Comparative review of reported outcomes from interventions for children with hearing loss
First Voice
Final literature review
5 January 2017
## Glossary

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AOT</td>
<td>auditory-oral therapy</td>
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<tr>
<td>ASL</td>
<td>American Sign Language</td>
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<tr>
<td>AVT</td>
<td>auditory-verbal therapy</td>
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<tr>
<td>ECIA</td>
<td>Early Childhood Intervention Australia</td>
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<tr>
<td>JCIH</td>
<td>Joint Committee on Infant Hearing</td>
</tr>
<tr>
<td>LOCHI</td>
<td>Longitudinal Outcomes of Children with Hearing Impairment</td>
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<tr>
<td>LSL</td>
<td>listening and spoken language</td>
</tr>
<tr>
<td>PCHI</td>
<td>permanent childhood hearing impairment</td>
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<tr>
<td>SSD</td>
<td>Sign Supported Dutch</td>
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</tbody>
</table>
Comparative review of reported outcomes from interventions for children with hearing loss

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Executive summary

First Voice commissioned Deloitte Access Economics to undertake a literature review of the measureable outcomes arising from different communication learning pathways for children who are deaf or hearing impaired. The purpose of the review was to ascertain the effectiveness of the listening and spoken language approach provided by First Voice centres for children who are deaf or hearing impaired compared with other models of learning language. Findings also serve to inform the subsequent cost benefit analysis.

The context for the review is the introduction of a ‘disability services market’ under the new National Disability Insurance Scheme (NDIS) in Australia. An essential prerequisite for any market to succeed is reliable and accessible information. This is required both to enable consumers to make informed decisions and for the funding authority (in this case the Commonwealth Government National Disability Insurance Agency (NDIA)) to ensure that public funding for early intervention programs is directed through eligible NDIS participants to evidence-based providers with proven outcomes.

First Voice is the national voice for six member organisations whose primary focus is the provision of listening and spoken language (LSL) therapy services in Australia and New Zealand. Each organisation provides early intervention services to develop listening and spoken language skills in children and infants who are deaf and hearing impaired. This is a family-based, multi-disciplinary model which predominantly utilises auditory-verbal therapy and auditory-oral approaches.

The approach adopted for the review comprised seven key steps, as outlined in Figure i.

The measureable outcomes of interest for hearing-impaired children are outlined in Section 4. These were:
- Early development outcomes (communication, speech, language)
- Learning outcomes (school and post-secondary)
- Life-long social and wellbeing outcomes.

These outcomes align with parents’ aspirations for their child, service provider objectives, and the goal of the NDIS “to optimise the social and economic independence of people with disabilities”.

Most information retrieved related to early development speech and language endpoints. Across the broad range of articles retrieved, some common shortfalls were observed. These were small sample sizes, a reliance on self-reported data, no comparison group and the retrospective nature of studies. Put simply, evidence-based literature with a strong study design and demonstrated sustained effect at least one year beyond intervention was not found.

The available evidence shows that the most effective pathway for hearing-impaired children in bringing about early development and schooling outcomes is early intervention in the context of a multi-disciplinary team and with high levels of family involvement.

A multi-disciplinary approach is seen as vital to the development of children with hearing loss. This is because of the complexity of developing fluent communication in pre-lingual children who are deaf or hearing impaired and the need for shared expertise and close collaboration between the key disciplines of spoken language therapy, paediatric audiology, speech pathology, deaf education, family counselling and relevant disciplines.

Figure i: Literature review methodology

Steps

1. Define research questions
2. Identify key search terms
3. Systematically apply search criteria to search engines
4. Identify relevant reports
5. Read and note contents, begins organising into themes
6. Using themes, develop report structure and undertake drafting
7. Iteratively review and refine draft
medical sciences. This is even more the case in assisting hearing-impaired children with additional needs. Given the significant impact of family on a child’s development, a family-based practice also means learning and support is more likely to be sustained.

With regard to early development and learning outcomes, evidence supports the listening and spoken language approach (auditory-verbal therapy and auditory-oral therapy) as an effective therapy. Given that the vast majority of children with hearing loss are born to parents who hear and speak, this is an important finding.

– Deloitte Access Economics

These outcomes align with parents’ aspirations for their child, service provider objectives, and the goal of the NDIS “to optimise the social and economic independence of people with disabilities”.

First Voice centres are located across Australia and New Zealand. These centres provide listening and spoken language early childhood intervention programs for children who are deaf or hard of hearing and their families. Services provided by First Voice centres are family-based and delivered by highly skilled multi-disciplinary teams of health and education professionals. Services are strongly focused on developing children's communication and social outcomes.

After three years of trials, the National Disability Insurance Scheme (NDIS) is now moving into full scheme implementation. In August 2016, many aspects of eligibility, access, services and funding are yet to be determined. The overall aim of the NDIS is to optimise the social and economic independence of people with disabilities. The scheme is based on 'the insurance principle' and places a premium on the principles of participant choice and control, funding for reasonable and necessary supports, evidence-based practice, early intervention (including childhood intervention) and value-for-money.

In June 2016 First Voice commissioned Deloitte Access Economics to undertake a literature review in regard to published outcomes of different approaches to developing communication in hearing-impaired children in the context of the still-evolving NDIS.

The Project brief called for a targeted literature search focusing on:

- Communication, learning, social participation and later outcomes for hearing-impaired children undertaking listening and spoken language, and other, early childhood intervention
- Any significant factors influencing outcomes such as a multi-disciplinary team approach and family-based practice.

The Literature Review also serves to inform the subsequent social and cost benefit analysis study.

**1.1 First Voice**

First Voice is the national voice for member organisations whose primary focus is the provision of listening and spoken language therapy services in Australia and New Zealand. Member organisations include:

- Cora Barclay Centre, South Australia
- Hear and Say, Queensland
- Taralye, Victoria
- Telethon Speech & Hearing, Western Australia
- The Shepherd Centre, New South Wales and Australian Capital Territory
- The Hearing House, New Zealand.

**Figure 1.1: First voice centres**

![First Voice Centres Map]
First Voice champions the right of all deaf people to listen and speak, and campaigns for first rate early intervention services for children who are deaf or hearing impaired.¹

First Voice members provide family-centred, multi-disciplinary early childhood intervention services to develop listening and spoken language skills in deaf and hearing-impaired infants and children. This is a parent-based model of therapy, where one or both parents are taught how to teach their hearing-impaired child to listen and speak. Parents are taught how to create and use a listening and learning environment in the home and elsewhere so that their child can develop spoken language using their ‘aided’ hearing.²

First Voice services and programs are provided by multi-disciplinary teams of health and education professionals including:

- listening and spoken language specialists (internationally certified by the Alexander Graham Bell Listening and Spoken Language Academy)
- speech pathologists
- paediatric audiologists
- teachers of the deaf
- psychologists, family counsellors, social workers and youth workers
- early childhood educators
- occupational therapists
- paediatric ear nose and throat surgeons, paediatricians, and other relevant medical practitioners.

The First Voice model has a strong focus on family-centred practice. This ensures that the family is involved throughout the intervention and that there is collaboration between the multi-disciplinary team and the family. Within the intervention services, intensive counselling for the parents is provided, along with education sessions which aim to provide the parents with information about the intervention approach as well as other topics of importance. Both intensive and comprehensive services are provided to families to ensure the child is supported in their family environment.

A number of children who are hearing impaired may also have additional disabilities. In these cases First Voice will work with other agencies and the child’s family to ensure the child’s needs are being met.

In addition to regular AVT sessions and parent education, children and families have access to family counselling and support; a range of music, play and language groups; on-site audiology and cochlear implant support services; supplementary speech pathology; and a range of additional health and educational specialists as and when required.

Home-based therapy is provided to families who prefer this as well as therapy via video-conferencing and tele-audiology, for children and families living in regional, rural and remote areas.

Hallmarks of First Voice practice include:

1. Annual assessment of each child’s receptive and expressive vocabulary and speech articulation to inform clinical case management
2. Annual publication of consolidated children’s outcomes data (over 700 children)
3. A strong commitment to research and development.

