Research Request – Unilateral Hearing Loss

Brief	We currently have an application for access to the scheme from a person with a unilateral hearing loss (UHL), and with technology seeming to improve function we may have more people seeking the scheme. Can you please look into: • What are the functional impacts of unilateral hearing loss? • What strategies can be utilised to support function? • The effectiveness of these strategies in overcoming the functional impact of UHL?
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Research Summary

- The prevalence of hearing loss globally and in Australia is immense.
- The immensity of the prevalence of hearing loss in Australia is reflected by the Australian government's current inquiry into and report on the Hearing Health and Wellbeing of Australia, together with its current examination of the issue of how hearing services are transitioned to, and delivered through, the NDIS.
- Whilst Unilateral Hearing Loss (UHL) is included in hearing loss studies, studies specific to Unilateral Hearing Loss are largely US based.
- No statistics with regard to global prevalence specific to UHL could be found.
- No statistics with regard to prevalence in Australia specific to UHL could be found.
- There is plentiful literature and research on the functional impacts of UHL.
- The predominant strategy to support functional impacts of UHL is the use of technological hearing devices.
- A Bone Anchored Hearing Aid (BAHA) appears to be the most common and successful device used for UHL.
- The review of studies on Cochlear Implants for UHL indicate positive results.

What is Unilateral Hearing Loss?

Unilateral Hearing Loss (UHL) is also known as Single Sided Deafness (SSD), although the former term appears to be the most frequently used.

A unilateral hearing loss means that hearing has been found to be different in each ear. On one side, hearing is at a level considered within the normal range. On the other side, hearing is below the normal range. There are different levels of hearing loss. They are described as mild, moderate, severe or profound. A unilateral loss can be at any of these levels. [1]

According to the World Health Organisation:

[1] New Zealand Government, Ministry of Health, "What is unilateral hearing loss?", [website], 2014, https://www.nsu.govt.nz/system/files/resources/unilateral-hearing-loss.pdf, (accessed 11 September 2019)

Deafness means complete loss of the ability to hear from one or both ears; this is profound hearing impairment, 81 dB or greater hearing threshold, averaged at frequencies 0.5, 1, 2, 4 kHz.

Hearing impairment means complete or partial loss of the ability to hear from one or both ears; this is mild or worse hearing impairment, 26 dB or greater hearing threshold, averaged at frequencies 0.5, 1, 2, 4 kHz.

Disabling hearing impairment means moderate or worse hearing impairment in the better ear; that is the permanent unaided hearing threshold level for the better ear of 41 or 31 dB or greater in age over 14 or under 15 years respectively, averaged at frequencies 0.5, 1, 2, 4 kHz. [2]

Grades of Hearing Impairment (WHO, 2008) [3]

Grade of impairment*	Corresponding audiometric ISO value**	Performance	Recommendations
* Grades 2, 3 and 4 are classified as disabling hearing impairment (for children, it starts at 31 dB) ** The audiometric ISO values are averages of values at 500, 1000, 2000, 4000 Hz.			
0 - No impairment	25 dB or better (better ear)	No or very slight hearing problems. Able to hear whispers.	
1 - Slight impairment	26-40 dB (better ear)	Able to hear and repeat words spoken in normal voice at 1 metre.	Counselling. Hearing aids may be needed.
2 - Moderate impairment	41-60 dB (better ear)	Able to hear and repeat words spoken in raised voice at 1 metre.	Hearing aids usually recommended.
3 - Severe impairment	61-80 dB (better ear)	Able to hear some words when shouted into better ear.	Hearing aids needed. If no hearing aids available, lip-reading and signing should be taught.
4 - Profound impairment including deafness	81 dB or greater (better ear)	Unable to hear and understand even a shouted voice.	Hearing aids may help understanding words. Additional rehabilitation needed. Lip-reading and sometimes signing essential.

Causes of UHL

The causes of UHL may include:

- acoustic neuroma (a benign tumour developing on the nerve that connects the ear to the brain).
- sudden idiopathic hearing loss, which is commonly due to viral infection
- blunt trauma to the head

[2] World Health Organisation, "Facts about deafness", [website], 2019, https://www.who.int/pbd/deafness/facts/en, (accessed 11 September 2019)
[3] ibid

- Vascular insults that damage the auditory pathway; congenital loss of hearing
- Ménière's disease, a disorder that affects balance and hearing, resulting from the build-up of fluid in part of the inner ear. [4]

In addition to head or ear injuries or the presence of a foreign body in the ear, the following medical conditions can result in UHL:

- Eardrum rupture: a small hole or tear in the ear drum
- Labyrinthitis: a disorder that causes the inner ear apparatus to become swollen and irritated
- Neurofibromatosis type 2: an inherited disease that causes noncancerous growths to appear on the auditory nerve
- Otitis externa (swimmer's ear): inflammation of the outer ear and ear canal
- Otitis media with effusion: an infection with thick or sticky fluid behind the eardrum
- Shingles: an infection caused by the same virus that causes chickenpox
- Reye's syndrome: a rare disorder, most often seen in children
- Temporal arteritis: inflammation and damage to the blood vessels in the head and neck
- Vertebrobasilar insufficiency: poor blood flow to the back of the brain [5]

UHL may also be the result of prescription medications like:

- chemotherapy drugs
- diuretics such as furosemide
- salicylate (aspirin) toxicity
- antibiotics such as streptomycin and tobramycin [6]

How someone with UHL may present

Compiled from several references [7]a person with profound UHL may present in the following ways:

- Irritability
- Sound aversion: any presence of noise, no matter how low
- Body language and mannerisms which appear socially awkward or unusual, like staring at others mouths or tilt the head frequently
- Frequent headaches, stress
- Social isolation
- Chronic interpersonal communication difficulties due to inability of brain to isolate or beam form sounds and voices of other individuals
- Appearance of anxiousness even in low noise situations
- Jumpiness
- Trouble figuring out where sounds are coming from.
- Variable light dizziness
- Trouble paying attention to what people are saying: "evasive" behaviour.
- Misdiagnoses as ADHD

[4] J. Weaver, "Single-Sided Deafness: Causes, and Solutions, Take Many Forms", The Hearing Journal, Vol. 68, no. 3, 2015, pp. 20-24, https://urlzs.com/S8SAj
[5] Healthline, "Hearing Loss on One Side", [website], 2019, https://www.healthline.com/health/hearing-loss-on-one-side, (accessed 11 September 2019)
[6] ibid
[7] Wikipedia, "Unilateral hearing loss", [website], 2019, https://en.wikipedia.org/wiki/Unilateral_hearing_loss, (accessed 11 September 2019)

- Seeming lack of awareness of other people's personal space and moods since brain is hyper-focused on deciphering auditory information in lieu of non-verbal social cues.
- Lack of sound depth: any background noise (in the room, in the car) is flat and wrongly interpreted by the brain. The effect is similar to what happens when trying to hear someone speaking in a noisy crowd on a mono TV. The effect is also similar to talking on the phone to someone who is in a noisy environment
- Inability to filter out background noise or selectively listen to only the important portion of the noise in the environment.
- Talking loudly or "broadcasting": the affected person cannot perceive the volume of his or her voice relative to other people in the same room or close company, resulting in being characterized by others (who may be located beyond normal auditory range) as domineering or boorish

Prevalence - Global

Overview

Although there are plentiful studies on UHL outside of Australia, no recent global statistics could be found. However, a significant 2013 literature review which accessed papers from a published literature review and obtained additional detailed data tabulations from investigators, estimated "that 92.4% (89.1–94.4%) of children and 68.1% (62.0–73.1%) of adults have unilateral or no hearing impairment". [8]

It terms of general hearing loss:

- Over **5% of the world's population, or 466 million people,** has disabling hearing loss (432 million adults and 34 million children).
- It is estimated that by 2050 over 900 million people will have disabling hearing loss.
- 60% of childhood hearing loss is **due to preventable causes**
- 1.1 billion young people (aged between 12–35 years) are at risk of hearing loss due to exposure to noise in recreational settings.
- Approximately one third of people over 65 years of age are affected by disabling hearing loss. The prevalence in this age group is greatest in South Asia, Asia Pacific and sub-Saharan Africa. [9]

Social and Economic Impact

In 2017 the World Health Organisation reported on the global costs of unaddressed hearing loss. [10] The report found:

- The cost to the health-care sector, for adults and children, is estimated to be in the range $67–107 billion. This does not include the cost of providing hearing devices such as hearing aids and cochlear implants.
- A conservative estimate of the cost to the education sector of providing support to children (5–14 years) with unaddressed hearing loss is $3.9 billion. This assumes that only children

[8] G. Stevens et al., "Global and regional hearing impairment prevalence: an analysis of 42 studies in 29 countries", European Journal of Public Health, vol. 23, no. 1, 2013, pp. 146–152. https://academic.oup.com/eurpub/article/23/1/146/460112

[9] World Health Organisation, "Deafness and hearing loss", [website], 2019, https://www.who.int/news-room/fact-sheets/detail/deafness-and-hearing-loss, (accessed 11 September 2019)

[10] World Health Organisation, "Global Costs Of Unaddressed Hearing Loss and Cost-effectiveness of Interventions, 2017, https://www.who.int/pbd/deafness/world-hearing-day/GlobalCostsOfUnaddressedHearingLossExeSum.pdf?ua=1

with at least moderately severe hearing loss (hearing level greater than 50 dB in the better-hearing ear) require educational support.

- Between 63% and 73% of the global costs to health and education sectors are incurred in low- and middle-income countries.
- Loss of productivity, due to unemployment and premature retirement among people with hearing loss, is estimated to cost $105 billion annually.
- Societal costs – the result of social isolation, communication difficulties and stigma – add a further $573 billion each year. These costs are calculated on the basis of the monetary value attached to avoidance of a year lived with disability and draw upon disability-adjusted life years (DALYs) attributed to hearing loss.

Overall, this analysis suggests that the annual cost of unaddressed hearing loss is in the range $750 - $790 billion globally. The analysis takes no account of certain aspects of hearing loss, the costs of which are not well documented in literature, such as the costs of providing informal care, or preschool learning and higher education for people with unaddressed hearing loss.

(NOTE: The costs above are estimated in 2015 international dollars, a unit of currency defined by the World Bank).

Prevalence - Australia

<u>Overview</u>

In 2017, Hearing Care Industry Association (HCIA) commissioned Deloitte Access Economics to update a 2006 report which quantified the impact and estimated impact of both the financial costs and the loss of wellbeing from hearing loss in Australia.[11] The intention of the new landmark report was to raise awareness of the economic cost of hearing impairment in Australia and to inform policy making. The report found that:

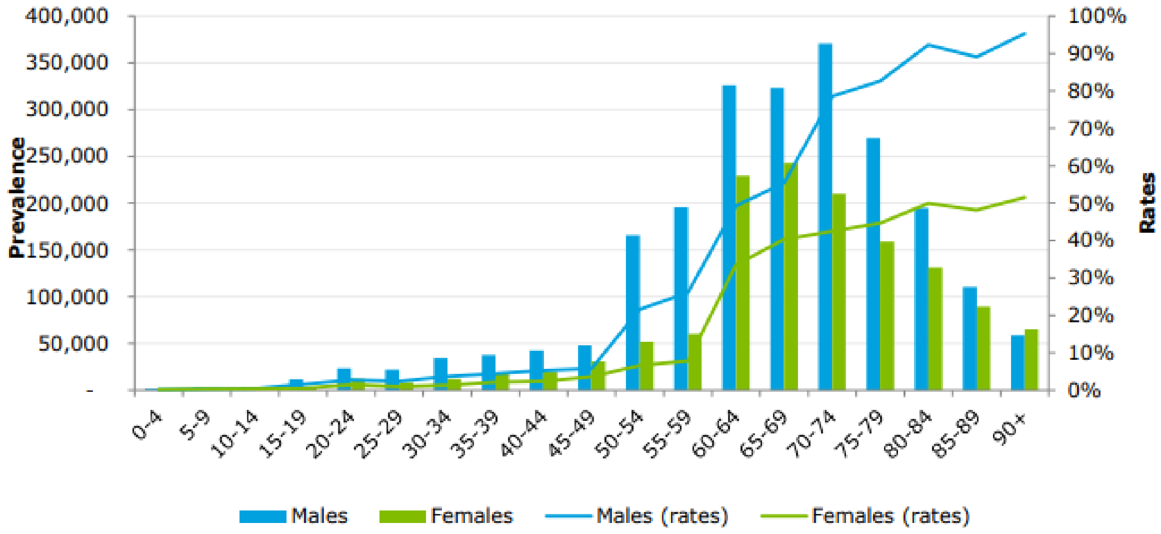
- The prevalence of hearing loss in Australia (better ear) in 2017 was estimated to be 3.6 million people – 2.2 million males and 1.4 million females. This represents 14.5% of the Australian population.

- 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 is estimated to be preventable, while for adults it is thought that 37% of hearing loss is preventable.

The prevalence rates and number of people who have hearing loss in Australia in 2017 is shown in the table below.

[11] Hearing Care Industry Association (HCIA), The Social and Economic Cost of Hearing Loss in Australia. DeLoitte Access Economics Australia, June 2017. https://www.hcia.com.au/about-hearing-loss/#.XW8DkCgzaUk



Social and Economic Impact

The Australian Government's recent report on the inquiry into the Hearing Health and Wellbeing of Australia, [12]indicates the severity of rising hearing loss in Australia, and amongst its recommendations suggesting that hearing health should be made a National Health Priority Area.

"On a broad scale, it has been estimated that hearing loss costs the Australian economy $33.3 billion, comprised of $15.9 billion in financial costs and $17.4 billion in lost wellbeing for individuals. The economic impact of balance disorders is less certain but one estimate suggested that their cost for hospital emergency departments alone could be as high as $148 million per year".

"… the level of hearing loss among Aboriginal and Torres Strait Islander children is at a crisis. Among working age Australians hearing loss can make it difficult to find or retain a job, and among older people hearing loss may lead to social isolation and has been linked to an increased risk of cognitive decline and dementia".

Functional Impacts of UHL

There is much research indicating that UHL has physical, cognitive, psychological, and social impacts on the individual.

"A unilateral hearing loss (UHL) can have a significant functional and social impact on children and adults, affecting their quality of life. In adults, UHL is typically associated with difficulties understanding speech in noise and sound localization, and UHL increases the self-perception of auditory disability for a range of listening situations. Furthermore, despite evidence for the negative

[12] Parliament of the Commonwealth of Australia, "Report on the Inquiry into the Hearing Health and Wellbeing of Australia", 2018. https://parlinfo.aph.gov.au/parlInfo/download/committees/reportrep/024048/toc_pdf/Stillwaitingtobeheard....pdf;fileType=application%2Fpdf

effects of reduced unilateral auditory input on the neural encoding of binaural cues, the perceptual consequences of these changes are still not well understood." [13]

General Impacts

- **Auditory abilities**: UHL affects a range of auditory abilities, including speech detection in noise, sound localization, and self-perceived hearing disability. CAEPs elicited by speech sounds are sensitive enough to evidence changes within the auditory cortex due to an UHL. [14]

In 2019 the National Acoustic Laboratories (NAL) explored the impacts of UHL in adults life, using semi-structured interviews and open ended surveys, with theme outcomes below:

- **Difficulties with listening in noise and localisation:** Difficulty in loud environments and when there were lots of sound sources.
- **Fatigue**: From the increased cognitive load required during activities such as conversation in loud noise.
- **Fear/anxiety**: The perception that the person's safety, or the safety of those around them, might be at risk due to their hearing impairment
- **Self-esteem and difficulty in social situations:** Poor perception of themselves, in which they felt like they were a burden to those around them, or felt anxious and self-conscious about their difficulties communicating.
- **Reduced social engagement:** Problems with communication in social situations, resulting in feelings of disconnection from the world around them.
- **Stigma in the workplace:** Strong perception of stigma, particularly in the workplace, where they did not want others to know and judge them for their hearing loss.
- **Coping mechanisms:** Development of various coping mechanisms in response to the difficulties encountered because of their hearing loss. In some cases, coping mechanisms were applied through conscious effort or adapted without conscious thought. [15]

Impacts on Children

- General communication difficulties
- Psycholinguistic dysfunction (ability to learn language)
- Social-emotional problems
- Quality of life effects [16]
- Academic: Children with UHL are 10 times more likely to need to repeat a year of school than children with normal hearing [17]

[13] O. Canete et al., "Impact of Unilateral Hearing Loss on Behavioral and Evoked Potential Measures of Auditory Function in Adults", J Am Acad Audiol., vol. 30, no. 7, pp. 564-578, 2019. https://www.ncbi.nlm.nih.gov/pubmed/30424835
[14] ibid
[15] J. Galloway et al., "The Impact of Unilateral Hearing Loss on Adult Life", Hearing Review, vol. 26, no. 4, 2019. http://www.hearingreview.com/2019/03/impact-unilateral-hearing-loss-adult-life
[16] D. Bowers, "Unilateral Hearing Loss in Children: Impact and Solutions", [website], 2017, https://www.audiologyonline.com/articles/unilateral-hearing-loss-in-children-19953, (accessed 11 September 2019)
[17] F. Bess, & A. Tharpe, "Case history data on unilaterally hearing-impaired children", Ear and Hearing, vol.7, pp. 14-19, 1986, https://www.ncbi.nlm.nih.gov/pubmed/3949096

- Support Services: Children are 5 times more likely to need support services. [18]

Strategies to support functional impacts of UHL

Overview

Research of the literature indicates that the predominant strategy to support functional impacts of UHL is the use of technological hearing devices. Some patients may chose surgery over wearing a hearing aid as they may perform better with a bone-conductive option, and others prefer not to wear any device on their ear and a bone-anchored implant offers that opportunity. [19]

Early Intervention

No research could be found regarding adults with hearing loss who did not receive early intervention support. However, there is much literature on early intervention for children with hearing loss in terms of communication skills and social interaction.

The Australian government's Hearing Australia asserts that "There is currently no high-quality evidence on how to best manage unilateral hearing loss in young children." [20]

"Research has shown that babies with a hearing loss of about 40dB or more in both ears benefit from wearing hearing aids in the first six months.

However, research hasn't yet shown us the best approach to take for babies with a unilateral hearing loss.

Fitting a hearing aid early to children with a significant unilateral loss might stimulate the child's brain to use hearing in the affected ear. This applies especially to children who have a moderate or severe hearing loss in the affected ear.

Children who have only very mild loss in the affected ear are unlikely to need or benefit from aid use. Children with a profound unilateral loss may not have any useable hearing in the affected ear even with a hearing aid.

Children with unilateral loss appear to be at higher risk than other children of developing hearing loss in the unaffected ear. While only a small risk, this may be another reason to consider early use of a hearing aid, as it may be wise to make greatest use of the hearing in the affected ear just in case the hearing in the good ear worsens in the future." [21]

Behavioural Strategies

No research could be found with regard to using behavioural strategies such as Cognitive behavioural therapy, as a management option for unilateral hearing loss. However there have been studies conducted regarding such as applied to reducing mental stress of the impacts of the loss.

Devices and Technologies used in the management of UHL

[18] R. Oyler et al., "Unilateral hearing loss: demographics and educational impact", Language, Speech, and Hearing Services in Schools", vol.19, pp.201–210, https://doi.org/10.1044/0161-1461.1902.201
[19] Cleveland Clinic, "Single-Sided Deafness _ What Are Your Options", [website], 2019, https://my.clevelandclinic.org/health/transcripts/1489_single-sided-deafness-what-are-your-options, (accessed 17 September 2019)
[20] Hearing Australia, "NAL research is CUHL for kids with hearing loss", [website], 2019, https://www.hearing.com.au/About-Hearing-Australia/Hearing-news/NAL-research-is-CUHL-for-kids-with-hearing-loss, (accessed 17 September 2019)
[21] ibid

Device/Technology	Description
CROS (Contra Lateral Routing of Signal) Hearing Aids / BiCROS	CROS aids are hearing aids where one aid contains a microphone, and the other the amplifier and receiver. CROS aids can be used by people who have one good hearing ear and one ear where the loss is so great that a hearing aid will provide no benefit. Essentially, a CROS aid is a hearing device with a microphone on one side carrying sound from that side of the head to the other side. [22] The technology allows two implementations: CROS and BiCROS. The BiCROS implementation is for a user with little or no hearing on one side and with some hearing loss in their better ear. It works just like the CROS implementation, except that the device on the good side is actually a fully capable hearing aid for hearing sounds from the good side that is also capable of receiving the sound transmitted from the CROS aid on the other side. Transmission in a CROS or BiCROS configuration can be via wire around the back of the neck or wirelessly via radio. [23]
Transcranial CROS	Transcranial CROS transmits a signal received by an air conduction hearing aid in the deaf ear to the contralateral cochlea via bone conduction. Theoretically, transcranial CROS represents an improvement over air conduction CROS because of a smaller reduction in the sound signal across bone versus electronically or wirelessly. [24]
Bone Anchored Hearing Aid (BAHA)	A BAHA is a surgically implantable system for the treatment of hearing loss. This device allows sound to be conducted through the bone rather than the middle ear - a process known as direct bone conduction. [25]
SoundBite Intraoral bone conduction (SoundBite™ Hearing System)	A non-surgical bone conduction prosthetic device that transmits sound via the teeth. It is an alternative to surgical bone conduction prosthetic devices, which require surgical implantation into the skull to conduct sound. In the US the device has FDA clearance to treat patients with UHL There are two parts to the SoundBite system: A small behind-the-ear (BTE) unit that picks up sounds in the environment, processes the sound, and then wirelessly transmits them to the second component: The in-the-mouth (ITM) device. This fits securely around the upper back portion of the teech but does not require any modifications to the teeth. It wirelessly picks up the sound detected by the BTE unit and transmits it into sound vibrations. These sound vibrations travel via the teeth through the bones of your ear and into the cochlea (hearing organ) where the sound is detected. [26]

[22] Australian Government, Department of Health, "Hearing Services Program: Glossary of Terms", [website], 2018, http://www.hearingservices.gov.au/wps/wcm/connect/hso/67959cbd-9683-4219-86d5-486b41cb72cd/Glossary+of+Terms+Sept2018.pdf?MOD=AJPERES&CONVERT_TO=url&CACHEID=67959cbd-9683-4219-86d5-486b41cb72cd, (accessed 11 September 2019)

[23] Hearing Loss Association of America, "CROS and BiCROS", [website], 2018, http://www.nchearingloss.org/bicros.htm?fromncshhh, (accessed 11 September 2019)

[24] C. Giardina et al., "Cochlear Implants in Single-Sided Deafness", Curr Surg Rep, vol. 2, no. 75, 2014, https://link.springer.com/article/10.1007/s40137-014-0075-9#citeas

[25] Australian Government, Department of Health, "Hearing Services Program: Glossary of Terms", [website], 2018, http://www.hearingservices.gov.au/wps/wcm/connect/hso/67959cbd-9683-4219-86d5-486b41cb72cd/Glossary+of+Terms+Sept2018.pdf?MOD=AJPERES&CONVERT_TO=url&CACHEID=67959cbd-9683-4219-86d5-486b41cb72cd, (accessed 11 September 2019)

[26] Everyday Hearing, "SoundBite Hearing System – Is it right for me?", [website],2019, https://www.everydayhearing.com/hearing-technology/soundbite-hearing-system-is-it-right-for-me, (accessed 11 September 2019)

Device/Technology	Description
Cochlear Implants (CI)	A cochlear implant is a surgically implanted device which enables a person to experience sounds by sending electrical signals to the nerve endings in the inner ear (the cochlear). [27]
Bone conduction implants	Bone conduction implants are an alternative option to hearing aids, suitable for people with conductive and mixed hearing loss, as well as those with single sided deafness. Bone conduction implants can also help people who are physically unable to wear conventional hearing aids for medical or anatomical reasons. [28]

Effectiveness of strategies to support functional impacts of UHL

BAHA (Bone Anchored Hearing Aid) and CROS/BiCROS

BAHA

In researching the literature it appears that BAHA is currently the most used and most successful device in the management of UHL.

