Research Article

Hearing Loss Treatment in Older Adults With Cognitive Impairment: A Systematic Review

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Purpose: The purpose of this systematic review was to assess studies of treating hearing loss in older adults with cognitive impairment. Of interest to this review is identifying clinical adaptations that may be used to tailor hearing loss treatment to older adults with cognitive impairment in order to better serve this vulnerable population.

Method: A systematic search with controlled vocabulary and key word terms was applied to PubMed, the Cochrane Library, Embase, CINAHL, and PsycINFO. Search concepts included terms related to hearing loss and cognitive impairment. The overall search resulted in 4,945 unique references, 50 of which were eligible for full-text review and 13 of which were included in the final review. Included manuscripts were categorized according to the American Speech-Language-Hearing Association's levels of evidence and the National Institutes of Health Quality Assessment Tools.

Results: Only 1 study implemented a randomized controlled trial design to assess cognitive function and behavioral symptoms after treatment with hearing aids. Other quasiexperimental studies evaluated dementia-related symptoms and/or auditory function after treating hearing loss in pre/post research designs. Finally, evidence from case studies suggested that hearing loss treatment is feasible, reduces stressful communication for caregivers, and improves dementia-related behavior problems.

Conclusion: Based on the systematic review, evidence suggests that treating hearing loss in persons with cognitive impairment can have benefits to communication and quality of life. Because of the quasi- and nonexperimental nature of most of the evidence found in this review, further studies are necessary to understand the effect of treatment in the context of a variable and progressive disease.

Dementia diagnosis among the elderly population is projected to increase rapidly. In 2016, the World Alzheimer Report projected a doubling of dementia cases every 20 years as a result of the growing older population (Prince, Comas-Herrera, Knapp, Guerchet, & Karagiannidou, 2016). Importantly, the prevalence of hearing loss doubles with each decade of life and is present in nearly two thirds of adults over 70 years of age (Lin, Metter, et al., 2011; Lin, Niparko, & Ferrucci, 2011), yielding a reasonable likelihood of comorbidity of hearing loss and cognitive impairment. When dementia and age-related hearing loss are comorbid, communication difficulties

tend to increase and induce stress and fatigue in both the individuals with dementia as well as their caregivers. These communication difficulties can also exacerbate dementia-related behavioral problems in the patient, such as apathy, depression, and aggression. (Palmer, Mulla, Dervin, & Cohan, 2017; Slaughter, Hopper, Ickert, & Erin, 2014).

Although the prevalence of age-related hearing loss is high, the rate of hearing aid (HA) use among older adults with cognitive impairment is low; approximately 30% of those with hearing loss reported using HAs in a sample of older adults ($n = 100$) screened in a memory disorders clinic (Nirmalasari et al., 2017). Currently, there is a national effort to increase the accessibility and affordability of hearing loss treatment for older adults (Donahue, Dubno, & Beck, 2010; National Academies of Sciences, Engineering, and Medicine, 2016; President's Council of Advisors on Science and Technology, 2015). In parallel, there is an emphasis on nonpharmacological management of dementia-related behaviors (American Geriatrics Society, 2013), which has the potential to improve care and reduce costs among this growing population (de Oliveira et al., 2015). The potential benefit of addressing the unmet need of

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access to good hearing has been recognized by dementia care experts (Cohen-Mansfield, Dakheel-Ali, Marx, Thein, & Regier, 2015). Moreover, a recent Lancet Commission on prevention, intervention, and care for persons with dementia highlights the importance of optimizing hearing in its recommendations for the management of psychosis, of agitation, and of depression in persons with dementia (Livingston et al., 2017). However, given the unique needs of individuals and families caring for a loved one with cognitive impairment, the standard process for pursuing treatment for hearing loss may be particularly burdensome for this population. Nevertheless, treating hearing loss may serve as a low-risk, low-cost intervention that can improve symptom burden and care management for dementia-related behaviors.

Rationale and Objective

Unfortunately, there is a paucity of research focused on the impact of treating hearing loss in this dually (sensory and cognitively) impaired population and on best practices for treating hearing loss in persons with mild cognitive impairment (MCI) or dementia. Using the PRISMA structured approach to reviewing the literature (Moher, Liberati, Tetzlaff, Altman, & The PRISMA Group, 2009), this study sought to evaluate the evidence for hearing loss treatment in a vulnerable population of older adults with hearing loss and cognitive impairment. The goal of this study was to broadly review the impact of hearing loss treatment as well as determine if there was evidence for novel approaches to providing treatment to this unique population. The intention of this review was to generate novel ideas for integrating hearing loss treatment into comprehensive care plans for persons with cognitive impairment to increase access to hearing care in this dually impaired population. In this review, we will discuss the treatment approaches reported in the literature and treatment outcomes related to cognition, dementia-related symptoms, and hearing and communication.

Method

Literature Search Strategy

We searched PubMed (via National Center for Biotechnology Information; 1946–2017), Embase (via Elsevier; 1947–2017), the Cochrane Library (via Cochrane Library; from inception), PsycINFO (EBSCOhost; 1967–2017), and CINAHL Plus (via EBSCOhost; 1961–2017) on August 20, 2015, and performed subsequent updates of the search on January 11, 2016, and September 11, 2017, in order to ensure up-to-date reporting. The dates included in the updated searches were bracketed to prevent overlapping dates, and any duplicates from previous searches were removed.

We performed a pilot search in PubMed to identify key articles and then proceeded to create the search strategy to ensure that relevant terms were included. We used a broad set of controlled vocabulary and key word terms related to hearing loss, communication barriers or cognitive

impairment, and auditory rehabilitation for retrieval of literature. The search concepts reflected elements of the PICO framework by isolating population, intervention, comparison, and outcome controlled vocabulary and key word terms where appropriate. No limit was made for language or study type; however, we excluded animal studies with a filter based on the Cochrane Highly Sensitive Strategy for Identifying Randomized Trials in MEDLINE (Cochrane Community, n.d.) and pediatric research with an exclusion of specific title words. The full search strategies can be found in the Appendix.

