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Exploring Speech and Language Intervention for Preschoolers who are Deaf and Hard of Hearing: A Scoping Review

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Abstract

Purpose: The objective of this study was to summarize the extant literature on the effectiveness of speech and spoken language interventions for young children who are deaf or hard of hearing (DHH) to determine which types of speech-language interventions might be most effective, for which hearing levels and types of hearing losses, and at which dosage.

Methods: Using a scoping review methodology, a database search identified 10,360 studies of which 16 met the requirements for inclusion. Data was extracted from each for analysis.

Results: Due to the limited number of studies available, high variability in the nature of the studies, and insufficient details about the interventions and sample in many of the papers, fully addressing the study objectives was difficult. However, common themes included the positive effect of caregiver-centered approaches on language outcomes, the equal effectiveness of virtual versus in person intervention, the addition of other speech and language intervention techniques to Auditory-Verbal Therapy may improve outcomes, and the effect of speech and language therapy on auditory skills is unclear.

Conclusions: This scoping review offers an initial step in analyzing and implementing evidence-based speech and language treatment protocols for children who are DHH.

Keywords: Early intervention; auditory-verbal therapy; auditory-oral therapy; scoping review

Acronyms: AVT = Auditory-Verbal Therapy; AVTs = auditory-verbal therapists; BAHAs = bone anchored hearing aids; CI = cochlear implant; DHH = deaf or hard of hearing; HA = hearing aid; MLU = mean length utterance; PCIT = Parent-Child Interaction Therapy; SLPs = speech-language pathologists; ToDs = teachers of the deaf

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Between 0.5 and 5 in 1,000 children are born deaf or hard of hearing (DHH) in high income countries and that number increases in low- and middle-income countries (World Health Organization, 2010). Hearing loss can have negative effects on speech and language development, academic outcomes, and socioemotional skills (Carney & Moeller, 1998; Geers et al., 2009; Hintermair, 2006; Qi & Mitchell, 2012). To meet the developmental needs of these children, the Joint Committee on Infant Hearing (JCIH) recommends access to universal newborn hearing screenings by one month of age and immediate provision of optimal hearing technology (JCIH, 2019). Children identified with hearing loss at a very early age typically have better communication outcomes compared to peers identified later (Nelson, 2008) as do children who receive their hearing technology earlier (Ching, 2015).

The JCIH also stipulates that language intervention by six months of age is vital for children who are DHH to meet their highest communication potential (JCIH, 2019). They recommend family-centered, culturally responsive, unbiased, developmental, inclusive, accessible, and naturalistic communication intervention for all children who are DHH provided by knowledgeable and well-trained clinicians (JCIH, 2019). For children who are DHH and learning a spoken language, one way of monitoring the capabilities of clinicians is through Nanette Thompson's *Listening and Language Self-Checklist for Colorado Home Intervention Program (CHIP) Facilitators*, which is presented in JCIH's 2013 Supplement (Muse et al., 2013). It lays out specific techniques that clinicians should use during spoken language intervention with children who are DHH to ensure fidelity of implementation. These include developing listening skills by checking for consistent listening ability, incorporating music and nursery rhymes, maximizing the home listening environment, and holding high expectations for listening in a variety of activities and settings. Thompson also provides recommendations for language development such as including literacy activities in sessions, modeling and expanding child language, rewarding communication attempts, and developing spoken language through audition. Speech sound techniques include expecting, eliciting, and encouraging verbal responses; using acoustic highlighting techniques; and noting speech errors. Specific strategies for spoken language development cited by the JCIH (Muse et al., 2013) include informing caregivers of the session objectives, scaffolding techniques, pause time, incorporating intervention strategies into daily life, communicating with all of the professionals supporting the family, and ensuring that the family leaves each session with a feeling of empowerment (Muse et al., 2013). Although the JCIH concludes that well-trained, competent clinicians can meet the needs of families of children who are DHH by monitoring their use of these strategies, they do concede that no literature exists linking fidelity of implementation of these strategies with children who are DHH and successful outcomes (Muse et al., 2013).

The language intervention literature investigating communication in children who are DHH primarily focuses on communication modality (Geers et al., 2017; Thomas & Zwolan, 2019), often to great debate (Napoli et al., 2015). Communication options for children who are DHH are on a spectrum from primarily manual, in which families communicate solely in a sign language, like American Sign Language, to Auditory-Verbal Therapy (AVT; Ganek et al., 2012). AVT follows 10 principles that support caregivers who are teaching their children to listen and talk through audition alone (AG Bell Academy for Listening and Spoken Language, 2007). Clinicians can become certified in AVT through an intense three-year training program. More than 90% of children who are DHH are born to families with typical hearing who do not use sign language as their family communication (Mitchell & Karchmer, 2004). In combination with newborn hearing screenings and early access to audition with modern hearing technology, 90% of them choose the listening and spoken language side of the communication spectrum (Fitzpatrick et al., 2013).

AVT, however, is not the only method of spoken language communication intervention available. Other listening and spoken language options include auditory-oral intervention, in which listening and spoken language is the goal but visual and tactile cues may be incorporated during language learning, and cued speech, a system of hand gestures used to augment lip reading. In addition, these methods can be used in combination, as can forms of speech-language intervention that were not specifically designed for children who are DHH, such as drilling, which is effective for children with developmental language delay regardless of hearing status (Shriberg & Kwiatkowski, 1982). It is very rare, however, that these modalities are investigated against one another in high quality randomized control studies (Eriks-Brophy et al., 2020). Although AVT is governed by distinct principles of practice that oversee the consistency of the treatment across clinicians (AG Bell Academy for Listening and Spoken Language, 2007), other speech-language treatment approaches used with children who are DHH typically do not have prescribed protocols that can be precisely implemented by clinicians in the field.

The present study was a scoping review of research on speech and spoken language interventions for preschoolers who are DHH. We aimed to evaluate whether the evidence supports the effectiveness of speech and spoken language interventions for children who are DHH (and if so, for whom), to determine whether certain speech and spoken language interventions led to better outcomes than others, and to identify essential ingredients for the most effective interventions for children who are DHH. We hypothesized that (a) speech and language interventions would positively affect the communication outcomes of children who are DHH, (b) different speech and language intervention protocols would differentially affect the communication outcomes of children who were DHH, and (c) intervention effectiveness would be influenced by hearing status and dosage.