A recent systematic review study which was conducted on Pubmed and which retrieved 549 articles, evaluated the impact of different types of hearing rehabilitation after hearing loss and their impact on quality of life.

The main finding was that hearing rehabilitation is beneficial in all types of hearing loss and treatment regarding quality of life. However, bone-anchored hearing devices and cochlear implants were shown to produce greater improvements in terms of quality of life than conventional hearing aids. [29]

"The BAHA is increasingly used for single sided deafness (SSD) because it effectively eliminates the head shadow effect by bringing sound trancranially to the good ear. In SSD, BAHA shows significant benefits in situations involving background noise and reverberation and a reduced aversion to loud sounds in comparison to the unaided and conventional CROS conditions. These studies also were reassuring in finding that wearing the BAHA did not interfere with the function of the normal contralateral ear by the interference through bone conduction." [30]

A 2003 cohort study evaluated the effectiveness of BAHA in transcranial routing of signal by implanting the deaf ear. Eighteen patients with UHL were included in the study. They had a 1-month pre-implantation trial with a contralateral routing of signal (CROS) hearing aid. Their performance with BAHA was compared with the CROS device using speech reception thresholds, speech

[27] Australian Government, Department of Health, "Hearing Services Program: Glossary of Terms", [website], 2018, http://www.hearingservices.gov.au/wps/wcm/connect/hso/67959cbd-9683-4219-86d5-486b41cb72cd/Glossary+of+Terms+Sept2018.pdf?MOD=AJPERES&CONVERT_TO=url&CACHEID=67959cbd-9683-4219-86d5-486b41cb72cd, (accessed 11 September 2019)
[28] Ear Science Clinic, "Bone Conduction Implants", [website], 2019, https://www.earscience.org.au/clinic/hearing-implants/bone-conduction-implants, (accessed 16 September 2019)
[29] A. Brodie et al., "The impact of rehabilitation on quality of life after hearing loss: a systematic review", Eur Arch Otorhinolaryngol, vol. 275, no. 10, pp 2435–2440, 2018. https://link.springer.com/article/10.1007/s00405-018-5100-7
[30] A. Abdulrahman, "BAHA: Bone-Anchored Hearing Aid", Int J Health Sci (Qassim), vol., 1, no. 2, pp. 265–276, 2007. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3068630

recognition performance in noise, and the Abbreviated Profile Hearing Benefit and Single Sided Deafness questionnaires.

- Patients reported a significant improvement in speech intelligibility in noise and greater benefit from BAHA compared with CROS hearing aids.
- Patients were satisfied with the device and its impact on their quality of life. No major complications were reported.

The study concluded that "BAHA is effective in unilateral deafness. Auditory stimuli from the deaf side can be transmitted to the good ear, avoiding the limitations inherent in CROS amplification". [31]

CROS/BiCROS

A 2019 study compared the CROS/BiCROS and a soft-band bone-anchored hearing aid (BAHA) in patients with UHL, and assessed the relationship between hearing aid benefits and personal factors. Sound localization, consonant, hearing in noise, and psychoacoustic tests were performed. The study found:

- Sound localization ability in the horizontal plane was significantly decreased in the CROS/BiCROS condition because it diminished the monaural level and spectral cues for monaural listeners.
- A CROS/BiCROS hearing aid provided a slight but significant additional benefit for speech perception in a quiet and speech-in-noise perception when speech and noise were presented from the front.
- Both the CROS/BiCROS hearing aid and BAHA helped reduce the head shadow effect, and they significantly enhanced speech-in-noise perception when the target speech was presented to the poorer ear.
- A CROS/BiCROS hearing aid was superior to a BAHA in overcoming the head shadow effect.
- A CROS/BiCROS hearing aid appeared to have a rather negative effect when the noise was delivered to the better ear. [32]

A contemporary literature review on the comparison of CROS hearing devices and BAHA suggested that "there is indication in the literature that BAHA provides greater relief of hearing handicap associated with USNHL than CROS hearing aids; however, both have been found to provide limited patient satisfaction and seemingly fall short of restoring true sound localization". [33]

An article which referenced and interviewed several practicing physicians looked at the benefits on both BAHA and CROS devices. Although each device has its advantages and disadvantages, BAHA appeared to be the preferred option due to better hearing quality and patient comfort, according to the physicians interviewed for the article:

- Although CROS doesn't require surgery, Baha tends to have a high level of user satisfaction
- Baha routes sound more efficiently, and the patient receives a clearer, stronger sound in the hearing impaired ear than with traditional or transcranial CROS
- One recent study (Otol Neurotol 2006; 27:172-82) of 23 patients with unilateral deafness conducted by Dr. Niparko and his colleagues found that Baha used for single-sided deafness provided greater benefits for patients than CROS. Advantages of Baha were related to averting the interference of speech signals delivered to the better ear, as occurs with

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[31] J. Eazen et al., "Transcranial Contralateral Cochlear Stimulation in Unilateral Deafness", Sage Journals, vol. 129, no.3, pp. 248-254, 2003, https://journals.sagepub.com/doi/abs/10.1016/S0194-5998(03)00527-8

[32] J. Choi et al., "A comparison between wireless CROS/BiCROS and soft-band BAHA for patients with unilateral hearing loss", PLoS ONE, vol. 14, no. 2, 2019, https://doi.org/10.1371/journal.pone.0212503

[33] C. Bishop and T. Eby, "The current status of audiologic rehabilitation for profound unilateral sensorineural hearing loss", The Laryngoscope, vol. 120, no. 3, 2009, https://onlinelibrary.wiley.com/doi/abs/10.1002/lary.20735

conventional CROS amplification, while alleviating the negative head-shadow effects of unilateral deafness.
- In a recent study (Otolaryngol Head Neck Surg. 2003;129:248-54), Dr. Wazen and his colleagues studied 30 patients who received a CROS hearing aid for a one-month period and then switched to the BAHA system. Patients reported a significant improvement in speech intelligibility in noise, greater improvement in perceived benefit, increased satisfaction, and better quality of life with BAHA than with CROS. [34]

Cochlear Implants (CI)

Whilst BAHA devices appear to be the most used in the management of UHL, the review of studies of Cochlear Implants indicate positive results.

A recent systematic literature review (2016) studied the influence of cochlear implantation in patients with unilateral hearing loss with regards to (a) sound localization, (b) speech perception, (c) tinnitus, and, (d) quality of life. [35] The study concluded:

- A cochlear implant is the only option that provides ear-specific information and, thus, potentially benefits SDD patients' bilateral listening.
- Outcomes regarding enhancement of sound localization, speech perception, and, mainly, improvement of tinnitus are promising indications as well; however, high quality studies are required before standardizing cochlear implantation as a treatment for single-sided deafness.
- Results obtained up to this point from cochlear implantation in patients with single-sided deafness are encouraging in deeming this procedure a reasonable treatment.
- Given that the cochlear implant seems to bring greater benefits than contralateral routing of sound (CROS) and osseointegrated implants, it should be the first choice of treatment for patients with SSD in that which pertains to satisfactory selection criteria.

A cohort study aimed to investigate:

1. How a hearing aid needs to be adjusted for an adult who uses a cochlear implant in the contralateral ear
2. Whether the use of a hearing aid with a cochlear implant leads to interference
3. Whether adults derive binaural benefits from using a hearing aid with a cochlear implant for speech perception, localization, and functional performance in everyday life.

Twenty one patients who used a cochlear implant system in one ear participated in the study. The study concluded that "binaural advantages can be obtained from using a hearing aid with a cochlear implant in opposite ears. It is recommended that bimodal stimulation be standard practice for rehabilitation of adults who wear unilateral cochlear implants. A hearing aid should be fitted to the non-implanted ear using the NAL-NL1 prescription as a starting point, and the frequency response slope and gain could be fine-tuned to suit individual needs". [36]

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[35] F. Cbral et al., "Cochlear Implantation and Single-sided Deafness: A Systematic Review of the Literature", Int Arch Otorhinolaryngol, vol. 20, no. 1, pp. 69-75, 2016, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4687988

[36] T. Ching et al., "Binaural Benefits for Adults Who Use Hearing Aids and Cochlear Implants in Opposite Ears, Ear and Hearing, vol. 25, no. 1, pp. 9-21, https://journals.lww.com/ear-hearing/Abstract/2004/02000/Binaural_Benefits_for_Adults_Who_Use_Hearing_Aids.2.aspx

SoundBite™

There is very little research available on the SoundBite Hearing System which was introduced to the US in 2010 and which has FDA clearance to treat patients with UHL.

A cohort study compared the effectiveness of BAHA and SoundBite. Participants wore one device for 30 days and then swapped for the other device for 30 days. Measures included unaided and aided sound-field thresholds, sound localization, and perception of speech in babble. The study concluded that "Speech perception and sound localization were similar for the two types of device, but the SoundBite led to lower aided thresholds and better APHAB scores than the BAHA". The outcomes of the study were:

- Mid-frequency aided thresholds were lower for SoundBite than for BAHA
- Both devices gave benefits for localization after 30 days, but there was no difference between devices.
- Speech perception was better for both devices than for unaided listening when the target speech came from the poorer hearing side or in front, and the interfering babble came from the better-hearing side.
- There was no consistent difference between devices.
- APHAB scores were better for SoundBite than for BAHA. [37]

[37] B. Moore and G. Popelka, "Preliminary comparison of bone-anchored hearing instruments and a dental device as treatments for unilateral hearing loss", International Journal of Audiology, vol. 52, no.10, pp. 678-686, 2013. https://www.tandfonline.com/doi/abs/10.3109/14992027.2013.809483

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Research Request – Guidance for prescribing premium versus basic level hearing aids

Brief	***1.*** *What constitutes a 'good functional' outcome for speech discrimination ability (% score) in background noise?* ***2.*** *What is a 'good' signal-to-noise (SNR) ratio for hearing impaired people wearing hearing aids? Compared to people with normal hearing?* ***3.*** *What constitutes a 'significant improvement' in speech discrimination score (%)? As the participant tries higher levels of hearing aids.*
Date	30/10/20
Requester	Leeanne [redacted] (Senior Technical Advisor TAB) Jane [redacted] Assistant Director TAB)
Researcher	Jane [redacted] (Research Team Leader TAB)
Cleared by	Jane [redacted] (Research Team Leader TAB)

Contents

Please note:

The research and literature reviews collated by our TAB Research Team are not to be shared external to the Branch. These are for internal TAB use only and are intended to assist our advisors with their reasonable and necessary decision making.

Delegates have access to a wide variety of comprehensive guidance material. If Delegates require further information on access or planning matters they are to call the TAPS line for advice.

The Research Team are unable to ensure that the information listed below provides an accurate & up-to-date snapshot of these matters

What constitutes a 'good functional' outcome for speech discrimination ability (% score) in background noise?

Summary

- There are not scientifically grounded guidelines for what constitutes are 'good functional' outcome for speech discrimination scores in background noise
  - Significant variation between scores exists even in those with similar pure tone thresholds
  - Studies utilise different testing environments and present sounds at different thresholds making comparisons difficult
  - Various studies have shown that on average, normal listeners perform 20% better in noise than those with mild-moderate hearing loss
    - A single study by Dimitrijevic (2004) found that unaided hearing impaired listeners achieved a word discrimination score of 17% (±10) at 67 dB masking compared to normal hearing listeners who achieved 62% (±12)
  - A table provided developed by Phoenix Hearing Instruments shows that at a 'good' SNR of 6-12 dB hearing impaired listeners are able to achieve speech discrimination scores of 30-50%

A major limitation of performing word recognition in quiet is that it is not representative of the "real world" and therefore does not reflect the range of listening conditions hearing-impaired listeners face on a daily basis. For instance, a study that examined noise levels of restaurants found that nearly 78% had signal-to-noise ratios (SNRs) considered detrimental to speech intelligibility for hearing-impaired patrons (1). The same people who struggle in restaurants and other noisy environments often present with good or excellent word recognition scores in quiet (1). Keith and Talis (2) measured word recognition scores in 170 hearing-impaired veterans and found that approximately 60% obtained word recognition scores of 90% or better. This study and others suggest a ceiling effect exists and word recognition scores measured in quiet are simply not sensitive enough to the communication difficulties in background noise that occur for patients with sensorineural hearing loss (3).

It is difficult to define what constitutes a 'good functional outcome' for speech discrimination scores in quiet or noise. This is because substantial variation exists within individuals and among populations based on patterns of hearing loss and speech levels. A maximum speech recognition score can be achieved using a range of speech levels (4-7). Except in cases of relatively normal hearing or profound hearing loss, it is difficult to predict the maximum word recognition score for a particular individual (7). Beattie, Barr (3) present examples to illustrate how patients with similar pure tone threshold testing can have very different speech discrimination scores when tested in noise (Figure 1).

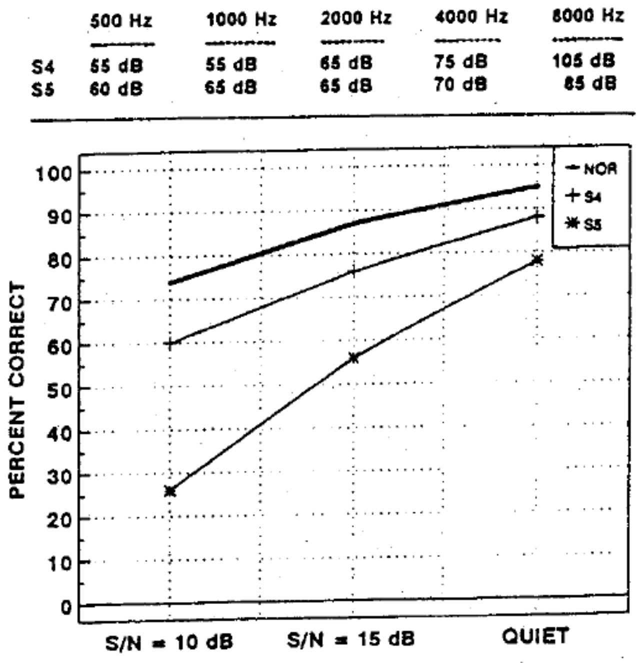

Figure 1. Word recognition functions for two participants with similar hearing losses (moderate, flat to gradually sloping audiograms) with substantially different scores, particularly for the 15 dB SNR. Puretone thresholds are shown at the top of the figure for each participant. The bold line represents mean scores for normal hearing participants.

Because of this variation it is difficult to group individuals into poor, good, excellent etc. Each individual will have different functional goals and likely experience different listening environments in their daily life. Therefore, 50% discrimination in noise may be good for one person and 70% for someone else. Figure 1 has been taken from the Phoenix Hearing Instruments website. The source of the data and the definition of "hearing impairment" is unknown, however it provides a basic guideline of average speech discrimination scores as SNR is increased.

Signal to Noise Ratio	Excellent		Good		Poor	Very Poor
	24dB	18dB	12dB	6dB	0dB	-6dB
Speech Discrimination Score						
Normal Hearing	100%	100%	100%	90%	60%	10%
Impaired Hearing	90%	70%	50%	30%	5%	0%

Figure 1. Speech discrimination scores across varying signal to noise ratios for normal and hearing impaired patients.

Two studies by Beattie (8) and Beattie, Barr (3) compared individuals with normal hearing and those with hearing loss to show how noise impacts word recognition scores.

Beattie (8) recruited 18 normal-hearing participants (age 18-26) and 12 with mild-moderate sensorineural hearing loss (age 54-80). Lists 1-4 (Forms A and B) of the CID W-22 test (monosyllabic words) and a recording of multitasker noise (20 voices) were utilised in the experiment. The stimuli were presented at 45 and 65 dB hearing loss as these were representative of average conversational speech and very loud speech. Signal to noise ratios of 0, 6, 12, 18 and 24 dB were selected. Testing was not conduced at 45 dB hearing loss signal or at a 0 dB SNR for hearing loss participants because preliminary data had suggested these conditions would provide little useful information.

Beattie, Barr (3) recruited 51 normal-hearing women (age 18-30) with no history of otoneurologic pathologies. Each participant passed a 15 dB hearing loss screening at octave frequencies from 500 Hz to 4000 Hz. Lists 1-3 (Form A) of the CID W-22 test (monosyllabic words) and a recording of multitasker noise (20 voices) were utilised in the experiment and tested at a fixed intensity of 50 dB HL across SNRs of 5 dB, 10 dB and 15 dB. A total of 30 participants with mild-moderate hearing loss were recruited. Stimuli were presented at patient loudness discomfort level (LDL) in quiet, 10 dB and

15 dB. Maximum word recognition scores (PB Max) ranged from 48% to 100% with a **mean of 83%** for hearing impaired listeners.

Table 1 and Table 2 provide the results of these two experiments for normal and hearing impaired participants.

Table 1. Normal hearing participants

Signal-to-noise-ratios					
Beattie (1989) (8) Normal hearing participants					
Presented at 45 dB HL					
Statistic (% word recognition score)	**0 dB**	**6 dB**	**12 dB**	**18 dB**	**24 dB**
Mean	18	56	84	93	94
SD	10	16	9	5	5
Range	4-34	38-90	70-98	84-100	84-100
Presented at 65 dB HL	**0 dB**	**6 dB**	**12 dB**	**18 dB**	**24 dB**
Mean	13	45	79	85	94
SD	11	18	14	10	5
Range	0-34	16-88	54-100	64-100	84-100
Hearing impaired participants					
Presented at 65 dB HL		**6 dB**	**12 dB**	**18 dB**	**24 dB**
Mean		35	56	64	72
SD		14	13	11	13
Range		0-58	32-80	48-84	42-90

Table 2. Hearing impaired participants

Signal-to-noise-ratios
Beattie, Barr (3) Normal hearing participants
Presented at 50 dB HL

	5 dB	10 dB	15 dB
Mean	45.4	73.9	86.7
Median	46.0	76.0	86.0
SD	6.2	5.8	5.3
Range	32-56	58-84	76-100
Hearing impaired participants			
Presented at LDL			
Statistic (% word recognition score)	**Quiet**	**10 dB**	**15 dB**
Mean	84.8	40.4	59.5
Median	88.0	62.0	36.0
SD	12.8	14.0	15.0
Range	40-100	34-86	20-66

Results for normal hearing participants in both experiments for monosyllables in noise can serve as a reference for what constitutes an 'excellent' functional outcome. Those with mild to moderate hearing loss in the study by Beattie, Barr (3) exhibited poorer word recognition scores in noise than normal hearing subjects. These result suggest that background noise which has little effect on normal hearing participants can substantially affect word recognition performance of hearing impaired listeners. This adds further weight to the argument that it is difficult to predict performance in noise using scores in quiet.