The results of the database searches were processed, deduplicated, and provided by the team's librarian (C. P.) in Endnote. The original search yielded 5,595 total references; 1,527 duplicates were removed for a total of 4,068 unique references. The updated searches (August 1, 2015, to January 11, 2016, and January 1, 2016, to September 11, 2017) produced 1,207 total new references, with 330 duplicates removed and 877 unique references for review.

Eligibility Criteria

A team of four researchers divided the references, such that two independent reviewers assessed titles and abstracts of each article retrieved according to the inclusion and exclusion criteria. Studies were included for the following criteria: (a) prospective, retrospective, experimental, observational, qualitative, or case studies; (b) study population included adult individuals with cognitive impairment; (c) treatment intervention with a goal of improving communication problems due to hearing loss; and (d) outcomes related to improving communication and/or behaviors. Studies were excluded for the following criteria: (a) addressed associations between hearing loss and cognitive impairment; (b) focused on diagnostic practices related to hearing loss rather than treatment of hearing loss; and (c) unpublished or ongoing studies, conference proceedings, dissertations, or other gray literature.

Study Selection

Each title/abstract reviewed was placed into one of three categories: "full text review," "uncertain," and "exclude." Discrepancies were resolved by the lead author (S. K. M.) or by the other audiologist (N. S. R.) on the research team. Articles that fell into the "uncertain" category were resolved through discussion between the two audiologists (S. K. M. and N. S. R.).

Data Collection Process

The two reviewers (S. K. M. and N. S. R.) independently extracted data, and data entry was performed by each reviewer and compared for discrepancies. Any disagreement was resolved through discussion. Extracted data include author, year, age of participants, characteristics of participants (e.g., degree of hearing loss, stage of dementia), unit of analysis (individual/group), treatment intervention

description, and description of primary and secondary outcomes.

Results

The combined initial and updated database searches resulted in 6,802 titles/abstracts, and after removing duplicates, 4,945 unique references were identified. After screening the titles and abstracts, 50 articles were deemed eligible for full text review. Of those references, 37 were determined ineligible based on the defined inclusion/exclusion criteria. Finally, 13 manuscripts were included for detailed analysis (see Figure 1). Detailed results of each study are provided in Table 1. The results from the literature review provide details related to study design, participants, intervention approach, outcomes, risk of bias, and quality of the research approach.

Study Design Characteristics

The studies fell into the following study design categories: randomized placebo-controlled trial¹ (Adrait et al., 2017; Nguyen et al., 2017), two-treatment arm randomized trial (Ghiringhelli & Iorio, 2013), pre/post quasiexperimental (Allen et al., 2003; Hopper, Slaughter, Hodgetts, Ostevik, & Ickert, 2016; Mamo et al., 2017; Palmer, Adams, Bourgeois, Durrant, & Rossi, 1999), case study (Haque, Abdelrehman, & Alavi, 2012; Hopper, 2003; Hopper & Hinton, 2012; Palmer, Adams, Durrant, Bourgeois, & Rossi, 1998), and cross-sectional survey (Lupsakko, Kautiainen, & Sulkava, 2005; see Table 1).

Participant Characteristics

Across studies, participants ranged from 57 to 100 years old. There was also a wide range in degree of hearing loss and the extent of detail provided regarding how the hearing loss was assessed and how the degree of loss was determined. Likewise, the diagnosis and description of cognitive impairment varied across studies, ranging from a previous report of a diagnosis to low scores on a single measure, such as Mini-Mental Status Exam (MMSE; Folstein, Folstein, & McHugh, 1975; Haque et al., 2012; Lupsakko et al., 2005) or Alzheimer's Disease Assessment Scale–Cognitive Subscale (ADAS-Cog; Ghiringhelli & Iorio, 2013; Rosen, Mohs, & Davis, 1984; details provided in Table 1).

Intervention Characteristics

Seven studies included HAs as the treatment approach for hearing loss (Adrait et al., 2017; Allen et al., 2003; Ghiringhelli & Iorio, 2013; Hopper & Hinton, 2012; Lupsakko

et al., 2005; Nguyen et al., 2017; Palmer et al., 1998, 1999). Two studies used noncustom personal amplification (e.g., headset amplifier; Hopper et al., 2016; Mamo et al., 2017). One study used communication training (Hopper, 2003), one employed computer-based auditory training (Krishnamurti, Tingle, Bannon, & Armstrong, 2015), and one case study established a care plan for maintenance of an already-owned HA (Haque et al., 2012).

Among the HA interventions, the treatment protocols among the studies reviewed differ. Palmer et al. (1998, 1999) and Allen et al. (2003) provide clear descriptions of fitting the devices to evidence-based prescriptive targets using real ear measures. The Adrait/Nguyen study (Adrait et al., 2017; Nguyen et al., 2017) relies on a proprietary “first-fit” algorithm from the HA manufacturer. In the Ghiringhelli and Iorio (2013) study, the authors do not provide any details regarding the HA fitting procedure besides the compression recovery times, which was their experimental parameter. Finally, in the cross-sectional survey study of HA use, the data are not available to determine the HA fitting procedures; survey questions focused on whether HAs had been prescribed and whether those individuals reported using the devices (Lupsakko et al., 2005).

Outcomes of Interest

Primary outcomes varied across studies (see Table 1). Two studies measured cognitive change after a period of HA use as a primary outcome (Allen et al., 2003; Nguyen et al., 2017). One study measured performance on a cognitive-communication test (Functional Linguistic Communication Inventory; Bayles & Tomoeda, 1994) as an immediate treatment outcome with and without amplification (Hopper et al., 2016). One study was interested in basic auditory processing tasks and working memory abilities (Krishnamurti et al., 2015). The majority of studies measured behavioral improvement. Behaviors of interest included, but were not limited to, apathy, depression, aggression, lack of interest, and/or lack of energy. Multiple studies used direct observation of behaviors (Haque et al., 2012; Hopper, 2003; Hopper & Hinton, 2012; Palmer et al., 1998, 1999). There was a variety of standardized measures of behaviors—a few used in multiple studies include the Neuropsychiatric Inventory Questionnaire (Adrait et al., 2017; Mamo et al., 2017), the Cornell Scale for Depression in Dementia (CSDD; Allen et al., 2003; Mamo et al., 2017), and the Zarit Burden Interview (Adrait et al., 2017; Mamo et al., 2017). The Neuropsychiatric Inventory Questionnaire has the caregiver respond to 12 questions and rate the severity of each different behavior (Kaufer et al., 2000). The CSDD has 19 questions that are all related to depressive symptoms (Alexopoulos, Abrams, Young, & Shamoian, 1988). The Zarit Burden Interview is designed to measure the amount of burden experienced by the informal/family caregiver (Zarit, Reever, & Bach-Peterson, 1980). Other behavioral outcomes measured using a range of metrics included improvement in activities of daily living (Allen

¹Note that the two manuscripts reviewed here (Adrait et al., 2017; Nguyen et al., 2017) detail different outcome measures that pertain to a single study. When possible, this study will be referred to as Adrait/Nguyen. Sometimes the individual manuscripts will be cited/discussed separately due to the different outcomes reported in each.

