, Ageing and Carers, Australia: Summary of Findings, 2015*, Cat. No. 4430.0, Commonwealth Government, Canberra.

2015c, *3101.0 - Australian Demographic Statistics, Jun 2015*, Commonwealth Government, Canberra.

Australian Hearing 2014a, *Diagnosis,* https://www.hearing.com.au/milestone/newborn-hearing-screening/, accessed February 2017.

2014b, *'Who is eligible for Australian Hearing services?' Hearing Solutions Blog*, https://www.hearing.com.au/eligible-australian-hearing-services/, accessed March 2017.

2014c, *'Why you should book a free hearing check' Hearing Solutions Blog*, January 25, 2014, https://www.hearing.com.au/book-free-hearing-check/, accessed March 2017.

2015*, Demographic details of young Australians aged less than 26 years with a hearing impairment, who have been fitted with a hearing aid or cochlear implant* at 31 December 2014

2016, *Annual Report 2016*. https://www.hearing.com.au/wp-content/uploads/2016/10/Australian-Hearing-Annual-Report-2016-FINAL.pdf, accessed March 2017.

Australian Institute of Health and Welfare AIHW 2016a, *Australian Burden of Disease Study: Impact and causes of illness and death in Australia 2011,* Australian Burden of Disease Study series no. 3. BOD 4. Canberra: AIHW

2016b, *Health expenditure Australia 2014-15,* Cat. No. HWE 67, Canberra: AIHW.

2016c, Cervical screening in Australia 2013–2014. Cancer series no. 97. Cat. no. CAN 95. Canberra: AIHW.

2016d, *National Bowel Cancer Screening Program: monitoring report 2016*. Cancer series no. 98. Cat. no. CAN 97. Canberra: AIHW.

2016e, BreastScreen Australia monitoring report 2013–2014. Cancer series no. 100. Cat. no. CAN 99. Canberra: AIHW.

Australian Research Council 2014, *Number of successful linkage projects proposals for funding commencing in 2014 by state and organisation,* http://www.arc.gov.au/sites/default/files/filedepot/Public/NCGP/LP14/LP14_Listing_by_all_State_and_Organisation.pdf, accessed December 2016.

Australian Securities and Investments Commission 2015, *Paying for your funeral,* https://www.moneysmart.gov.au/life-events-and-you/over-55s/payingfor-your-funeral , accessed December 2016.

Australian Taxation Office 2017, *Simple tax calculator,* https://www.ato.gov.au/Calculators-and-tools/Host/?anchor=STC&anchor=STC#STC/report, accessed May 2017.

2016, *Taxation Statistics 2013-14,* Commonwealth Government, Canberra.

Barnett S and Franks P 1999, 'Deafness and Mortality: analyses of Linked Data from the National Health Interview Survey and National Death Index', *Public Health Reports*, 114(4): 330-336.

Bartlett G, Blais R, Tamblyn R, Clermont RJ and MacGibbon B 2008, 'Impact of patient communication problems on the risk of preventable adverse events in acute care settings'. *Canadian Medical Association Journal*, 178(12):1555-1562.

Better Hearing Institute 2014, 'Address Hearing Loss in the Workplace and Reap the Rewards, BHI Urges Employers and Employees for National Employee Wellness Month', Washington.

Cao L, Hosking A, Kouparitsas M, Mullaly D, Rimmer X, Shi Q, Stark W, Wende S 2015, *Understanding the economy-wide efficiency and incidence of major Australian taxes*, The Australian Government the Treasury, Canberra.

Children's Health Queensland Hospital and Health Service 2016, Annual Report 2015-15.

Chou R, Dana T, Bougatsos C, et al 2011, 'Screening for Hearing Loss in Adults Ages 50 Years and Older: A Review of the Evidence for the U.S. Preventive Services Task Force' Evidence Syntheses, No. 83, Agency for Healthcare Research and Quality.