In addition to their early childhood intervention programs, different First Voice members provide a range of other services and programs; key examples include:

1. Intensive transition to school programs
2. Hearing implant services
3. Services to school-age children
4. Peer support programs
5. Community hearing screening and audiology.

1. www.firstvoice.org.au
Comparative review of reported outcomes from interventions for children with hearing loss

1.2 Childhood hearing loss in Australia

Although the exact number of babies born each year in Australia with congenital permanent childhood hearing impairment (PCHI) is unknown, Australian Hearing estimates that between nine and 12 children per 10,000 live births will be born with moderate or greater hearing loss in both ears. This equates to an incidence of between 275 and 366 children in 2015. A further 2.3 children per 1,000 will acquire hearing impairment before the age of 17 (which necessitates hearing aids).4

Australia offers a universal neonatal screening program which comprises a simple, non-invasive hearing test, most commonly offered within the first few days of birth. About half of all children born with a hearing loss have no known risk factors. Known causes of congenital hearing loss include genetics, maternal infections during pregnancy such as rubella or syphilis, low birth weight, hypoxia at the time of birth, and certain medications during pregnancy (World Health Organisation 2015).

A plethora of evidence (such as Kennedy et al. 2006 and Yoshinaga-Itano 2004) has demonstrated that detecting hearing impairment early (ideally within the first six months of life) and providing immediate and effective interventions leads to better outcomes for children. There are in fact a number of different language development pathways that children with hearing loss can take, and evidence demonstrates than when an efficacious intervention is offered consistently during the first years of life, this will help both families and children, as well as decrease costs to society (ECIA, 2016).

Programs for infants and children who are deaf or hearing impaired typically work in tandem with devices which amplify sound and stimulate residual hearing. Studies have shown that for children with severe or profound hearing loss, cochlear implantation before 12 months of age brings about significantly more developed language skills than delaying the procedure (Colletti et al, 2011). Australian Rod Saunders was the world’s first cochlear implant recipient in 1978 with the first paediatric patients receiving implants in 1985.5 Now more than 10,000 adults and children in Australia are using cochlear implants and the requisite surgery is considered a routine procedure, performed in around two hours. A team of health professionals, including audiologists and medical specialists, assess the suitability of hearing impaired candidates for implantation and/or other devices including hearing aids.

1.2.1 Current service delivery framework

Through the combined efforts of all levels of government, Australia is a world leader in the planning and provision of services and supports to children who are deaf or hard of hearing. Current arrangements include:

1. Early detection through universal neonatal hearing screening
2. Prompt confirmation of diagnosis and referral to Australian Hearing, Australia’s expert provider of paediatric audiology and hearing aids for all Australian children up to the age of 26 years
3. Fitting of free hearing aids within 8 to 12 weeks of diagnosis by Australian Hearing
4. Cost-free access across Australia to cochlear implants for children when clinically appropriate
5. Timely and effective referral (in most states/territories) to early childhood intervention programs for the development of communication, generally within the international/national guideline of less than six months
6. Access throughout Australia to high-quality, multi-disciplinary, family-centred listening and spoken language early intervention providers
7. World leading research and research collaborations through the Australian Government; Hearing CRC; Macquarie University Hearing Hub; other universities; and leading service providers including First Voice centres.

These arrangements are formed and guided by the 2013 National Framework for Neonatal Hearing Screening6 and consistent with the internationally acknowledged Supplement to the American Academy of Paediatrics, Joint Committee on Infant Hearing (JCIH) 2007 Position Statement; Principles and Guidelines for Early Intervention after Confirmation that a Child Is Deaf or Hard of Hearing.7

The approach adopted in Australia also ensures that children who are deaf or hard of hearing have the greatest possible access to sound (including all the sounds of the speech spectrum) in the shortest possible time, thereby providing a platform for the development of speech and language through audition.

7. http://pediatrics.aappublications.org/content/120/4/898
1.3 This project
First Voice commissioned Deloitte Access Economics to undertake a comprehensive literature review which will be used to inform a subsequent cost-benefit analysis. The purpose of the literature review (this report) was to examine the effectiveness of the First Voice multi-disciplinary approach compared to other models of intervention in achieving measurable outcomes.

The scope of this review was limited to a focus on research findings regarding the outcomes of interventions designed to commence early in the life of children diagnosed with hearing loss. It has not considered other issues, such as access or equity.

The review involved seven key steps:

1. Define research questions
2. Identify key search terms
3. Systematically apply search criteria to search engines
4. Identify relevant reports
5. Read and note contents, begins organising into themes
6. Using themes, develop report structure and undertake drafting
7. Iteratively review and refine draft
In the first instance, research questions were defined. These are shown in Figure 1.2.

**Figure 1.2: Research questions**

- What are the outcomes of multidisciplinary early interventions for children with hearing loss?
- What are the costs of providing instructions?
- Are these interventions effective?
- What is the comparator used in the studies?
- What other interventions should be considered?
- What are the outcomes of these models?

Search terms were identified in collaboration with First Voice. These are listed in Table 1.1. The overall search strategy was to concentrate on meta-analyses and systematic reviews to ensure overall effectiveness of an intervention was established. Then, individual trials within the included studies were retrieved to obtain data on specific outcomes and interventions.

Table 1.2 presents an example of the terms used in the literature search for each of the interventions.

**Table 1.1: Search terms for the review**

- Parent-based model
- Hearing impairment
- Deaf
- Hearing loss
- Hard of hearing
- Unilateral hearing loss
- Bilateral hearing loss
- Sign only
- Early intervention
- Cued speech
- Lip reading
- Total communication
- Auditory-verbal therapy
- Oral-aural
- Native sign
- Meta analysis
- Literature review
- Speech reading
- Bilingual-bicultural
- Multi-disciplinary
- Interagency
- Outcomes
- Systematic review
- Auditory-oral.
A targeted search of the following references was conducted:

- PubMed, Google Scholar and the Cochrane Library (for published papers using search terms listed in Table 1.1)
- Papers provided, or suggested by First Voice; and
- Past work done by Deloitte Access Economics related to hearing impairment such as Listen Hear: The Economic Impact and Cost of Hearing Loss in Australia.

Relevant works were identified, read and pertinent information organised into themes. The interventions of interest were compared and contrasted in relation to the main research outcomes and findings drawn together into a complete review.

### 1.4 Report structure
The remainder of this report is structured as follows:

- Section 2 – Pathways for children with hearing loss
- Section 3 – Common characteristics of early interventions
- Section 4 – Overview of findings
- References.
2 Pathways for children with hearing loss

In essence, there are four main language development pathways that infants with hearing impairment can follow.

- **Listening and spoken language therapies (which includes auditory-verbal and auditory-oral therapies)**
- **Total communication approaches**
- **Therapies with sign language components**
- **Cued speech.**

However, the pathways have some overlapping characteristics and may be used in conjunction with each other. For example, total communication embraces a variety of communication methods which may also be used in alternate approaches. One such method is signed English, which is also a component of signed language focused therapies. Additionally, a multi-disciplinary approach may be adopted by each pathway and this has been discussed separately.

These pathways may also include the use of aids to enable the child to access sound. For the listening and spoken language pathway, a critical feature is the optimal use of aids to provide the best possible access to sound. These aids include:

- Hearing aids
- Cochlear implants (also middle ear and bone conduction implants)
- Brain stem implants
- Assistive mechanisms.

Family involvement and collaboration is desirable across all pathways.

There are two broad cultural perspectives on interventions for children with hearing impairment. Access Economics (2006) described these as the medical-disability model and cultural-linguistic model. Proponents of the first model, particularly hearing parents whose children are born deaf, often identify with hearing culture. Parents seek to help their child integrate into the hearing community and wish for their child to have similar life opportunities as their hearing counterparts.

By comparison, under the cultural-linguistic model, deafness is viewed with a sense of pride and as a unique cultural linguistic experience. Members of this community commonly use sign language to communicate and may not pursue treatments to improve their speaking or hearing ability. Individuals identity as a deaf person, and do not view the hearing loss as something requiring a clinical intervention.