Method

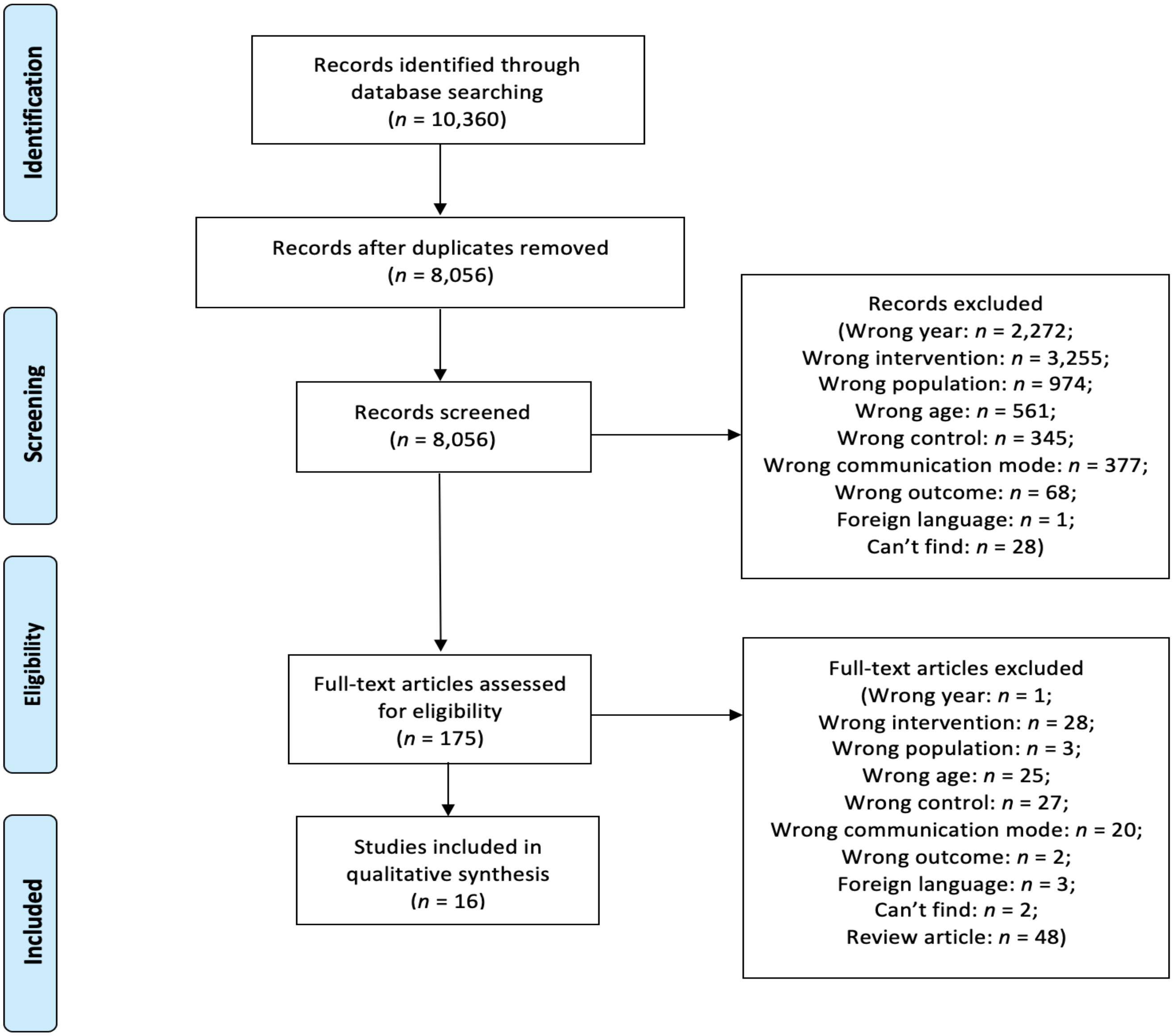
We conducted a systematic search of the literature using seven databases: CINHL, Education, EMBASE, MEDLINE, Nursing & Allied Health, PsychInfo, and SCOPUS. The search was comprised of publications from before June 2021. Search terms appear in Table 1. Broad search terms were chosen to ensure capture of all speech and language related intervention studies for children who are DHH.

Table 1
Search Terms

Participants	Intervention	Hearing loss
Preschooler/s	Speech therapy	Hearing loss
Toddler/s	Language therapy	Hearing impairment/ ed
Baby/s	Aural re/habilitation	Hearing disorder/s
Infant/s	Deaf education	Deaf/ness
Newborn		Auditory neuropathy spectrum disorder/ ANSD
Child/Children		

As shown in Figure 1, studies were excluded if they were published prior to 2002. This review was initiated as part of a quality improvement project for the Ontario Infant Hearing Program, which implemented its provincial newborn hearing screening program in 2002 (Hyde et al., 2004). Children identified before this period had fundamentally different intervention needs (Yoshinaga-Itano, 2003). Studies were also removed if participants were over five years old and/or did not have a hearing loss. In addition, studies that investigated interventions focused on manual communication methods, did not have an appropriate control group (e.g., a control group with hearing loss), and/or measured outcomes that were not directly related to the child (e.g., caregiver perceptions of intervention) were excluded. Review studies were also excluded. Finally, studies were not included if they did not report an intervention or the intervention was not speech and language related (e.g., provision of a cochlear implant). Papers were excluded if they were not published in English or French or were unavailable through the Western University library service or other online resources.

Figure 1
Included and Excluded Studies Presented in the Style of Moher et al., 2009



The first author screened all identified records by title and abstract. A second coder independently made judgements based on title and abstract for 10% of the identified studies. Point-by-point comparison was conducted to determine interrater reliability. The first author then reviewed the remaining full-text articles for inclusion. For each included study, the authors agreed to collect information in the following categories: (a) study information (author, year, title, design, journal), (b) participant characteristics (sample size, age, gender, socioeconomic status, language of intervention, culture/race), (c) hearing status (hearing level, hearing type, hearing technology), and (d) intervention (treatment type, service provider, length, dosage, outcome measure, outcome). Effect size was also collected from each study and was calculated manually when not provided. All effect sizes were converted to Cohen's d for comparability when reported by a different measure. Effect sizes of $d = .2$ were considered small, $d = .5$ were considered moderate, $d = .8$ large, and $d = 1.2$ very large (Sawilowsky, 2009).