Figure 1. Flow diagram of search strategy.

et al., 2003; Lupsakko et al., 2005) and subjective improvement of a perceived hearing handicap (Allen et al., 2003; Ghiringhelli & Iorio, 2013; Mamo et al., 2017; Palmer et al., 1998, 1999).

Cognitive Outcome Measures

Three studies provided empirical data related to at least one cognitive measure as a primary outcome of interest (Allen et al., 2003; Hopper et al., 2016; Nguyen et al., 2017). Among the studies that provided empirical data and statistical analyses, consistent measures were not used, and so comparative analyses across the studies in this review are not possible. The only study with a control group found no group differences on the ADAS-Cog after a 6-month period of HA use in the experimental group (Nguyen et al., 2017). On the other hand, one study that used a pre/post study design suggested “less decline than expected” on the MMSE after 3 months of HA use (Allen et al., 2003). In fact, both the control group and the placebo control group in the Adrait/Nguyen study (Adrait et al., 2017; Nguyen et al., 2017) exhibited less cognitive decline than expected during the intervention period. Another study tested a cognitive outcome (Functional Linguistic Communication Inventory) as an acute outcome measure comparing scores

with and without amplification (Hopper et al., 2016), thus inherently different than the assessment of cognitive performance after several months of hearing loss intervention.

Dementia-Related Symptom Burden Outcomes

Similarly, for the studies that focused on dementia-related symptoms and behaviors, there was little empirical data provided and no possibility of comparing findings across studies. Of the 13 included studies, four provided empirical evidence related to dementia-related behavioral symptoms after treatment of hearing loss (Adrait et al., 2017; Allen et al., 2003; Mamo et al., 2017; Palmer et al., 1999). The only significant finding in the placebo-controlled study related to behavioral outcomes was a slightly improved quality of life score after 1 year in the experimental group (Adrait et al., 2017). In the two studies that measured pre/post within-subject outcomes that addressed dementia-related behavioral symptoms, there were proxy-rated improvements in some participants. Specifically, roughly a third of the participants in the intervention tested by Mamo et al. (2017) showed reductions in depressive and/or neuropsychiatric behaviors 1 month postintervention as rated by an informal caregiver. Similarly, 42% of the patients in the HA intervention by Allen et al. (2003) were

Table 1. Study design characteristics.

Study	Design	Participant characteristics	Interventions	Outcome measures	Major findings
Nguyen et al. (2017)	Double-blind randomized control trial ($n = 38$) Level of evidence: Ib NIH Quality Assessment: Poor	<u>Age:</u> ≥ 65 years (range: 68–99 years) <u>Hearing status:</u> Within the HA fitting range (between 21 and 80 dB HL ^a) <u>Cognitive status:</u> Probable dx per DSM-IV and NINCDS-ADRDA; MMSE = 10–28	Binaural HAs Tx group = proprietary fitting algorithm Control group = mild gain	<u>Primary:</u> ADAS-Cog <u>Secondary:</u> MMSE 16-item Free and Cued Recall DST	<u>At 6 months:</u> <ul style="list-style-type: none"> No difference between groups for any cognitive performance measures Good compliance was the only predictive factor for slower decline No significant findings at 12 months
Adrait et al. (2017) (Note: Companion paper to Nguyen et al., 2017; same study, but reported behavioral and QoL outcomes)	Double-blind randomized control trial ($n = 38$) Level of evidence: Ib NIH Quality Assessment: Poor	<u>Age:</u> ≥ 65 years (range: 68–99 years) <u>Hearing status:</u> Within the HA fitting range (between 21 and 80 dB HL ^a) <u>Cognitive status:</u> Probable dx per DSM-IV and NINCDS-ADRDA; MMSE = 10–28	Binaural HAs Tx group = proprietary fitting algorithm Control group = mild gain	NPI IADL ZBI ADRQL Duke health profile	<u>At 6 months:</u> <ul style="list-style-type: none"> No significant difference between groups for NPI, IADL, ZBI, ADAS-Cog, and Duke scores <u>At 12 months:</u> <ul style="list-style-type: none"> ADRQL score in favor of treatment group as compared to HA placebo group
Mamo et al. (2017)	Quasiexperimental pre/post treatment design ($n = 20$) Level of evidence: IIb NIH Quality Assessment: Fair	<u>Age :</u> $M = 76.9$ years ($SD = 12.4$) <u>Hearing status:</u> ≥ 25 dB HL (1, 2, 4 kHz PTA) in better hearing ear <u>Cognitive status:</u> Current patient at the Johns Hopkins Memory and Alzheimer's Treatment Center	Aural rehabilitation program including a PSAP and communication strategies education delivered to the individual and a caregiver	<u>Primary:</u> CSDD NPI-Q ZBI <u>Secondary:</u> IOI-AI-SO Qualitative program evaluation	<ul style="list-style-type: none"> 65% reported using the device for > 1 hour/day Qualitative written responses suggested improvements in Social Activity/Engagement and Functional Interactions No pre/post statistical differences for CSDD, NPI-Q, ZBI 43% of persons with clinically meaningful depression symptoms at baseline showed improvement at 1-month follow-up 40% of participants showed improvements in NPI-Q at 1-month follow-up

(table continues)

Table 1. (Continued).