Cochlear 2017, *Inquiry into the hearing health and well-being of Australia*

2016, *Funding options for Cochlear Implants in Australia,* http://www.cochlear.com/wps/wcm/connect/e9ee345a-5fde-461f-99f6-2155acc6cd00/CI%20N35260F%20Funding%20Brochure%20DL%20LR.pdf?MOD=AJPERES, accessed February 2017.

2015, *Product Comparison Chart,* http://www.cochlear.com/wps/wcm/connect/01b973f5-a9b3-431a-9267-8e38bd389e76/FUN1890+ISS5+OCT15+CI+Comparison+Chart+2.pdf?MOD=AJPERES&CONVERT_TO=url&CACHEID=01b973f5-a9b3-431a-9267-8e38bd389e76, accessed February 2017.

Commonwealth of Australia 2016, Budget 2016-17, Federal Financial Relations, Budget Paper No. 3, May, Canberra.

Davis AC, 1989, 'The prevalence of hearing impairment and reported disability among adults in Great Britain' International Journal of Epidemiology, 18(4):911-917.

Deloitte Access Economics 2017a, *Social and economic costs of hearing loss in New Zealand,* report for The National Foundation for the Deaf. Available at: using age-gender demographic changes and population growth.

2017b, *Cost-benefit analysis of FirstVoice's early intervention program*, report for FirstVoice.

Department for Education and Child Development South Australia 2017, *Schools offering an Auslan language program for all students*, https://www.decd.sa.gov.au/sites/g/files/net691/f/decd-schools-offering-auslan.pdf, accessed March 2017.

2016a, *School Teachers Effective 7/10/2016,* https://www.decd.sa.gov.au/sites/g/files/net691/f/school_teachers_pay.pdf, accessed March 2017.

2016b, School Services Officer Effective 7/10/2016, School Services Officer with Leave Conditions. https://www.decd.sa.gov.au/sites/g/files/net691/f/school_services_officer_pay.pdf, accessed March 2017.

2015, *Review of Centres for Hearing Impaired*, https://www.decd.sa.gov.au/sites/g/files/net691/f/review_of_centres_for_hearing_impaired_report.pdf , accessed March 2017.

Department of Broadband, Communications and the Digital Economy 2010, *Investigation into access to electronic media for the hearing and vision-impaired*, http://www.abc.net.au/mediawatch/transcripts/1105_bcd.pdf, accessed March 2010.

Department of Communications and the Arts 2017, *Accessible Television*, https://www.communications.gov.au/what-we-do/television/accessible_television, accessed March 2017.

Department of Education and Training 2014*, Higher Education Report 2011-2013*, Commonwealth Government, Canberra.

Department of Health 2017, *Medicare Statistics,* http://www.health.gov.au/internet/main/publishing.nsf/Content/34A89144DB4185EDCA257BF0001AFE29/$File/MBS%20Statistics%20Financial%20Year%202015-16%20external%2020160808.pdf, accessed February 2017.

2016a, *Annual Report: 2015-2016,* Commonwealth Government, Canberra.

2016b, *Budget 2016-17: Portfolio Budget Statements 2016-17. Budget Related Paper No.1.10,* Commonwealth Government, Canberra.

2016c, *OHS - Am I eligible to receive subsidised hearing services?* ,http://hearingservices.gov.au/wps/wcm/connect/hso/781008f7-9438-45a6-9a98-8f85576640ff/Am+I+eligible+March+2017.pdf?MOD=AJPERES&CONVERT_TO=url&CACHEID=781008f7-9438-45a6-9a98-8f85576640ff, accessed February 2017.

2016d, *OHS – Hearing Services Program: Under 26 years.* http://hearingservices.gov.au/wps/wcm/connect/hso/b6a2b7ca-9697-45f0-b14b-619dd525a62f/FINAL+-+Under+26+years.pdf?MOD=AJPERES&CONVERT_TO=url&CACHEID=b6a2b7ca-9697-45f0-b14b-619dd525a62f, accessed February 2017.