The remainder of this section provides detail about each of the pathways listed above.
2.1 Listening and spoken language
Therapies to improve listening and speaking skills in hearing-impaired children include AVT and auditory-oral therapy (AOT). The aim of this pathway is for the child to learn spoken language. As a result of this, aids and modifications are essential to the listening and spoken language pathway. The First Voice model falls into the listening and spoken language category as a result of its use of AVT and AOT.

2.1.1 Auditory-verbal therapy (AVT)
AVT is an intensive early intervention approach which aims to teach children with hearing loss how to listen, understand spoken language and speak. This is done in conjunction with amplifying their residual hearing with aids and implants. AVT may or may not be a multi-disciplinary approach (Australian Hearing, 2005).

Principles of AVT are set out by the AG Bell Academy for Listening and Spoken Language. These are:
1. Promote early diagnosis of hearing loss in newborns, infants, toddlers, and young children, followed by immediate audiologic management and AVT
2. Recommend immediate assessment and use of appropriate, state-of-the-art hearing technology to obtain maximum benefits of auditory stimulation
3. Guide and coach parents to help their child use hearing as the primary sensory modality in developing listening and spoken language
4. Guide and coach parents to become the primary facilitators of their child’s listening and spoken language development through active consistent participation in individualised AVT
5. Guide and coach parents to create environments that support listening for the acquisition of spoken language throughout the child’s daily activities
6. Guide and coach parents to help their child integrate listening and spoken language into all aspects of the child’s life
7. Guide and coach parents to use natural developmental patterns of audition, speech, language, cognition, and communication
8. Guide and coach parents to help their child self-monitor spoken language through listening.
9. Administer ongoing formal and informal diagnostic assessments to develop individualised AVT plans, to monitor progress and to evaluate the effectiveness of the plans for the child and family
10. Promote education in regular schools with peers who have typical hearing and with appropriate services from early childhood onwards.

This method seeks to assist children to participate more fully in the hearing world, including mainstream schools, and in communicating with their parents, recognising that nine out of ten babies with a hearing impairment are born to hearing parents.10

2.1.2 Auditory oral therapy (AOT)
AOT aims to teach deaf children to speak and lip read, with the help of aids and modifications such as cochlear implants. This method focuses on speaking and sound production unlike the AVT approach which places greater importance on listening (Gravel et al. 2003). Unlike AVT, this method also might use lip reading, facial expressions and natural gestures, but does not involve signed language. This pathway seeks to enable individuals with hearing impairment to function independently in the hearing world, including attending mainstream schools and engaging in social interaction opportunities similar to those of their hearing peers.

2.2 Total communication
Total communication comprises a variety of communication methods including speech, lip-reading, listening, formal signing and finger spelling. Simultaneous communication is a form of total communication.

These methods may be used alone, or in combination with each other and alongside hearing aids and/or cochlear implants to amplify residual hearing (Australian Hearing, 2005). Children using total communication may use more sign language, more spoken language, or a similar amount of each (Fletcher 2013). The signed system used in a Total Communication method is signed English as Auslan has a considerably different grammatical structure.

9. Audiologic infers relating to audiology, the study of hearing impairment and care of individuals with a hearing disorder
The purpose of this approach is to enable children who are deaf or hearing impaired to communicate through all available modalities and to make interactions flexible, whereby the individual can adopt whichever mode of communication is most appropriate for the situation.

Some parents elect this approach for their child to provide them with an opportunity to assume a cultural identity as part of the deaf community (Hyde and Power, 2005) whilst aiding their integration into a hearing society. Parents need to learn sign language and in the home environment are encouraged to use sign language in conjunction with clear, visible speech. The child then uses any hearing capability, signs and lip reading for communication. In practice, it is difficult to sign and speak simultaneously and parts of either form of communication may be left out, thus making communication more cumbersome.

2.3 Sign language
Auslan, or Australian sign language, is the primary language of the Australian deaf community. Auslan is a unique language with a distinct grammatical structure. Often children of deaf parents learn Auslan as their first language and, naturally, parents choosing this approach for their infant are required to learn this sign language.

In 1991 the Australian government recognised Auslan as the principal means of communication within the Australian deaf community and an indigenous Australian language (Dawkins 1991). For deaf people who communicate using Auslan, English is taught as a second language through reading, writing or sign systems (Australian Hearing, 2005). Signed English is rarely used by deaf adults. Schools may use signed English to help a child’s understanding of the English language whereby the signing plus finger spelling exactly replicates what is spoken. These interventions are referred to as bilingual-bicultural programs.

2.4 Cued speech
This pathway uses hand shapes, hand positions and lip reading to communicate. The hand shapes are specific to cued speech and represent different consonants and vowels are distinguished by placement of the hand (Gravel et al. 2013). The signed movements are different to those used in Auslan.

Sometimes this intervention is referred to as a total communication pathway due to the various techniques used in the intervention, while other times this pathway might be grouped with AVT and AOT due to the focus on language development. For this report’s purposes it is treated separately as literature was retrieved which explicitly referred to the cued speech pathway.

It should be noted that cued speech is rarely used in isolation and is normally used with other pathways. Cued speech is also rarely used in Australia (Aussie Deaf Kids, 2015).
2.5 Summary

Table 2.1 provides a summary of the main characteristics of each approach. Each of the pathways may also involve the use of devices such as hearing aids or cochlear implants. In some pathways, such as AVT and AOT, the use of devices is a critical component of the pathway for the child.

Table 2.1: Summary of defining characteristics of different pathways

<table>
<thead>
<tr>
<th></th>
<th>Auditory-verbal therapy</th>
<th>Auditory-oral therapy</th>
<th>Total communication</th>
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<th>Cued speech</th>
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<td>Finger spelling</td>
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<td>equivalent) second language</td>
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<td>Hearing aids and/or implants</td>
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3 Common characteristics of successful interventions for hearing impaired children

This section discusses components of interventions that have been found to result in positive outcomes for children. These characteristics may be factored into any pathway for a child with hearing loss.

3.1 Multi-disciplinary team
A multi-disciplinary approach is where professionals from a variety of fields work together to provide services to a child with hearing loss. The professionals who are involved in this process are referred to as a multi-disciplinary team. The specialists who may be included in a multi-disciplinary team for children who are deaf or hearing impaired are listed in Section 1.1.

A multi-disciplinary approach acknowledges that children who have hearing loss may potentially have a range of comorbidities along with their hearing loss such as cognitive impairment plus communication challenges at school and within the family unit.

Each pathway included in this section may be provided in a multi-disciplinary setting and therefore multi-disciplinary is not viewed as a separate pathway, or as a mutually exclusive intervention. As an example, most interventions include family counselling and can therefore be deemed multi-disciplinary.

Sydney Children’s Hospital, Randwick, adopts a multi-disciplinary approach in its Hearing Support Service clinic for children and babies who have a recent diagnosis of a permanent hearing loss, as does the Deafness Centre within The Children’s Hospital at Westmead.

3.2 Family-based practices
Early intervention with family involvement is crucial for a child's development. Early intervention has found to be more successful when family is involved in the intervention and at the beginning of the intervention so that a solid foundation for the child is developed and can then be maintained.

This approach recognises that family is the primary influencer on children's learning and development. A child may undergo an early intervention program, but this program may only consist of a child having exposure to a professional for a few hours each week. The family of a child therefore plays a crucial role in ensuring that what a child learns in their early intervention program is implemented in their day to day lives. To do this, the family must have adequate knowledge of the early intervention objectives and teachings so that they may guide and support their child.

Family-based practice involves the collaboration between the family of the child and the professionals involved in delivering the intervention. This may involve the family attending therapy sessions with their child, and/or having a separate session with the professional working with their child to discuss the early intervention.

Early Childhood Intervention Australia (ECIA) is a government funded organisation which represents professionals and organisations that provide early intervention services. ECIA created a Best Practice Guide for early childhood intervention practitioners on how to become more inclusive in their practices. This publication arose from recent findings that showed inclusive interventions have positive outcomes for children. At the core of this guide is family-based practice. Many elements of the guide focus on discussing family matters that may impact the child, and how to communicate with the family about the child’s needs (ECIA, 2014).
The outcomes most commonly reported in the retrieved papers, and therefore the focus of this review, were:

• Early development outcomes (speech, language)
• Learning outcomes (school and post-secondary)
• Social and wellbeing outcomes.