Study	Design	Participant characteristics	Interventions	Outcome measures	Major findings
Hopper et al. (2016)	Quasiexperimental crossover study ($n = 31$) Level of evidence: IIb NIH Quality Assessment: Good	<u>Age:</u> $M = 88.0$ years ($SD = 4.37$) <u>Hearing status:</u> Mild-to-moderate hearing loss per 4-freq PTA <u>Cognitive status:</u> Physician dx of AD, vascular dementia or mixed dementia	Headset amplification with REM for frequency shaping and volume adjustments	<u>Primary:</u> FLCI <u>Secondary:</u> • BCRS, Axis 3: Past Memory • Story retelling task, immediate recall • Word Recognition • Clock-drawing test	<ul style="list-style-type: none"> LTC residents did not show improvement on cognitive-communication test scores when tested with and without amplification Authors suggest this null finding could be due to testing in ideal conditions that do not reflect more difficult everyday listening environments Regarding comparison between staff perception of hearing loss and measured hearing status of participants ($n = 25$), nearly half were misclassified
Palmer et al. (1999)	Quasiexperimental multiple baseline treatment design across participants ($n = 8$) Level of evidence: IIb NIH Quality Assessment: Good	<u>Age range:</u> 71–89 years <u>Hearing status:</u> Moderate SNHL (3-freq PTA) <u>Cognitive status:</u> Physician dx of AD; MMSE range: 5–18	Monaural HA treatment provided in the home Research associate visited the home to provide follow-up HA training/troubleshooting once a month for 2–5 months posttreatment	<u>Primary:</u> Problem-behavior modification <u>Secondary:</u> HA compliance HHIE MMSE Social Validity Questionnaire	<ul style="list-style-type: none"> Reduced problem behaviors in 7 of 8 participants 4–13 hr of daily HA use Reduced hearing handicap reported by 7 of 8 caregivers and 3 of 4 AD participants who were able to complete the questionnaire 6 of 8 caregivers indicated that the HA had improved communication for the AD participant
Allen et al. (2003)	Quasiexperimental pre/post treatment design ($n = 31$) Level of evidence: IIb NIH Quality Assessment: Fair	<u>Age range:</u> 67–96 years <u>Hearing status:</u> Moderate hearing loss (Failed whisper screen & 4-freq PTA ≥ 40 dB HL) <u>Cognitive status:</u> Dx of primary dementia per DSM-IV criteria	Monaural HA treatment provided via best practice clinical protocol HA compliance closely monitored by research staff	<u>Primary:</u> MMSE CGI NHHHIP NHHHC <u>Secondary:</u> Euro-ADAS IDDD MOUSEPAD CSDD Carer Strain Scale Carer Burden scale	<ul style="list-style-type: none"> Suggest less cognitive decline than expected in 24 weeks 42% of participants were rated “Better” on the CGI at 24 weeks Reduced hearing handicap perceived by patients and carers Patient scores 27.5 $\rightarrow$ 20.5 Carer scores 34.3 $\rightarrow$ 21.7 (NHHHIP/C; $p < .01$) No notable or significant changes in secondary outcome measures

(table continues)

Table 1. (Continued).

Study	Design	Participant characteristics	Interventions	Outcome measures	Major findings
Palmer et al. (1998)	Case study ($n = 1$) Level of evidence: III NIH Quality Assessment: Fair	Age: 78 years <u>Hearing status:</u> Moderate to severe SNHL based on complete hearing evaluation <u>Cognitive status:</u> Physician dx of probable AD, multiple infarct dementia MMSE = 18	Monaural HA treatment provided in the home Weekly visits for 8 weeks posttreatment for HA training/troubleshooting Administered a modified BEHAVE-AD questionnaire to identify problem behaviors	<u>Primary:</u> Problem-behavior modification <u>Secondary:</u> HHIE Social Validity Questionnaire	<ul style="list-style-type: none"> Reduction in problem behaviors Reduced hearing handicap perceived by caregiver and AD participant Caregiver indicated improved communication and quality of life as a result of the HA
Hopper (2003)	Case Study ($n = 1$) (Note: Only the case with AD and hearing loss is included in this review.) Level of evidence: III NIH Quality Assessment: Poor	Age = 93 years <u>Hearing status:</u> Previous dx of a moderately severe hearing loss <u>Cognitive status:</u> Dx of AD	Communication training <u>Participant:</u> spaced retrieval training to request repetition (cue card) <u>Staff:</u> Instructed to use 3 communication strategies (engage in conversation in quiet environment, repeat/rephrase what was said, and refer to written cues/labels during care routines)	Reduce verbal outbursts, agitation, and aggression	<ul style="list-style-type: none"> Reduced frequency of verbal outbursts and aggression toward staff Staff reported increased satisfaction in communication with the participant Through implicit learning, the participant developed a compensatory strategy Reminders in medical charts and log books increased staff use of effective communication strategies Participant use of the cue card reminded staff to use effective communication strategies Taking time to establish a trusting relationship with the audiologist led to successful assessment of his undiagnosed hearing loss and use of HAs Using the HAs and having a caregiver with communication training reduced verbal outbursts and increased attendance at recreational activities Device maintenance needs to be clearly assigned in the care plan to LTC staff or family to avoid sensory deprivation and serious episodes of agitation
Hopper & Hinton (2012)	Case study ($n = 1$) (Note: Only one case is included in this review; the second case was previously reviewed in Hopper, 2003.) Level of evidence: III NIH Quality Assessment: Poor	Age = 86 years <u>Hearing status:</u> Moderate to severe SNHL; On-site (LTC) behavioral testing <u>Cognitive status:</u> Dx of multiple infarct dementia	Binaural HAs prescribed after using a Pocketalker over a sensitization time period Communication strategies training provided by the audiologist to paid caregiver	Reduced verbal disruptions and reduced anxiety	<ul style="list-style-type: none"> Taking time to establish a trusting relationship with the audiologist led to successful assessment of his undiagnosed hearing loss and use of HAs Using the HAs and having a caregiver with communication training reduced verbal outbursts and increased attendance at recreational activities Device maintenance needs to be clearly assigned in the care plan to LTC staff or family to avoid sensory deprivation and serious episodes of agitation
Haque et al. (2012)	Case study ($n = 1$) Level of evidence: III NIH Quality Assessment: Fair	Age = 91 years <u>Hearing status:</u> Perception of a 512-Hz tuning fork was the same with and without her HA in place <u>Cognitive status:</u> 12 of 30 on MMSE	Set up a care plan and schedule for changing the batteries in her HA (which took two attempts to ensure HA battery upkeep between the LTC staff and family)	Bouts of agitation and confusion resolved	<ul style="list-style-type: none"> Device maintenance needs to be clearly assigned in the care plan to LTC staff or family to avoid sensory deprivation and serious episodes of agitation

(table continues)

Table 1. (Continued).