Results

After removing duplicates, 8,056 articles were identified in our search. Sixteen papers met our inclusion criteria and were included in this analysis. They are listed in the reference section of this paper with an asterisk. There was 95% agreement between coders. Two of the 16 studies were randomized control trials (Monshizadeh et al., 2019; Zamani et al., 2016), one was a retrospective nested case-control study (Moog & Geers, 2010), six were prospective cohort studies (Behl et al., 2017; Brooks, 2017; Costa et al., 2019; Nanjundaswamy et al., 2017; Talebi et al., 2015; Zhou et al., 2013), and the remaining seven were retrospective cohort studies (Arumugam et al., 2021; Bunta et al., 2016; Chen & Liu, 2017; Constantinescu et al., 2014; Davidson et al., 2021; Percy-Smith et al., 2018; Yanbay et al., 2014).

Participant Demographics

The intervention studies reviewed here were relatively diverse, representing programs from seven countries on four continents (United States [6], Iran [3], Australia

[2], India [2], China [1], Denmark [1], & Taiwan [1]) and seven languages (English, Danish, Kannada, Mandarin, Persian, Spanish, & Tamil). Only one study (Costa et al., 2019) reported demographic information related to culture or race. Nine of the studies reported maternal education as a proxy for socioeconomic status (SES; Arumugam et al., 2021; Behl et al., 2017; Bunta et al., 2016; Chen & Liu, 2017; Costa et al., 2019; Davidson et al., 2021; Monshizadeh et al., 2019; Percy-Smith et al., 2018; Yanbay et al., 2014). Five studies reported a range of maternal education from less than high school to a graduate degree (Bunta et al., 2016; Davidson et al., 2021; Monshizadeh et al., 2019; Percy-Smith et al., 2018; Yanbay et al., 2014), three reported that all caregivers had at least some post-secondary education (Behl et al., 2017; Chen & Liu, 2017; Costa et al., 2019), and one reported that all participants were from a low socio-economic group (Arumugam et al., 2021).

Demographic information related to the study participants can be found in Table 2. On average, studies included 22 (*SD* = 24) experimental participants and 20 (*SD* = 21) controls after removing one outlier with 702 experimental participants and 302 controls (Arumugam et al., 2021). Of the ten papers that reported participant sex, 51% (*SD* = 13%) of children in the experimental groups and 48% (*SD* = 11%) in the control groups were female. Children were between 10 and 72 months old when they participated in the studies.

Participant Hearing Status

Participants' hearing status appears in Table 3. Three studies did not report hearing level and 62% (*n* = 8) of those that did included children with a range of levels of hearing loss from mild to profound. The remaining studies (*n* = 5) included participants with only severe or profound hearing losses. Nine studies provided information on type of hearing loss. Of them, 56% (*n* = 5) reported that all participants had bilateral hearing loss while 11% (*n* = 1) reported a mix of bilateral and unilateral hearing loss, including atresia. Twenty-two percent (*n* = 2) of the studies explicitly stated that participants had sensorineural hearing loss. Another 11% (*n* = 1) of the studies included only participants with congenital hearing loss, 11% (*n* = 1)

Table 2
Participant Demographics

Study	*N*		Gender (Female)		Age (months)	
	Experimental	Control	Experimental	Control	Experimental	Control
Arumugam et al., (2021)	702	302	NA	NA	NA	NA
Behl et al. (2017)	23	25	NA	NA	20.2	19
Brooks (2017)	5	8	NA	NA	10–23	NA
Bunta et al. (2016)	10	10	5	5	55.3 (*SD* = 13.2)	55.6 (*SD* = 20.4)
Chen & Liu (2017)	5	5	4	2	60.6 (*SD* = 6.46)	58.2 (*SD* = 6.11)
Constantinescu et al. (2014)	7	7	3	4	29.4 (*SD* = 2.9)	29.16 (*SD* = 3.4)
Costa et al. (2019	15	12	9	9	51 (*Mdn* = 48)	49.5 (*Mdn* = 49)
Davidson et al. (2021)	32	16	11	10	42.8 (*SD* = 8.3)	66.8 (*SD* = 16.8)
Monshizadeh et al. (2019)	26	25	11	9	20–24	20–24
Moog & Geers (2010)	107	27	NA	NA	60–72	60–72
Nanjudaswamy et al. (2017)	10	10	5	3	45.6	44.4
Percy-Smith et al. (2018)	31	94	14	52	*Mdn* = 47	*Mdn* = 49
Talebi et al. (2015)	15	15	7	7	48–72	48–72
Yanbay et al. (2014)	14	14	8	7	50.52 (*SD* = 14.16)	56.76 (*SD* = 15.78)
Zamani et al. (2016)	33	33	NA	NA	29.06 (*SD* = 4.18)	28.78 (*SD* = 3.42)
Zhou et al. (2013)	19	15	NA	NA	14.8 (*SD* = 2.85)	13.95 (*SD* = 2.98)

Note. NA = Not Available; *SD* = Standard Deviation, *Mdn* = median.