Information or study gaps were identified. Although articles provided an indication of outcomes, evidence was limited and no well-controlled prospective studies were found.

Across the broad range of articles retrieved, some common shortfalls were observed, namely:

• Small sample sizes
• Reliance on self-reported data
• No comparison group
• Retrospective studies.

Additionally, given the widespread use of cochlear implants and/or hearing aids, most papers studied the impact of different therapies in combination with these devices. Whilst this reflects current practice, it makes attributing outcomes exclusively to the pathways of interest (outlined in Section 2) more uncertain because the presence of implants and/or aids confounds analysis of other interventions in isolation.

Systematic reviews and meta analyses of interventions for children who are deaf or hearing impaired were desired however a number of those retrieved concluded there was insufficient or minimal evidence to assure the outcomes of AVT. A similar challenge existed for the other interventions.

These shortcomings compromise the robustness of findings and the ability to extrapolate them to the Australian context. To take these factors into account, findings have been presented along with an indicator of the strength of the finding. This indicator is based on the rankings that Eriks-Brophy (2004) and Dornan et al. (2008) adopted in their literature review which were derived from the strength of the article’s methodology. The strength of the literature has been assigned one of the following levels:

• Promising practice: shows some research on outcomes and is non-experimental in design. Includes articles which use questionnaires, case studies or group judgements
• Evidence informed: evidence of effect with a strong research design, defined as experimental (randomised) or quasi experimental (match control groups)
• Evidence based: evidence of effect with a strong research design and sustained effect at least one year beyond treatment.

High level findings are presented in Table 4.1, along with the strength of the evidence – noting that no ‘evidence based’ information was found, as per the highest tier above. Further detail is provided in the sections that follow.
**Table 4.1: Summary of defining characteristics of different pathways**

<table>
<thead>
<tr>
<th>Intervention</th>
<th>Early development</th>
<th>Learning and later outcomes</th>
<th>Social and wellbeing outcomes</th>
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<tr>
<td>Total communication</td>
<td><img src="icon" alt="Early development" /> <img src="icon" alt="Learning and later outcomes" /> <img src="icon" alt="Social and wellbeing outcomes" /></td>
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<td>Cued speech</td>
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<td>Sign language</td>
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<td>Multi-disciplinary</td>
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**Strength of evidence**
- ![Promising practice](icon)
- ![Evidence informed](icon)
- ![Evidence based](icon)

**Outcomes**
- ![Positive impact](icon)
- ![Neutral or mixed feelings](icon)
- ![No information](icon)
4.1 Variables that impact outcomes

It is noted that a number of factors impact the outcomes for children with hearing impairment. A literature review performed by the Centre for Allied Health Evidence (2007) appraised all available evidence concerning variables that influence outcomes for children who have hearing loss. The study identified the following parameters that influence outcomes:

- Age at onset of hearing loss
- Age at implantation
- Duration of hearing loss
- Age at detection of hearing loss
- Educational factors (whether the child is in mainstream education or special education).

The study also highlighted a number of variables that potentially influence outcomes. The study describes these variables as ‘potentially’ influencing outcomes because the articles reviewed either had conflicting results, or there was a limited research on the variable. A selection of the variables that potentially influence outcomes are:

- Socioeconomic status
- Gender
- Parental communication
- Family structure
- Comorbidities
- Cause of hearing loss.

Outcomes from the prospective Australian Longitudinal Outcomes of Children with Hearing Impairment study concurred with these findings. Ching (2015) reported that at three years of age study participants who had received earlier implantation displayed superior language outcomes. By five years of age strong, clear evidence was found that earlier age at intervention was associated with better outcomes such as better language outcomes. Other factors associated with higher language scores were higher maternal education, use of an oral mode of communication, and the absence of additional disabilities.
4.2 Early development outcomes

Outcomes within this section focus on communication outcomes of children who are in preschool or prior to starting primary school (typically children under the age of five). The section is divided into studies that reported findings which were positive, neutral or mixed and negative.

As noted earlier, literature focused on interventions for children with hearing loss suffers from a number of methodological issues. However, some interventions appear to be better than others with respect to the outcomes of interest. Whilst the available literature revealed mixed results, AVT and AOT were mostly shown to have a greater impact on language and speech outcomes than total communication programs and bilingual-bicultural programs. When total communication programs and bilingual-bicultural programs were compared, outcomes were superior in the total communication programs.

4.2.1 Positive findings

A systematic review of the literature undertaken by Kaipa and Danser (2016) found that AVT had a positive impact on speech perception abilities. The review found two studies (Sahli and Belgin 2011 and Fairgray et al. 2010) which reported a positive change in the speech perception abilities of children who were receiving AVT. Both studies found that speech perception scores of children post AVT were higher than before AVT. However, Kaipa and Danser (2016) criticised these studies for not including a control group.

Another study that looked at the speech and language outcomes of children who underwent AVT was Diller et al. (2001). At the end of this study 50.5% of children in the sample had hearing level similar to children with normal hearing and 48.4% had level of speech and language similar to children with normal hearing. Diller et al. (2001) had 103 children in their study who were all under the age of 24 months. This study tested children in three different time periods using questionnaires.

Eriks-Brophy (2004) and Dornan et al. (2008) performed a review of all AVT literature. These reviews found that children who were enrolled in AVT were able to make substantial progress in the development of speech, language, and reading skills. The first of these published articles, Eriks-Brophy (2004) found seven appropriate articles that report on AVT outcomes. The author concluded that the available evidence supports AVT and the potential positive outcomes for speech, language and reading. However, there were a number of issues with available evidence. Mainly that evidence was retrospective, based on small sample sizes and unable to be compared due to a number of different outcomes being measured in the literature. As a result, Eriks-Brophy called for future research to be more collaborative and sophisticated.

Dornan et al. (2008) came to a similar conclusion as Eriks-Brophy (2004) and found that existing literature demonstrated the potential for speech and language development with AVT, but the articles suffered from methodological issues. Dornan et al. (2008) also noted that children receiving other forms of interventions also have positive outcomes, but the benefits are greater for children in oral programs than programs that include sign language.

Other than the rate of language development, Dornan et al. (2010) also looked at speech and language outcomes, reading and mathematical ability and self-esteem of children. In all areas, the Dornan et al. (2010) study found that children who underwent AVT did not have statistically significant different results from hearing children in speech, language and self-esteem.

A literature review conducted by Econtext (2011) found a variety of articles that discuss the outcomes of AVT. One such study by the University of Michigan (Heavner K et al 2006) which found that speech and language outcomes for AVT in children with cochlear implants were superior to those compared to total communication and oral communication methods. According to Econtext (2011) the University of Michigan was so convinced by these results, specialists there began to recommend AVT to parents over other interventions.

Positive AVT outcomes were also reported in another study by Percy-Smith et al. (2010). This study found that children who used auditory-verbal as a mode of communication were more likely to achieve a high score on a phonological test compared to children who used auditory-oral or total communication modes of communication. The authors also found that the children in the auditory-verbal group performed better than those children who were exposed to aural-oral or total communication in terms of language abilities. The study included 155 children and all children had cochlear implants. The average age that children underwent cochlear implantation was 19.6 months. To analyse speech production, the authors had the children read out different words. The speech of the children was then assessed for phoneme accuracy of vowels and consonants. To measure language ability the authors used the Reynell Developmental Language Scales, a tool used by therapists to study a child’s speech and language, and also a Danish vocabulary test called ‘vibord materilet’. One shortcoming of the Percy-Smith et al. (2010) study was the absence of a comparator group with normal hearing, as highlighted by Fletcher (2013).
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Another study by Dettman et al. (2013) compared children who used auditory-verbal, auditory-oral and bilingual-bicultural communication. The results of this study found that children who used auditory-verbal and auditory-oral communication had better speech perception and language outcomes than those children who used bilingual-bicultural communication. The rate of language growth for the three groups was 1.1, 1.2 and 0.7 for auditory-verbal, aural-oral and bilingual-bicultural respectively (1.0 is defined as the normal rate for all children). Results for a speech perception test showed that mean phoneme score for the auditory-verbal, aural-oral and bilingual-bicultural groups were 81%, 74% and 57% respectively. These results indicate that in terms of language and speech perception outcomes, children who use auditory-verbal modes of communication and aural-oral modes of communication outperformed children who use bilingual-bicultural modes of communication.