Study	Design	Participant characteristics	Interventions	Outcome measures	Major findings
Krishnamurti et al. (2015)	Quasiexperimental pre/post treatment design ($n = 8$) Level of evidence: IIb NIH Quality Assessment: Poor	Age range: 57–100 years <u>Hearing status:</u> Bilateral SNHL; range: slight to moderate in better hearing ear <u>Cognitive status:</u> Mild to moderate 'cognitive decline' recruited from nursing home specializing in dementia care	Basic training and auditory resolution training via Angel Sound software (Fu & Wang, 2006)	<ul style="list-style-type: none"> Auditory discrimination (Just Noticeable Difference 1 kHz tone) Consonant recognition Working Memory measured via Subtest 9 from the Woodcock Johnson Test of Cognitive Abilities 	<ul style="list-style-type: none"> Authors report improved accuracy on trained auditory tasks but do not provide statistical evidence Report significant changes in Working Memory scores Authors suggest adults with cognitive decline show improvements in auditory discrimination and cognitive function subsequent to intensive and consistent auditory training
Ghiringhelli & Iorio (2013)	Randomized between-groups trial ($n = 50$) Level of evidence: Ib NIH Quality Assessment: Poor	Age range: 60–80 years <u>Hearing status:</u> Mild to severe bilateral SNHL (3-freq PTA between 26–70 dB HL) <u>Cognitive status:</u> Grouped based on the Alzheimer's Disease Assessment Scale–Cognitive Subscale ($n = 24$ with cognitive impairment)	Binaural HAs 4 comparison groups: <ul style="list-style-type: none"> With & without cognitive impairment Fast or slow HA digital signal processing (random assignment) 	Perceived hearing handicap (HHIE) Speech perception in noise (LSP)	ANOVA <ul style="list-style-type: none"> HHIE: improvement pre/post for all groups ($p < .01$) LSP: improvement pre/post for all groups ($p < .01$) After 4 months, all groups showed improvement in perceived hearing handicap and speech-in-noise performance regardless of HA processing strategy
Lupsakko et al. (2005)	Cross-sectional survey ($n = 100$) Level of evidence: III NIH Quality Assessment: Good	Age: 75+ years ($M = 83$) <u>Hearing status:</u> Report having been provided a HA <u>Cognitive status:</u> No dx; median MMSE (IQR) = 26 (20,28)	N/A Surveyed on HA use in the context of a population-based interview/geriatric assessment observational study	<u>Demographics:</u> sex, age, education, income, institutionalization <u>Clinical:</u> MMSE, ADL, depression	Among HA "nonusers" ($n = 24$) <ul style="list-style-type: none"> Lower income ($p = .002$) Lower MMSE ($p = .006$) Lower ADL scores ($p = .011$)

Note. Quality Assessment Tools available from National Heart, Lung, and Blood Institute (2013). Levels of evidence = descriptions provided by the American Speech-Language-Hearing Association (n.d.). Dx = diagnosis; AD = Alzheimer's disease; SNHL = sensorineural hearing loss; DSM-IV = Diagnostic and Statistical Manual of Mental Disorders–Fourth Edition; NINCDS-ADRDA = National Institute of Neurological and Communicative Diseases and Stroke/Alzheimer's Disease and Related Disorders Association; MMSE = Mini-Mental Status Examination; HA = hearing aid; ADAS-Cog = Alzheimer's Disease Assessment Scale–Cognitive Subscale; BEHAVE-AD = Behavioral pathology in Alzheimer's disease; IQR = interquartile range; PSAP = personal sound amplification products; DST = Digit Symbol Test; NPI-Q = Neuropsychiatric Inventory Questionnaire; IADL = Instrumental Activities of Daily Living; ADRQL = Alzheimer Disease Related Quality of Life; PTA = pure-tone average (3-freq = 0.5, 1, 2 kHz; 4-freq = 0.5, 1, 2, 4 kHz); CSDD = Cornell Scale for Depression in Dementia; ZBI = Zarit Burden Interview; IOI-AI-SO = International Outcomes Inventory–Alternative Interventions–Significant Other; REM = real ear measures; FLCI = Functional Linguistic Communication Inventory; BCRS = Brief Cognitive Rating Scale; LTC = long-term care; HHIE = hearing handicap inventory for the elderly; CGI = Clinical Global Impression of Change; NHHHIP(C) = Nursing Home Hearing Handicap Index for Patient(Carer); IDDD = Instrumental Deterioration for Daily Living in Dementia; QoL = quality of life; ANOVA = analysis of variance; Tx = treatment; LSP = Listas de Sentenças em Português (Costa, Iorio, Mangabeira-Albernaz, 1997); Euro-ADAS = European Alzheimer's Disease Assessment Scale.

^aDid not state how "bilateral SNHL" was defined.

reported as being generally “better” on the Clinical Global Impression of Change Scale; however, it is unclear who the proxy raters were for the Clinical Global Impression of Change measure. Despite observed improvement in 30%–40% of participants in both of those pre/post studies, when analyzed as a group, there were no significant pre/post findings for depression (CSDD) or neuropsychiatric behaviors (measured via different tools) in either study.

Hearing and Communication Outcomes

All of the studies had a primary or secondary outcome related to improvement in hearing and/or speech understanding. For the studies reported above, the novel findings were related to cognition and dementia-related symptoms; as such, reports of reduced hearing handicap, for example, can be found in Table 1 but are not detailed in the text. However, there were two studies that were not primarily interested in cognitive and dementia-related outcomes but rather were specifically interested in auditory skills (Krishnamurti et al., 2015) or in performance with HAs based on signal processing strategies (Ghiringhelli & Iorio, 2013). In general, the findings from these studies suggest that older adults with age-related cognitive decline show signs of improved auditory function with treatment.