Comparison of word recognition functions for normal and hearing impaired listeners in the Beattie (8) study revealed that **scores for normally hearing listeners were about 20% higher than for the hearing impaired listeners (2.6% per dB for hearing impaired and 3.6% per dB for normal listeners).** Therefore, smaller increases in SNR result in greater speech discrimination scores for normal listeners. The functions also indicated that **thresholds (50%) were obtained at a SNR of approximately 6 dB for normally hearing participants and a SNR of approximately 11 dB for the hearing impaired group.**

Dimitrijevic, John (9) investigated the word recognition scores of 10 young normal hearing participants (mean age 28 years), 10 elderly normal hearing participants (mean age 68 years) and 10 elderly hearing impaired participants with typical sloping audiograms with the greatest loss at high frequencies (mean age 75 years). Word recognition scores were measured using Auditec recordings of W-22 and NU-6 word lists. Fifty words from a list were presented at 70 dB SPL through two free-field speakers. Hearing-impaired subjects were tested using their hearing aids and no masking. Results (see below) showed that hearing impaired listeners has statistically significantly (P <0.001) worse word recognition scores in quiet and in noise. **Even when aided, the hearing impaired group were 20% worse.** At 67 dB masking, unaided hearing impaired participants were 45% worse compared to normal hearing participants.

Table 3. Results from Dimitrijevic study.

	Quiet	67 dB Masking	70 dB Masking
Young normal-hearing	97 ± 5	62 ± 12	38 ± 18
Elderly normal-hearing	97 ± 2	43 ± 13	17 ± 9
Elderly hearing-impaired (unaided)	56 ± 30	17 ± 10	—
Elderly hearing-impaired (aided)	76 ± 18	—	—

Percentages, mean ± SD.

Maximum word recognition scores for those with hearing loss in quiet

Clinical judgements are often made regarding whether maximum word-recognition scores (PB_{max}) are appropriate in relation to degree of sensorineural hearing loss. In order to determine if word recognition is significantly poorer than expected, it is necessary to consider the lower boundary of PBmax associated with a particular degree of hearing loss for speech materials commonly used to measure word recognition.

In the study by Dubno, Lee (7) word recognition scores were obtained at several speech levels from 407 ears with sensorineural hearing loss of cochlear origin. Of the 407 ears, approximately 25% were under 60 years of age and 75% were greater than 60 years of age. PB_{max} was defined as the highest point on the score level function. Scores at all levels were assembled in 11 Puretone average groups. A computer simulation was used to find the 95% confidence limit (CL) for maximum word recognition scores for each group. PB_{max} values corresponding to the 95% CL are provided in Table 4 and 5 below for 25-item and 50-item NU-6 word lists. These can be used to define the PB_{max} upper and lower limit for different levels of hearing loss. **No table could be located which provides these scores in noise.**

Table 4. 95% CL for PB_{max} for the 25-item NU-6 word lists

PTA (dB HL)[a]	95% CL for PB_{max} (%) Equation	Discrete
−3.3	97.6	100
0.0	96.7	100
1.7	96.2	100
3.3	95.5	96
5.0	94.9	96
6.7	94.1	96
8.3	93.2	96
10.0	92.3	96
11.7	91.3	92
13.3	90.2	92
15.0	89.0	92
16.7	87.7	88
18.3	86.2	88
20.0	84.7	88
21.7	83.1	84
23.3	81.4	84
25.0	79.6	80
26.7	77.7	80
28.3	75.8	76
30.0	73.7	76
31.7	71.6	72
33.3	69.5	72
35.0	67.3	68
36.7	65.0	68
38.3	62.7	64
40.0	60.4	64
41.7	58.1	60
43.3	55.8	56
45.0	53.5	56
46.7	51.3	52
48.3	49.0	52
50.0	46.8	48
51.7	44.7	48
53.3	42.6	44
55.0	40.5	44
56.7	38.5	40
58.3	36.7	40
60.0	34.8	36
61.7	33.0	36
63.3	31.3	32
65.0	29.6	32
66.7	28.1	32
68.3	26.6	28
70.0	25.2	28
71.7	23.8	24

[a]PTA (dB HL) is the average pure-tone threshold at 0.5, 1.0, and 2.0 kHz.

Table 5. 95% CL for PB_{max} for the 50-item NU-6 word lists

PTA (dB HL)[a]	95% CL for PB_{max} (%) Equation	Discrete
−3.3	97.5	98
0.0	96.5	98
1.7	96.0	96
3.3	95.3	96
5.0	94.6	96
6.7	93.8	94
8.3	92.9	94
10.0	91.9	92
11.7	90.9	92
13.3	89.7	90
15.0	88.5	90
16.7	87.2	88
18.3	85.7	86
20.0	84.2	86
21.7	82.6	84
23.3	80.9	82
25.0	79.2	80
26.7	77.3	78
28.3	75.4	76
30.0	73.4	74
31.7	71.4	72
33.3	69.3	70
35.0	67.2	68
36.7	65.0	66
38.3	62.8	64
40.0	60.6	62
41.7	58.4	60
43.3	56.2	58
45.0	54.1	56
46.7	51.9	52
48.3	49.8	50
50.0	47.7	48
51.7	45.7	46
53.3	43.7	44
55.0	41.7	42
56.7	39.8	40
58.3	38.0	38
60.0	36.2	38
61.7	34.5	36
63.3	32.8	34
65.0	31.2	32
66.7	29.7	30
68.3	28.3	30
70.0	26.9	28
71.7	25.5	26

[a]PTA (dB HL) is the average pure-tone threshold at 0.5, 1.0, and 2.0 kHz.

What is a 'good' signal-to-noise (SNR) ratio for hearing impaired people wearing hearing aids? Compared to people with normal hearing?

Summary

- No normative data exists for what is considered a poor, good or excellent (etc.) SNR for hearing impaired people both unaided and aided. A general trend is that SNR loss increases with hearing loss
- SNR loss varies significantly between individuals and cannot be predicted based on pure tone average results
- Normal hearing people on average require +2 dB SNR to correctly repeat 50% of the key words
- Guidelines for interpreting SNR loss are:
    - **Normal** 0-2dB SNR loss
    - **Mild** 3-6dB SNR Loss
    - **Moderate** 7-12dB SNR Loss
    - **Severe** >12dB SNR loss
- Studies have shown that hearing aids that incorporate directionality can improve the SNR by approximately 3 to 8.5 dB
    - Several studies have identified that a difference of at least 3 dB is required to detect a 'just noticeable difference' in real world settings

Difficulty hearing in noise can be quantified by measuring a listener's signal-to-noise ratio (SNR) loss (10, 11). SNR loss is the increase in SNR (in dB) required by someone with a hearing loss to understand speech in noise, relative to the average SNR required for listeners with normal hearing (10). On average, people prefer a 10 dB SNR for listening, regardless of age or hearing status (12).

There are various tests which measure SNR loss: the Speech-In-Noise test (SIN) or Quick SIN are the most commonly used and cited in the literature (13, 14). The SNR loss score represents the SNR which a listener with hearing loss requires above the SNR which a normally hearing listener requires to achieve 50% correct sentence identification; this is called the SNR-50 (10, 11, 15, 16). Normally hearing people on average require **+2 dB SNR**, i.e. target talker 2 dB louder than background babble talkers, to correctly repeat 50% of the key words on the QuickSIN test (15, 16). As an example, a hearing-impaired person who requires the target speech to be 12 dB higher than the noise to achieve a 50% correct score would have a 10 dB SNR loss.

Some guidelines have been provided for interpreting performance on the QuickSIN test based on adjectives that describe the amount of SNR loss (17):

Normal 0-2dB SNR loss

Mild 3-6dB SNR Loss

Moderate 7-12dB SNR Loss

Severe >12dB SNR loss

These categories of SNR loss (normal, mild, etc.) and their associated recommendations are only suggestions. **There is no formally recognised scale of SNR loss categories or appropriate intervention** (17).

There are large individual differences among hearing-impaired listeners on measures of SNR loss. A general trend is that SNR loss increases with hearing loss, but the variance is quite large and can range from no loss (normal-hearing performance in noise) to greater than 20 dB of SNR loss (10).

Predicting a listener's SNR-50 from hearing thresholds can be difficult. In Figure 2, high variability among listeners with similar hearing thresholds can be seen (17). For example, people with an average hearing threshold (pure tone average of 500, 1000, and 2000 Hz) of 40 dB HL may only need a SNR of -3 dB to perceive 50% of speech, while others need +6 dB SNR. This range suggests that some people have greater or worse abilities to cope with competing noise, even with similar hearing threshold levels (18).

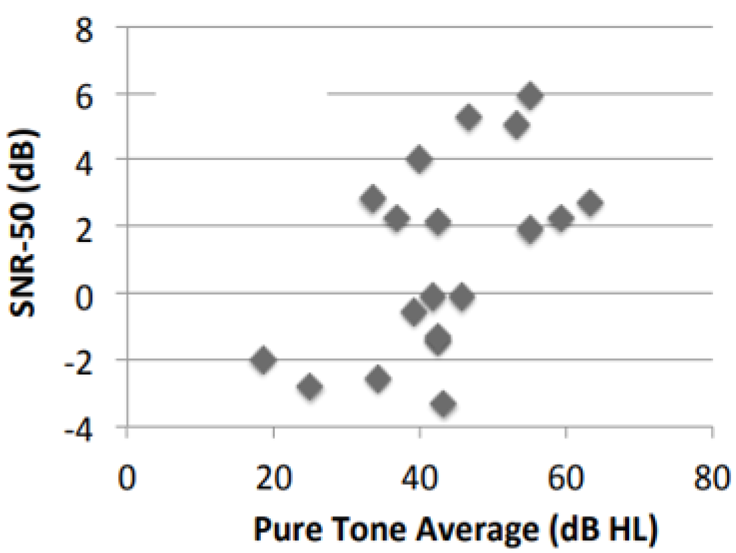

Figure 2. The relationship between pure tone average hearing thresholds and a listeners SNR-50. Predicting how a person performs in background noise can be difficult, due to the variability observed between people with the same pure tone average.

Several studies have supported the effect of aging on perceptual abilities. A comparison of these influences in older and younger people revealed that older people required a 3–4 dB higher SNR than younger people to have the same proper perception under similar noise conditions. It appears that age-related changes in auditory–cognitive system functions are responsible for the requirement of an enhanced SNR in the elderly (19-21).

There have been several studies which investigate SNR improvement through the use of hearing aids. Those that incorporate directionality can improve the SNR approximately 3 to 8.5 dB (22, 23), but this is dependent on factors such as the distance and spatial location of the noise in relation to the speech signal, the type and number of noise sources, and the amount of reverberation in the environment (24).

- Walden and colleagues (25) found that directional microphones in hearing aids are most effective when the signal of interest is in front of the listener, within 10 feet, and the background noise is spatially separated from the signal of interest location. These conditions limit directional benefit, but the provided improvement in SNR **can help those with SNR losses ranging from 4 to 8 dB** in many environments.
    - For those with greater SNR losses, a directional-microphone hearing aid can still provide the benefits of listening comfort and can help with understanding of speech in noise as long as contextual and speech cues are available (10). Listeners with SNR losses greater than 8 or 10 dB will need additional help to understand in noise, such as visual cues (10).
- A pilot study by Beck & Benite (26) showed that using different hearing aid parameters change the level of SNR improvement. For example, an average of 4 dB improvement was seen when noise reduction settings were not set to maximum. When testing using the maximum noise reduction an average of 6 dB SNR improvement was seen.

The ability to detect changes in SNR has been investigated in two separate studies.

- A report into what constitutes a meaningful or 'just-noticeable-difference' in SNR found that a 3 dB difference was required independent of hearing ability. **These results suggest that noise reduction technologies may need to achieve a benefit greater than 3 dB to be reliably discriminable** (24).
- A study of 16 hearing-aid wearers made paired comparisons between different SNRs, using values from 6 dB to þ6 dB in 2 dB steps. The results showed that subjects performed at

chance level with a 2-dB difference but achieved about 90% correct with a 4-dB difference and 100% for both a 6-dB and an 8-dB difference. The authors concluded that while **a 2-dB change in SNR could bring benefit, such benefit was unlikely to be noticed in a real-world setting** (27).

What constitutes a 'significant improvement' in speech discrimination score (%)? As the participant tries higher levels of hearing aids.

Summary

- There is no consensus in the literature as to what constitutes a 'significant improvement'
  - Most commonly a difference of 8% has been suggested (2% has been noted as not being clinically relevant) however it is highly likely that differences of 8% may occur by chance, especially if small word lists are used (50 or less).
  - Few papers compared different device types and used speech discrimination scores/word recognitions scores as an outcome measure. Findings suggest that:
    - Depending on the devices being compared, there was a wide range of improvements seen (ranging from 4.3% and 40%)
    - Homogenous devices rarely produce significant differences
    - Level of hearing loss and the type of noise delivered impacts improvements
- Peer reviewed literature from product manufactures comparing devices is sparse (publish product brochures and 'white papers') – product brochures always sell the benefits of top of the range products
- Studies tend to group patients together as "mild to moderate' hearing loss and participants with severe or proud loss are rarely included
- A 1 dB improvement in SNR is said to equate to a 10% improvement in word recognition score

Carhart (28) is often credited with recommending that the hearing aid corresponding to the highest speech discrimination score in noise should be chosen, but he also stated that in most cases patients will obtain excellent scores with each of several hearing aids. He suggested, however, that a **score difference of 8%** was sufficient to indicate selecting the hearing aid that yielded the superior score. Berger (29) also recommended that a speech discrimination score of 8% or less, obtained in quiet with commonly used word lists**, should not be considered significant**. In contrast, Walden, Holum-Hardegen (30) considered a difference of **approximately 6%** between aided discrimination scores be taken to represent a significant performance difference. However, these methods are only arbitrary and have not received experimental validation in terms of benefit or satisfaction (31).

A further consideration is the reliability of speech discrimination and word recognitions scores. The score of one of two hearing aids will exceed the other nearly 30% of the time purely by chance for scores in the 30-70% range, using 25 word lists (31). Even with 50 word lists, an 8% difference would occur by chance 21% of the time between equally performing hearing aids (31). In order to identify a difference between two conditions (ears, hearing aids, individuals) of 8%, and assuming an error rate of 5% and word recognition scores in the 20%-80% range, **approximately 200 test items must be presented in each of the two conditions** (8). More test items must be used if the 5% error rate is judged too high or if the clinician wants to identify true differences of less than 8%. Conversely, fewer items may be used if clinicians are willing to tolerate more errors and/or if they are willing to identify true differences that exceed 8%.

The traditional method of hearing aid selection developed by Carhart (28) evaluates patient performance with selected hearing aids in three ways.

1) Spondee words are used to measure the acoustic gain of the hearing aid
2) Phonetically balanced (PB) words are used to measure the patient's ability to understand aided speech at conversational loudness in an optimum (quiet) listening condition
3) Competing noise is added to the PB words in order to 'stress' the hearing aid.

The hearing aid that gives the best scores is then recommended. A common limitation of this approach is the inability to delineate differences among hearing aids due to only single words being used (32). Jerger and Hayes (32) proposed an alternative method of hearing aid evaluation using synthetic sentences and speech competition in varying degrees of difficulty. The method uses five potential test conditions from "very easy" to "very difficult" within "life like listening conditions" to enable greater capacity to determine differences in hearing aids. The authors presented six case studies (all with at least mild to moderate hearing loss) to illustrate their new testing method. In some conditions, improvement of 40% was seen between hearing aids.

Unfortunately, the authors **don't provide** a recommendations for what level of improvement would constitute a change in hearing aid technology/level. Instead, they suggest that improvements in the 'very easy' and 'easy' listening conditions are sufficient for recommending a hearing aid in those with more severe hearing impairments. In contrast, patients with minimal hearing loss might not be recommended a hearing aid unless improvements are seen in the difficult or very difficult listening conditions.

In a study by Beck (33), a sample of 25 participants with mild to moderate symmetric hearing loss underwent listening tasks in what is described as a “lab based, yet realistic, background noise situation”. Three hearing aids from different manufactures were compared. These included one with ‘directionality’, ‘narrow directionality’, and an ‘open sound navigator’ (Opticon). Speech babble and background noise were delivered at 75 dB sound pressure loudness (SPL). The German-language Oldenburg sentence test (OLSA) was delivered to each participant while wearing each of the hearing aids. The speech stimuli loudness varied to determine the 50% SRT using a standard adaptive protocol. Each participant was seated centrally while three talkers were located in front of, as well as ±60 degrees (left and right) of the listener. Target speech was randomly presented from one of the three talker locations. Listeners were free to turn their heads as desired. Results showed that for the central speaker, word recognition scores were 20% greater for narrow directionality and open sound navigator hearing aids compared to directionality alone. For the left and right speaker there were no word recognition score differences between the directionality and narrow directionality hearing aids, however, the open sound navigator hearing aid achieved 15% higher word recognition scores. Overall scores showed that WRS were 18% greater for open sound navigator compared to the directionality hearing aid and 11% greater than the narrow directionality hearing aid.

A study conducted by Walden, Holum-Hardegen (30) randomly assigned participants with high frequency sensorineural hearing impairments into one of two parallel experiments. Experiment 1 used three electro-acoustically similar instruments while Experiment 2 involved dissimilar ones. 100-item word lists were administered in the presence of multi-tasker speech babble. The primary speech signal was presented at 50 dB HL at a zero degree azimuth, and the competing babble was delivered at a 0 dB primary-to-secondary ratio from a loudspeaker located at 180 degrees. Average inter-aid differences for the aids that were electro-acoustically similar was 4.3% (SD ±4%). The average inter-aid difference between electro-acoustically dissimilar hearing aids was 14.2% (SD ±11.8%). This data suggests that when instruments are relatively homogenous, significant performance differences on hearing aid evaluation often will not occur. In contrast, when the hearing aids are very different electro-acoustically, significant inter-aid differences may occur frequently.

A study by Shanks, Wilson (34) compared three hearing aid circuits (peak clip, compression limiting and wide dynamic range compression. Participants were divided into <40 dB and >40 dB hearing loss. All three hearing aids circuits provided benefit over the unaided condition in both quiet and noise. The greatest benefit was measured for soft speech in the more severe hearing loss groups. Although small statistical advantages were found for the wide dynamic range compression for the word recognition test, the differences were **~2% and are not considered clinically relevant.**

Percentage word recognition improvement with increases in signal-to-noise ratio

It is generally accepted in the literature that for each decibel of SNR improvement (when presented in noise), there is an increase in word recognition ability of approximately 10% (33, 35). Similar to suggestions made by Jerger and Hayes (32), this improvement can vary due to patient characteristics and the type of noise presented. Figure 3 below shows a 'typical' performance-intensity (PI) function showing changes in word recognition score (%) as a function of SNR (dB). *The middle region is where the slope is the steepest with potentially the greatest word recognition score improvement for a given increase in SNR.* A 10% improvement can only be obtained when one is in the *middle* of the PI function, and depending on the nature of the noise and the speech stimulus used. It is true that, with single-syllable words when measured in the centre of the PI function, the slope is on the order of 10%/dB. But if improvements are measured in more adverse listening situations, the improvement may be negligible (35).

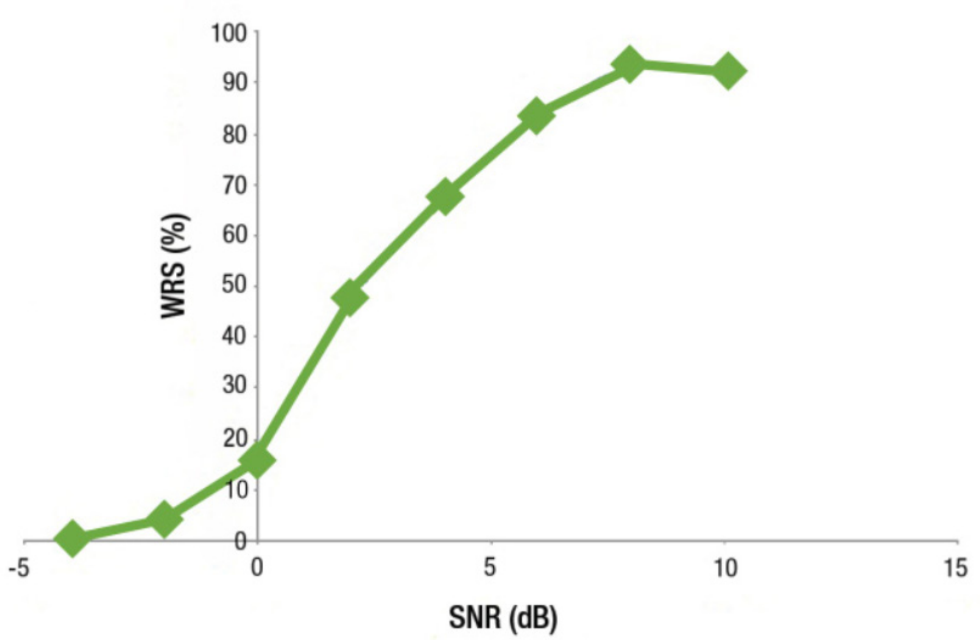

Figure 3. Typical performance-intensity (PI) function showing changes in word recognition score (%) as a function of SNR (dB).

Independent research on basic versus premium hearing aids

Practitioners do not have any scientifically grounded guidelines to help them determine when to recommend basic-feature technology and when to recommend premium features. Because independent research is lacking, practitioners rely mostly on unverified manufacturer claims about feature benefits when they decide which hearing aid(s) to recommend to patients (36).

A survey of hearing care professionals has shown that hearing aid technology levels are recommended based on their perception of the patient's activity level in life, the level of hearing aid usage for experienced users, their age, and their speech discrimination score (36). Surprisingly, the patient's lifestyle as perceived by the hearing care professional, followed by speech discrimination, were the strongest factors in explaining treatment recommendation (36). An active patient with poor speech discrimination had a 17% chance of being recommended the highest technology level hearing aid. For a very active patient with good speech discrimination, the probability increased to 68%. Discrepancies in hearing aid technology level recommendations are not justified by academic research or evidence of optimal patient outcome with a different hearing aid technology level (36).