The Dettman (2013) study included eight children in the auditory-verbal group, 23 in the aural-oral and eight in the bilingual-bicultural group. The authors used the Peabody Picture Vocabulary Test to assess language outcomes of children. To assess speech perception outcomes the authors had the children repeat words from a consonant-nucleus-consonant word list and sentences from the Bench-Kowal-Bamford Sentence Test. One criticism of this study identified by Fletcher (2013) was that the mean age of the three groups differed. The mean ages of the auditory-verbal, aural-oral and bilingual-bicultural groups were 6.2, 4.9 and 4.9 respectively. Fletcher (2013) emphasised that age will impact the results as older children will have more developed skills.

A study by Archbold et al. (2000) also compared outcomes of children who underwent oral communication approaches to those who underwent total communication approaches with a focus on signed language. This study found that children in the oral communication setting outperformed those that used total communication approaches in terms of speech intelligibility. This study analysed children’s outcomes at three, four and five years post implantation and comprised of 46 children. An issue with this study was the small sample size of cohorts as time progressed. Although the sample size was initially 46, some results are based on sample sizes as small as seven.

A more recent review by Sarant (2016) also analysed the outcomes of children in an oral communication education setting compared to those in an oral plus sign setting. Sarant found that children in an oral setting had significantly better speech perception and speech production outcomes than children in an oral and sign setting.

A study by Wiefferink et al. (2008) looked at two groups of deaf children, one group which was educated in a bilingual-bicultural environment and another which was educated in a simultaneous communication environment (a form of total communication). The study found that the group of children who were exposed to simultaneous communication performed better than the group exposed to bilingual communication in terms of receptive and expressive spoken language development. The study also found that the children in the simultaneous communication group who received cochlear implants before the age of 18 months had similar scores to hearing children of the same age.

All children in the study had cochlear implants and differed in age of implantation (the range was 9 to 27 months). In the group of children who were exposed to bilingual education, there were six children who spoke Dutch and knew Sign Language of the Netherlands (SLN). In the group of children who were exposed to simultaneous communication there were 12 children. These children spoke Dutch but also used some supported signs. Children in the study were assessed once prior to implantation and then again 6, 12, 24 and 36 months after implantation. The Categories of Auditory Performance test was used to assess auditory perception, the Speech Intelligibility Rating Scale and the Meaningful Use of Speech Scale was used to measure speech intelligibility. The Dutch version of the Reynell Developmental Language Scale and the Schlichting Scale was used to assess spoken language and spontaneous language was assessed through the use of conversations with adults and analysis through Computerised Language Analysis tools. A methodological problem identified with this study was that the children in the simultaneous communication group had on average been implanted earlier than the bilingual group given that earlier implantation is linked to better outcomes.

A longitudinal study by Cochard et al. (2003) analysed the impact of cued speech had on speech outcomes for children. This study found that children who were exposed to cued speech had superior speech outcomes compared to those exposed to sign language or to an oral setting. Results of this analysis found that cued speech users outperformed the other two groups when perception of words in open and closed lists was assessed. Similarly, children who were exposed to cued speech also

11. A phoneme, in linguistics, is the smallest unit of speech distinguishing one word from another. https://www.britannica.com/topic/phoneme
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outperformed the other two groups in terms of speech intelligibility. This study also looked at family involvement and found that children whose family attended cued speech sessions performed better than those that did not. For one and three years post cochlear implantation, cued speech had an advantage over the other two settings, but lost this advantage after five years. This study also looked at sentences in open sets where the cued speech group was again superior to the other groups.

The Cochard et al. (2003) study analysed three groups of children who were exposed to different modes of communication prior to cochlear implantation. One group was exposed to an oral setting, the second group to a signed French setting, and the third to a cued speech setting, in total there were 53 children. The groups were assessed one, three and five years after receiving their cochlear implants. The children were tested regarding auditory discrimination, speech comprehension, spoken intelligibility, and language development.

Other studies that looked at cued speech also found positive language development and language processing outcomes. Studies such as Kipila (1985), Anthony et al. (1991) and Metzger (1994) all found that deaf children with hearing parents who used cued speech had language outcomes similar to hearing children. However, the Kipila (1985) study only looked at the outcomes of one child and so did the Anthony et al. (1991) study. The Metzger study (1994) study was a follow up study to the Kipila study (1985) and therefore had the same issue of only looking at the outcomes of one child. Therefore, any conclusions drawn from these articles should be treated with caution due to the small sample sizes.

4.2.2 Neutral or mixed findings
Another outcome that Kaipa and Danser (2016) included in their systematic review was the impact of AVT on the rate of language development. The authors found four studies that showed AVT had a positive impact on the rate of language development, but also found two studies which found that AVT had a negligible impact on other outcomes of interest.

The authors calculated the mean rate of language development for participants before and after AVT and then compared rates, taking into account the participant’s age, reading level and length of participation in AVT. This review is inconsistent with three studies (Hogan et al. 2008, Hogan et al. 2010 and Rhoades and Chisholm 2000) which reported considerable growth between the before and after language development score following AVT. These studies indicated that AVT had a positive impact on rate of language development.

An important longitudinal study by Dornan et al. (Dornan et al. 2007, 2009 and 2010) was reviewed by Kaipa and Danser (2016). The Dornan et al. studies followed children with hearing impairment who were part of a multi-disciplinary family-centred AVT. The study gave rise to three articles; an analysis of outcomes before and after a 9-month period of AVT, before and after a 21-month period of AVT and then before and after a 50-month period. The first of these studies (Dornan et al. 2007) found that there was considerable language growth following AVT, while the other two studies (Dornan et al. 2009 and Dornan et al. 2010) showed negligible growth.

Despite these positive initial findings, Kaipa and Danser (2016) postulated methodological issues with the Dornan et al. longitudinal study. For instance, when Kaipa and Danser investigated the results from the Dornan et al. articles, they found that the participants had a high average rate of language development to begin with when compared to the other studies. The authors suggested that Dornan et al. were too selective in the inclusion of participants in their study.

4.2.3 Negative findings
As was reported earlier, studies by Dettman et al. (2013), Wiefferink et al. (2008), Percy-Smith et al. (2010) and Cochard et al. (2003) compared interventions to each other. The first study by Dettman et al. (2013) found that children who were enrolled in bilingual-bicultural programs had inferior outcomes to those of children who were enrolled in AVT or AOT. A study by Percy-Smith et al. (2010) compared children who used auditory-oral, auditory-verbal and total communication modes of communication. This study found that children who used total communication modes of communication had inferior outcomes to those who used auditory-verbal or auditory-oral modes of communication. Wiefferink et al. (2008) compared outcomes from children educated in bilingual-bicultural programs to those of children in simultaneous communication outcomes. The study found that bilingual-bicultural was inferior to simultaneous communication. Lastly, Cochard et al. (2003) found that outcomes for children who were exposed to sign language or an oral setting were inferior to those who were exposed to cued speech.
4.3 Learning and later outcomes

This section focuses on studies which involved school aged children. The reviewed studies reported that children enrolled in auditory-oral or auditory-verbal programs outperformed those who were enrolled in total communication programs.

4.3.1 Positive findings

A study by Robertson and Flexer (1993) analysed the reading outcomes of children who had undergone AVT. The authors found that 30 out of the 37 children included in the study scored at the 50th percentile or higher on reading tests when compared to children with normal hearing. For this study, the authors had the parents of children who had undergone AVT complete a survey. There were 37 responses with children ranging from 6-19 years. Included in the survey were a number of questions about their child’s reading progress. However, these study results are compromised by a small sample, large variation in ages of the studied children and self-selected data.