Risk of Bias Within and Across Studies

A major limitation of the results in the reviewed studies is the risk for bias within studies due to a reliance on proxy ratings of behavioral outcomes (Adrait et al., 2017; Allen et al., 2003; Mamo et al., 2017; Palmer et al., 1998, 1999) and anecdotal case study reports of improvement (Haque et al., 2012; Hopper & Hinton, 2012). These bias risks within studies are highlighted in the quality rating system discussed below. In addition, the risk for bias across studies stems from the fact that conference proceedings and other gray literature were not included, which may limit the scope of the reviewed literature because it is plausible that clinicians have strategies for working with the patient population that are not being reported in the published literature.

Quality of Studies

Included manuscripts were categorized according to the American Speech-Language-Hearing Association’s (ASHA) levels of evidence (ASHA, n.d.) and the National Institutes of Health Quality Assessment Tools (National Heart, Lung, and Blood Institute, n.d.). The ASHA hierarchy of levels of evidence is intended to support the process of developing evidence-based practices. There are six tiers (Ia, Ib, IIa, IIb, III, and IV), with Ia reflecting the highest level of evidence (i.e., meta-analysis of > 1 randomized controlled trial). The levels of evidence presented in this review include the following: Ib (Adrait et al., 2017; Ghiringhelli & Iorio, 2013; Nguyen et al., 2017), IIb (Allen et al., 2003; Hopper et al., 2016; Krishnamurti et al., 2015; Mamo et al., 2017; Palmer et al., 1999), and III (Haque

et al., 2012; Hopper, 2003; Hopper & Hinton, 2012; Lupsakko et al., 2005; Palmer et al., 1998; see Table 1).

The National Institutes of Health Quality Assessment Tools provide guidance on evaluating the quality of a study per various study types (e.g., randomized controlled trial, case study series). Each study type has 10–12 criteria to consider with descriptions of the expected reporting on topics such as clearly defined research questions, subject population, power calculations, and analyses. Using these guidelines, the stronger studies reviewed here were ranked as follows: good (Hopper et al., 2016; Lupsakko et al., 2005; Palmer et al., 1999) and fair (Allen et al., 2003; Haque et al., 2012; Mamo et al., 2017; Palmer et al., 1998; see Table 1). For the quasiexperimental studies ranked as fair, the most common limitation was lack of a power calculation (Allen et al., 2003; Mamo et al., 2017). Most of the case studies did not receive a strong quality assessment due to the high risk of bias in the subjective descriptions of outcomes posttreatment. In addition, the two studies with the highest level of evidence (Adrait et al., 2017; Nguyen et al., 2017; Ghiringhelli & Iorio, 2013) both received poor quality assessments. The treatment (i.e., proprietary “first fit” protocol) and treatment adherence (i.e., self-report) in the Adrait/Nguyen study (Adrait et al., 2017; Nguyen et al., 2017) were not sufficiently verified to ensure that the active and placebo-controlled participants were receiving different interventions. The Ghiringhelli and Iorio randomized two-treatment arm study was not explicit in many study details needed to determine truly randomized treatment groups who were similar at baseline, nor was there any explicit discussion of treatment adherence during the 4-month duration of the study.

Discussion

The purpose of this research was to systematically review the literature for studies related to treating hearing loss in persons with MCI or dementia in order to determine best practices for managing hearing loss in this vulnerable and growing population. An important factor that motivated this review was to evaluate clinical adaptations that tailor hearing loss treatment to adults with MCI or dementia given the unique needs of this population of patients where conventional clinic-based models of care using HAs may not be ideal. Nevertheless, most studies relied on standard HA use with little customization for the individual and family needs of an older adult with hearing loss and cognitive impairment.

The outcomes of interest across studies varied with some addressing cognitive function, some addressing dementia-related behavioral symptoms, and some addressing hearing and communication outcomes. These differences in outcomes of interest across studies pose a challenge in synthesizing the findings from this review. There were no significant findings with regard to change in cognitive function post-hearing rehabilitation in the studies reviewed. As such, the discussion will focus on findings related to dementia-related behavioral symptoms and hearing and communication

outcomes. These two main outcomes will each be addressed with regard to the strength of the evidence provided to support improvements in dementia-related behavioral symptoms and hearing and communication subsequent to treatment of hearing loss in a cognitively impaired older adult population.

Dementia-Related Behavioral Symptom Outcomes

Two quasiexperimental studies showed improvements in dementia-related behaviors on standardized questionnaires as rated by a proxy; however, the quality of the evidence is limited by the pre/post test design and the potential bias in the proxy reporting (Allen et al., 2003; Mamo et al., 2017). Although it is difficult to blind the researcher or proxy rater as to whether or not the hearing loss treatment is being utilized (i.e., the HAs are either on or they are not), the implementation of a delayed baseline control group would allow for evaluation of the normal variations in dementia-related behaviors in a nontreatment group.

The case series reported by Palmer and colleagues (1998, 1999) employed a single-subject design research approach to track specific behaviors pre- and posttreatment with HAs. Although this approach is also susceptible to rater bias, it provides insight to the frequency and variability of problem behaviors prior to treatment. This approach is highly useful to investigate novel approaches prior to implementation of more extensive efficacy trials.

Two of the case studies examined interventions to reduce verbal disruptions and outbursts. One study used HAs, whereas the other used communication training as the intervention (Hopper, 2003; Hopper & Hinton, 2012). Both interventions yielded a reduction in verbal disruptions and outbursts. One intent of our search criteria was to broaden the range of treatment approaches to determine if options other than HAs might be feasible and successful in this patient population. For the case study that explicitly used communication training in the absence of amplification, the communication training focused on spaced retrieval training for an individual with hearing loss and dementia, in which he was trained to use a cue card to remind staff members to look at him and speak slowly, so that he could understand them (Hopper, 2003). In addition, the staff were trained to use effective communication strategies, and reminders regarding his hearing status were posted in the resident's chart and care plan to trigger good communication behaviors when the staff worked with him.