2016e, *OHS - Annual Program Statistics 2015-16,* Commonwealth Government, Canberra.

2016f, *Eligibility Criteria for Refitting – FAQ's*, Commonwealth Government, Canberra.

2016g, *Schedule of Fees 2016-17,* http://www.hearingservices.gov.au/wps/portal/hso/site/about/legislation/contracts/schedule_fees%202016-2017/!ut/p/a1/04_Sj9CPykssy0xPLMnMz0vMAfGjzOK9A03NDD0NjLwtwvzdDBwd_UJ9vNxMjAz8DYAKIvEoMDAlTr8BDuBoQEi_FxEWGBX5Ovum60cVJJZk6GbmpeXrR-SkpmcW54B9qR-RnJ9XUpSYXFKsH1GcnJGaUpqTGp-WmlqsYGRgaKYLJMz1w_Wj8FoE8ihYAR6fFOSGRlT5OFl6pisqAgBrADIx/dl5/d5/L2dBISEvZ0FBIS9nQSEh/, accessed February 2017.

2015a, *Minimum Hearing Loss Threshold,* http://www.hearingservices.gov.au/wps/portal/hso/site/about/legislation/other/mhlt/!ut/p/a1/04_Sj9CPykssy0xPLMnMz0vMAfGjzOK9A03NDD0NjLwtwvzdDBwd_UJ9vNxMjAz8DYAKIvEoMDAlTr8BDuBoQEi_FxEWGBX5Ovum60cVJJZk6GbmpeXrR-SkpmcW54B9qR-RX5KRWqQfkZuRU6Ifrh-F10SQj8AK8Di5IDc0osrHydIzXVERAA9CmFE!/dl5/d5/L2dBISEvZ0FBIS9nQSEh/, accessed January 2017.

2015b, 'Australian Government 2015-16 Health Portfolio Budget Statements'. Commonwealth Government, Canberra.

Department of Human Services 2017a, DSPN, https://www.humanservices.gov.au/customer/services/centrelink/disability-support-pension, accessed March 2017.

2017b, *SA,* https://www.humanservices.gov.au/customer/services/centrelink/sickness-allowance, accessed March 2017.

2017c, *Newstart Allowance,* https://www.humanservices.gov.au/customer/services/centrelink/newstart-allowance, accessed March 2017.

2017d, *Carer Allowance,* https://www.humanservices.gov.au/customer/services/centrelink/carer-allowance, accessed March 2017.

Department of Social Services 2016a, *Budget 2016-17: Portfolio Budget Statements 2016-17 Budget Related Paper No.1.15a,* Commonwealth Government, Canberra.

2016b, *Annual Report 2-15-16,* Commonwealth Government, Canberra.

Devlin Y 2000 "Students with disabilities in higher education: at whose cost and at what price?" Discussion paper. Equity and Diversity Unit, University of New South Wales, August, Sydney.

Dobie RA 2008, 'The burdens of age-related and occupational noise-induced hearing loss in the United States'. Ear and Hearing, 29(4):565–577.

Ear Science Institute Australia 2014, *Annual Report 2014,* https://www.earscience.org.au/sites/www.earscience.org.au/files/field/pdf/easc069_2014_annual_report_web4.pdf, accessed February 2017.

European Hearing Instrument Manufacturers' Association 2015, *EuroTrak UK 2015,* www.ehima.com/wp-content/uploads/2016/02/EuroTrak_2015_UK.pdf, accessed March 2017.

Fair Work Commission 2016, *National Minimum Wage Orders,* https://www.fwc.gov.au/awards-and-agreements/minimum-wages-conditions/national-minimum-wage-orders, accessed April 2017.

Feeny D, Huguet N, McFarland B, Kaplan M, Orpana H and Eckstrom E 2012, 'Hearing, mobility, and pain predict mortality: a longitudinal population-based study', *Journal of Clinical Epidemiology*, 56:764-777.