Given the advanced capabilities, it might be presumed that premium-feature hearing aids would outperform basic feature hearing aids in terms of sound localization. However, there is **limited independent evidence** to support this notion, and what evidence there is tends to have been conducted in laboratory conditions with other features disabled. Therefore, it is of considerable interest and importance to compare localization outcomes with premium-feature hearing aids to those with basic-feature hearing aids when both types of models are used as they are in daily life, with all sound processing features simultaneously active (37, 38). In the long run, it is the performance in daily living in the circumstances of the particular listener that determines the usefulness of a hearing aid fitting. Only the subjective observations of the hearing-impaired listener can provide this type of outcome data. It is reasonable to assert that the patient’s perspective is the gold standard for determining whether one type of hearing aid is better than another for that patient in the particular circumstances of his/her world (37).

This lack of independent research which investigates whether more advanced technologies provide further improvement to outcomes in selected listening situations means that hearing aid practitioners often rely on manufacturer-produced data and marketing to make recommendations about the level of technology most appropriate for a given client (39). An example is the marketing material provided by Bernafon for the Zerena device (premium). This device was compared to the basic level hearing aid called the Juna using 30 participants with a pure tone weighted average of 45.6 dB. Results from the **unpublished/non-peer reviewed assessment** showed that compared to unaided results, there was an overall improvement of Speech Reception Threshold (SRT) of 3.3 dB ($p < 0.001$) for the Zerena device. The results also showed a significant difference between the Zerena and the Juna hearing aids (mean difference 1.4 dB, $p < 0.001$). Whilst this is a "statistically significant" difference, it has been proposed that **the just-noticeable difference of SNR measured in well-controlled listening conditions in the laboratory is 3 dB** indicating that this difference of 1.4 dB would not deliver a noticeable difference to a patient in the real world (24).

Table 6 below provides the outcomes (subjective and objective) of several independent studies investigating the differences between basic and premium levels hearing aids. The overall consensus is that;

- Laboratory data showed that, overall, the premium-feature hearing aids yielded more accurate localization, reduced listening effort and greater speech understanding than the basic-feature hearing aids
- Self-reports from everyday life and quality of life measures revealed no differences between basic and premium levels hearing aids
    - The vast majority of participants could not differentiate between basic and premium
- The benefit of premium features might not be large enough to be noticed in the real world

Table 6. Independent research comparing basic to premium level hearing aids

Author (year)	**Study aim/objective**	**Methods/participant characteristics/outcome measures**	**Outcome/summary**	**Quality of included evidence +/- conclusion** **(High/Medium/Low/Very Low)**
Basic Vs Premium hearing aid features				
Johnson et al. (2017) (38)	To explore the difference between premium-feature and basic-feature hearing aids in horizontal sound localisation in both laboratory and daily life environments.	**Single-blinded double crossover trial** 4 types of hearing aids (2x basic feature and 2x premium) from 2 manufacturers) 45 Older adults (mean age 70.3 years) with mild to moderate sensorineural hearing loss Each pair of hearing aids worn for 4 weeks and fitted used best practice guidelines Outcome measures Laboratory localisation test: conducted in a sound-treated room with a 360°, 24-loudspeaker array. Test stimuli were high frequency and low frequency filtered short sentences. Both tested in noise and quiet. Speech Spatial, Qualities of Hearing Scale Questionnaire (to test daily environments)	Laboratory data showed that unaided localization was not significantly different from aided localization when all hearing aids were combined. Questionnaire data showed that aided localization was significantly better than unaided localization in everyday situations. Self-reports from everyday life, the premium-feature and basic-feature hearing aids yielded essentially the same improved localization performance. Laboratory data showed that, overall, the premium-feature hearing aids yielded more accurate localization than the basic-feature hearing aids when high-frequency stimuli were used, and the listening environment was quiet. <u>Otherwise, the premium-feature and basic-feature hearing aids yielded essentially the same performance in other laboratory tests and in daily life.</u>	**MEDIUM** Premium-feature and basic-feature hearing aids yielded essentially equal performance in other laboratory conditions and in daily life In hearing aids research, laboratory findings do not always predict everyday performance. Audiologists and hearing aid users require not only laboratory evidence, but also daily life evidence, to make evidence-based decisions when choosing hearing aid technology levels.

Johnson et al. (2016) (39)	To explore differences in speech-understanding and listening-effort outcomes for older adults using premium-feature and basic-feature hearing aids in their daily lives	Same study design and population as above **Speech Understanding** American-dialect version of the Four Alternative Auditory Feature test. Tested conditions simulated everyday environments with soft, average, and loud noise. **Listening effort** Listening effort was measured alongside speech understanding. Participants indicated how effortful they found groups of speech understanding trials to be. 1-"No effort" to 7-"Extreme effort". **Questionnaires** 3 different questionnaires with subscales that assessed real-world speech understanding and/or listening effort: the Abbreviated Profile of Hearing Aid Benefit, the Speech, Spatial and Qualities of Hearing Scale (SSQ), and the Device-Oriented Subjective Outcome (DOSO) Scale **Participant Diaries** Participants received a blank diary in each of the 4 1-month trials. They used the diaries to describe in their own words one communication situation that went well, and one that went poorly, each day for five days at the end of the trial	**Speech Understanding** Unaided listening consistently produced poorer scores than each aided listening condition No contrasts exploring differences between premium-feature and basic-feature HAs were statistically significant. **Listening effort** Listening with HAs significantly reduced listening effort compared to listening without HAs for the soft and average listening environments, but not for the loud listening environment. Significantly less perceived effort when listening with the premium B HAs compared to the basic B HAs in the loud condition (effect size of d = .36 (p <0.001)). No other comparisons of premium and basic devices were statistically significant. **Questionnaires** There are no clear differences in reported speech-understanding benefit between the basic A and premium A HAs or the basic B and premium B HAs. Small difference in favour of the premium-feature devices for listening effort, however, analyses showed that these visual trends were not statistically significant. Participants' perceived aided speech-understanding benefit in their daily listening environments was not significantly affected on average by the HA technologies that they used	**MEDIUM** It is important to acknowledge that implementations of HA features are engineered differently for different manufacturers. The possibility exists that some features are superior for some brands. Payers should remain circumspect about device benefits without independent proof of real-world effectiveness. Although it is possible that individuals with different or more complicated hearing losses might obtain greater benefit from premium features, there is no existing evidence to suggest that this would be the case. Combined results of laboratory measures, self-report questionnaires, and participant diary information all point to a

			in this research, F (1.801, 79.245) = 0.132, p > 0.05. Participants' perceived listening-effort in their daily listening environments was not significantly affected by the HA technologies that they used for this research, F (2.056, 90.449) = 0.044, p > 0.05. **Participant diaries** No defined differences found between premium and basic hearing aids for performance in daily living.	conclusion that premium-feature and basic-feature HAs are capable of providing essentially equivalent improvements to speech understanding and listening effort in daily listening for this population.
Cox et al. (2016) (37)	To explore reported differences in hearing abilities for adults using premium- and basic-feature hearing aids in their daily lives	Same study design and population as above Three types of patient-point-of-view data were collected: • Changes in QoL related to hearing • Six-item questionnaire encompassing topics that are considered critical for satisfaction with amplification and often targeted in the engineering design of new premium features • In-depth qualitative interviews to further explore participants' personal experiences and preferences with the hearing aids.	**QoL** There was not a clear difference in the pattern of QoL changes reported across the four hearing aids. The QoL change responses were scored from −7 (A very great deal worse) to +7 (A very great deal better). The mean scores were 4.93 (brand A basic), 4.62 (brand B basic), 4.87 (brand A premium), and 4.56 (brand B premium). Not statistically significant differences between basic and premium HAs **Questionnaire** Planned contrasts exploring results for basic and premium devices for the two brands combined and for each brand separately failed to reveal any significant differences (speech clarity, noise bother, wearing HA, listening fatigue, sound comfort or localisation)	**MEDIUM** The outlay of substantially higher dollar amounts to purchase premium feature engineering technology typically would not have resulted in meaningful incremental gain in overall effectiveness relative to basic-feature technology.

			Preference data Preferences were equally divided between basic- and premium feature devices. Two participants could not differentiate between basic and premium. Mean scores generated by the overall goodness ratings for the four models on the visual analogue scale used in interview 4 were brand A basic = 75.7, brand B basic = 74.4, brand A premium = 72.6, brand B premium = 74.4. There were no significant differences among these means.	
Wu et al. (2019) (40)	To investigate the laboratory efficacy and real-world effectiveness of advanced directional microphones (DM) and digital noise reduction (NR) algorithms (i.e., premium DM/NR features) relative to basic-level DM/NR features of contemporary hearing aids (HAs). The study also examined the effect of premium HAs relative to basic HAs and the effect of DM/NR features relative to no features.	**Single-blinded crossover trial** Population: Fifty-four older adults with mild-to-moderate hearing loss Two HA models 1) basic-level device (basic HA) 2) advanced-level device (premium HA) Features of the basic HAs were adaptive DMs and gain-reduction NR with fewer channels. In contrast, the features of the premium HAs included adaptive DMs and gain-reduction NR with more channels, bilateral beam formers, speech-seeking DMs, pinna-simulation directivity, reverberation reduction, impulse NR, wind NR, and spatial NR. 4 trial conditions consisted of	Laboratory data generally supported the use of premium HA features (DM & NR) for speech understanding and localisation performance. Premium HA were supported for speech understanding. For listening effort and sound quality the results were similar across features and premium Vs basic. Small effect sizes for all listening conditions for Premium V Basic (< 0.26) Retrospective and in-situ self-reports showed there was no strong evidence to support the benefit of premium DM/NR features and premium HAs over basic DM/NR features and basic HAs, respectively. Although statistically significant in the laboratory, the benefit of premium features might not be large enough to be noticed in the real world.	**MEDIUM** Concerns around generalizability, including disabled HA volume controls (which could overestimate the effect of features) and minimal participant training on features Although both premium and basic DM/NR technologies have the potential to improve HA outcomes, older adults with mild-to-moderate hearing loss are unlikely to perceive the additional benefits provided by the

		• Factorial combinations of HA model (premium versus basic) • DM/NR feature status (on versus off) In each condition, participants wore bilateral HAs for 5 weeks. Laboratory outcomes; • Speech understanding (Hearing in Noise Test) • Listening effort • Sound quality • Localization Retrospective self-reports for HA satisfaction • Abbreviated Profile of Hearing Aid Benefit • Speech, Spatial, and Qualities (SSQ) Hearing Scale • Satisfaction With Amplification in Daily Life (SADL) • In-situ self-reports (i.e., self-reports completed in the real world in real time).	Because most differences in HINT scores across the four HA conditions were smaller than 3 dB (3 dB is deemed just noticeable), participants might not notice the difference in the real world and therefore did not report it in retrospective and in-situ self-reports.	premium DM/NR features in their daily lives.

Hearing impairment and dementia

The Lancet commission on dementia prevention, intervention and care life-course identified 12 modifiable risk factors for dementia. These include (41):

1) Less education
2) Hypertension
3) Hearing impairment
4) Smoking, obesity
5) Depression
6) Physical inactivity
7) Diabetes
8) Infrequent social contact
9) Excessive alcohol consumption
10) Head injury
11) Air pollution

Modification of these 12 risk factors might prevent or delay up to 40% of dementias (41).

Hearing loss has the highest population attributable fraction for dementia. A meta-analysis by the Lancet commission found that those with normal baseline cognition and hearing loss present at a threshold of 25 dB had a relative risk of 1.9 for dementia (in populations followed up over 9–17 years). A subsequent meta-analysis using the same three prospective studies measuring hearing using audiometry at baseline, found an increased risk of dementia (OR 1·3, 95% CI 1·0–1·6) per 10 dB of worsening of hearing loss (42).

A 25-year prospective study of 3777 people aged 65 years or older found increased dementia incidence in those with self-reported hearing problems except in those using hearing aids (43). Similarly, a cross–sectional study found hearing loss was only associated with worse cognition in those not using hearing aids (44). A US nationally representative survey of 2040 people older than 50 years, tested every two years for 18 years, found immediate and delayed recall deteriorated less after initiation of hearing aid use, adjusting for other risk factors (45). Hearing aid use was the largest factor protecting from decline (regression coefficient β for higher episodic memory 1·53; $p < 0.001$) adjusting for protective and harmful factors. The long follow-up times in these prospective studies suggest hearing aid use is protective, rather than the possibility that those developing dementia are less likely to use hearing aids. Hearing loss might result in cognitive decline through reduced cognitive stimulation (41).

No evidence could be located which assessed whether the prescription of basic versus premium hearing aids has an impact on the development or progression of dementia. As of 2020, whether hearing aid use can delay the onset of cognitive decline is unknown (46).

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Research – Sign language as a communication option for non-hearing impaired children and adults

Brief	Two briefs for this request exist. 1) Relates to the efficacy of teaching sign language to non-verbal or minimally verbal children 2) Relates to the delivery of sign language to hearing impaired adults rather than other conventional options (hearing aids etc.) Please refer to the request for further detail.
Date	03/03/2021
Requester(s)	Jean [redacted] - Senior Technical Advisor (TAB) Judith [redacted] Senior Technical Advisor (TAB)
Researcher	Jane [redacted] (Research Team Leader - TAB)
Cleared	

Please note:

The research and literature reviews collated by our TAB Research Team are not to be shared external to the Branch. These are for internal TAB use only and are intended to assist our advisors with their reasonable and necessary decision-making.

Delegates have access to a wide variety of comprehensive guidance material. If Delegates require further information on access or planning matters they are to call the TAPS line for advice.

The Research Team are unable to ensure that the information listed below provides an accurate & up-to-date snapshot of these matters.

1 Contents

2 Summary

1) There is no peer reviewed evidence that shows that sign language (Auslan, American Sign Language, British Sign Language etc.) is an effective communication system for nonverbal on minimally verbally children with an autism diagnosis (literature tends to focus on autism rather than intellectual disability)
    a. Literature shows that some children with autism (usually higher functioning with good motor coordination) are able to pick up various manual signs and use them to communicate. Although the term 'sign language' is used in these studies, it is more commonly Signed Exact English or a type of Key Word Sign being taught. Children are generally taught a small subset of signs (normally those that are iconic) and are not learning pure forms of sign language such as Auslan.
    b. Literature investigating aided and unaided AAC devices for children with autism show that aided devices such as speech generating devices are more commonly preferred and are learnt more quickly (refer to Table 1 for more in-depth results).
    c. Due to the cognitive and motor demands, as well nonverbal communications skills (eye contact, gestures, facial expression) required to master sign language it is not an appropriate form of communication for non-hearing impaired children with autism.
    d. Manual signs should be used as part of a 'total communication' approach which included aided AAC interventions so they can communication with a range of individuals

2) There is no peer reviewed evidence that investigates the efficacy or advantages of delivering sign language over other rehabilitations options (hearing aids, remote microphones etc.) for those with acquired hearing loss/progressive hearing loss
    a. Literature suggests there is a critical period when it comes to learning a second language as an adult. Although there is no consensus, the cut off is somewhere around the age of 17 to 18.
    b. Learning sign language is difficult and requires extensive practice/input (approx. 1000 hours). There are few opportunities for new signers to immerse themselves in the language due to small number of native Auslan speakers
    c. Deaf culture can make it difficult for new signers to be accepted into the community

3 Australian Sign Language (AUSLAN)

Sign language refers to the use of manually produced signs to convey information or ideas. It is the method of communication used by most moderately or profoundly deaf persons. Sign language is not just a manual representation of oral language; rather, it is an independent language [1]. When combined with facial expression and gestures, it conveys rich meaning, humour, anguish, and many subtleties of communication [1].

Descriptive research and publications have established sign languages as syntactically complex languages with distinctive morphological, phonological and sociolinguistic features [2].
At present, there are sixty-two handshapes listed in the Signs of Australia dictionary of Auslan [3]. Of these sixty-two handshapes, thirty-seven are the core handshapes used and the other twenty-five are seen as non-significant variations of these (the exception to this is with productive signing where small differences can represent a different and precise meaning) [3].

Fingerspelling is generally mixed in with signing and is especially used for spelling nouns (place names, people's names, objects' names) or for spelling words that don't have a sign. Fingerspelling is using your hands to represent the letters of a writing system. In English, this means using 26 different hand configurations to represent the 26 letters of the English alphabet. As such, fingerspelling is not a signed language in and of itself, rather it is a manual code for representing the letters of the English alphabet [3].

It is now increasingly recognised that signing deaf people constitute a group like any other non-English-speaking language group in Australia, with a distinct sub-culture recognised by shared history, social life and sense of identity, united and symbolised by fluency in Auslan.

4 What is Key Word Sign?

Key Word Sign (KWS) is a type of augmentative and alternative communication (AAC). It is a way of communicating that uses hand signs to represent the main or key words in a sentence at the same time as the words are spoken [4]. Key Word Sign was formerly known as Makaton in Australia and is also known as manual signing [4].

There is very little research on KWS as an intervention for children with autism exists [5, 6]. There are some studies with positive outcomes that investigate educator's perception, experience and ability to learn KWS [7, 8] as well as in the intellectual disability population [9].

5 Signed Exact English

Signing Exact English (SEE) is a sign system aimed at representing English vocabulary and syntax as literally as possible by providing visual access to English morphology [10]. It uses Sign Language signs

(American, British, Australian etc.), as well as invented signs, in combination with signed representations of English affixes; the invented signs are necessary for (a) representing English grammatical words that do not exist in ASL (e.g., "the") and (b) differentiating English synonyms that correspond to the same ASL sign [10]. Signs are produced sequentially, in English word order, in conjunction with the mouth movements of English, with the goal of establishing a one-to-one mapping between signs and English words [10].

Signed English was developed by teachers of the deaf and other professionals to assist in the English literacy development of deaf (sign language using) children [11].

6 Diagnosis of Autism – non-verbal deficits

Professionals diagnose autism spectrum disorder on the basis of difficulties in two areas – 'social-communication', and 'restricted, repetitive and/or sensory behaviours or interests'.

The DSM-5 criteria lists the below criteria in the 'social communication' domain [12].

Deficits in nonverbal communicative behaviours used for social interaction, ranging, for example, from poorly integrated verbal and nonverbal communication; to abnormalities in eye contact and body language or deficits in understanding and use of gestures; to a total lack of facial expressions and nonverbal communication.

Eye contact, gestures and facial expressions are key components in sign language. Facial and head movements are used in sign languages at all levels of linguistic structure. At the phonological level some signs have an obligatory facial component in their citation form [13].

Because of the nonverbal deficits associated with autism it is highly unlikely that proficiency in sign language will ever be achieved, therefore, it isn't inappropriate as a communication technique.

7 Literature investigating the use of signs for non-verbal individuals with autism

The literature search **did not** identify any peer reviewed research that investigated the delivery or efficacy of sign language training to individuals diagnosed with ASD.

In the literature, the terms sign language, manual signs and finger spelling are often used interchangeably. In reality, one of two systems are being used and consist of 1) taking various signs from the language of the deaf community (Auslan, American Sign Language or British Sign Language) and putting the signs in English order or 2) using SEE signs, which is a system that attempts to duplicate English syntax and morphology in the manual mode. The sign language input in most cases has been augmented by the teacher or therapist's simultaneous use of spoken English and is not the same sign language that is utilised by the deaf community [14].

For many years, AAC interventions for individuals with ASD focused primarily on the use of unaided communication strategies, and sign language in particular [15]. The literature review (see Table 1 for full review) revealed that studies investigating the effectiveness of manual sign-based interventions are generally;

1) Case series designs with no control/comparison group
2) Low in quality
    a. provide no measure of reliability, few are generalizable to the greater ASD community, and many fail to disclose sufficient detail for either clinical application or experimental replication

Results show a wide range in individual outcomes;

1) Some participants appears to readily learn signs and others are unable to attain even the most basic signing skills
    a. Very low-functioning autistic children do not appear to make as rapid progress
2) **Studies mostly taught a small number of basic signs and productive combinations were less frequently observed**
3) No evidence to suggest that signing leads to a meaningful increase in speech production
    a. signs alone or in conjunction with speech training is not harmful or in any way contraindicated (early theories were that teaching sign language would be harmful to speech production)

Proponents of sign language training have reported several advantages over the delivery of speech training for children with ASD:

1) Many individuals with ASD or other developmental disorders cannot echo sounds, but they can imitate at least a few gross motor movements presented by communication partners.
    a. the facilitator can make use of physical prompting and fading procedures
2) Some signs resemble the object or action it represents which may help people with ASD to learn rapidly. Oral speech, on the other hand, is not iconic.
    a. *Example*: the sign for drink is produced by moving a hand close to the mouth and turning it slightly back and forth as if holding a cup and drinking from it.
3) Manual signs are unaided and free from access to external supports, are highly portable and cannot be left behind [15]

One proposed explanation for the failure of sign language training in many individuals with ASD is that the successful acquisition and use of sign language as a communicative tool is dependent on the ability to form a variety of manual motor signs, and there are many individuals with ASD who do not possess the fine motor skills required [16, 17]. Mirenda and Erickson [18] outline “the three I’s” that contribute to successful sign language acquisition:

1. *Imitation*
2. *Iconicity*, and
3. *Intelligibility*

They maintain that children with ASD demonstrate a lack of imitation, symbolic representation, and motor coordination/planning skills, while the successful acquisition and use of sign language relies largely on the possession of these abilities. In each of these proposed explanations, deficits and delays in motor and motor-related skills are key to explaining why children with ASD generally fail to develop both sign language-based communication and speech and language skills [16].