One study that implemented a randomized placebo-controlled HA treatment trial was unfortunately limited by the design of the hearing intervention (e.g., no real ear verification of evidence-based prescriptive targets for the HA fitting, lack of provision of adequate counseling, and self-report regarding treatment adherence; Adrait et al., 2017; Nguyen et al., 2017). This study demonstrated no significant benefit of the hearing intervention on cognitive decline or improvement in behavioral symptoms. However, patients who reported high compliance with HA use

in this study showed a small benefit in quality of life at 12 months posttreatment, suggesting a need to maximize treatment adherence (Adrait et al., 2017).

Hearing and Communication Outcomes

Another alternative approach to care was a computer-based auditory training program for individuals with hearing loss and poor working memory abilities (Krishnamurti et al., 2015). The specifics of cognitive impairment diagnosis for these individuals were not included in the manuscript—only that the participants were recruited from a nursing home that specialized in dementia care. Participants completed 7–8 weeks of auditory training that focused on frequency discrimination and consonant identification. Although the study reported a significant difference in working memory scores post-auditory training, the results do not report any outcomes specific to communication or dementia-related behavioral symptoms. Nevertheless, the study argues that there is potential for sensory and cognitive changes subsequent to consistent training.

One study examined different HA processing algorithms (i.e., slow vs. fast compression) to see if older adults with cognitive impairment were adversely affected by fast compression systems (Ghiringhelli & Iorio, 2013). Although the cognitively impaired group had more perceived hearing handicap and poorer speech-in-noise scores than the cognitively healthy control group of older adults, they showed similar improvement on both outcomes after 4 months of HA use. In addition, there was no difference between the subgroups who were randomized to fast or slow compression algorithms. A limitation in generalizing these findings to adults with MCI or dementia is that the “cognitively impaired group” seemed not to have a diagnosis of cognitive impairment per se but rather was composed of the poorer half of performers in that sample on the ADAS-Cog.

HA Use and Maintenance Outcomes

A cross-sectional study conducted in a town in Finland surveyed individuals who had been issued an HA (free in their medical system) as to whether they were active users or nonusers (Lupsakko et al., 2005). Among the descriptive statistics reported, there was a significant trend of lower income, lower MMSE scores, and lower activities of daily living scores among the group of non-HA users compared to HA users. This cross-sectional survey suggests that even when HAs are provided, persons with lower cognitive and functional scores may have greater difficulty maintaining and routinely using the device.

A similar finding from one of the case studies was that, although the woman had been an HA user for many years, without someone assigned to ensure the battery was changed regularly, she was unable to manage that aspect of HA use and unable to report when the HA was not functioning (Haque et al., 2012). After a major episode of confusion and agitation, the medical team realized during the assessment that the HA she was wearing had

a dead battery and the sensory deprivation was contributing to the episode. However, 8 weeks after having established a care plan with the family of changing the batteries routinely, the resident had another upsetting and agitating episode, and it was again determined that her HA battery was dead. This sort of simple, routine maintenance being hard to adhere to for individuals, families, and long-term care (LTC) staff highlights a particular burden of hearing loss treatment in this population.

Overall Study Conclusions

Overall, the studies reviewed suggested hearing loss treatment was beneficial in improving dementia-related symptoms and communication. Despite a general consensus of improvement in dementia-related behavioral symptoms, it should be noted that the available literature is dominated by case studies and subjective outcome measures. There are several challenges to performing high-quality studies in this population, including the ethical problem of not treating the hearing loss and the near impossibility of blinding the researchers to cognitive status and treatment group. As such, future research should implement experimental designs with control groups and objective measures related to change in dementia-related behavioral symptoms. In addition, future research should also be conducted to understand the most accessible approaches to providing hearing care to persons with dual diagnosis of hearing loss and cognitive impairment. Objective as well as subjective measures should be collected and compared to provide sufficient validation of different treatment and intervention options.

Clinical Application

Importantly, evidence from this review suggests that some older adults with cognitive impairment show positive outcomes related to HA use that include reduced dementia-related behavioral symptoms, reduced hearing handicap, and improved speech-in-noise abilities. Most of the studies used standard clinical approaches to care, that is, HA prescriptions and clinic-based services.

A few clinical adaptations were shown to be successful. One study delivered standard HA fitting care but provided the service in the home to reduce access to care barriers (Palmer et al., 1998, 1999). One of the quasi-experimental studies delivered a simple aural rehabilitation intervention using noncustom personal sound amplifiers within a memory disorders clinic (Mamo et al., 2017). Other novel approaches were presented through case studies. In particular, one study relied on speech therapy and communication training to improve communication between the person and the LTC staff (Hopper, 2003). Finally, one case study used a period of building trust using a Williams Sound Pocketalker® prior to undergoing the standard HA fitting routine—both of which proved to have a positive benefit on the person's verbal outbursts and agitation (Hopper & Hinton, 2012).

Limitations

The most significant limitation is that most of the studies were very small. Specifically, six studies had sample sizes of less than 10 participants, and four studies had only a single case report. The ability to generate clinical protocols tailored to the needs of this vulnerable population requires more generalizable findings from larger sample populations.

A noticeable limitation to our review is reflected in the number of full-text manuscripts deemed ineligible due to only having access to a published abstract for the study (see Figure 1). Because we did not include unpublished or ongoing studies, conference proceedings, dissertations, other gray literature, or hand-searched articles, we recognize that this may have been a limitation of our review due to issues of publication bias. It seems from the number of published conference abstracts that there is broad interest and recognition that hearing loss exacerbates dementia-related behavioral symptoms; however, because of challenges in undergoing experimental investigation in this population, there is little empirical evidence to guide clinical treatment. Interestingly, among the full-text review manuscripts that were not included in this systematic review, nine of them presented Summary/Review articles on the topic rather than experimental findings.

Conclusions

One goal of this review was to determine what successful adaptations to standard HA and clinic-based services have been tested. Future research may be able to randomize treatment groups to clinic-based and home-based care to evaluate treatment outcomes related to adherence to care, improvements in communication, and improvements in dementia-related behaviors. In addition, case studies from LTC facilities indicate opportunities for more alternative approaches to care (e.g., communication training, noncustom headset amplifiers), and randomized trials could test different approaches (i.e., factorial designs) that provide custom and noncustom hearing loss treatment plans across multiple LTC settings.