Fisher D, Li C, Chui M, Themann C, Petersen H, Jonasson F, Jonasson P, Sverrisdottir J, Garcia M, Harris T, Launer L, Eiriksdottir G, Gundason V, Hoffman H and Cotch, M 2014, 'Impairments in hearing and vision impact on mortality in older people: the AGES-Reykjavik Study, *Age and Ageing*, 43:69-76.

FirstVoice 2016, Hearing Loss, http://www.firstvoice.org.au/hearing-loss/, accessed October 2016.

Flinders University 2017, *The Australian Longitudinal Study of Ageing,* http://www.flinders.edu.au/sabs/fcas/alsa/, accessed March 2017.

Friberg E, Gustafsson K and Alexanderson K 2012, 'Hearing difficulties, ear-related diagnoses and sickness absence or disability pension – a systematic literature review', *BMC Public Health,* 12:772.

Genther D, Betz J, Pratt S, Kritchevsky S, Martin K, Harris T, Helzner E 2015, 'Association of hearing impairment and mortality in older adults', *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences*, 70(1):85-90.

Gopinath B, Rochtchina E, Wang JJ, Schneider J, Leeder SR and Mitchell P 2009, 'Prevalence of age-related hearing loss in older adults: Blue Mountains Study', *Archives of Internal Medicine*, 169(4):415-418.

Gurgel RK, Ward PD, Schwartz S, Norton MC, Foster NL, Tschanz JT 2014, 'Relationship of hearing loss and dementia: a prospective, population-based study', *Otology and Neurotology,* 35(5):775-81.

Hearing Care Shop 2017, *Hearing aid,* http://thehearingcareshop.com.au/product-category/hearing-aids/, accessed February 2017.

Hogan A, O'Loughlin K, Davis A, Kendig H 2009, 'Hearing loss and paid employment: Australian population survey findings', *International Journal of Audiology*, 48:117-122.

Hogan A, Taylor A, Wilson D, Code C 1999, 'Employment and economic outcomes for deafened adults with cochlear implants', *Australian Journal of Rehabilitation Counselling,* 5(1):1-8.

Humes LE, Busey TA, Craig J, Kewley-Port D 2013. 'Are age-related changes in cognitive function driven by age-related changes in sensory processing?', *Atten Percept Psychophys,* 75(3):508–524

Independent Hospital Pricing Authority 2016, *National Hospital Cost Data Collection: Australian Public Hospitals Cost Report 2013-2014 Round 18,* Commonwealth Government, Canberra.

Jones M, 1994, '*Financial benchmarking of students with disabilities',* Evaluations and Investigations Program, DEET, Canberra.

Joore MA, Brunenberg DEM, Chenault MN, Anteunis LJC 2003, 'Societal effects of hearing aid fitting among the moderately hearing impaired', *International Journal of Audiology,* 42:152-160.

Karpa M, Gopinath B, Beath K, Rochtchina R, Cumming R, Wang J and Mitchell P 2010, 'Assocations between hearing impairment and mortality risk in older persons: the Blue Mountains Hearing Study'*, Annals of epidemiology*, 20(6):452-459.

Kehren K, *$7.8 million for cochlear implants,* http://www.brisbanetimes.com.au/queensland/78-million-for-cochlear-implants-20130529-2nb66.html, accessed February 2017.

Kiely KM, Gopinath B, Mitchell P, Luszcz M and Anstey KJ 2012. 'Cognitive, health, and sociodemographic predictors of longitudinal decline in hearing acuity among older adults', *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences*, 67(9):997-1003.

Kochkin S 2010, 'The efficacy of hearing aids in achieving compensation equity in the workplace', *The Hearing Journal*, 63(10):19-24.

Kochkin S and Rogin CM 2000, 'Quantifying the obvious: The impact of hearing instruments on quality of life'. *Hearing Review*, 7(1):6-34.