Another longitudinal study by Goldberg and Flexer (1993 and 2001) found positive outcomes for AVT graduates in terms of educational and employment attainment. Goldberg and Flexer conducted a survey of Canadian and American AVT graduates in 1993 and in 2001. The 2001 responses found that children who attended AOT programs had better speech intelligibility when compared to children who attended total communication programs. The AOT group of children and the total communication group achieved average speech intelligibility scores of 70.8% and 39.4% respectively.

Another study by Tobey et al. (2004) looked at 131 deaf children aged eight to nine years who had cochlear implants. This study found that children who attended AOT programs had better speech intelligibility when compared to children who attended total communication programs. The AOT group of children and the total communication group achieved average speech intelligibility scores of 70.8% and 39.4% respectively.

Within the study, the two groups of children were also broken down into the three classroom settings that the children in the group were exposed to and then the results were compared for each group. The three classroom settings were referred to as special, partial and full. Special referred to education settings that had exclusive enrolment in a deaf classroom, partial referred to part-time enrolment in classes with children without hearing loss, and full mainstream referred to children who were exclusively enrolled in classes with children without hearing loss. When speech intelligibility was analysed in the children three years after cochlear implantation, the AOT group on average, outperformed the total communication group, regardless of the educational setting. When educational settings were compared, the children in the full mainstream group on average outperformed the other groups.

Chart 4.1: Speech intelligibility of children three years after cochlear implantation

![Chart 4.1: Speech intelligibility of children three years after cochlear implantation](Image)
To measure intelligibility, the authors of the Tobey et al (2004) study found words that were used to predict intelligibility in deaf children and put these in a sentence which the children repeated. Three judges listened to the children and scored their intelligibility. Results from the three judges were then averaged to give a score for each child. Children in the study were grouped into either attended AOT (74 children) or total communication programs (55 children). However, Tobey et al. used different definitions than those presented in the earlier chapter. The AOT designation was used for children who did not use sign language in their mode of communication. This group therefore included children who participated in cued speech, auditory-verbal programs. While the total communication group included children who participated in programs that emphasised use of sign language. This implies that the results from this study are a comparison between signed language groups and cued speech, auditory-verbal programs.

A study by Geers and Moog (1992) looked at children aged 16 and 17 years who were enrolled in either a total communication program or an auditory-verbal program. In all the tests, the auditory-verbal group of children out performed the total communication group. There were 227 children in the study and the oral communication skills of those in later adolescence were investigated. The study aimed to look at the impact the programs had on speech perception and production skills. However, a number of limitations of this study were highlighted. The two groups had different socioeconomic status (the total communication group had lower median income than the auditory-verbal group) and the two groups had different educational settings (the total communication group attended residential schools for the deaf while the auditory-verbal group mainly attended mainstream educational centres).

A study by Bouton et al. (2011) focused on cochlear implantation and compared groups of children who have been exposed to cued speech before and after implantation to groups of children who had not been exposed to cued speech. The analysis found that the group of children who had been exposed to cued speech had greater phonemic awareness plus high reading task accuracy. The children were asked to perform phonemic awareness tasks and reading tasks.

Torres et al. (2008) also conducted research related to the reading ability of children who had been exposed to cued speech. This study found that students in the cued speech group were skilled readers compared to standardised norms for their age groups. The study also found that the children who had exposure to cued speech had age-appropriate linguistic competence. The small sample size (of four children) was aged between 12-13 years and had been exposed to cued speech from an early age (between 8 and 16 months). There were two other groups of children who served as controls and the children in these groups had normal hearing. The representative nature of these findings to the hearing impaired population is limited owing to the small sample size.

Aparicio et al. (2012) studied 45 adults, some of which were exposed to cued speech and auditory-verbal settings and others who were exposed only to auditory-verbal settings. The results of this study found that the participants who were exposed to cued speech outperformed hearing participants in reading skills. Of the 45 participants, 30 were exposed to auditory-verbal French of which 15 were also exposed to cued French. The remaining 15 participants had normal hearing. All participants underwent a speechreading test which involved participants viewing sentences being read and then undergoing tests that assessed the level of understanding of the participant.

Hermans et al. (2008) studied 87 deaf children from the Netherlands to appraise a relationship between reading skills and signing skills. The children knew SLN or Sign Supported Dutch (SSD). A positive correlation between vocabulary scores for signing and written skills was identified. Children's reading skills were assessed using a reading vocabulary test and a written story comprehension test. Sign language skills were also assessed using a receptive vocabulary test and a story comprehension test.

An earlier study by Strong and Prinz (1997) analysed the relationship between American Sign Language (ASL) skills and English literacy skills. A statistically significant relationship between ASL skill and English literacy was found with English literacy performance increasing with ASL capability. There were 160 deaf children included in the study who were aged between eight and 15 years. ASL skills were assessed using an ASL test developed by Strong and Prinz. The test measured ASL production and comprehension. To assess English literacy the authors used subtests from the Woodcock-Johnson Psychoeducational Test Battery and the Test of Written Language.

4.3.2 Neutral or mixed findings
A longitudinal study by Hay et al. (2009) looked at deaf children who had cochlear implants and used auditory-verbal as their mode of communication compared to hearing children. The study found that the children with cochlear implants performed below the average of the hearing group. However, the study found that the children with cochlear implants had a faster rate of growth in receptive vocabulary gains compared to the expected age-appropriate level of growth. As a result of this finding, the authors predicted that although there was a sizeable gap between children with cochlear implants and hearing children, the gap would eventually close and the children with hearing impairment would assume
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There were 65 children included in the study and they were given the Peabody Picture Vocabulary Test annually. The results of the tests were standardised and compared to results from normal hearing children.

A study by Connor et al. (2000) compared two groups of children who had cochlear implants and received different educational programs. One group had been in an educational setting using an oral communication approach while the other group had been in a different educational setting using a total communication approach. In general, the study found no significant difference between the two groups when age of cochlear implantation was taken into account. In total there were 147 children in the study. The study looked at the relationships between the two educational approaches and the child’s consonant-production accuracy and vocabulary development over time. Results showed that children in oral communication programs had on average better consonant-production accuracy and greater rates of improvement than the total communication cohort. There was however no difference between the two groups in receptive spoken vocabulary scores.

Another study by Kos et al. (2008) observed children who had received cochlear implants later in life and appraised their language outcomes. This study found that children who had received cued speech prior to implantation compared to those who had received sign language education were better at vowel and consonant identification without visual and cognitive cues. Although, there was no difference between the two cued speech and signed groups prior to implantation, therefore the authors concluded that the impact of cued speech in relation to vowel and consonant identification is negligible without cochlear implantation. In this study, 13 children were included, with the age of implantation ranging from 8 to 22 years of age.

4.3.3 Negative findings

Two studies discussed earlier, Tobey et al. (2004) and Geers and Moog (1992), compared intervention approaches. Tobey et al. (2004) found that speech intelligibility outcomes for children who were in total communication programs were inferior to those of children who were in AOT. While Geers and Moog (1992) also found similar results as total communication outcomes were inferior to those from children in AOT. Rydberg et al. (2009) considered educational outcomes resulting from the bilingual education of deaf children. The study found limited educational gain, noting that there was still a gap between deaf children and their hearing counterparts in terms of education outcomes. Whereas a study by Mayer and Leigh (2010) found there was insufficient evidence to assess whether children who undergo bilingual education achieved similar language and reading outcomes to children with normal hearing.
4.4 Social and wellbeing outcomes

A presentation by Constantinescu et al. (2014) noted that there are no current studies looking at social inclusion for young children with hearing loss who are enrolled in listening and spoken language early intervention programs. As a result, there are limited findings reported in this section.

4.4.1 Positive findings

Goldberg and Flexer (2001) considered the social integration of the individuals who are deaf or hearing impaired who had graduated from AVT. In particular, whether hearing impaired study participants were married and the rate of divorce. Overall, 76% of respondents said they felt like they functioned in the ‘hearing’ world, whereas 21% felt like they were in both the ‘hearing’ and ‘deaf’ worlds. Of the 111 respondents, 23 recorded being married, which the authors used as a proxy for individuals being in ‘regular’ living environments, however 10 of these 23 also recorded as having their marriage end in divorce. The study also considered participation in community activities with study participants reporting that they participated in numerous activities.