Following the discovery of visual processing strengths that many children with ASD demonstrate, greater attention was paid to the application of aided strategies such as pictographic symbol sets and other graphic sets/systems to enhance communication. From a practical perspective, graphic symbols (especially when highly iconic) seem to present several potential advantages over manual signs or abstract symbols [15]:

1) Demands on memory and cognitive skill may be lower
    a. Picture-based systems are concrete, remain present to refer back to (unlike manual signs, which are transient), and many resemble their referents [19, 20]
2) Motor ability requirements are lower
    a. Fine motor difficulties are common in individuals with ASD, thus causing difficulty in learning manual signs [19]
3) Graphic symbols are more easily understood by unfamiliar communication partners and are easier to prompt
    a. A study by Rotholz, Berkowitz [21] highlights this point: Adolescents with ASD were taught to use both manual signs and PECS to order food in a restaurant. None of the students' manual signs were understood, relative to successful request rates of between 80% and 100% when PECS were used. Thus, the intelligibility of an AAC approach is an important consideration when deciding upon which strategy to teach [22]
4) Lower training demands placed on communication partners compared to when learning manual signs
    a. High teaching costs associated with manual signing and the need to establish prerequisite skills such as eye contact and imitation [22].

In more recent years, low and high technology aided ACC technologies have been used successfully with individuals with ASD and appear to be more promising communication strategies [20, 23, 24]. A systematic review by Gevarter, O'Reilly [24] compared aided and unaided communication options across 10 studies (n = 33).

- Seven of the studies comparing mand acquisition of sign to picture exchange (PE) systems and/or speech generating devices (SGDs) found that aided systems were more effective than sign for 14 participants, aided and unaided systems were equally effective for 12, and data were inconclusive for 1 participant.
- Three studies attempted to account for differential outcomes among learners provided support for the fact that PE systems were more effective than sign when participants had low motor imitation abilities.
- Four studies assessed preference, and found that aided systems were preferred by 10 participants (3 PE or picture card and 7 SGD) and sign was preferred by one.

Overall, this review suggests that *aided systems are acquired quicker and generally preferred by users over manual signing.* This finding was also supported by Couper, van der Meer [23] who suggested that for some children, acquisition may be quicker when learning a preferred option.

Manual signs are still a useful means of communication, however, might best be included as one component of a multimodal communication system that also includes graphic symbols, SGDs, and an individual's extant communication modalities (i.e. gestures, vocalisations and facial expressions) [15].

8 Cost effectiveness

No health economic analysis or cost effectiveness studies have been conducted that compare sign language (Auslan) to other AAC devices. However, sign language training is considered to be high cost due to the time consuming training compared to low tech AAC such as picture exchange [25].

Author	Aim/Objective	Methods	Results	Level & Quality of evidence
Studies investigating Sign Language/Manual Signs/Key Word Sign				
Bonvillian, Nelson [14]	To review the findings of studies of sign language acquisition in autistic children	**Commentary/Literature Review** No info on search strategy or inclusion criteria All findings presented narratively	20 studies including 100 participants. Average age 8 years (range 3-23 years). Wide range in individual outcomes, however, almost every participant acquired the ability to comprehend trained signs. • Large majority mastered production of 5 or more signs, and maximum learning exceeded 350 signs • Productive combinations were less frequently observed • 20% produced spontaneous combinations at least occasionally, and in many cases the children moved to daily production of many complex sign utterances <u>Very low-functioning autistic children do not appear to make as rapid progress. The child's ability to imitate speech also has been positively associated with eventual levels of language mastery, in both sign and speech.</u>	**Very Low** No methods No information provided about reviewed studies
Wendt [15]	To provide a summary of appraised research evidence related to the use of manual signs and	**Systematic review** (chapter in an edited book, not peer reviewed)	21 experimental studies included (18 single subject designs and 3 group designs)	**Low** Included in book chapter and not peer reviewed.

	graphic symbols for individuals with ASD.	Search strategy used a combination of electronic and hand searches for articles between 1976 and 2006. <u>Inclusion</u> Studies that focused on manuals signs, gestures and selection based graphic symbol sets/systems	4 studies had inconclusive results. The remaining were conclusive or preponderant/suggestive. The majority of studies documented successful acquisition of manual signs, however, PECS often achieved better outcomes.	Mostly single subject designs.
Tan, Trembath [5]	The aim of this study was to examine the effect of Key Word Sign (KWS) intervention on the acquisition and generalization of manual signing among three children with ASD, and to measure any changes in their production of spoken words and gestures following intervention.	**Multiple baseline single-case design** Independent variable was the KWS intervention, dependent variable the children's production of core signs and fringe signs. Inclusion criteria • Speak English • Demonstration of intentional communication based on parent report and observation during intake assessment • Assessed as having moderate–severe expressive language delay using the Mullen Scales of Early Learning • Demonstrated adequate upper extremity gross motor skills and indications of potential to produce motor movements • No reported hearing or vision impairments. Intervention treatment delivered by a speech pathologist	3 male participants, aged 3-4 years with a clinical diagnosis of ASD. All three children began using signs following the introduction of the KWS intervention, and generalized their use of some signs across activities. The introduction of the intervention was associated with either neutral, or statistically significantly positive (p 0.002 to 0.036 across participants), changes in the children's production of spoken words and natural gestures.	**Very Low** Unable to generalise to the ASD population due to small sample size Results should be viewed as offering preliminary evidence, due to the modest and varied outcomes Further research is needed to identify for whom KWS is most likely to be beneficial

		• signing using appropriate signs and natural gestures with corresponding spoken words • Incorporating signs in natural interactions • Providing opportunities for the child to communicate • Responding to the child's communicative behaviours Baseline, 3 phases of teaching and follow up for data collection over 12 weeks.		
Mccleery, Elliott [16]	Review and examine the current language and communication-based intervention research that is relevant to motor and motor resonance deficits in children with autism.	**Commentary/Literature Review** No info on search strategy or inclusion criteria *interventions are for non-verbal and minimally verbal children	Sign Language Training (SLT) described as teaching a child to use hand, arm, facial, and other actions to create symbolic communications. <u>Summary</u> • Extensive research base • Weak but mixed evidence for learning of sign language • Weak evidence for learning of speech Weak evidence for learning of speech via sign plus speech training.	**Very Low** No methods Only low level quality studies included (mainly case reports/single subject designs)
Schwartz and Nye [26]	To summarize and synthesize existing research examining the efficacy of sign language intervention (sign alone or total communication) to improve the sign or oral communication skills of children with autism.	**Systematic review and meta-analysis** <u>Design criteria</u> Experimental or quasi-experimental group design, or experimental single subject design <u>Statistical criteria</u>	8 included studies (1 experimental group design, 7 single subject design). Data from the experimental study offers little quantitative support for the use of sign alone or in conjunction with spoken language (total communication) to improve the spontaneous sign or oral communication of children with autism. The effect size analysis (0.73) showed	**Low** Robust systematic review/meta-analysis methods, however, included studies are of poor quality. Evidence on the use of sign language provides

		-All study data had to be presented in a quantifiable form <u>Participant criteria</u> Children with autism between 4 and 18 years <u>Outcome criteria</u> Sign or oral communication measured	that none of the outcomes observed were statistically significant. Data from single subject designs demonstrated a moderate degree of communication improvement, however, treatment fidelity not reported and therefore generalisability is not possible. Lack of information on follow up and size/sign structure. <u>Types of interventions</u> • American Sign Language (*n*= 2) • Signed English (*n*=1) • Not Reported (*n*=4) <u>Number and Length of Treatment Sessions</u> Length of treatment program reported in only two of the studies, at four weeks and seven weeks, respectively. The number of treatment sessions ranged from 3 to 10 sessions per week with the number of minutes per session ranging from 5 to 60 minutes. The number of overall treatment sessions per individual was highly variable, ranging from 3 to 72 sessions. No evidence from the studies included in the meta-analysis suggested that using signs alone or in conjunction with speech was harmful or in any way contraindicated.	limited support for its concentrated application for children with autism, as there is little compelling evidence that sign language provides substantial improvements in either oral or sign language communication.
Goldstein [27]	To review peer-reviewed research articles published in the	**Commentary/Literature Review** Findings presented narratively	Only findings relating to communication interventions incorporating sign language will be presented.	**Very Low**

	past 20 years that evaluated communication treatments with children with autism	The following minimal selection criteria were used to justify reviewing an article: 1. Program descriptions or case studies with no experimental design were excluded. 2. Only empirical studies that reported results with measures of some aspect of language form, content, or use in individuals with autism were included. 3. Only studies reporting reliability estimates for the dependent variables under investigation or studies using standardized instruments were included.	9 experiments including 146 participants No studies implemented sign language alone Most of the studies employed single-subject experimental designs with 1 to 10 participants. Two studies enrolled 60 participants each and randomly assigned participants to four treatment conditions Total communication appears to be a viable treatment strategy for teaching receptive and expressive vocabulary to individuals with autism. The presentation of speech alone is less effective for individuals who have poor verbal imitation skills in particular.	Poor approach to methods, included studies of low quality
Studies comparing aided and/or unaided AAC				
Couper, van der Meer [23]	To compare how quickly children with ASD acquired manual signs, picture exchange, and an iPad/iPod based SGD and to compare if children showed a preference for one of these options.	**Case Series – Multiple baseline** 9 children with ASD <u>Inclusion criteria</u> • Diagnosis of ASD • Aged 13 years or under • Age equivalent performance of two years six months of age or less on the communication domain of the Vineland Adaptive Behaviour Scales	Five children learned all three systems to criterion. Four children required fewer sessions to learn the SGD compared to manual signs and picture exchange. Eight children demonstrated a preference for the SGD. For some children, acquisition may be quicker when learning a preferred option.	**Very low** Small number of participants. Diverse group in terms of ages and prior experiences with AAC. Number of procedural modifications and oversights

		• No observed physical or sensory impairments that would prevent the use of the three AAC systems Each participant was taught to request access to a box of toys or a preferred toy item using the SGD, MS, and PE systems. *Manual sign* Children were taught to request access to preferred toys using the New Zealand Sign Language sign for ''more'' Each session consisted of five opportunities to request access to the toys, for each device. The presence or absence of a correct request was recorded by the instructor on a trial-by-trial basis. The percentage of correct requests was calculated for each session.		were made during the study that may have compromised the integrity of the experimental design for some children
Gevarter, O'Reilly [24]	To synthesize comparisons between multiple communication modalities and outcomes to provide an array of clinical recommendations and future research directions.	**Systematic Review** Database searches and hand searches completed Inclusion/exclusion criteria • At least one participant with developmental disability • used a **single subject design** to compare at least two different communication systems with at least one being an AAC system • the study evaluated outcomes related to communication and/or collateral effects of communication	28 studies including 77 participants, aged 2-52 years. Studies compared non-electronic picture systems to SGDs (n = 10), aided AAC to unaided AAC (n = 10), and AAC versus vocal speech interventions (n = 10). Studies supported a greater likelihood for advantages of aided systems over sign for acquiring mands. Across the seven studies comparing mand acquisition of sign to PE and/or SGD systems, aided systems were more effective than sign for 14 participants,	**Low** Methodologically strong review, however, only single case studies included. Authors state that findings for some outcomes within studies were rated as suggestive or inconclusive due to limitations or inconsistent patterns specific to that outcome

		the study had to have been an English-language dissertation or peer-reviewed journal article from the years 2004 to 2012, inclusive	aided and unaided systems were equally effective for 12, and data were inconclusive for 1 participant. Aided systems were preferred over unaided. Overall, results suggest that clear and consistent differences between communication systems are rare, precluding definitive statements regarding a universal best approach for all people with developmental disabilities.	
Ganz, Earles-Vollrath [20]	To investigate the effectiveness of various AAC systems and procedures that are currently implemented with individuals with ASD	**Systematic review and meta-analysis** Database searches and hand searches completed Inclusion criteria (a) participants were diagnosed with an ASD (b) outcome measures included one or more of these: social skills, adaptive behaviour, challenging behaviour, communication, and academic skills (c) interventions included **aided AAC system** (e.g., PECS, SGDs, voice output communication aids, picture-point systems) (d) single case research design demonstrating experimental control (i.e., reversal, multiple-baseline, alternating treatment); (e) no dichotomous dependent variables (e.g., yes/no, 0/1)	24 studies including 58 individual participants. 27 (47%) aged up to age 5 years), 18 (31%) aged 6–10 years, 7 (12%) were aged 11–15, and 6 (10%) were categorized as young adults or adults Meta-analysis indicates strong effects for aided AAC on targeted behavioural outcomes in individuals with ASD. Targeted behavioural outcomes Communication 0.99 (84% CI 0.99-0.99) Social skills 0.90 (84% CI 0.84.0.95) Academic (spelling) 0.79 (84% CI 0.76-0.82)	**Low** Limited to single case studies; therefore, by excluding group studies it does not summarize all available evidence on the effects of AAC interventions. An 84% CI was used when calculating IRD. This is considered a conservative approach. Therefore, caution must be taken when interpreting results.

		Used (f) data were displayed as line graphs; (g) articles were published in peer-reviewed journals (h) articles were in English Improvement rate difference (IRD) used to determine effect size. IRD is the difference or change in percent of high scores from baseline to intervention phase Interpretation 0.50 or lower = small or questionable effects .50 and .70 = moderate effects .70 Or .75 or higher = large or very large effects.	Challenging behaviours 0.80 (84% CI 0.76-0.84) Intervention types Picture exchange communication system 0.99 (84% CI 0.98–0.99) Other picture-based AAC systems 0.61 (84% CI 0.57–0.64) Speech-generating devices 0.99 (84% CI 0.99–1.00)	
Goldstein [27]	To review peer-reviewed research articles published in the past 20 years that evaluated communication treatments with children with autism	**Commentary/Literature Review** Findings presented narratively The following minimal selection criteria were used to justify reviewing an article: 1. Program descriptions or case studies with no experimental design were excluded. 2. Only empirical studies that reported results with measures of some aspect of language form, content, or use in individuals with autism were included. 3. Only studies reporting reliability estimates for the dependent variables under investigation or studies using standardized instruments were included.	Only findings relating to communication interventions incorporating sign language will be presented. 9 experiments including 146 participants No studies implemented sign language alone Most of the studies employed single-subject experimental designs with 1 to 10 participants. Two studies enrolled 60 participants each and randomly assigned participants to four treatment conditions Total communication appears to be a viable treatment strategy for teaching	**Very Low** Poor approach to methods, included studies of low quality

			receptive and expressive vocabulary to individuals with autism. The presentation of speech alone is less effective for individuals who have poor verbal imitation skills in particular.	
Millar Diane, Light Janice [28]	To determine the relationship between AAC intervention and speech development in individuals with developmental disabilities	**Systematic Review & Meta-Analysis** Database searches and hand searches completed Inclusion criteria a) Studies published between 1975 and 2003 b) Involved individuals with developmental disabilities who had significant speech impairments c) Included implementation of AAC (aided or unaided) d) Included data on speech production before, during and after AAC intervention Methodological rigour of each included study was evaluated on the basis of the level of experimental control, reliability of the dependent variable and the treatment integrity.	23 studies met inclusion criteria with 67 participants descriptive case studies, 6 single participant, alternating treatment designs, 6 single participant, multiple baseline designs, 1 single participant, withdrawal design, 1 single participant alternating treatment design, 1 group pre-test-post-test design 61% investigated unaided AAC (manual signs) and 31% non-electronic aided AAC, 4% combined aided AAC with and without speech output, 4% multimodal aided and unaided AAC Increase in speech production was observed in 89% of cases. The mean gain was an increase of 13 words (range 1-52) and an increase of 6 spoken 2-word phrases (range 4-7)	**Low** Many studies didn't establish experimental control Studies provided limited data on participants speech repertoires pre-intervention so unclear whether increases are significant Few of the included studies were of sufficient methodological quality No separation of findings between aided and unaided studies so can't comment of efficacy of manual signs alone

9 Learning a second language as an adult

The role that age plays in second language learning /acquisition (SLA) has been the central topic of many studies in SLA over various decades. Biological, social, and psychological maturation phenomena are factors which have been hypothesised as reasons why adults find it more difficult to learn a second language [29].

The concept of a critical age for learning was first suggested in 1959 when the age of 9 was claimed as the limit in terms of successful language learning because of physiological constraints such as progressive loss of brain plasticity (this age is also considered the cut off for visual development) [30]. The critical period has been researched extensively with no agreement on what the upper age limit is [29, 30]. Inconsistencies have been found across various studies relating to the impact that age has on learning different language domains [29, 30]:

1) *Onset and offset* – no consensus reached, although newer research has suggested the offset is somewhere between 17 and 18 years of age [31].
2) *Language domains* – most researchers agree that pronunciation/phonology is more affected by age than other language domains.
3) *Existence of a critical period* – no consensus has been reached so far, but age is believed to be an important factor in SLA.

Neuroplasticity begins to decrease after adolescence, making it practically impossible or very difficult for adult students to reach a native language level, especially when "input" levels are small [32]. A combination of individual and contextual factors determines the learning journey and affects the time each individual needs to make progress [33]. Although there is no unanimous agreement as to how many hours are needed to gain increasing language proficiency, attempts have been made to produce learning time estimates [33]. The table below provides estimates for fast and slow learners using the Common European Framework for Reference of Languages (CEFR) [33]. For example, it would take 4491 hours for a slow learner to go from a basic user (A1) to a proficient user (C1).

Basic user = A1 & A2
Independent user = B1 & B2
Proficient user = C1 & C2

CEF		CSE		Hours per level		Total cumulative		Hours required 3 pt GSE-gain	
Start	Finish	Start	Finish	Fast	Slow	Fast	Slow	Fast	Slow
<A1	A1	10	22	95	480	95	480	24	120
A1	A2	22	30	95	290	190	770	36	109
A2	B1	30	43	190	616	380	1386	44	142
B1	B2	43	59	380	1109	760	2495	71	208
B2	C1	59	76	760	1996	1520	4491	134	352

*Actual hours will depend on individual factors such as L1, motivation, intensity of study, etc.

Adult learners often lack the level of linguistic knowledge that their younger peers possess because of factors that stem from cognitive and affective limitations. These limitations have been described by Bernal Castañeda [32].

Cognitive limitations

- *A decrease in memory levels:* Adult students generally present a reduced ability to memorize, which limits learning when acquiring the second language lexicon and grammar. This leads to the belief that translation is an indispensable tool for learning the language and the need to search for equivalences in their native language [34, 35].
- *Loss of sensory acuity:* older students lose their ability to imitate sounds and to memorize, consequently they are forced to start a production process based on trial/error and the oral response is decidedly slower [34]. Thus, in addition to the cognitive factors associated with late language acquisition, adult students must also face progressive losses in sensory acuity that have accumulated since their adolescence.
- *Tendency to fossilization:* Adult students tend to fossilize their knowledge of the target language. They generally tend to systematize errors, and their lack of correction or habit can lead to the repetition of such errors and, consequently, the lack of acquisition. The most commonly investigated areas in the field of fossilization are grammar and pronunciation [30, 34].
- *Language 1 Transfer:* Adult learners generally feel a more constant need to transfer the knowledge they possess in their L1 to learning a second language. Such transfer can result in a positive outcome when the common characteristics of certain languages encourage learning through equivalences and comparisons. However, there is a thin line between facilitation of an L2 through transference and the constant and negative interference of L1 in all L2 skills [35, 36]. This has also been termed 'tyranny of the mother tongue' where the native language comes to dominate the linguistic map space and the second language finds it hard to compete [37].

Affective limitations

- *Language anxiety:* Anxiety is an important variable in adult L2 learning because students face an elevated pressure to acquire a second language at the same pace or rhythm as their younger peers. Frequently the outcome is not as positive as adults would expect, which leads to stress and a very high pressure in class. Recent studies argue that language anxiety is a complex and dynamic construct and that it is linked to psychological variables such as self and personality [38].
- *Self-concept:* Adult students' self-concept is also crucial and directly affects motivation in L2 class [39]. Adult students usually present a distorted self-concept or image due to a lack of confidence in themselves and insecurities towards L2 learning and new methodologies [39].
- *L2 enjoyment:* Interest and enjoyment towards learning a foreign language are the key points of success in linguistic education. When teaching a second language subject in age-heterogeneous contexts, a sense of enjoyment must be found [32].

10 Delivery of sign language training to those with early hearing loss

No peer reviewed research could be sourced on the efficacy or advantages of delivering sign language as a communication option for those with acquired hearing loss/progressive hearing loss. Research in the area of early intervention exclusively focuses on the delivery of sign language to deaf and hearing impaired children, often at the time a cochlear implant is provided.

A systematic review was conducted in 2018 to investigate the effectiveness of early sign and oral language intervention compared with oral language intervention only for children with permanent hearing loss [40]. The review found there is no evidence that adding sign language facilitates spoken language acquisition. However, the review also found no conclusive evidence that adding sign language interferes with spoken language development. Overall, the literature related to intervention methods for children with hearing loss lacks properly designed cohort studies of today's generation of children.

10.1 Difficulties in learning a signed language

A major misconception about sign language is that it is an easily learnt, picture-like language [41]. This misunderstanding is due partly to the fact that some of the first basic signs learned may be thought of as iconic (e.g. signs for eat, drink and sleep) [41]. Sign language has been established as a distinctive language separated from other languages. It contains the linguistic components that constitute a sophisticated, independent language [41].