KPMG, 2015, *Department of Education and Training Evaluation of Disability Support Program Final Report,* https://docs.education.gov.au/system/files/doc/other/dsp_evaluation_report_final_june_2015.pdf, accessed March 2017.

2010, *CGE analysis of the current Australian tax system,* Report for the Australian Government the Treasury, March, Canberra.

Kramer SE, Kapteyn TS and Houtgast T 2006, 'Occupational performance: comparing normally-hearing and hearing-impaired employees using the Amsterdam Checklist for Hearing and Work', *International Journal of Audiology,* 45: 503-512.

Laforge R, Spector W and Sternberg J 1992, 'The Relationship of Vision and Hearing Impairment to One-Year Mortality and Functional Decline', *Journal of Aging and Health*, 4(1):126-148.

Lévesque B, Fiset R, Isabelle L, Gauvin D, Baril J, Larocque R, et al 2010, 'Exposure of high school students to noise from personal music players in Québec City, Canada', *Int J Child Adolesc Health* 3:413-20.

Liljas A, Wannamethee S, Whincup P, Papacosta O, Walters K, Iliffe S, Lennon L, Carvalho L and Ramsay S 2016, 'Hearing impairment and incident disability and all-cause mortality in older British community-dwelling men', *Age and Ageing*, 0:1-6.

Lin FR, Ferrucci L, An Y 2014, 'Association of hearing impairment with brain volume changes in older adults', *Neuroimage*; 90(84–92).

Lin FR., Yaffe K, Xia J, Xue QL, Harris TB, Purchase-Helzner E, Satterfield S, Ayonayon HN, Ferrucci L, Simonsick EM and Health ABC Study Group 2013, 'Hearing loss and cognitive decline in older adults', *JAMA internal medicine*:173(4):293-299.

Lin FR, Metter EJ, O'Brien RJ, Resnick SM, Zonderman AB, Ferrucci L 2011, 'Hearing loss and incident dementia'. *Arch Neurol*;68(2):214–220

Lin MY, Gutierrez PR, Stone KL, Yaffe K, Ensrud KE, Fink HA, Sarkisian CA, Coleman AL, Mangione CM 2004, 'Vision impairment and combined vision and hearing impairment predict cognitive and functional decline in older women', *J. Am. Geriatrics Soc:* 52(12):1996–2002

London Economics 2010, 'Cost benefit analysis of hearing screening for older people, final report for RNID'. London, United Kingdom, accessed March 2017.

Lowthian JA, Britt CJ, Rance G, Lin FR, Woods RL, Wolfe R, Nelson MR, Dillon HA, Ward S, Reid CM and Lockery JE 2016, 'Slowing the progression of age-related hearing loss: Rationale and study design of the ASPIRIN in HEARING, retinal vessels imaging and neurocognition in older generations (ASPREE-HEARING) trial'. *Contemporary Clinical Trials,* 46:60-66.

Luppino, FS, de Wit LM, Bouvy PF, Stijnen T, Cuijpers P, Penninx BW and Zitman FG 2010, 'Overweight, obesity, and depression: a systematic review and meta-analysis of longitudinal studies'. *Archives of general psychiatry*, 67(3), pp.220-229.

Mathers C, Smith A, Concha M 2000. 'Global burden of hearing loss in the year 2000', *Global Burden of Disease 2000.*

Martini A, Castiglione A, Bovo R, Vallesi A and Gabelli C 2015. 'Aging, cognitive load, dementia and hearing loss'. *Audiology and Neurotology*, 19:2-5.

Martini A, Stephens D, Parving A, Petit C, Cremers CWRJ, Read A, Willems P, E*uropean working group on genetics of hearing impairment,* http://audiology.unife.it/www.gendeaf.org/hear/infoletters/Info_02.PDF, Accessed February 2017

Mohr PE, Feldman JJ and Dunbar JL 2000, 'The societal costs of severe to profound hearing loss in the United States', *International Journal of Technology Assessment in Health Care,* 16(4):1120-1135.