Duncan (1999) compared conversations of 11 children undergoing AVT to 10 children with normal hearing. Parameters that were studied included conversation topic initiation, maintenance, the shifting of topics, and conversation termination. The study found that the results of children receiving AVT were comparable to those of the children who had normal hearing although the results were compromised in part by the small study sample size.

The wellbeing of families with children who are deaf was considered by Liliegran et al. (2012). The authors analysed the impact AVT had on a caregiver’s level of empowerment. This study showed that the duration of AVT and level of empowerment felt by parents was positively correlated. The number of hours that parents participate in therapy sessions was also positively correlated with the level of empowerment felt by parents.

A study by Greenberg et al. (1984) analysed a group of children who underwent simultaneous communication intervention and the impact this had on social and communication development. The study found that children who were enrolled in the intervention had longer episodes of social interaction and had on average a higher number of interactions. This study compared matched 12 children who were in the intervention to 12 children who were not enrolled in the treatment, but did have hearing loss.

Hyde and Punch (2011) reported on the use of signed language and its impact on children’s social circles. It was found that many children with hearing impairment who do not have many deaf friends who sign, or parents who sign, did not feel connected to a deaf community. This study also reported that some children in the study have become more interested with meeting and mixing with more deaf people.

The Meadow (2005) study also looked into social functioning, but compared children who signed and had deaf parents to those who signed and had hearing parents. In most cases the children with deaf parents rated higher than the children with hearing parents. For example, children with deaf parents were considered more mature, responsible, popular and independent than those with hearing parents. To rate the social functioning of the children in the study the author used ratings from the child’s classroom teacher, dormitory counsellor and either the vocational arts teacher or another counsellor. A child with a hearing parent and a child with a deaf parent were then matched and results were compared.
4.5 Outcomes of multi-disciplinary interventions and family-based interventions

There were limited articles that analysed the impact of multi-disciplinary teams on outcomes of children with hearing loss. Of those that did discuss the role of the multi-disciplinary team, it was mainly to state that a multi-disciplinary team should be included in early intervention and in delivering universal newborn hearing screening programs. Also of note was the variability in the composition of multi-disciplinary teams.

According to the JCIH (JCIH, 2000), 30–40% of children with hearing loss demonstrate additional disabilities. For this reason, JCIH (2000) state that a multi-disciplinary approach to assessing children and developing early interventions should be utilised. Interestingly, First Voice (2015) reported that just 11% of program participants had an additional disability that impacted on their learning.

Another article by Wiley et al. (2011) re-affirms this finding. Wiley et al. (2011) performed a chart review of patient’s charts from a population of 260 children. Through this analysis they were able to highlight the importance of involving an interdisciplinary team when assessing children with hearing loss. Of the team involved in this analysis, there were genetic specialists, ophthalmologists, developmental paediatrics, speech pathologists, and aural rehabilitation specialists. The evaluation provided by all specialists enabled genetic causes of hearing loss to be analysed. Of the group, 27.8% had hearing loss as a result of genetic causes. From ophthalmologic assessments, it was found that 57% of the children had clinically significant findings. The developmental paediatrics assessment also found that 69% of the children who completed an evaluation with a developmental paediatrician had findings which could impact their education or development. Wiley et al. (2011) state that as a result of these comorbidities, multi-disciplinary teams should be employed when assessing children with hearing loss.

Other literature encourages a multi-disciplinary approach to managing early intervention and developing a plan for a child with hearing loss. Although there have been limited studies on the outcomes of multi-disciplinary interventions, a number of articles discuss the importance of adopting such an approach for interventions. As a result of children with hearing loss being at higher risk of having additional disabilities, a number of articles argue that a multi-disciplinary intervention should be created for the child so that all conditions of the child are treated. The JCIH (2000) states that an early intervention approach should be flexible and have the ability to be tailored to a child’s needs, this includes accommodating their additional disabilities.

An article by Yucel (2008) also provides an argument for multi-disciplinary interventions so that the needs of the parents are addressed. This study surveyed 65 parents of children who were enrolled in an AVT program which also provided family counselling services. This study found that 55.4% of families expressed a need to talk to someone, indicating that families needed social support. Of those in the survey, 78% reported a need in helping to locate babysitters and 53.4% needed help in locating day care programs. All these statistics indicate additional stress for parents and the need to support families of children with hearing loss. Yucel (2008) argues that a multi-disciplinary team should be employed to ensure that the needs of the family are met.

A study that looked at the outcomes of a family-based multi-disciplinary intervention found an important relationship between family involvement and language outcomes. The study by Moeller (2000) found that children who had high family involvement in their intervention had better language outcomes than those who had lower than average family involvement. Results also showed early intervention was more impactful. Children who had received intervention services before the age of 11 months had better outcomes than those that had received intervention services after 11 months. And although later enrolment in the therapy was found to negatively influence language outcomes, this could be offset by high levels of family involvement. Together, late uptake and low levels of family involvement had the worst rates of language outcomes.

Moeller (2000) also analysed a group of 112 children who were graduates of the Diagnostic Early Intervention Program. Following an initial diagnosis and an initial intervention, program participants are then referred to an appropriate early intervention therapy. The children included in this study either went to an auditory-oral program or a total communication program. The study found that age of enrolment and family involvement played significant roles in language outcomes. Vocabulary skills of children at five years of age were assessed through the use of the Peabody Picture Vocabulary Test and the Preschool Language Assessment Instrument. Family involvement was determined using a rating scale which was administered to early interventionists who had contact with the families.

Another study by Nelson et al. (2007) analysed vowel production in children with hearing loss who were enrolled in a family-based multi-disciplinary intervention. This study found that children who were enrolled in a family-based multi-disciplinary intervention had similar vowel acquisitions to those of hearing children of similar age. Of the 54 children in the study, 52 were enrolled in the Colorado Home Intervention Program. The Program is a family-centred intervention program that provides families with multi-disciplinary specialists as well as AVT. The results from this intervention show the benefits of family-based multi-disciplinary approaches.
Conclusion

The foci of this review were primarily outcomes related to early development (speech, reading and language) and learning (schooling and later outcomes) which arise from different interventions for hearing impaired children. Social and wellbeing outcomes were less of a focus due to limited evidence available on these outcomes. As noted, the robustness and transferability of reported outcomes is compromised to some extent by a lack of evidence based studies, and absence of studies which demonstrated sustained effect at least one year beyond treatment. Additionally, it is recognised that outcomes are influenced by other independent factors including the age of onset of hearing loss and age at aiding or implantation.

There was negligible literature that compared the outcomes of multi-disciplinary focused interventions with a sole practitioner approach. Instead the literature concentrated on the importance of multi-disciplinary interventions and screening processes in light of the fact that some children with hearing loss also have other disabilities. The small body of evidence concerning family-based multi-disciplinary interventions found that family involvement in any intervention was a key determinant of successful outcomes.

In summary, the available evidence shows that the most effective pathway for hearing impaired children in bringing about early development, schooling and employment outcomes is to deliver an intervention with a multi-disciplinary team and with high levels of family involvement.
References


Comparative review of reported outcomes from interventions for children with hearing loss


Comparative review of reported outcomes from interventions for children with hearing loss


Comparative review of reported outcomes from interventions for children with hearing loss


Snoddon K 2008, American Sign Language and early intervention, University of Toronto Press, Toronto.