It has been argued that learning sign language is as difficult for native English speakers as learning Chinese or Japanese [42]. The 'foreignness' of sign language makes it more difficult to learn than, perhaps, Spanish or French [35]. Rosen [43] noted that second language learners of sign language often make phonological errors in producing signs, which makes the signing seem awkward and unnatural. The Defense Language Institute have grouped languages into four categories in terms of their level of difficulty for native English speakers to learn [28]. The degree of difficulty is based on how long it takes to learn the target language before reaching a proficiency level of two (limited working proficiency) on a scale of 0 (memorised proficiency) to 5 (functionally native proficiency) [41]. There is no published guide on which category sign language falls into. Some authors have suggested Category 2 (36 weeks, 1080 hours) or Category 4 (44 weeks, 1320 hours) [33].

One of the problems in learning a signed language as a second language is the limited opportunity for immersion in the language and the associated culture that many learners experience. In Australia, there is estimated to be about 6,500 signing deaf people/ 'native speakers'. This number would more than double if all hearing people who use Auslan were included [44]. A 'native speaker' is defined as someone who has learned sign language from birth through Deaf parents – which is a small minority group [42]. Immersion is often only available to learners by attending and participating in activities in the Deaf community, such as social events. For many reasons it may be difficult for hearing individuals to access such situations. In some cases such difficulties may be exacerbated by the often-held perception by some Deaf people that hearing people are members of an oppressive majority group [41, 42]. Alternatively, some Deaf adults may warmly embrace the families of deaf children that are endeavouring to learn to sign. *Further information on Deaf culture is covered below.*

A major barrier in providing sign language as the prominent communication support for adults with acquired hearing loss is that family members/support networks would also need to learn sign language to enable communication and increased participation. If parents/spouse can sign, but siblings or other extended family cannot, then the deaf individual will miss out on much of the conversations with other people [42].

11 Deaf Culture

The term “Deaf culture” is used to identify a set of beliefs, practices, and a common language shared by a group of deaf people [45]. Culturally Deaf people prefer to look at their deafness positively as a different culture instead of as impairment, which is at odds with the medical/professional community’s view of deafness as an illness [45].

Sign language is at the centre of Deaf culture and community and the single most unifying characteristic. Anyone who does not value sign language is unlikely to either feel comfortable within the Deaf culture, or to be accepted by it. Those who use sign language, especially as a first language, are viewed as members of a tightly knit in-group, or "Deaf culture," while those who are not "pure" signers are viewed as members of the out-group, or "hearing world” [46]. Even people who by medical definition are deaf can be considered "hearing" by the Deaf culture if they do not communicate using pure sign [46].

This perception can limit access to the culture by persons who desire to enter the culture after childhood, for example people who lose their hearing in adolescence or adulthood, or who were raised with English as their first language, but who wish to learn sign language later in life [46].

Beginner signers often complain that native users sign too fast. When Deaf people use their own language among themselves they use it at their own pace [41]. It is believed to be the newcomer’s responsibility to keep up. In this respect, it isn’t any different to any other culture [28].

There are various values, behaviours and customs followed in the Deaf community.

11.1 Values

Sharing similar values is very important in any culture. In Deaf culture, some of the shared values are [45, 47]:

Respect for sign language: This is a core value, as mentioned above.

Deaf is normal: For culturally Deaf people, to be Deaf is a natural state of being. It is an everyday part of their life and their identity. To express sadness or regret for a person's deafness can be considered a lack of acceptance of who they are. Deaf people do not usually see themselves as disabled or impaired and dislike being referred to as "hearing impaired". They see themselves as "normal Deaf people" not as "people with impaired hearing". The disability they experience is a result of assumptions and barriers that hearing society imposes on them.

Deaf babies are highly valued: For Deaf people, having a deaf baby is something to celebrate, not something to grieve over. Deaf people value their children, whether they are deaf or hearing. They also value other people's deaf babies and welcome them into their community.

11.2 Behaviour

Within Deaf culture there are behaviours that are considered rude, but which are perfectly acceptable in hearing culture, and vice versa. Some examples are [41, 45, 47]:

Eye contact: Eye contact is extremely important. Hearing people often talk to each other with comparatively little eye contact, but within Deaf culture, avoiding eye contact can be seen as rude. Looking away while someone is signing to you is definitely a no-no.

Touch: In Deaf culture, it is acceptable to touch another person to gain their attention, even if you do not know them well. However, there are rules about where or how to touch. A light touch on the arm or shoulder is acceptable.

Physical proximity: When two hearing people are having a conversation they often sit or stand close to each other, sometimes side by side. Deaf people sit or stand further apart and preferably opposite each other so that they can see each other's "signing space" comfortably. This physical distance may appear unfriendly to hearing people, but Deaf people usually find it uncomfortable trying to converse in close physical proximity.

Directness: From Deaf people's perspective, hearing people seem to say things in oblique and roundabout ways. From hearing people's point of view, Deaf people may appear blunt or abrupt. These are cultural differences which need to be understood and accommodated.

Thumping on tables or floors: Deaf people often thump on tables or floors to gain each other's attention, in the same way as hearing people call a person's name or shout. This behaviour can appear aggressive to hearing people, but in Deaf culture it is not.

11.3 Customs

Some customs are common in the Deaf community and include [45, 47]:

Who are you?: When Deaf people meet each other for the first time, or when they introduce each other, they will often provide more personal details than a hearing person might. They always give their first and last names, because there is a higher chance, in a small community, that this will provide information about their family or community connections. This can be particularly important if they come from a family with several generations of Deaf people.

If you are a hearing person, you will most likely be asked questions about your connection with Deaf people. This introductory information establishes where you "fit" in the community - or to be direct about it as is often the Deaf way, whether or not you are acceptably "Deaf".

The long goodbye: When Deaf people are leaving a gathering of friends (and Deaf people who belong to the Deaf community tend to have many friends) they take much longer than most hearing people do to say goodbye. The custom is to seek out one's friends and in the process of saying goodbye, discuss when they next expect to meet.

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Are Hearing Aids Everyday Equipment?

The content of this document is OFFICIAL.

Please note:

The research and literature reviews collated by our TAB Research Team are not to be shared external to the Branch. These are for internal TAB use only and are intended to assist our advisors with their reasonable and necessary decision-making.

Delegates have access to a wide variety of comprehensive guidance material. If Delegates require further information on access or planning matters they are to call the TAPS line for advice.

The Research Team are unable to ensure that the information listed below provides an accurate & up-to-date snapshot of these matters.

Research Questions:

The project does not comprise of one broad research question. Instead, it comprises of 10 specific shorter research questions. The 10 research questions are:

- "What is the evidence that 1 in 6 Australians have a hearing loss?"
- "Hearing loss increases as age increases. What is the percentage of Australians with a hearing loss between 26 and 65 years of age?"
- "How many Australians use a hearing aid?"
- "Is the use of a hearing aid as common as the use of a walking stick?"
- "Have there been any AAT cases about access to the scheme and hearing loss? If so, could you please provide a summary of why someone did NOT gain access to the Scheme?"
- "How many participants whose primary disability is hearing impairment are meeting the criteria and gaining access to the system?" (Instigated by the researcher for greater insight)
- "Of the above, how much are their plans costing on average?" (Instigated by the researcher for greater insight)
- "What percentage of hearing loss in Australia is permeant loss, i.e. Not medically treatable?"
- "Is there any information regarding the incidence of hearing loss at different levels? E.g. How many people have a 'mild', versus 'moderate', versus 'severe' hearing loss?"

- "What is the definition of 'commonly used assistive technology', as used / referred to in the Operational Guidelines for Access 8.3.1?"

Date Request Received: 29/10/2021

Date Request Commenced: 22/11/2021

Requestor: Jean s22(1)(a)(ii) - irrelevant [redacted] (contact person Peta s22(1)(a)(ii) - irrelevan [redacted])

Endorsed by (EL1 or above): Melinda s22(1)(a)(ii) - irrelevant mat [redacted]

Cleared by: Felicity s22(1)(a)(ii) - irrelev [redacted]

1. Contents

2. Summary

This project relates to hearing impairment and more specifically 'hearing aids' (and associated services) and its implications for the NDIS and NDIS participants with potential eligibility rates increasing. On a wider level, concerns have been raised about 'access eligibility', and whether there is a trend that some participants have potentially incorrectly gained support, without qualifying based on the criteria (or whether the criteria in fact needs to be better refined, articulated and interpreted). It may pose as a financially risk to the NDIA if 1 in 6 Australians are eligible for the NDIS on the basis where the primary disability is 'hearing impairment' (particularly with rates expected to rise). The advisors are ultimately interested in assessing any risk to the scheme in relation to the increasing prevalence of hearing loss.

Additional rationale for the research was to help ascertain whether hearing aids are to be considered 'everyday equipment'. A literature review was not requested.

The overview of the key facts derived from this study include the following:

- 1 in 6.5 (15.3%) Australians were likely to have experienced hearing loss in 2020. By 2050, this will increase to 1 in 4.
- In 2017, approximately 35% of Australians with a hearing loss were between the ages of 25 and 64 years.
- In both 2017 and 2020 studies stated that 15.3% of the total Australian population (then of 25,499,884) lived with a hearing impairment.
- In 2017, approximately 35% of Australians with hearing loss were between the ages of 25 and 64 years.
- 'Presbycusis' (age related hearing loss) is the most common cause of acquired sensorineural hearing loss and is slowly progressive with age (Westcott, 2018). A third of Australians over the age of 50 experience a hearing impairment, and this number rises such that half of the population over 60 will experience a hearing impairment.
- In 2015 on average 32% of people with hearing loss used hearing aids. Other 2018 studies only recorded that 18.4% of people with a hearing impairment in fact use a hearing aid/s (skewed by lack of those people who use one, either not being denoted as

having a disability and / or not captured by data analysis). Noted also is that some individuals who have a hearing aid, do not necessarily always use it.

- On a global basis, according to the World Health Organization (WHO 2021), they estimate that there will be over 700 million people with a hearing impairment by 2050, equating to one in every ten people. The likely increase in those living with hearing loss is predicted to more than double to approximately 7.8 million people by 2060 (DAE, 2017).
- Although the data suggests that the use of a hearing aid is more prevalent than those who use other aids such as a walking stick, this information is most likely skewed as those using walking sticks and other such aids are not necessarily denoted as having a permanent disability nor are true usage figures recorded as statistic data (so any comparisons drawn cannot be validated as truly reflective and nor conclusive).
- It was noted by the CEO of the NDIS (in week commencing 22nd November, 2021) stated that *“75% of NDIS costs related to support work hours”, and not the cost of capital equipment per say”.* This highlights the importance of a closer evaluation of the ‘auxiliary’ services denoted in columns [2] in the state / territorial annual budgetary provisions under 3.7 Research Question 7.
- Only one AAT case where the participant’s primary disability was ‘hearing impairment’ ruled in favour of the Agency (details below under 3.5 Research Question 5). There have only been a total of two ‘hearing impairment’ cases that have been heard where a final ruling was delivered (others were either settled beforehand or withdrawn etc.).
- No specific data was found on the percentage of permanent and not medically treatable hearing loss in Australia. However, some data does indicate that substantially less than 37% of hearing loss is treatable.
- As of 2017, 2,817,164 people had mild hearing loss, 1,181,472 had moderate hearing loss, and 740,532 people had severe hearing loss.
- The NDIA does not have a publicly available definition of ‘commonly used assistive technology’ but the examples our resources provide do give some indication (refer to 3.10 Research question 10).
- **The total number of NDIS participants (aged 25 – 64) years, encompassing all ranges of disabilities is 183,440**
- **The total number of NDIS participants (aged between 25 – 64 years) whose primary disability is ‘hearing impairment’ is 9,347, comprising of only 5.1%**
- **Total costs to the NDIS, as at 30th June, 2021, encompassing all participants aged between 25 – 64 years whose primary disability is ‘hearing impairment’, totals**

$167,730,000, however includes ‘auxiliary’ costs (refer 3.7 Research Question 7) (NDIS, 2021).

- **Of the total $167,730,000, $33,327,000 comprised of ‘capital’ costs (19.9%) (refer 3.7 Research Question 7) [added to version VO1.1].**
- **Of the total $167,730,000, $134,403,000 comprised of ‘auxiliary’ costs (80.1%) (refer 3.7 Research Question 7) [added to version VO1.1].**

2.1 NDIS eligibility criteria where the primary disability is hearing loss

Hearing impairments may result in reduced functional capacity to undertake communication, social interaction, learning and self-management activities.

Generally, the NDIA will be satisfied that hearing impairments of ≥ 65 decibels in the better ear (pure tone average of 500Hz, 1000Hz, 2000Hz and 4000Hz) may result in substantially reduced functional capacity to perform one or more activities. This audiometric criterion reflects the lower limit of what is likely to constitute a substantially reduced functional capacity to undertake relevant activities.

Hearing impairments < 65dB decibels in the better ear (pure tone average of 500Hz, 1000Hz, 2000Hz and 4000Hz) in conjunction with other permanent impairments (for example vision or cognitive impairments), or where there is evidence of significantly poorer than expected speech detection and discrimination outcomes, may also be considered to result in substantially reduced functional capacity to undertake relevant activities. (NDIS, Access to the NDIS - The disability requirements | NDIS).

3. Research Questions

The latest information on hearing loss in Australia has been derived from two reports both commissioned by the Hearing Care Industry Association (HCIA): *Social and Economic Cost of Hearing Loss in Australia* (Deloitte Access Economics (DAE) 2017) and *Hearing for Life: The Value of Hearing Services for Vulnerable Australians* (DAE, 2020). Information was also derived directly from ABS data.

3.1 Research Question 1 – *“What is the evidence that 1 In 6 Australians have a hearing loss?”*

In DAE 2017, hearing loss is defined as 25 decibels or worse in the better ear. As per this definition, an estimated 3.6 million Australians experienced hearing loss in 2017. Based on the report’s projections, this number would grow to 3.88 million in 2020 (DAE, 2017, p.25). **This means that approximately 1 in 6.5 (15.3%) Australians are likely to have experienced hearing loss in 2020**. By 2050, this will increase to 1 in 4 (World Health Organisation, 2020).

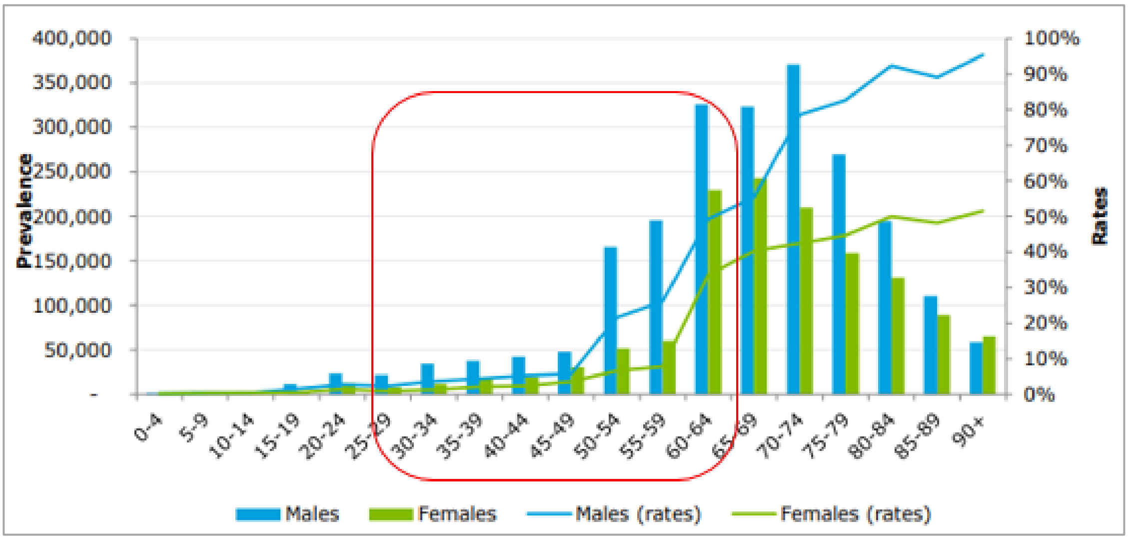
DAE 2020 (p.12) also supports these above statistics, stating that approximately **15.3% of the total Australian population (then of 25,499,884) lived with a hearing impairment.** Both reports support the same statistical conclusion, indicating no shift in trends between 2017 and 2020.

Therefore, the above evidence that 1 in 6 Australians have a hearing loss is correct and founded, supporting the two cited resources mentioned in the original research request, being the 'Roadmap for Hearing Health', and the 'Parliamentary Report, Chapter 3'. (As these are not cited in this report, they are not reflected in the reference list).

3.2 Research Question 2 – *"Hearing loss increases with age. What is the percentage of Australians with a hearing loss between the age of 26 and 65 Years?"*

It was not possible to extract exact information about the prevalence of hearing loss in Australians between 26 and 65 years of age due to how the data is arranged in DAE 2017. Based on approximations contained in the reported figures, there were roughly 1.3 million Australians with hearing loss between the ages of 25 and 64 years in 2017 (refer to Figure 1; DAE, 2017,p.19).

Figure 1 – Number of Australians with hearing loss in 2017 by age and sex



There were 716,313 Australians with hearing loss between the ages of 30 and 59 in 2017. There were 1,903,974 Australians with hearing loss between the ages of 20 and 69 in 2017 (refer to Figure 2; DAE, 2017, p.25). **In 2017 approximately 35% of Australians with hearing loss were between the ages of 25 and 64 years**. This may have increased somewhat by 2021, though projections are difficult to calculate for the age cohort specified as this was not a cohort specified by either DAE report.

Slightly lower percentages were noted in DAE 2020, where extrapolated statistics denoted that in 2020 approximately 30.79% of Australians with hearing loss were between the ages of 20 and 69 years. Neither report categorises the cohorts into the ages of 26 and 65 years precisely, but their aligned age categories provide some relevant data. As stated above in answering the first research question, DAE 2020 confirms the statistics stated in DAE 2017, with no significant variation.

The issue of projected numbers of Australians expected to present with a hearing impairment in the future is worthy of discussion. On a global perspective, according to the World Health Organization (WHO 2021), they estimate that there will be over 700 million people with a hearing impairment by 2050, equating to one in every ten people. The likely increase in those living with hearing loss is predicted to more than double to approximately 7.8 million people by 2060 (DAE, 2017).

Projections are also based on the assumption of an ageing Australian population so the increase in prevalence will be felt mostly at the higher age brackets. The report also estimates that approximately one third of instances of hearing loss are preventable. 'Presbycusis' refers to age related hearing loss and 'is the most common cause of acquired sensorineural hearing loss and slowly progresses with age (Westcott, 2018). Projections do not account for any actions taken to reduce the rate of preventable hearing loss.

According to DAE 2020, while it was noted that the majority of hearing loss is a result of genetics or the aging population, a third of those with a hearing impairment acquire that loss in hearing as a result of a preventable cause. Also highlighted was that a third of Australians over the age of 50 experience a hearing impairment, and this number rises such that half of the population over 60 will experience a hearing impairment. The final pertinent statistic noted was that approximately 50% of the Australian population with a hearing impairment or loss, are in fact younger than 65 years of age.

The issue of noise induced hearing related loss has been well researched. A recent paper assessed a sample of 1923 individuals over the age of 50 years and concluded that excessive noise in the workplace attributes to a far greater risk of hearing loss prevalence, during the 10-year period during and / or post exposure to the noisy workplace. Statistically, hearing loss was 35.5% versus 29.1% in those who had no workplace noise exposure (Gopinath et al. 2021). Although this wider problem is beyond the scope of this study, it is worthy of consideration, and who should bear the cost of hearing loss support, if the cause can be directly attributed to workplace Occupational Health and Safety noise level potential breaches.

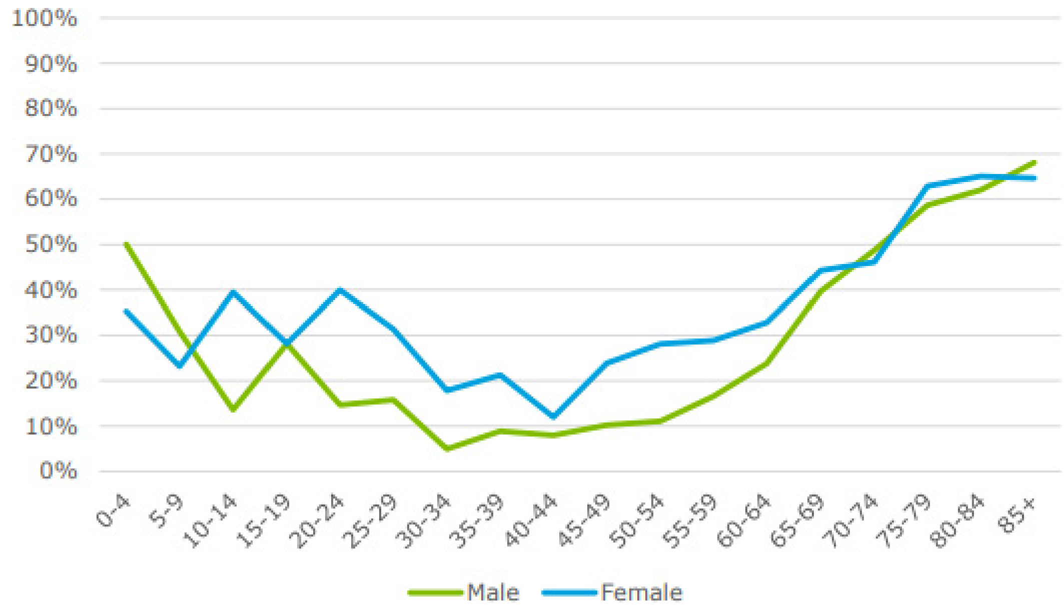
Figure 2 – Number of Australians with hearing loss in 2017 by age, sex and severity of hearing loss

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%)**

3.3 Research Question 3 – *"How many Australians use a hearing aid?"*

According to the Australian Institute of Health and Welfare in 2012 1 in 7 people wore hearing aids (Australian Institute of Health and Welfare (AIHW), 2016, p.118). However, this figure is hard to comprehend considering the more recent Australian Bureau of Statistics (ABS) survey of Disability, Ageing and Carers (SDAC 2015 & 2018) and the DAE reports. While the DAE 2017 does not state precise use of hearing aids among people with hearing loss in Australia, it does provide resources to estimate the prevalence (refer to Figure 3; DAE, 2017, p.66). In 2015 on average 32% of people with hearing loss used hearing aids. More recent studies confirmed that 1 in 6.5 Australians were likely to have experienced hearing loss. Interestingly, only one in five Australians who could benefit from a hearing aid, actually use one (Hearing Care Australia, 2021). Also worth noting is that up to 40% of people who have a hearing aid, either choose not to wear it, or do not use it to its optimal capacity (Barker et al. 2016). Also worth noting in the context of NDIS financial sustainability, some war returning veterans may be eligible for the Hearing Services program, so therefore would not require NDIS funded hearing aids. Many such individuals, however, return with a myriad of other physical and psychological disorders, where hearing impairment may not be the primary disability (Swan et al. 2017).