Nachtegaal J, Festen JM and Kramer SE 2012, 'Hearing ability in working life and its relationship with sick leave and self-reported work productivity', *Ear Hear,* 33 (1):94-103.

Nachtegaal J, Kuik DJ, Anema JR, Goverts ST, Festen JM and Kramer SE 2009, 'Hearing status, need for recovery after work, and psychosocial work characteristics: Results from an internet-based national survey on hearing', *International Journal of Audiology,* 48:684-691.

National Acoustics Laboratories 2017, *Welcome to the NAL CAPD Website,* https://www.outcomes.nal.gov.au/, accessed January 2017.

Nelson DI, Nelson RY, Concha-Barrientos M, Fingerhut M 2005, 'The global burden of occupational noise-induced hearing loss', *American Journal of Industrial Medicine*, 48(6):446–458.

Niparko JK 2012, *Evaluation of hearing loss,* http://www.merckmanuals.com/professional/ear,-nose,-and-throat-disorders/hearing-loss/evaluation-of-hearing-loss, accessed December 2016

NSW Health 2011, *Annual Report 2010 Volume One – Performance,* http://www.health.nsw.gov.au/publications/Publications/Annual-Report-2010-11/04-Performance.pdf, Accessed March 2017.

Mahboubi H, Zardouz S, Oliaei S, Pan D, Bazargan M and Djalilian HR 2013. 'Noise-induced hearing threshold shift among US adults and implications for noise-induced hearing loss: National Health and Nutrition Examination Surveys' *European Archives of Oto-Rhino-Laryngology*, 270(2):461-467.

Queensland DoH 2012, *2012 Report - Healthy hearing neonatal hearing program,* https://data.qld.gov.au/dataset/healthy-hearing-screening-report-children-s-health-queensland-hhs, accessed March 2017.

Rabinowitz PM 2012. 'The public health significance of noise-induced hearing loss' in Noise-induced hearing loss (13-25), Springer New York.

Rabinowitz PM, Slade MD, Galusha D, Dixon-Ernst C, Cullen MR 2006, 'Trends in the prevalence of hearing loss among young adults entering an industrial workforce 1985 to 2004'. *Ear and Hearing*, 27(4):369–375.

Roland PS, *Presbycusis,* http://reference.medscape.com/article/855989-overview, accessed March 2017.

Rolfe and Gardner 2016, 'Experiences of hearing loss and views towards interventions to promote uptake of rehabilitation support among UK adults'. *International Journal of Audiology*, 55(666-673).

RNID 2012, 'Everything you need to know about getting hearing aids', *Action on Hearing Loss*, London, United Kingdom.

2013, 'Caring for older people with hearing loss', Action on Hearing Loss, London, United Kingdom.

Ruben JR, 2000, 'Redefining the Survival of the Fittest: Communication Disorders in the 21st Century'. *Laryngoscope* 110:241-245.

Rybak LP, Whitford CA 2005, "Ototoxicity: therapeutic opportunities", *Drug Discovery Today,* 10(19):1313-21.

Rydberg E, Gellerstedt LC, and Danermark B, 2010, 'The position of the deaf in the Swedish labor market', *American Annals of the Deaf,* 155(1):68-77.

Salomon JA, Haagsma JA, Davis A, de Noordhout CM, Polinder S, Havelaar AH, Cassini A, Devleesschauwer B, Kretzschmar M, Speybroeck N and Murray CJ 2015, 'Disability weights for the Global Burden of Disease 2013 study', *The Lancet Global Health*, 3(11):e712-e723.

Safe Work Australia 2010, Occupational Noise-Induced Hearing Loss in Australia, ISBN 978-0-642-331512-6.

Scientific Committee on Emerging and Newly Identified Health Risks 2008, Potential health risks of exposure to noise from personal music players and mobile phones including a music playing function. http://ec.europa.eu/health/ph_risk/committees/04_scenihr/docs/scenihr_o_018.pdf, accessed March 2017.