Table 3
Participants' Hearing Status

Study	Hearing Level		Hearing Type		Hearing Technology	
	Experimental	Control	Experimental	Control	Experimental	Control
Arumugam et al. (2021)	Profound	Profound	NA	NA	702 CI	302 CI
Behl et al. (2017)	5 unilateral/atresia/ bilateral mild; 3 mild-moderate; 2 moderate; 6 moderate-severe; 1 severe-profound; 6 profound	5 unilateral/atresia/ bilateral mild; 4 mild-moderate; 3 moderate; 4 moderate-severe; 2 severe; 6 profound	Bilateral	Bilateral	2 unilateral CI; 12 bilateral CI	4 unilateral CI; 10 bilateral CI
Brooks (2017)	NA	NA	NA	NA	NA	NA
Bunta et al. (2016)	1 moderate; 2 moderate-severe; 1 severe; 1 severe-profound; 5 profound	1 mild; 2 severe; 7 profound	NA	NA	2 bilateral HA; 2 bilateral CI; 5 bimodal	3 bilateral HA; 2 bilateral CI; 5 bimodal
Chen & Liu (2017)	Mild to profound	Mild to profound	Bilateral	Bilateral	4 bilateral HA; 1 Bimodal	4 bilateral HA; 1 Bimodal
Constantinescu et al. (2014)	Mild-moderate to severe-profound	Mild-moderate to severe-profound	Bilatera	Bilateral	2 unilateral BAHA; 4 bilateral HA; 1 bilateral CI	6 bilateral HA; 1 bilateral CI
Costa et al. (2019)	Mild to profound	Mild to profound	5 congenital; 1 post-natal; 9 unknown	4 congenital, 1 post-natal, & 7 unknown	5 bilateral HA; 1 unilateral HA; 6 bilateral CI; 1 unilateral CI; 2 bimodal	6 HA & 5 CI
Davidson et al. (2021)	Mild to profound	Mild to profound	NA	NA	NA	NA
Monshizadeh et al. (2019)	NA	NA	NA	NA	NA	NA
Moog & Geers (2010)	Profound	Profound	NA	NA	4 bilateral CI; 104 unilateral CI	4 bilateral CI; 23 unilateral CI
Nanjudaswamy et al. (2017)	Moderately severe to profound	Severe to profound	Prelingual sensorineural bilateral	Prelingual sensorineural bilateral	10 bilateral HA	10 bilateral HA
Percy-Smith et al. (2018)	NA	NA	30 congenital; 1 other	85 congenital; 9 other	30 bilateral cochlear implants; 1 bimodal	78 bilateral CI; 16 unilateral CI
Talebi et al. (2015)	Moderate to severe	Moderate to severe	Bilateral sensorineural	Bilateral sensorineural	15 bilateral HA	15 bilateral HA
Yanbay et al. (2014)	Profound	Profound	Bilateral	Bilateral	2 unilateral CI; 12 bilateral CI	4 unilateral CI; 10 bilateral CI
Zamani et al. (2016)	Severe	Severe	NA	NA	33 HA	33 HA
Zhou et al. (2013)	Profound	Profound	Congenital	Congenital	19 CI	15 CI

Note. NA = not available; CI = cochlear implant; HA = hearing aid; BAHA = bone anchored hearing aid.

reported all participants had pre-lingual hearing loss, and 22% ($n = 2$) reported a mix of congenital, post-natal, and unknown etiologies.

Thirteen studies (81%) reported their participants' hearing technology. Of the experimental participants, 39% of the participants ($n = 109$) wore a unilateral cochlear implant, 31% ($n = 86$) wore bilateral cochlear implants, 26% ($n = 73$) wore bilateral hearing aids, and 3% ($n = 9$) wore bimodal hearing technology. The remaining 1% is comprised of two experimental participants who wore bone anchored hearing aids (BAHAs) and one who wore a unilateral hearing aid. Within the control groups, 49% ($n = 125$) wore bilateral cochlear implants, 30% ($n = 77$) wore bilateral hearing aids, 18% ($n = 47$) wore a unilateral cochlear implant, and the remainder were bimodal ($n = 6$).

Davidson et al. (2021) reported that 15 participants wore bilateral cochlear implants, 12 wore two hearing aids, 11 were bimodal, 3 wore BAHAs, 2 wore a hearing aid with an FM System, and 1 wore a bilateral contralateral routing of signal device. They did not, however, distinguish participants' device use by control or experimental group. In addition, all 1,004 of the participants in Arumugam et al. (2021) used cochlear implants, although the authors do not report if they were uni- or bilateral.

Interventions and Study Measures

Information related to the intervention programs investigated in each study is reported in Table 4. Each intervention is listed as described by the authors of the paper. Thirty-one percent of the studies reported these programs were provided by a combination of auditory-verbal therapists, speech-language pathologists, audiologists, and teachers of the deaf. Nineteen percent were provided by auditory-verbal therapists alone, and 13% by speech-language pathologists alone. Psychologists implemented intervention in one study. One study investigated treatment provided by a software program monitored by an audiologist. Three studies in this group did not report who provided the service and one reported trained habilitationists implemented intervention. Seven of the studies confirmed that the professionals providing intervention were certified in their roles or specially trained to work with children who are DHH (Arumugam et al., 2021; Brooks, 2017; Bunta et al., 2016; Costa et al., 2019; Davidson et al., 2021; Percy-Smith et al., 2018; Yanbay et al., 2014). The remainder either did not describe clinician training or asked the professionals to self-

Table 4
Speech & Language Protocols

Study	Experimental	Control	Experimental	Control	Experimental	Control
Arumugam et al. (2021)	A standard structured set of exercises to build understanding and recognition of a sound signal conducted at a satellite center	A standard structured set of exercises to build understanding and recognition of a sound signal conducted at a cochlear implant clinic	12 months	Trained habilitationists	Speech perception; Speech intelligibility	NA
Behl et al. (2017)	Parent-focused intervention that incorporated daily routines via Telepractice	Parent-focused intervention that incorporated daily routines via In-person intervention	55 minutes sessions, 1x per week for 6 months	AVTs, ToDs, & SLPs	Receptive & Expressive Language; Vocabulary; Auditory Skills	Receptive: d = .3; Expressive: d = .17; Total: d = .26; Vocabulary: d = .01; Auditory Skills: d = .12
Brooks (2017)	Real-time Embedded coaching with the Application of Andragogical Principles	Auditory-oral	20–45 minute sessions 2x per month for 6 months	AVTs & ToDs	Vocabulary	NA
Bunta et al. (2016)	Bilingual AVT	Monolingual AVT	25 minute sessions, 2–3x per week for 29.8 (*SD* = 12.5) months	AVTs & ToDs	Receptive & Expressive Language	Receptive: d = .97; Expressive: d = 1.7; Total: d = 1.4
Chen & Liu (2017)	AVT via telepractice	AVT via in-person intervention	50.6 (*SD* = 2.64) months	NA	Receptive & Expressive Language	Receptive: d = .23[-1.46,1.03]; Expressive: d = .12[-1.98,.59]
Constantinescu et al. (2014)	AVT via telepractice	AVT via in-person intervention	1 hour sessions, 2x per month for 2 years	AVTs	Receptive & Expressive Language	Receptive: d = .5[-.57,1.56]; Expressive: d = 1.19[.02,2.32]; Total: d = .83[-.28,1.9]
Costa et al. (2019)	Parent-Child Interaction Therapy (PCIT)	Push-in & individual language services	1x per week for 16.2 (*Mdn* = 16) weeks	Psychologists	Vocabulary; mean length utterance (MLU); Negative Behaviors	Vocabulary: d = .74; MLU: d = 1.5; Negative Behaviors: d = 2.5
Davidson et al. (2021)	Confirmation of hearing loss, monitoring of hearing thresholds, provision of hearing devices, and instruction for families related to hearing loss and language acquisition before 3 years old.	Confirmation of hearing loss, monitoring of hearing thresholds, provision of hearing devices, and instruction for families related to hearing loss and language acquisition after 3 years old.	22 months (range = 3 to 34 months)	Audiologists, ToDs, & SLPs	Language; Receptive & Expressive Vocabulary	Language: d = 1.3[.71,2.0]; Receptive Vocabulary: NA; Expressive Vocabulary: d = 1.2[.54,1.83]