Figure 3 – Percentage of people with hearing loss who use hearing aids by age and sex



3.4 Research Question 4 – *"Is the use of a hearing aid as common as the use of a walking stick?"*

SDAC (ABS, 2015 & 2018) provides data on prevalence of hearing aid use among people with a disability (refer to Figure 4). In 2018 18.4% of people with disabilities reported using hearing aids, up from 16.4% in 2015. In 2018, 6.2% of people with a disability used a walking stick, down from 6.5% in 2015. This means that at least 802,500 Australians used hearing aids in 2018 and at least 272,300 Australians used walking sticks in 2018.

It is important to emphasise that these numbers reflect the minimum estimated use of these aids in the Australian population. The use of both hearing aids and walking sticks could be much greater if people who do not identify as having a disability also make use of them.

Note, that the 2018 ABS estimate is significantly under the HCIA estimate even though HCIA used 2015 SDAC data as a base. This may be explained by the fact that the SDAC is a self-reported measure and so includes data for people who identify as having hearing loss rather than people who do have hearing loss. There is often a discrepancy between self-reporting hearing loss and audiometry results (DAE, 2017, p.13). The discrepancy may also be explained by HCIA report having access to more complete raw data from the SDAC than is publicly available.

This conclusion has been drawn on what data is available, with the added proviso that complete records of users of walking sticks are not available. Walking sticks may be purchased off-the-shelf for short term use and so will be difficult to track. Although the data below suggests that the use of a hearing aid is more prevalent than those who use aids such as a walking stick, this information is most likely skewed as those using walking sticks and other such aids may not identify as having a permanent disability.

Figure 4 – Use of aids and equipment among people with a disability

Aid	% PWD 2015	Est. 2015	% PWD 2018	Est. 2018
Cane	1.4	61,800	1.7	74,000
Walking stick	6.5	277,700	6.2	272,300
Crutches	0.7	28,000	1.0	43,300
Walking frame	7.0	301,700	7.6	330,800
Scooter	1.0	43,400	1.2	54,000
Hearing aid	16.4	701,600	18.4	802,500
Cochlear Implant	0.2	10,200	0.4	17,400
Handgrab rails	8.2	337,800	8.1	338,600

3.5 Research Question 5 – *"Have there been any AAT cases about access to the scheme and hearing loss? If so, what is the summary of why someone did not gain access to the Scheme?"*

Regular and ongoing contact has been made with NDIS internal departments who deal with AAT cases, seeking answers and clarification in an attempt to answer the above research question. The specific departments who have been asked to provide input / data relating to this research question include; Access and the TAB AAT, the AAT Case Management Branch and the Chief Council Division / Legal Reporting for data / statistical input. Mr William Neely, the Assistant Director, from the AAT Case Management Branch, has been instrumental in providing both AAT case information and assisting in interpretation of the data used in answer both research question 3.5 and research question 3.6.

Of the 5 recent noted cases raised by Peta Monley (NDIS SME audiologist) only one was heard at the AAT, which involved Gheorghe Timofticiuc – '*Timofticiuc and National Disability Insurance Agency [2021] AATA 3015 (23 August 2021)*. The 4 other cases were either withdrawn, waiting for the tribunal to hand down their finding or resolved with consent and did not proceed to a hearing.

Interestingly the case pertaining to Gheorghe Timofticiuc (right-sided sensorineural hearing loss) handed down a decision whereby the AAT affirmed the internal review decision that the Applicant did not meet the access criteria and ruled in the Agency's favour, formally stated as 'The Tribunal affirms the decision under review pursuant to paragraph 43(1)(a) of the Administrative Appeals Tribunal Act 1975 (Cth)' (Administrative Appeals Tribunal' (AAT). The case name was: *'Timofticiuc and National Disability Insurance Agency [2021] AATA 3015 (23 August 2021).*

Rationale in summary as to the decision included the following factors (determined by Member Buxton):

The respondent's contentions included (AAT, 2021):

- 'The Respondent submitted that the decision under review ought to be affirmed as the disability and early intervention requirements had not been met in this case'.
- 'The Respondent submitted that the Applicant met the requirements of paragraph 24(1)(a) of the Act, as they accept that the Applicant has impairments attributable to the following disabilities: sensorineural hearing loss in the right ear, tinnitus, tonic tensor tympani syndrome (TTTS) and adjustment disorder with depressed mood'.
- 'As to paragraph 24(1)(b) of the Act, the Respondent accepted that the hearing loss and related adjustment disorder were permanent but did not accept that the tinnitus or TTTS met the requirements for permanence. A substantial focus both during the hearing and in the Respondent's written submissions was the issue of whether the tinnitus episodes could be remedied by further treatment' (AAT, 2021).

Other pertinent extracts from the hearing's findings included:

- 'The Respondent submitted that, accordingly, if there are known, available and appropriate treatment available, that a prospective participant should generally undergo the medical treatment or review before making a determination on permanency, and identified two further processes that should first be exhausted by the Applicant in respect of his tinnitus before that condition could be regarded as permanent:

– 'Undertake online consultations with Dr P Selvaratnam, Musculo-skeletal physiotherapist, who is uniquely experienced in treating the symptoms of tinnitus - related TTTS and'

- ‘Undertake some cochlear implant testing recommended by Dr Brent McMonagle, ENT Surgeon, specialising in cochlear implants, in February 2019. This was again recommended by Dr O’Neill, ENT Surgeon in November 2020’.
    - ‘It was submitted by the Respondent that the bases upon which the Applicant has rejected cochlear implants was not reasonable. The Applicant has stated that he did not wish to undergo cochlear implant surgery because he would be unable to have an MRI after implantation, the rehabilitation would be challenging and the effect on his tinnitus would be unknown. The Respondent submitted that the Applicant effectively wants a “guarantee” that the tinnitus will be fixed before undergoing the procedure, which his treating doctors will not give. The Respondent submitted, with reference to an article in the Lancet Journal that was relied upon in a report prepared by Ms Myriam Westcott, that cochlear implantation has been shown to improve or eliminate tinnitus in up to 86% of patients with tinnitus. It was contended by the Respondent that the Applicant should, at least, undergo the testing for suitability for cochlear implants’.
    - ‘The Respondent submitted that, in respect of the impairments that it has accepted were permanent (and, with respect to the other impairments if the Tribunal found those to be permanent) that they did not lead to a substantial reduction in the Applicant’s functional capacity in order to meet paragraph 24(1)(c) of the Act.[36] Under paragraph 24(1)(c) of the Act, the Tribunal must be satisfied that the “impairment” results in a substantially reduced functional capacity to undertake, or psychosocial functioning in undertaking, one or more of the activities of communication, social interaction, learning, mobility, self-care or self-management’.
    - ‘The Respondent submitted that the Participant Rules provide further criteria on establishing paragraph 24(1)(c) of the Act. The Participant Rules have been held to be “deeming” provisions, in that the Participant Rules have the effect of mandatorily including some people in the category of persons with substantially reduced functional capacity’ (AAT, 2021).

A request was made to the Chief Council Division / Legal Reporting to obtain more extensive data on past AAT cases, where the primary disability was ‘hearing impairment’, in an attempt to identify any trends over recent years. More specifically the purpose was to assess how many hearing outcomes ruled in favour of the Agency. The summary is as follows:

- Only one case that has gone to AAT where the ruling was in favour of the agency (as above (‘*Timofticiuc and National Disability Insurance Agency [2021] AATA 3015 (23 August 2021)’.*
- Only one case that has gone to the AAT where the ruling was in favour of the participant (‘Evans and National Disability Insurance Agency [2019] AATA 754 (24 April 2019)’. See Hearing loss and substantially reduced functional capacity - Evans and NDIA [2019] AATA 754 (ndiscases.blogspot.com) // Evans and National Disability Insurance Agency [2019] AATA 754 (24 April 2019) (austlii.edu.au). In summary, The Tribunal sets aside the decision under review and in substitution decides that the Applicant satisfies the access criteria, pursuant to s 24 of the Act, to become a participant of the National Disability Insurance Scheme.
- There have been a total of 36 cases planned to go to the AAT where the primary disability was ‘hearing impairment’, but 34 of outcomes were neither clearly either ‘in favour of the agency’ or in ‘favour of the participant’, and were instead concluded with a status of either; ‘dismissed’, ‘hearing decision set aside’, ‘no jurisdiction’, ‘resolved by consent’ or ‘withdrawn’. The remaining two are listed / named above.

3.6 Research Question 6 (Instigated by the researcher to gain greater insight) – *“How many participants whose primary disability is hearing impairment are meeting the criteria and gaining access to the system?”*

A broader data search was undertaken to address the two additional research questions responded to in 3.6 Research Question 6 and 3.7 Research Question 7 (instigated by the researcher to gain more insight into financial costs and sustainability).

Derived from the Explore data | NDIS database (as at 30th June, 2021), the following data below was extrapolated pertaining to participant’s plans who are aged between 25 – 64 years (which was the categorisation of ages from this data source) whose primary disability is ‘hearing impairment’. A summary of numbers divided between all Australian states and territories is depicted below (NDIS, 2021):

State / Territory	*Participant Numbers*
ACT	188
NSW	3093
NT	78
QLD	2039
SA	731
TAS	200
VIC	2321
WA	697
	Total = 9347

Summary of pertinent facts:

- The total number of NDIS participants is 468,177, encompassing all ranges of disabilities
- The total number of NDIS participants (aged 25 – 64) years, encompassing all ranges of disabilities is 183,440 (*), as evidenced by, "There are 183,440 participants in state(s) of ACT, NSW, NT, OT, QLD, SA, TAS, VIC, WA and All Service Districts, disability group(s) of ABI, Autism, Cerebral Palsy, Developmental delay, Global developmental delay, Hearing Impairment, Intellectual Disability, Multiple Sclerosis, Other, Other Neurological, Other Physical, Other Sensory/Speech, Psychosocial disability, Spinal Cord Injury, Stroke, Visual Impairment and age band(s) of 25 to 34, 35 to 44, 45 to 54, 55 to 64" (NDIS, 2021).
- The total number of NDIS participants (aged between 25 – 64 years) whose primary disability is 'hearing impairment' is 9,347, comprising of only 5.1% of that above mentioned population group (data reflected above), as evidenced by, "There are 9,347 participants in state(s) of ACT, NSW, NT, OT, QLD, SA, TAS, VIC, WA and All Service Districts, disability

group(s) of Global developmental delay, Hearing Impairment and age band(s) of 25 to 34, 35 to 44, 45 to 54, 55 to 64" (NDIS, 2021).

3.7 Research Question 7 (Instigated by the researcher to gain greater insight) – *"Of the above, how much are their plans costing on average?"*

Also sourced from the Explore data | NDIS database (as at 30th June, 2021), the data below was extrapolated to indicate what the average Annual Budgets were for participants plans whose primary disability is 'hearing loss', indicating where the 'capital' expenditure was spent (presumably on the hearing aid/s devices) and 'other / auxiliary services within the participant's plans (where the specifics and nature of such services were not explicitly indicated). The data is also categorised into age brackets and all the individual Australian states and territories (NDIS, 2021).

ACT

Age Categories (Number of participants below)	*Average Budget [1] + [2] (per participant plan)*	*Average Budget Capital component (presumably the cost of the hearing aid/s) [1]*	*Average Budget (Auxiliary hearing support services component) [2]*	*Total Average Budget x No. of Participants [No. of participants x Average Budget [1[] + [2] = [3]*
25 – 34 years (49 participants)	$11,000	$3000	$8000	$539,000
35 – 44 years (34 participants)	$10,000	$0	$10,000	$340,000
45 – 54 years (40 participants)	$16,000	$3000	$13,000	$640,000
55 – 64 years	$10,000	$3000	$7000	$650,000

(65 participants)				
	Total = $47,000	**Sub-Total = $9000**	**Sub-Total = $38,000**	**Total cost to the NDIS = $2,169,000**

NSW

Age Categories *(Number of participants below)*	*Average Budget* *[1] + [2]* *(per participant plan)*	*Average Budget Capital component (presumably the cost of the hearing aid/s) [1]*	*Average Budget (Auxiliary hearing support services component) [2]*	*Total Average Budget x No. of Participants* *[No. of participants x Average Budget [1][] + [2] = [3]*
25 – 34 years (729 participants)	$12,000	$3000	$9000	$8,748,000
35 – 44 years (587 participants)	$17,000	$3000	$14,000	$9,979,000
45 – 54 years (764 participants)	$17,000	$3000	$14,000	$12,988,000
55 – 64 years (1013 participants)	$16,000	$3000	$13,000	$16,208,000
	Total = $62,000	**Sub-Total = $12,000**	**Sub-Total = $50,000**	**Total cost to the NDIS**

				= $47,923,000

NT

Age Categories (Number of participants below)	Average Budget [1] + [2] (per participant plan)	Average Budget Capital component (presumably the cost of the hearing aid/s) [1] (**)	Average Budget (Auxiliary hearing support services component) [2]	Total Average Budget x No. of Participants [No. of participants x Average Budget [1][] + [2] = [3]
25 – 34 years (15 participants)	$34,000	$0	$34,000	$510,000
35 – 44 years (20 participants)	$52,000	$0	$52,000	$1,040,000
45 – 54 years (22 participants)	$49,000	$0	$49,000	$1,078,000
55 – 64 years (21 participants)	$36,000	$0	$36,000	$756,000
	Total = $171,000	**Sub-Total = $0**	**Sub-Total = $171,000**	**Total cost to the NDIS = $3,384,000**

QLD

Age Categories (Number of participants below)	*Average Budget [1] + [2] (per participant plan)*	*Average Budget Capital component (presumably the cost of the hearing aid/s) [1]*	*Average Budget (Auxiliary hearing support services component) [2]*	*Total Average Budget x No. of Participants [No. of participants x Average Budget [1][] + [2] = [3]*
25 – 34 years (398 participants)	$17,000	$4000	$13,000	$6,766,000
35 – 44 years (338 participants)	$22,000	$4000	$18,000	$7,436,000
45 – 54 years (558 participants)	$20,000	$4000	$16,000	$11,160,000
55 – 64 years (745 participants)	$19,000	$4000	$15,000	$14,155,000
	Total = $78,000	**Sub-Total = $16,000**	**Sub-Total = $62,000**	**Total cost to the NDIS = $39,517,000**

SA

Age Categories (Number of participants below)	Average Budget [1] + [2] (per participant plan)	Average Budget Capital component (presumably the cost of the hearing aid/s) [1]	Average Budget (Auxiliary hearing support services component) [2]	Total Average Budget x No. of Participants [No. of participants x Average Budget [1][] + [2] = [3]
25 – 34 years (142 participants)	$14,000	$2000	$12,000	$1,988,000
35 – 44 years (119 participants)	$17,000	$3000	$14,000	$2,023,000
45 – 54 years (200 participants)	$20,000	$3000	$17,000	$4,000,000
55 – 64 years (270 participants)	$20,000	$5000	$15,000	$5,400,000
	Total = $71,000	**Sub-Total = $13,000**	**Sub-Total = $58,000**	**Total cost to the NDIS = $13,411,000**

TAS

Age Categories (*Number of participants below*)	*Average Budget* [1] + [2] (*per participant plan*)	*Average Budget Capital component (presumably the cost of the hearing aid/s)* [1]	*Average Budget (Auxiliary hearing support services component)* [2]	*Total Average Budget x No. of Participants* [*No. of participants x Average Budget* [1][] + [2] = [3]
25 – 34 years (44 participants)	$13,000	$4000	$9000	$572,000
35 – 44 years (38 participants)	$18,000	$4000	$14,000	$684,000
45 – 54 years (55 participants)	$19,000	$5000	$14,000	$1,045,000
55 – 64 years (63 participants)	$17,000	$4000	$13,000	$1,071,000
	Total =	**Sub-Total = $17,000**	**Sub-Total = $50,000**	**Total cost to the NDIS = $3,372,000**

VIC

Age Categories (Number of participants below)	*Average Budget [1] + [2] (per participant plan)*	*Average Budget Capital component (presumably the cost of the hearing aid/s) [1]*	*Average Budget (Auxiliary hearing support services component) [2]*	*Total Average Budget x No. of Participants [No. of participants x Average Budget [1[] + [2] = [3]*
25 – 34 years (611 participants)	$16,000	$3000	$13,000	$9,776,000
35 – 44 years (432 participants)	$18,000	$4000	$14,000	$7,776,000
45 – 54 years (594 participants)	$20,000	$4000	$16,000	$11,880,000
55 – 64 years (684 participants)	$20,000	$4000	$16,000	$13,680,000
	Total = $74,000	**Sub-Total = $15,000**	**Sub-Total = $59,000**	**Total cost to the NDIS = $43,112,000**

WA

Age Categories *(Number of participants below)*	*Average Budget* *[1] + [2]* *(per participant plan)*	*Average Budget Capital component (presumably the cost of the hearing aid/s) [1]*	*Average Budget (Auxiliary hearing support services component) [2]*	*Total Average Budget x No. of Participants* *[No. of participants x Average Budget [1][] + [2] = [3]*
25 – 34 years (160 participants)	$17,000	$5000	$12,000	$2,720,000
35 – 44 years (121 participants)	$23,000	$7000	$16,000	$2,783,000
45 – 54 years (201 participants)	$24,000	$4000	$20,000	$4,824,000
55 – 64 years (215 participants)	$21,000	$4000	$17,000	$4,515,000
	Total = $85,000	**Sub-Total = $20,000**	**Sub-Total = $65,000**	**Total cost to the NDIS = $14,842,000**

SUMMARY OF TOTAL COST ACROSS ALL 8 STATES / TERRITORIES

STATE / TERRITORY (Participant numbers below)	TOTAL AVERAGE BUDGETED COSTS x ALL PARTICPANTS (derived from column [3] above)
ACT (188)	$2,169,000
NSW (3093)	$47,923,000
NT (78)	$3,384,000
QLD (2039)	$39,517,000
SA (731)	$13,411,000
TAS (200)	$3,372,000
VIC (2321)	$43,112,000
WA (697)	$14,842,000
	TOTAL COST TO THE NDIS = $167,730,000 (as at 30th June, 2021)

Summary of pertinent fact impacting financial sustainability of the provision of 'hearing impaired' participant plans (with caveat that these figures include 'auxiliary' costs)::

- **Total costs to the NDIS, as at 30th June, 2021, encompassing all participants aged between 25 – 64 years whose primary disability is 'hearing impairment', totals $167,730,000 (NDIS, 2021).**

- **Of the total $167,730,000, $33,327,000 comprised of 'capital' costs (19.9%) (NDIS, 2021).**
- **Of the total $167,730,000, $134,403,000 comprised of 'auxiliary' costs (80.1%) (NDIS, 2021).**

Auxiliary costs associated with training of digital hearing aid usage etc, could be reduced by the use of 'group based' sessions, potentially even delivered online. Group follow-ups and group visits could lower costs and reduce the economic pressure on public resources (Vlastarakos et al. 2017). 'Auxiliary' hearing services could also be reduced, particularly in rural areas, if local community pharmacists played an active role in providing support to improve ear healthcare and broader associated quality of life, especially for indigenous and vulnerable populations. "Globally, Indigenous populations are at a high risk of hearing loss with an estimated 6.1% of the world's population living with hearing loss and an annual cost of unaddressed hearing loss of 750 billion USD" (Taylor et al. 2021, pg.1).

The question was asked to Mr William Neely to clarify what these 'auxiliary' costs precisely consisted of and were they 'hearing impaired' related. The response was, "*these auxiliary services could and in a number of participants would be related to "other" impairments the Applicant has. And the only way to ever narrow that down would be going in to each applicant and looking at their plans. Even then, in many cases it would be impossible to identify if a support is specifically linked to the hearing impairment*" (Neely, 2021).

3.8 Research Question 8 – *"What percentage of hearing loss in Australia is permanent loss, i.e. Not medically treatable?"*

Data answering this question was not readily available, though general insight can be derived from the information at hand.

DAE 2017 follows the World Health Organisation report in estimating preventable childhood hearing loss at 49% and adult preventable hearing loss at 37% (p.4). Of course, while total preventable hearing loss includes hearing loss that is permanent, it also includes the subset that is reversible or treatable. One can assume then that percentage of treatable hearing loss is lower than the percentage of preventable hearing loss.