Schubert C, Fisher M, Pinto A, Klein B, Klein R, Tweed T and Cruickshanks K 2016, 'Sensory Impairments and Risk of Mortality in Older Adults', *Journals of Gerontology: Medical Sciences*, 0:1-6.

Shargorodsky J, Curhan SG, Curhan GC, & Eavey R 2010, 'Change in prevalence of hearing loss in US adolescents'. JAMA, 304(7), 772–778.

Sliwinska-Kowalska M and Davis A 2012. 'Noise-induced hearing loss', Noise and Health, 14(61):274.

Stevens G, Flaxman S, Brunskill E, Mascarenhas M, Mathers C and Finucane M 2011, 'Global and regional hearing impairment prevalence: an analysis of 42 studies in 29 countries', European Journal of Public Health¸ 23 (1):146-152

Tak S, Calvert GM 2008, 'Hearing difficulty attributable to employment by industry and occupation: An analysis of the National Health Interview Survey—United States, 1997 to 2003' *Journal of Occupational and Environmental Medicine*, 50(1):46–56.

Taljaard DS, Olaithe M, Brennan‐Jones CG, Eikelboom RH and Bucks RS 2016. 'The relationship between hearing impairment and cognitive function: a meta‐analysis in adults', *Clinical Otolaryngology*, 41(6):718-729.

Tseng YP, Wilkins R 2002, *Reliance on Income Support in Australia*, Report for the Australian Government Department of Family and Community Services, Canberra.

Van den Heuvel SG, Geuskens GA, Hooftman WE, Koppes LLJ, and van den Bossche SNJ 2010, 'Productivity loss at work; health-related and work-related factors', *Journal of Occupational Rehabilitation,* 20:331-339.

Vogel I, Brug J, Van der Ploeg CP, Raat H 2011, 'Adolescents risky MP3-player listening and its psychosocial correlates'. *Health Educ Res*;26:254-6

Wallhagen MI 2009, 'The Stigma of Hearing Loss', *Gerontologist*, 50(1):66–75.

Wayne RV, and Johnsrude IS 2015. 'A review of causal mechanisms underlying the link between age-related hearing loss and cognitive decline', *Ageing research reviews*, (23):154-166.

Wilson D, Walsh P, Sanchez L, Davis A, Taylor A, Tucker G and Meagher I 1999, 'The epidemiology of hearing impairment in an Australian adult population', *International Journal of Epidemiology,* 28(2):247-252.

Wilson D, Walsh P, Sanchez L, Read P, 1998, *Hearing impairment in an Australian Population,* Centre for Population Studies in Epidemiology, South Australian Department of Human Services.

Winn S, 'Employment outcomes for people in Australia who are congenitally deaf: has anything changed?' *American Annals of the Deaf*, 152(4):382-390.

World Health Organization 2016, 'Childhood hearing loss: strategies for prevention and cure', ISBN 978 92 4 151032 5.

2015, *Deafness and hearing loss,* http://www.who.int/mediacentre/factsheets/fs300/en/, accessed December 2016.

2015b, Hearing loss due to recreational exposure to loud sounds: a review, ISBN 978 92 4 150851 3.

Yamada M, Nishiwaki Y, Michikawa T and Takebayashi T 2011, 'Impact of hearing difficulty on dependence in activities of daily living (ADL) and mortality: A 3-year cohort study of community-dwelling Japanese older adults', *Archives of Gerontology and Geriatrics*, 52:245-249.

Yamasoba T, Lin FR, Someya S, Kashio A, Sakamoto T and Kondo K 2013, 'Current concepts in age-related hearing loss: epidemiology and mechanistic pathways', *Hearing research*, 303:30-38.

Zhao F, Manchaiah VK, French D, Price SM 2010, 'Music exposure and hearing disorders: An overview'. *International Journal of Audiology* 49(1):54–64.

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