Table 4 (continued)

Speech & Language Protocols

Study	Experimental	Control	Experimental	Control	Experimental	Control
Monshizadeh et al. (2019)	An Education Package on Receptive Vocabulary Development for Persian Speaking Cochlear Implant Children	AVT	9–12 months	NA	Receptive & Expressive Language	Receptive: *d* = 2.02[1.33,2.69]; Expressive: *d* = 1.26[.65,1.85]; Total: *d* = 1.78[1.12,2.42]
Moog & Geers (2010)	Parent-infant program	Listening & Spoken Language (LSL) or mainstream classrooms	5 years	AVTs, ToDs, & SLPs	Receptive & Expressive Language; Vocabulary	NA
Nanjudaswamy et al. (2017)	Auditory training software	NA	45 minute sessions, 3x per week for 1 month	Computer software with audiologist support	Auditory Skills	NA
Percy-Smith et al. (2018)	AVT	Speech-language therapy not specialized for children who are DHH	1x per week/ month/quarter for 3 years	AVTs	Language; Vocabulary; Speech	Language: *d* = 1.25[.64,1.85]; Vocabulary: *d* = 1.11[.55,1.68]; Speech: *d* = .59[.05,1.13]
Talebi et al. (2015)	Traditional rehabilitation for children who are DHH & vowel training	Traditional rehabilitation for children who are DHH	2 hour sessions, 2x per week for 6 months	NA	Vowel identification; Reaction time	Identification[1]: /æ/: *d* = 2.71[1.69,3.70], /u/: *d* = 2.49[1.51,3.44]; Reaction time[1]: /æ/: *d* = 3.38[2.24,4.51], /e/: *d* = 2.67[1.66,3.66], /u/: *d* = 1.21[.42,1.99]
Yanbay et al. (2014)	AVT	Auditory-Oral	Weekly or monthly for 4.05 (*SD* = 1.18) years	AVTs	Receptive & Expressive Language; Vocabulary	Receptive: *d* = .05[-.05,.69]; Expressive: *d* = .12[-.62,.86]; Vocabulary: *d* = .15[-.89,.59]
Zamani et al. (2016)	AVT with gestures	AVT	1 hour sessions, 1x per week for 15 weeks	SLPs	Receptive & Expressive Language	Receptive: *d* = 1.64[1.08,2.19]; Expressive: *d* = 1.9[1.31,2.48]
Zhou et al. (2013)	Speech-language pathology with a focus on developmentally appropriate auditory, speech, and language skills	No treatment	2–3x per week for 6–12 months	SLPs	Speech perception; Speech intelligibility	NA

Note. AVTs = auditory-verbal therapists; DHH = deaf or hard of hearing; ToDs = teachers of the deaf; SLPs = speech-language pathologists; NA = not available; AVT = auditory verbal therapy.

[1]Effect sizes reported for vowels the authors identified as significant.

identify their role. Treatment duration and frequency varied widely across studies. Interventions were provided from 15 weeks to 60 months and children attended treatment sessions once a quarter to three times a week for between 25 and 120 minutes.

The interventions reported by the reviewed studies included measures of language (10 studies), vocabulary (6 studies), and auditory skills (5 studies). Five studies reported more than one outcome measure (Behl et al., 2017; Davidson et al., 2021; Moog & Geers, 2010; Percy-Smith et al., 2018; Yanbay et al., 2014). One study (Percy-Smith et al., 2018) also reported speech outcomes. Language results included receptive, expressive, and total language scores on standardized assessments. Vocabulary outcomes were also assessed using standardized assessments. Auditory skills were measured via speech perception testing, functional assessment tools, and auditory identification tasks.

Language Outcomes

Receptive and Expressive Language

Four of the studies reviewed here reported retrospective language outcomes for groups of children who received different types of intervention specialized for children who are DHH. Davidson et al. (2021) reported that children who received listening and spoken language intervention services before three years of age had significantly higher language outcomes than those who received intervention later (d = 1.3 [.71,2.0]). Moog and Geers (2010) found that young children who received one-on-one intervention with a clinician and a caregiver had higher receptive and expressive language scores than peers in mainstream and specialized classrooms. As the children grew, however, more benefit was seen in the classroom environments. The paper did not report the necessary data to calculate effect size. Percy-Smith et al. (2018) and Yanbay et al. (2014) both investigated AVT. Percy-Smith et al. (2018) compared children in AVT to those who received an intervention that was "not specifically targeted" (p. 40) at children who were DHH. Participants in this non-AVT group were recruited from across Denmark and did not receive a consistent treatment protocol. Sixty-six percent of caregivers in the non-AVT group reported that they did not participate in therapy sessions, whereas 100% of the caregivers in the AVT group did. AVT had a very large effect on language (d = 1.25 [.64,1.85]), a large effect on vocabulary (d = 1.11 [.55,1.68]), and a moderate effect on speech outcomes (d = .59 [.05,1.13]) relative to the non-AVT intervention. Yanbay et al. (2014) compared the language outcomes of children in AVT to those receiving auditory-oral therapy. In this study, caregivers were included in both interventions. Yanbay et al. (2014) found no significant effect of intervention type on language outcomes (Receptive: d = .05 [-.05,.69]; Expressive: d = .12 [-.62,.86]) or vocabulary outcomes (d = .15 [-.89,.59]), and the size of the effects can be considered trivial because the confidence intervals include zero.