## Appendix A: Summary of studies included in the review

<table>
<thead>
<tr>
<th>Study</th>
<th>Sample size</th>
<th>Summary of findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Centre for Allied Health Evidence</td>
<td>Literature review</td>
<td>Identified a number of parameters that influence outcomes for children with hearing impairment.</td>
</tr>
<tr>
<td>Kaipa and Danser (2016)</td>
<td>Literature review</td>
<td>AVT has positive speech perception findings and mixed results on rate of language development.</td>
</tr>
<tr>
<td>Sahli and Belgin (2011)</td>
<td>15</td>
<td>AVT resulted in a positive change in the speech perception abilities of children.</td>
</tr>
<tr>
<td>Fairgray et al. (2010)</td>
<td>7</td>
<td>AVT has positive speech perception findings.</td>
</tr>
<tr>
<td>Diller et al. (2001)</td>
<td>103</td>
<td>50.5% of children in the sample had hearing level similar to children with normal hearing and 48.4% had level of speech and language similar to children with normal hearing.</td>
</tr>
<tr>
<td>Dornan et al. (2007)</td>
<td>29</td>
<td>AVT results in considerable language growth.</td>
</tr>
<tr>
<td>Dornan et al. (2008)</td>
<td>Literature review</td>
<td>Existing literature demonstrated the potential for speech and language development with AVT.</td>
</tr>
<tr>
<td>Dornan et al. (2009)</td>
<td>25</td>
<td>AVT has negligible impact on language growth.</td>
</tr>
<tr>
<td>Dornan et al. (2010)</td>
<td>19</td>
<td>Children who underwent AVT did not have statistically significant different results from hearing children in speech, language and self-esteem.</td>
</tr>
<tr>
<td>Econtext (2011)</td>
<td>Literature review and CBA</td>
<td>Positive results for children enrolled in AVT.</td>
</tr>
<tr>
<td>Percy-Smith et al. (2010)</td>
<td>155</td>
<td>Found that AVT and AOT were superior to total communication on a phonological test.</td>
</tr>
<tr>
<td>Dettman et al. (2013)</td>
<td>39</td>
<td>Children who used auditory-verbal and auditory-oral communication had better speech perception and language outcomes than children who used bilingual-bicultural communication.</td>
</tr>
<tr>
<td>Archbold et al. (2000)</td>
<td>46</td>
<td>Children in the oral communication setting outperformed those that used total communication approaches in terms of speech intelligibility.</td>
</tr>
<tr>
<td>Kipila (1985)</td>
<td>1</td>
<td>Deaf children with hearing parents who used cued speech had language outcomes similar to hearing children.</td>
</tr>
<tr>
<td>Metzger (1994)</td>
<td>1</td>
<td>Deaf children with hearing parents who used cued speech had language outcomes similar to hearing children.</td>
</tr>
<tr>
<td>Anthony et al. (1991)</td>
<td>1</td>
<td>Deaf children with hearing parents who used cued speech had language outcomes similar to hearing children.</td>
</tr>
<tr>
<td>Sarant (2016)</td>
<td>Literature review</td>
<td>Children in an oral setting had better speech perception and production outcomes than children in an oral and sign setting.</td>
</tr>
<tr>
<td>Hogan et al. (2008)</td>
<td>37</td>
<td>AVT aids language growth.</td>
</tr>
<tr>
<td>Hogan et al. (2010)</td>
<td>49</td>
<td>Children who undertake AVT have considerable growth in language development.</td>
</tr>
<tr>
<td>Researcher(s) and Year</td>
<td>Sample Size</td>
<td>Findings</td>
</tr>
<tr>
<td>-----------------------------</td>
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<td>----------------------------------------------------------------------------------------------------------------------------------------------------</td>
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<tr>
<td>Robertson and Flexer (1993)</td>
<td>37</td>
<td>30 out of the 37 children scored in the 50th percentile or higher on reading tests when compared to children with normal hearing.</td>
</tr>
<tr>
<td>Goldberg and Flexer (1993)</td>
<td>157</td>
<td>Reported positive education, employment and social outcomes for graduates of AVT.</td>
</tr>
<tr>
<td>Tobey et al. (2004)</td>
<td>131</td>
<td>Speech intelligibility within children who had attended AOT programs was better than children who attended total communication programs.</td>
</tr>
<tr>
<td>Goldberg and Flexer (2001)</td>
<td>114</td>
<td>Reported positive education, employment and social outcomes for graduates of AVT.</td>
</tr>
<tr>
<td>Hayes et al. (2009)</td>
<td>65</td>
<td>Mixed findings of AOT. Children with cochlear implants performed below the average of the hearing group in terms of receptive vocabulary.</td>
</tr>
<tr>
<td>Geers and Moog (1992)</td>
<td>227</td>
<td>Children in an auditory-oral program outperformed children in total communication programs in terms of speech perception and production skills.</td>
</tr>
<tr>
<td>Wiefferink et al. (2008)</td>
<td>18</td>
<td>Children who were exposed to simultaneous communication performed better than children exposed to bilingual communication in terms of receptive and expressive spoken language development.</td>
</tr>
<tr>
<td>Connor et al. (2000)</td>
<td>147</td>
<td>No difference between oral communication and total communication approaches when age of cochlear implantation was taken into account.</td>
</tr>
<tr>
<td>Aparicio et al. (2012)</td>
<td>45</td>
<td>Adults who were exposed to cued speech outperformed those exposed to auditory-oral settings in reading skills.</td>
</tr>
<tr>
<td>Cochard et al. (2003)</td>
<td>53</td>
<td>Cued speech had superior outcomes to sign language and oral setting.</td>
</tr>
<tr>
<td>Bouton et al. (2011)</td>
<td>18</td>
<td>Children exposed to cued speech before and after cochlear implantation had better phonemic awareness and high reading task accuracy compared to children who had not been exposed to cued speech.</td>
</tr>
<tr>
<td>Torres et al. (2008)</td>
<td>4</td>
<td>Children exposed to cued speech were skilled readers compared to standardised norms for their age groups.</td>
</tr>
<tr>
<td>Kos et al. (2008)</td>
<td>13</td>
<td>Children who had received cued speech prior to implantation compared to those who had received sign language education were better at vowel and consonant identification without visual and cognitive cues.</td>
</tr>
<tr>
<td>Hermans et al. (2008)</td>
<td>87</td>
<td>Positive correlation between vocabulary scores for signing and written skills was identified for children who used Sign Supported Dutch and SLN.</td>
</tr>
<tr>
<td>Rydberg et al. (2009)</td>
<td>2,144</td>
<td>Analysed educational outcomes of children enrolled in bilingual education. Found that there was limited educational gain. There was still a gap between deaf children and their hearing counterparts.</td>
</tr>
<tr>
<td>Strong and Prinz (1997)</td>
<td>160</td>
<td>A statistically significant relationship between ASL skill and English literacy skills was found with English literacy performance increasing with ASL capability.</td>
</tr>
<tr>
<td>Meadow (2005)</td>
<td>59</td>
<td>Children who signed and had deaf parents had higher rates of social functioning than children who signed and did not have deaf parents.</td>
</tr>
<tr>
<td>Hyde and Punch (2011)</td>
<td>409</td>
<td>Many children with hearing impairment who do not have many deaf friends who sign, or parents who sign, did not feel connected to a deaf community.</td>
</tr>
<tr>
<td>Study</td>
<td>Sample Size</td>
<td>Findings</td>
</tr>
<tr>
<td>--------------------------------------------</td>
<td>-------------</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Greenberg et al. (1984)</td>
<td>24</td>
<td>Children enrolled in simultaneous communication intervention had longer episodes of social interaction and averaged a higher number of interactions compared to children with hearing loss not enrolled in the intervention.</td>
</tr>
<tr>
<td>Yucel (2008)</td>
<td>65</td>
<td>Conducted a survey of parents of children who were enrolled in an AVT program. Found that parents needed help with a variety of issues.</td>
</tr>
<tr>
<td>Wiley et al. (2011)</td>
<td>260</td>
<td>Analysed patient’s charts of participants to determine whether patients with hearing loss had other disabilities or medical conditions. Of the group, 27.8% had hearing loss as a result of genetic causes. From ophthalmologic assessments, it was found that 57% of the children had clinically significant findings. The developmental paediatrics assessment also found that 69% of the children who completed an evaluation with a developmental paediatrician had findings which could impact their education or development.</td>
</tr>
<tr>
<td>Duncan (1999)</td>
<td>21</td>
<td>The study found that the results of children receiving AVT were comparable to those of the children who had normal hearing.</td>
</tr>
<tr>
<td>Nelson et al. (2007)</td>
<td>54</td>
<td>Positive findings for family based multi-disciplinary interventions.</td>
</tr>
</tbody>
</table>
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