Several conditions which cause hearing loss are medically treatable. According to the HCIA report:

> "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" (2017, p.9).

It was not possible to find a breakdown of causes of hearing loss which might have provided some indication as to percentage of hearing loss that is treatable.

3.9 Research Question 9 – *"Is there any information regarding the incidence of hearing loss at different levels? E.g. How many people have a 'mild', versus 'moderate', versus 'severe' hearing loss?"*

The HCIA report provides information on prevalence of severity levels of hearing loss (refer to Figure 5).

Figure 5 – Total prevalent cases of hearing loss by severity levels, age and sex

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%)**

3.10 Research Question 10 – *"What is the definition of 'commonly used assistive technology', as used / referred to in the Operational Guidelines for Access 8.3.1?"*

NDIS Rules (Becoming a Participant) 2016 section 5.8(a) states that an impairment results in substantially reduced functional capacity if:

> the person is unable to participate effectively or completely in the activity, or to perform tasks or actions required to undertake or participate effectively or completely in the activity, without assistive technology, equipment (**other than commonly used items such as glasses**) or home modifications.

This is elaborated in the Access Operation Guidelines section 8.3.1 which states:

> By itself, reliance on commonly used items will not result in a substantially reduced functional capacity to participate effectively or completely in an activity. **Commonly used items include glasses, walking sticks, non-slip bath mats, bathroom grab rails, stair rails, age appropriate child safety locks, simple adapted kitchen utensils and dressing aids**.

The NDIA does not have a publicly available definition of "commonly used items" in the sense of a set of necessary and sufficient conditions by which we could determine whether something is "commonly used" or not. A definition may be drawn from the characteristics of the items listed in Access OG 8.3.1.

The list suggests possible interpretations. "Commonly used" might mean:

1. A large portion of the Australian population use the item
2. Something like "commonly available" or "easy to obtain", that is, you could probably purchase it from the chemist, supermarket or hardware store, it is likely to be low cost etc.

There are difficulties with both interpretations. A difficulty with (1) is that there is no formal definition of "a large portion of Australians". The example of glasses can be used, as this is referred to in the Rules. How much less commonly used than glasses does something have to be before it is not commonly used? A walking stick is less commonly used than glasses. How many people have to use an item for it to be commonly used? There are no existing answers to these questions. This interpretation would also not always assist in determining if something counts as commonly used when there is a dearth of data on their use.

(2) Does capture low-cost off-the-shelf items such as glasses with fixed prescriptions or walking sticks. It also makes sense to assume that something available from a supermarket is commonly used. However, it might not capture commonly used but customised items such as specialty prescription glasses, which require consultation with an optometrist and a higher cost than off-the-shelf chemist prescriptions. It might also capture too much, for example, a potential participant requires a low cost off the shelf wheelchair, grab rails, stair rails, walking

stick or walker, non-slip bathmat and several other low-cost items. Together all the items might be quite costly and burdensome to the individual, but because their need is met by commonly used equipment, they may not meet 5.8(a).

4. Recommendations

Wider implications to consider beyond the scope of this research task:

- Statistical analysis of total number of approved versus rejected hearing-impaired applications (provision and funding of hearing aids and auxiliary support services) and whether there any trends regarding source or demographic (both from participant and approver) to assist in identifying any other reasons for the increase in support being granted.
- A closer evaluation any 'interpretation' issues from the perspective of the assessor (one approving the request for support). Does better training need to be undertaken to ensure correct / enhanced assessment of degree of hearing impairment? Could there be misinterpretation of audiograms by the access team?
- Ensuring rigour re the quality of evidence being provided as rationale for eligibility.
- A closer evaluation / investigation into the discrepancy between relatively minimal 'capital' costs in participant's plans, versus the comparatively high budgetary allocation of the 'auxiliary' component of the budgetary provision. In some of the above data, there had been a '$0' allocation of capital provision in the plans, however excessive costs allocated to the 'auxiliary' services (a closer audit potentially recommended, particularly for WA). Is there a logical explanation as to why the 'auxiliary' costs far exceed the costs of the capital equipment (e.g. Presumably being the cost of the hearing aid/s)? (** - investigation is required to determine whether there are other State services which fund hearing aids in the NT).
- Are the 'auxiliary' costs being allocated to participant's plans in fact accurate and entirely 'reasonable and necessary'? And is the criteria being uniformly applied across all states and territories?
- A closer evaluation / investigation into the discrepancy between the budgetary allocations of participant's plans comparing each state / territory (a closer audit potentially recommended, particularly for WA).
- Is compliance for eligibility both correct and robust?
- Commercialisation – are there any external forces / pressures at play which may be influencing participant numbers (e.g. Advertising, incentives etc.) // and / or unconscious bias of the assessor / planner, or 'overestimation' of the amount / extent of 'auxiliary' services required.

- Other underlying factors impacting the increase in Australians presenting with a hearing impairment, such as increased exposure to noisy workplaces (e.g. Construction and building sites and associated OH&S compliance).
- Avoidable hearing loss scenarios. According to the WHO (2021, pg. 1), "Over 1 billion young adults are at risk of permanent, avoidable hearing loss due to unsafe listening practices".
- People with undiagnosed hearing loss, who may eventually seek diagnosis and support (further recommendation to try to determine the extent of those with 'undiagnosed' hearing loss, to determine future predictions as to NDIS support – although may be difficult to quantify).

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6. Version control

Version	Amended by	Brief Description of Change	Status	Date
0.1	AHR908	Draft of section related to prevalence of hearing loss and hearing aids	Draft	22-11-21
1.0	FFM634	Final version	Completed	2-12-21
1.1	FFM634	Final version (with added statistics)	Completed	6-12-21

Mental Health within the deaf population

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Delegates have access to a wide variety of comprehensive guidance material. If Delegates require further information on access or planning matters, they are to call the TAPS line for advice.

The Research Team are unable to ensure that the information listed below provides an accurate & up-to-date snapshot of these matters

Research question: How common is anxiety and depression within the deaf population?

Date: 11/10/2022

Requestor: Jeán s22(1)(a)(ii) - irrelevant

Endorsed by: Jane s22(1)(a)(ii) - irrelev

Researcher: Stephanie s22(1)(a)(ii) - irrelevant mate

Cleared by: Stephanie s22(1)(a)(ii) - irrelevant mat

1. Contents

2. Summary

Accurate information about the prevalence of anxiety and depression in the deaf population is lacking due to a paucity of research focusing on the mental health of this demographic. While there is conflicting research data, it is generally accepted that the deaf population are at higher risk of mental health problems than the general population, which is attributed to the deaf population's greater experience of significant adverse life events including social isolation, childhood and domestic abuse, and poorer educational achievement. Although the deaf population are at higher risk of mental health problems, they also face greater barriers to accessing mental health services than the general population. These barriers faced by the deaf population may affect the diagnosis and effective treatment of mental health problems.

Note: in this paper 'deaf' refers to people with severe or profound hearing loss and have limited oral communication, and 'Deaf' refers to the cultural identify of person who has severe or profound hearing loss and uses sign language as their primary language.

3. Prevalence of anxiety and depression in the deaf population

The prevalence of anxiety and depression is not well studied specifically for the deaf population, and existing research does not always recognise that different causes of deafness may impact mental health differently (Kushalnager et al., 2019; Levine, 2014; National Deaf Center, 2019). Fellinger et al. (2012) notes that the lack of studies regarding prevalence rates of mental disorders in the deaf population may be reflective of the isolation experienced by deaf individuals. Additionally, it is highlighted that the potential for systematic review/meta-analysis to evaluate the current literature is limited by the different assessment tools used, that not all assessment tools are validated for the deaf population, and that cultural misunderstandings may impact assessment of anxiety or depression symptoms (Long et al., 2021; Shoham et al., 2019).

Nonetheless, while there are disparities in the research findings, some papers indicate that mental health problems, such as anxiety, depression, emotional distress and poor self-esteem, are higher in both deaf children and adults compared to the general population (Fellinger et al., 2012; Levine, 2014; Shoham et al., 2019; Wright, 2021). The National Deaf Center (2019) cites research that deaf children and adults are 3-5 times more likely to have a serious emotional disturbance compared to their hearing peers. Further indicating that deafness may be associated with anxiety, it has been found that for some individuals' anxiety level has decreased after surgical intervention to improve hearing (Shoham et al., 2019).

4. Risk factors for mental health disorders in the deaf population

4.1 General risk factors

The experience of adverse events through life results in a greater potential for psychosocial difficulties. The deaf population are exposed to more mental health risk factors compared to the general population, including:

- peer rejection and being bullied as a child (Hall et al., 2017; Levine, 2014; Wright, 2021)
- experiencing greater social isolation (Levine, 2014; Pertz et al., 2018)
- greater incidence of abuse during childhood and domestic abuse in adulthood (Hall et al., 2017; Kvam et al., 2006; Levine, 2014; Wright, 2021)
- poorer educational attainment and greater unemployment (Levine, 2014)
- parental anxiety, depression or over-protection due to the child's deafness (Wright, 2021)
- deaf children who attend mainstream schools may lack a meaningful peer group with whom they can share experiences (Wright, 2021)
- some perinatal infections (e.g., rubella) and syndromal causes of deafness are associated with poor mental health along with other comorbid disability (Fellinger et al., 2012)
- inability to easily communicate with family members and in general (National Deaf Center, 2019)
- poor access to intervention health services (described further in Section 5) (National Deaf Center, 2019; Pertz et al., 2018)

4.2 Language Deprivation Syndrome

While Language Deprivation Syndrome is currently not a recognised diagnosis and has no consensus regarding diagnostic criteria (Glickman et al., 2020), there is an emerging trend in the literature describing the association between language deprivation in the early years with the development of socio-emotional issues as well as cognitive and behavioural problems (Fellinger et al., 2012; Glickman et al., 2020; Hall et al., 2017). The focus of this emerging research are deaf children who grow up without the opportunity to learn native language, including exposure to natural sign language, such that they do not develop the ability communicate fluently (Glickman et al., 2020). It has been suggested that this 'syndrome' may fundamentally be a result of inadequate neural development of environmental origin (Gulati, 2019; Hall et al., 2017).

Children with cochlear implants are not excluded from this 'syndrome', and it is noted that many deaf children with cochlear implants are significantly delayed in language skills despite the implant (Hall et al., 2017). It is speculated by Glickman et al. (2020) that children who are likely to be suitable for cochlear implant may be discouraged from exposure to early childhood sign language, therefore depriving them of foundational language skills.

Guilati (2019) describes some preliminary characteristics noted in a person with 'language deprivation syndrome':

- may superficially appear to use sign language fluently but upon closer inspection show linguistic deficits
- struggles with the concept of time
- struggles with cause and effect
- lack awareness of context in conversation
- lack theory of mind
- struggles with emotional regulation
- struggles with interpersonal relationships.

5. Barriers to mental health care for the deaf population

There is consideration in the literature regarding mental health care, and common barriers to care, for the deaf population. Difficulties accessing mental health care may arise from communication and language barriers, cultural conflict due to clinicians not having adequate training to care for Deaf signers (Pertz et al., 2018), and limited access to Australian Medicare rebated services. Adherence to medical treatment can also be problematic for the deaf population, which may arise from a lack of understanding about the care plan or from cultural differences (Pertz et al., 2018). A lack of information in a primary language can result in poor treatment and post-care that increases the likelihood of further health episodes impacting the individual's health and wellbeing (Boxall, 2021). As noted in Section 3, mental health diagnostic tools are often not validated for the deaf population and are English based, which can provide further barriers to timely diagnosis, or lead to misdiagnosis, and adequate treatment of mental health disorders (Levine, 2014; Shoham et al., 2019).

An additional concern raised by Dr Anne-Marie Boxall, 2021, on behalf of Deaf Australia was the Australian Federal Government's decision to bring the National Auslan Payment and Booking Services system under the NDIS umbrella. According to Dr Boxall, this transition may reduce a deaf individual's access to adequately trained interpreting services within the medical and allied health setting, further exacerbating existing health care barriers for the deaf population.

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Auslan and Mandarin interpreting services in New South Wales

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Research question: What mainstream and community interpreting supports (Auslan, Mandarin) are available for an NDIS participant living in Baulkham Hills, NSW?

Date: 22/3/24

Requestor: Sam s22(1)(a)(ii) - irrelevant m [redacted]

Endorsed by: Jean s22(1)(a)(ii) - irrelevant [redacted]

Researcher: Aaron s22(1)(a)(ii) - irrelevant ma [redacted]

Cleared by: Stephanie s22(1)(a)(ii) - irrelevant mat [redacted]

1. Contents

2. Summary

There are a number of community and mainstream organisations that provide free interpreting supports for people who are Deaf or hard of hearing and people who speak languages other than English, including Mandarin. Services may be provided by an organisation to facilitate contact with its customers or by an interpreting service to facilitate contact between other community organisations and those people requiring support.

Both the Federal government and NSW State government make interpreting services available for direct interaction with government departments and agencies. Some limitations may apply if requesting face-to-face interpreting services due to the availability of interpreters.

There are free national remote interpreting services to assist people who are Deaf or hard of hearing and people who speak languages other than English to communicate with community organisations:

Translating and Interpreting Services (TIS) provides interpreting services for spoken languages other than English. Services are free of charge when communicating with select organisations and community groups. An NDIS provider is responsible for offering and booking an interpreter via TIS to assist participants to utilise their funded supports.

National Relay Service (NRS) provides free interpreting services for people who are Deaf or hard of hearing. Text and voice services are available 24 hours, though Video Relay services have more limited availability.

3. Federal government services

3.1 Translating and Interpreting Services

TIS is a national program providing interpreting services between English and other spoken languages face-to-face, via phone or video. They do not provide Auslan or other signed language interpreting (TIS, n.d.a).

TIS is available to any individual or organisation in Australia. Some services are provided for a fee, though they note "The majority of TIS National interpreting services are free to non-English speakers. Generally, the organisation you are contacting will accept the charges for the service." (TIS, n.d.a). TIS provides free services to certain groups including:

Medical practitioners: when delivering Medicare-rebatable services in private practice. Nurses, reception and other practice support staff can also access the service when working with the registered medical practitioner.

Pharmacies: to provide community pharmacy services.

Non-government organisations: when providing casework and emergency services, where the organisation does not receive substantial government funding to provide these services.

Real estate agencies: to discuss any private residential property matter.

Local government authorities: to communicate about most local government services.

Trade unions: to assist workers to access support and advice.

Parliamentarians: for constituency purposes.

Eligible allied health professionals: when delivering Medicare-rebatable services in private practice within specific local government areas (TIS, n.d.b).

Additional terms and conditions for these groups are described on the TIS Terms and Conditions of use for the Free Interpreting Service (TIS, n.d.c).

NDIA and the NDIS Quality and Safeguards Commission direct NDIS participants to TIS for free interpreting services. An NDIS provider is responsible for offering and booking an interpreter via TIS to assist participants to utilise their funded supports (NDIA, 2022; NDISQSC, 2023).

3.2 National Relay Service

The National Relay Service provides free interpreting services for people who are Deaf or hard of hearing. The NRS provides text based, voice or video services. Text and voice services are available 24 hours a day. Video Relay calls are available 7am-6pm Monday to Friday and 8am-12pm Saturday and not available Sundays or national public holidays (Access Hub, n.d.a). Additional details is described in the factsheet Using the National Relay Service.

3.3 JobAccess

Through the Employment Assistance Fund (EAF), JobAccess can provide funding for Auslan interpreting services for use in the workplace or to assist with finding work (JobAccess, 2022). EAF provides three levels of support for Auslan interpreting services (refer to **Table 1**).

A person will be eligible for EAF if they:

- are an Australian Resident, Temporary Protection Visa holder or a Safe Haven Enterprise Visa holder
- have a job, or letter of offer for a job, that has or will continue for at least 13 weeks
- work at least 8 hours per week or if self-employed, have worked at least 8 hours per week over the last 13 weeks and earn an hourly income that is at least equivalent to the National Minimum Wage
- have an ongoing disability likely to last at least two years, which limits, restricts or impairs their ability to work
- require modification to their workplace to carry out their work as a result of their disability (Job Access, 2024).

Table 1 Funding for Auslan interpreting services through the Employment Assistance Fund (source: JobAccess, 2024)

Level	Includes funding for	Conditions
1	Work-related Auslan interpreting, Remote Interpreting, Captioning, note-taking, interpreter travel time	Maximum $12,498/year Capped funding resets if employee is promoted, transferred or finds other employment
2	Reimbursement for interpreting services for job interviews and related activities	No limit on number of interviews
3	Training for co-workers who require Auslan to communicate with Deaf or hard of hearing employees	$890 per co-worker

3.4 Services Australia

Services Australia provides free interpreting services when calling or when visiting a Services Australia service centre. This includes Auslan and over 200 spoken languages other than English (Services Australia, 2023a). They also have a dedicated multilingual phone service where customers can speak with a multilingual Centrelink officer (Services Australia, 2023b).

4. NSW Government services

Interpreting services required for interactions with NSW government departments or agencies are arranged and paid for by the department or agency. Requests for interpreting services should be made to the relevant department or agency (Multicultural NSW, n.d.).

NSW Health. It is the responsibility of all NSW Health services to make available professional health care interpreters for patients, families and carers who do not speak English as a first language, including people who are Deaf or hard of hearing (NSW Health, 2024). For further detail refer to NSW Health policy Standard Procedures for Working with Health Care Interpreters.

Service NSW. Live captioning services and Auslan video remote interpreting are available at all Service NSW service centres (Service NSW, 2023a-b). Interpreting services for spoken languages other than English are provided by Multicultural NSW Language Services (Service NSW, 2024).

Schools. The Department of Education will fund face-to-face, telephone or video interpreting services for most meetings or interviews for those who do not speak English as a first language, including people who are Deaf or hard of hearing. The Department of Education won't fund interpreting services for events such as graduation ceremonies, performances or excursions, though schools may fund this directly (Department of Education, 2024).

TAFE NSW. Students of TAFE NSW who are Deaf or hard of hearing can access Auslan interpreters and other learning support services (TAFE NSW, n.d.a). Students requiring interpreting services in spoken languages other than English are directed to Translating and Interpreting Services or Multicultural NSW Language Services. Some TAFE NSW service centres may have community language specialists who can speak to the student in their preferred language (TAFE NSW, n.d.b).

Housing. Department of Communities and Justice (DCJ) provides free language services for people requiring assistance or information about housing. This includes Auslan and spoken languages other than English (DCJ, 2020; 2023b). DCJ Housing offices have fac-to-face Mandarin interpreters available at scheduled times according to the Block Booking Interpreting Service:

- Burwood, Monday, 1pm-4pm
- City, Monday and Thursday, 1pm-4pm

- Riverwood, Tuesday, 9am-12pm
- Surry Hills, Tuesday, 1pm-4pm
- Hurstville, Thursday, 1pm-4pm
- Waterloo, Thursday, 9am-12pm
- Parramatta, Friday, 9am-12pm (DCJ, 2020).

Courts and tribunals. A court or tribunal is responsible for booking and funding interpreters for criminal proceedings, matters relating to an Apprehended Violence Order, NSW Civil and Administrative Tribunal proceedings, and proceedings in the Children's Court, Coroner's Court or Industrial Relations Commission (DCJ, 2023a).

4.1 Multicultural NSW Language Services

Multicultural NSW provides face-to-face, telephone and video interpreting services, including Auslan interpreting and specialist medical and legal interpreting for NSW Government departments and agencies and services related to the activities of the NSW Government (Multicultural NSW, 2023a-b; n.d.).

When not related to direct interaction with NSW Government department or agency, services may incur a fee. Multicultural NSW offers fee exemptions in some circumstances (Multicultural NSW, 2023a-b). Exemptions are offered:

- on a case-by-case basis
- based on resource availability
- for activities related to NSW Government activities or services
- for organisations registered with Multicultural NSW
- only for interview-type situations (Multicultural NSW, n.d.).

Fee exemptions are not offered for:

- workshops, information sessions or conferences
- most civil legal matters
- issues outside the jurisdiction of NSW Government (e.g. issues related to compensation, social security, family court, non-payment of debts) (Multicultural NSW, n.d.).

Emergency interpreting services or cases involving severe hardship may be granted an exemption on a case-by-case basis. Services required by Community Legal Centres may be eligible for fee exemption even if matters overlap with jurisdiction of local, federal or other state governments (Multicultural NSW, n.d.).

Usually, registered organisations should submit requests for fee exemptions at least 5 days before the service is required. Organisations can register for a fee exemption if the organisation:

- is non-profit making
- is non-government
- provides services to people from a non-English speaking background in NSW
- does not have access to funding for appropriate interpreter services from another funding body or service provider (e.g. TIS, other State or Federal government department or agency)
- is not funding primarily by either Commonwealth or Local governments (Multicultural NSW, n.d.).

5. Non-government services

National Auslan Interpreter Booking Service. National Auslan Interpreter Booking Service (NABS) provides Auslan interpreting to NDIS participants and the general public. It is a paid service for NDIS participants and for people aged under 65 years. NABS provides free interpreting services Aboriginal and Torres Strait Islander people and for people aged over 65 years with no NDIS plan to attend medical appointments (NABS, n.d.a-b).

Deaf Connect. Deaf Connect provides a range of services for the Deaf community. Interpreting is provided as a paid service, though they offer Auslan and live captioning free of charge to people aged over 65 years (and over 50 years for Aboriginal and Torres Strait Islander people) (Deaf Connect, n.d.).

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