The principles of AVT state that intervention techniques should be integrated into daily activities through audition alone (AG Bell Academy for Listening and Spoken Language, 2007). These principles encourage listening and spoken language strategies be integrated into activities of daily living and that hearing be the primary sensory modality for language learning, rather than drill activities and visual cues. Two studies reviewed here, however, integrated these strategies in AVT. Zamani et al. (2016) added gestures when teaching verbs while Monshizadeh et al. (2019) added a vocabulary drilling activity to AVT. In both cases, they found very large and significant positive effects on receptive and expressive language compared to children receiving standard AVT (Monsizadeh et al., 2019: Receptive: d = 2.02 [1.33,2.69]; Expressive: d = 1.26[.65,1.85]; Total: d = 1.78 [1.12,2.42]; Zamani et al., 2016: Receptive: d = 1.64 [1.08,2.19]; Expressive: d = 1.9[1.31,2.48]). A third study by Bunta et al. (2016) found that providing bilingual AVT to bilingual families had a large effect on receptive language (d = .97) and a very large effect on expressive language (d = 1.7; Total Language: d = 1.4) relative to providing monolingual AVT to bilingual families.

Three studies investigated the use of telepractice to provide speech and language intervention to children who are DHH. Constantinescu et al. (2014) and Chen and Liu (2017) found no significant differences in receptive language outcomes between AVT provided via telepractice relative to in-person AVT (Chen & Liu, 2017: d = .23[-1.46,1.03]; Constantinescu et al., 2014: d = .5[-.57,1.56]). Constantinescu et al. (2014) did find a large effect of telepractice compared to in-person AVT for expressive language (d = 1.19[.02,2.32]) but Chen and Liu (2017) did not (d = .12[-1.98,.59]). Behl et al. (2017) compared parent-focused intervention that incorporated daily routines and was provided via telepractice to a similar intervention provided in-person. They found a small effect in favor of telepractice over in-person intervention on receptive language (d = .3), but negligible effects for expressive language (d = .17) and vocabulary skills (d = .01).

Vocabulary

Three studies reported vocabulary measures as primary outcomes. Davidson et al. (2021) found that children who entered early intervention before three-years old had significantly higher receptive (effect size could not be calculated) and expressive (d = 1.2[.54,1.83]) vocabulary scores than their peers who entered rehabilitation later. Brooks (2017) compared children whose caregivers were receiving real-time embedded coaching with the application of andragogical principles (i.e., principles of adult learning) to those receiving auditory-oral intervention. The amount and type of caregiver engagement in the auditory-oral intervention group was not clearly stated. Brooks reported over the course of 6 months of intervention, children in both groups showed increases in their receptive vocabulary age equivalents ranging from 2 to 11 months while the real-time coaching group improved their expressive vocabulary by 5 to 7 months and the auditory-oral group improved 2 to 6 months. However, data and analysis were not provided to calculate statistical significance or effect size, and the reporting of only age equivalent data limits interpretation. Costa et al. (2019) also implemented a caregiver coaching protocol, Parent-Child Interaction Therapy (PCIT). Designed as a method for reducing negative behaviors, rather than a language intervention, PCIT includes aspects of both play therapy and caregiver coaching focused on behavior management techniques. The children receiving PCIT were compared to children in a reverse inclusion classroom who also received individualized speech-language therapy. The authors found moderate and very large positive effects of PCIT on vocabulary outcomes (d = .74) and mean length utterance (MLU; d = 1.5), respectively, relative to the control intervention.

Auditory skills

Five studies measured auditory skills post-speech and language intervention. In one of the only studies reviewed here to compare an intervention group to a no-treatment group, Zhou et al. (2013) measured speech perception and speech intelligibility in children who received a cochlear implant and speech therapy, "with an emphasis on auditory training, speech orthodontic treatment, articulation training, and language training according to the child's performance" (p. 2), compared to those who had only received a cochlear implant. No significant differences were found between the groups. Insufficient data was reported to calculate effect size. Arumugam et al. (2021) compared "a structured set of exercises designed to help the cochlear implant user to understand and recognize the sound signal" (p. 1) conducted in the primary cochlear implant clinic versus in satellite locations throughout the state. Like Zhou et al. (2013), Arumugam et al. (2021) found no significant differences in speech perception or speech intelligibility scores between groups and insufficient data was reported to calculate effect size.

Talebi et al. (2015) investigated a group of children receiving a "traditional rehabilitation program for their disability" (p. 15). Half of the participants also received vowel training in which six vowels were presented without visual cues in nonsense syllables with voiceless consonants. Participants were asked to verbally identify each syllable. They found that adding vowel training to "traditional rehabilitation" led to large improvements in speed and accuracy of vowel identification in half of the vowels. (Identification: /æ/: d = 2.71[1.69,3.70], /u/: d = 2.49[1.51,3.44]; Reaction time: /æ/: d = 3.38[2.24,4.51], /e/: d = 2.67[1.66,3.66], /u/: d = 1.21[.42,1.99]). There was no difference between the groups on the other vowels. Nanjundaswamy et al. (2017) designed an auditory training software program that caregivers used with their children. Their results on functional assessments were compared to a matched control group, but it was not clearly stated whether the control group received any form of language intervention. The children who received the computerized intervention made significantly greater improvements in parent report of listening skills in real word situations as measured by the Infant-Toddler Meaningful Auditory Integration Scale (IT-MAIS; Zimmerman-Phillips et al., 2001) but similar changes in hearing and communicating with others as measured by the Parents' Evaluation of Aural/Oral Performance of Children (PEACH; Ching & Hill, 2007) compared to peers who were not enrolled in the experimental intervention. Information to calculate effect size was not provided. Behl et al. (2017) measured auditory skills using a caregiver checklist with children receiving intervention (described previously) via telepractice versus in-person therapy and found no significant differences and negligible effects between the two modes of delivery on auditory skills (d = .12).

Discussion

This scoping review was conducted to summarize the extant literature on the effectiveness of speech and spoken language interventions for young children who are DHH. We not only wished to determine whether speech and language interventions have been shown to be effective, but which types might be most effective, for whom, and at which dosage. We identified 16 papers that investigated outcomes of speech and language interventions for children who are DHH. Two studies compared the presence versus absence of speech-language intervention. The remaining 14 studies compared two interventions to determine whether one led to better language and/or speech outcomes than the other. In many cases, the papers described the control, and often the experimental, treatments in very broad terms. They referred to "traditional rehabilitation" (Talebi et al., 2015) or "speech-language therapy" (Percy-Smith et al., 2018) with little further explanation of what techniques and philosophies were employed. The studies also varied widely in the sample characteristics, including hearing status, of the children and in the duration and frequency of the interventions. As a result, determining essential ingredients for the most effective interventions for which children and at which dosage based on the scientific literature is, therefore, difficult. Nonetheless, a variety of themes did emerge that can inform future clinical research to support optimal spoken language outcomes for children who are DHH.

Caregiver-Centered Approaches May Positively Affect Outcomes

None of the studies reviewed here explicitly controlled for caregiver involvement in treatment. However, methodologies that specifically included caregiver-centered techniques positively affected language and vocabulary outcomes in children who are DHH compared to those in which caregiver participation was not overtly stated. AVT, which incorporates caregivers throughout treatment, had no differential effect on language outcomes compared to auditory-oral intervention involving a caregiver (Yanbay et al., 2014) and produced a very large effect compared to children receiving intervention with inconsistent caregiver attendance (Percy-Smith et al., 2018). Two studies reported interventions built on methods for coaching caregivers. Although Brooks (2017) did not provide statistical analysis or sufficient data to calculate the magnitude of effect for real-time parent coaching with the application of andragogical principles, Costa's team (2019) showed that PCIT can have a moderate effect on vocabulary outcomes. Neither of these studies, however, clearly excluded less formal or other methods of caregiver coaching. Moog and Geers (2010) also found that in young children, parent-infant therapy sessions yielded significantly higher language scores than classroom environments, although, again, effect sizes could not be calculated. Overall, this pattern of results provides converging evidence to suggest that caregiver-centered intervention approaches may be particularly effective for developing the spoken language skills of young children who are DHH and should be further investigated.

Caregiver-centered interventions have successfully improved outcomes for patients within a variety of allied health fields (Lawler et al., 2013), including pediatric speech and language disorders. By training caregivers, children with speech and language delays (like those associated with hearing loss) have the opportunity to receive the high quality language input they need to learn to listen and talk (Roberts & Kaiser, 2011). In addition, caregivers likely know their children better than any professional could and may, therefore, be more successful at integrating language goals into the child's daily life in a meaningful and motivating manner.

Taking a caregiver-guided approach when serving children who are DHH is especially fitting when considering that children typically learn language by engaging with adults (Romeo et al., 2018). By instructing caregivers to use strategies that allow young children who are DHH to engage with age appropriate language stimulation, the children can capitalize on their critical period for language learning. Optimizing this developmental window, in which most children are learning to listen and talk, can allow children who are DHH to achieve listening and spoken language skills similar to their peers with typical hearing. Focusing on parent-child interactions alone, however, may miss some important features of language learning. Although most language acquisition research investigates parent-child talk, the influences of peer-to-peer verbal interactions may also play an important role in language learning. Studies conducted in non-industrialized countries have found children receive a large proportion of their language exposure from other children (Shneidman & Goldin-Meadow, 2012). Additionally, studies have identified pragmatic difficulties in children who are DHH and suggest the need to expand intervention to include peer-to-peer communication (Most et al., 2010). These findings indicate the potential importance of peer-to-peer talk in many societies and highlight how these types of interactions may also influence language development in high-income countries. None of the studies reviewed here investigated intervention methods that included other children, nor did they measure pragmatic skills development.

Virtual Delivery May Produce Similar Outcomes to In-Person Interventions

Three studies reported on the use of teleintervention compared to in-person therapy. Two investigated AVT (Chen & Liu, 2017; Constantinescu et al., 2014) and one described a more general methodology that included a caregiver-centered approach (Behl et al., 2017). In all three studies, there were no differences (and any effects on language, vocabulary, and auditory skills were negligible in magnitude) between the two modes of delivery, with the exception of Constantinescu's team (2014) who found virtual AVT had a large effect on expressive language outcomes relative to in-person AVT. This large effect in the context of the small sample size (7 participants per group) suggest that the study may have been underpowered. Nonetheless, no evidence was found to suggest that virtual delivery is inferior.

Given social distancing mandates put in place as a result of the COVID-19 pandemic, evidence suggesting that telepractice may be as effective as in-person intervention for preschoolers who are DHH is encouraging. Families requiring specialized speech and language services being able to access effective care remotely can ensure better equity and accessibility of intervention to more families, both in the pandemic context and beyond. Telepractice protocols presented here were designed for children under five years old and, therefore, required a substantial amount of caregiver involvement. Caregiver-centered approaches, such as those reviewed here, reduce the need for the child who is DHH to listen and process potentially degraded auditory signals from computer speakers during teleintervention. The clinician instead instructs the caregiver not just through the logistics of running the telepractice software but also toy manipulation and high-quality language stimulation provision, and reports the child's response back to the clinician in real-time. Out of necessity, teleintervention may thereby inherently increase caregiver participation in intervention. More research is needed to confirm the outcomes of children who receive speech and language intervention via telepractice.

Adding Other Speech-Language Techniques Improved AVT Outcomes

In two studies, the authors modified AVT with techniques that are relatively common in other speech-language treatment approaches and compared those outcomes to traditional AVT. Modifications included the addition of gestures (Zamani et al., 2016) and vocabulary drills (Monshizadeh et al., 2019). Both modifications yielded large or very large positive effects for the modified AVT programs relative to AVT alone. The addition of gesture, as described by Zamani et al. (2016), clearly violates the principles of auditory-verbal practice, which mandate that audition be the child's primary sensory mode for language learning (Estabrooks et al., 2020). However, in combination with formal AVT, the addition of pantomimed gestures for verbs did significantly and positively affect language outcomes. Similarly, AVT advocates for language learning through daily activities integrated into all aspects of the child's life (Estabrooks et al., 2020) rather than formal didactic drilling as proposed in Monshizadeh et al. (2019). Once again, however, in combination with other AVT methods, their protocol produced large positive effect sizes.

It should be noted that Monshizadeh et al.'s (2016) treatment program was specific to Persian. AVT was developed in North America (Estabrooks et al., 2020) and was, therefore, modeled after the language socialization practices followed there. Given that both culture and SES have been linked to language development (Hart & Risley, 1995; Ochs & Schieffelin, 2016), future study into the impact of cultural adaptation of AVT is needed, although the diversity of the countries from which the included studies originated, as well as the variety of languages in which services were provided, is encouraging. Bunta and colleagues' (2016) investigation of the effect of bilingual AVT (English/Spanish) compared to AVT provided in the culturally dominate language alone (English), found large positive effects on expressive language when bilingual families were treated in both the majority language and their home language. This protocol aligns well with the AVT commitment to having caregivers serve as primary language models (Estabrooks et al., 2020) while, at the same time, incorporating cultural differences into intervention in an effective manner.

Auditory Skills Outcomes of Speech and Language Interventions Remain Unclear

Five studies reported auditory outcomes using a variety of methods including functional assessments, auditory identification tasks, and speech perception testing. In a teleintervention study, Behl et al. (2017) found that virtual intervention was as effective as in person intervention for parent rated auditory skills. Talebi et al. (2015) added vowel recognition training to traditional intervention and found large effects on recognition skills for three of six vowels. Nanjudaswamy et al. (2017) reported differences between a group of participants who received auditory training via a software program and a control group of children (who may or may not have been receiving other intervention) on one of two functional assessments of auditory skills. Zhou et al. (2013) found no difference in speech perception or intelligibility between children with cochlear implants who did versus did not receive speech and language intervention and Arumugam et al. (2021) reported that the speech perception and intelligibility outcomes of children who received intervention at a cochlear implant clinic were the same as those who attend services at satellite centres. Neither Zhou et al. (2013), Arumugam et al. (2021), nor Nanjudaswamy et al. (2017) provided sufficient information to calculate effect size. The minimal and inconsistent effects of the intervention protocols reviewed here indicate that the impact of speech and language treatment for auditory skills development remains unclear. Further exploration of techniques and strategies to improve listening abilities for children who are DHH is needed. Future studies should include clear descriptions of both the experimental and control treatment protocols as well as effect sizes.

Effect of Hearing Status Could Not be Evaluated

Half of the papers reviewed reported participants had a range of hearing levels and five reported participants with exclusively severe or profound hearing losses. Due to the variability within studies and the lack of variability between studies, the effect of specialized interventions on different hearing levels could not be conducted nor compared across studies. Mild and moderate hearing losses have been associated with delays in both expressive and receptive vocabulary (Tomblin et al., 2015). Future research should explore differences in intervention outcomes for these children compared to those with more profound hearing losses.

Hearing type was inconsistently reported in the reviewed papers. Six studies specified that participants had bilateral hearing loss, although more study participants could be assumed to have bilateral hearing loss by the reported use of bilateral hearing technology. Like mild hearing loss, unilateral hearing loss can also negatively affect language outcomes (Lieu et al., 2010). Future studies should identify the intervention needs of children with both unilateral and bilateral hearing losses, as well as those with permanent conductive versus sensorineural hearing losses.

Limitations and Future Directions

This scoping review faced a number of limitations. Studies that potentially fit inclusion criteria were excluded due to being published in languages other than those the authors read fluently. Thirty studies that potentially fit the inclusion criteria could not be accessed. Of the studies that were reviewed, many had inadequate reporting of demographic information. Five did not include effect sizes or the data required to calculate effect size and six were manually calculated. Future studies should include effect size within the analysis. With only two exceptions (Davidson et al., 2021; Zhou et al., 2013), the studies reviewed compared two treatment groups but did not additionally examine whether clinically meaningful improvements attributable to the intervention were observed in either group. Additionally, Davidson and colleagues (2021) did not control for age at amplification, which is highly correlated with age at intervention. Without disentangling these two variables, the role of language therapy in a child's outcomes cannot be clearly identified, even though a *no-treatment* group was employed. Future studies should include designs and analyses to facilitate the evaluation of change due to intervention.

With two exceptions (Monshizadeh et al., 2019; Zamani et al., 2016), the studies examining AVT were retrospective, which creates opportunities for confounding variables, association rather than causation, and poor population representation in samples. Although retrospective studies allow researchers to capitalize on participants who have been receiving treatment for many years, results must be interpreted with caution. By contrast, the studies of speech-language approaches other than AVT were primarily prospective, which yield more accurate results but may, in this case, lack the same ecological validity as the retrospective AVT studies.

Although AVT and some of the other interventions explicitly stated the use of a caregiver-centered approach, the speech-language approaches other than AVT typical of the control groups in many of the reviewed studies did not overtly state the role of caregivers in intervention. It is possible that these other approaches reported here were encouraging significant caregiver involvement. Future studies should provide more detailed descriptions of their control interventions. In addition, length and dosage of treatment ranged significantly across studies. No conclusions could be made related to amount of intervention necessary to affect communication outcomes. Future studies should explore this question further.

Speech-language pathologists and teachers of the deaf provided the bulk of the interventions. In most high-income countries, these positions both require a graduate degree or certificate indicating extensive professional training. Within hearing loss intervention, it is not unusual for speech-language pathologists and teachers of the deaf to provide similar early intervention services. Most of the AVT protocols were provided by auditory-verbal therapists. Certification as Listening and Spoken Language Specialist Certified Auditory-Verbal Therapist requires a minimum of three years of intensive training after receiving a degree in some form of clinical communication disorders (AG Bell Academy for Listening and Spoken Language, 2017). Although clinicians who are not certified can follow the 10 principles of AVT, regardless of their level of training, those with certification are more likely to report implementing listening and spoken language strategies consistently in intervention compared to those who were not (Rosenzweig & Smolen, 2021). None of the studies reported the certification status of the auditory-verbal therapists and it is, therefore, possible that AVT was administered in an inconsistent manner between and within studies, making comparisons and replications challenging.

Conclusion

This scoping review explored specialized speech and language interventions for children who are DHH. The results of these studies were often unclear due to poor reporting of intervention techniques and effects sizes. Future studies might seek to better define speech-language therapy as well as how clinicians and families choose one methodology over another.

Emerging themes, however, suggest that caregiver-centered approaches, teleintervention, adding other speech and language intervention techniques to AVT, and the effect of speech and language therapy on auditory skills should be further considered within the context of speech and spoken language therapy for children who are DHH. Additionally, the effect of intervention on children with different levels and types of hearing loss could not be calculated due to within sample variability. Continued investigations of the effects of specialized interventions are necessary for children from a wider set of demographics with different hearing statuses to ensure that all children who are DHH are receiving the most effective and efficient intervention.

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On World Hearing Day 2022, WHO will focus on the importance of safe listening as a means of maintaining good hearing across the life course. In 2021, WHO launched the World report on hearing that highlighted the increasing number of people living with and at risk of hearing loss. It highlighted noise control as one of the seven key H.E.A.R.I.N.G. interventions and stressed the importance of mitigating exposure to loud sounds.

The World Hearing Day 2022 with the theme "To hear for life, listen with care" will focus on the importance and means of hearing loss prevention through safe listening.