With the rapidly aging population and the growing costs of dementia care, treating hearing loss in this population seems to be a low-cost essential component to the larger care plan. Evidence that older adults with cognitive impairment benefit from HAs both in terms of speech and communication measures as well as in terms of reduced dementia-related behavioral symptoms supports the need for research with this population. Importantly, research that focuses on access to care and sustained adherence to HA use will improve hearing loss treatment coverage in this population.

Acknowledgments

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Search Strategies

**PubMed, Embase, Cochrane, CINAHL, PsycINFO
Endnote**
Searches processed and run by Carrie Price, MLS
From inception to August 20, 2015

PubMed

("auditory comprehension"[tw] OR "auditory defect"[tw] OR "auditory defects"[tw] OR "auditory deficit"[tw] OR "auditory deficits"[tw] OR "auditory threshold"[mesh:noexp] OR "auditory threshold"[tw] OR "auditory thresholds"[tw] OR "hard of hearing"[tw] OR "hearing acuities"[tw] OR "hearing acuity"[tw] OR "hearing deficit"[tw] OR "hearing deficits"[tw] OR "hearing disorder"[tw] OR "hearing disorders"[mesh] OR "hearing disorders"[tw] OR "hearing dysfunction"[tw] OR "hearing dysfunctions"[tw] OR "hearing impaired"[tw] OR "hearing impairment"[tw] OR "hearing impairments"[tw] OR "hearing loss"[mesh] OR "hearing loss"[tw] OR "hearing loss, noise-induced"[mesh] OR "noise injury"[tw] OR "noise injuries"[tw] OR "hearing losses"[tw] OR "impaired hearing"[tw] OR "loss of hearing"[tw] OR "persons with hearing impairments"[mesh] OR "presbycusis"[Mesh] OR presbycus*[tw] OR presbyacus*[tw] OR hypoacus*[tw]) AND ("alzheimer disease"[mesh] OR "cognition"[mesh:noexp] OR cogniti*[tw] OR "communication barrier"[tw] OR "communication barriers"[mesh:noexp] OR "communication barriers"[tw] OR "dementia"[mesh:noexp] OR "language barrier"[tw] OR "language barriers"[tw] OR "mci"[tw] OR "mcis"[tw] OR "memory deficit"[tw] OR "memory deficits"[tw] OR "memory disorder"[tw] OR "memory disorders"[tw] OR "mental disorder"[tw] OR "mental disorders"[mesh:noexp] OR "mental disorders"[tw] OR alzheimer*[tw] OR dement*[tw]) AND ("auditory rehabilitation"[tw] OR "habilitation"[tw] OR "audiologic rehabilitation"[tw] OR "aural habilitation"[tw] OR "aural rehabilitation"[tw] OR "clear speech"[tw] OR "communication method"[tw] OR "communication methods"[tw] OR "communication"[mesh:noexp] OR "communication"[tw] OR "Correction of Hearing Impairment"[Mesh] OR "correction"[tw] OR "corrections"[tw] OR "correction of hearing loss"[tw] OR "hearing aid"[tw] OR "hearing aids"[mesh] OR "hearing aids"[tw] OR "hearing rehabilitation"[tw] OR "hearing loss correction"[tw] OR "lip reading"[tw] OR "lipreading"[tw] OR "manual communication"[tw] OR "manual communications"[tw] OR "rehabilitation of hearing impaired"[tw] OR "rehabilitation of hearing impaired"[tw] OR "rehabilitation of hearing impairment"[tw] OR "sign language"[tw] OR "sign languages"[tw] OR "speech reading"[tw] OR "speechreading"[tw] OR ampli*[tw] OR device*[tw] OR gestur*[tw] OR intervent*[tw] OR manag*[tw] OR treat*[tw]) NOT ("animals"[mesh] NOT ("animals"[mesh] AND "humans"[mesh]))
NOT (child*[ti] OR newborn*[ti] OR neonat*[ti] OR pediatric*[ti] OR paediatric*[ti] OR infant*[ti])

1,466 results as of August 20, 2015

46 results from August 1, 2015, to January 11, 2016

227 results from January 1, 2016, to September 11, 2017

Embase

('auditory comprehension':ti,ab,de or 'auditory defect':ti,ab,de or 'auditory defects':ti,ab,de or 'auditory deficit':ti,ab,de or 'auditory deficits':ti,ab,de or 'auditory threshold'/de or 'auditory threshold':ti,ab,de or 'auditory thresholds':ti,ab,de or 'hard of hearing':ti,ab,de or 'hearing acuities':ti,ab,de or 'hearing acuity':ti,ab,de or 'hearing deficit':ti,ab,de or 'hearing deficits':ti,ab,de or 'hearing disorder':ti,ab,de or 'hearing disorder'/de or 'hearing disorders':ti,ab,de or 'hearing dysfunction':ti,ab,de or 'hearing dysfunctions':ti,ab,de or 'hearing impaired':ti,ab,de or 'hearing impairment':ti,ab,de or 'hearing impairments':ti,ab,de or 'hearing impairment'/exp or 'hearing loss':ti,ab,de OR 'noise injury'/exp or 'noise injury':ti,ab,de or 'noise injuries':ti,ab,de or 'hearing losses':ti,ab,de or 'impaired hearing':ti,ab,de or 'loss of hearing':ti,ab,de or 'presbycusis'/exp or presbycus*:ti,ab,de or presbyacus*:ti,ab,de or hypoacus*:ti,ab,de) AND ('alzheimer disease'/exp or 'cognition'/de or cogniti*:ti,ab,de or 'communication barrier':ti,ab,de or 'communication barriers':ti,ab,de or 'dementia'/de or 'language barrier':ti,ab,de or 'language barriers':ti,ab,de or 'mci':ti,ab,de or 'mcis':ti,ab,de or 'memory deficit':ti,ab,de or 'memory deficits':ti,ab,de or 'memory disorder':ti,ab,de or 'memory disorders':ti,ab,de or 'mental disorder':ti,ab,de or 'mental disorders':ti,ab,de or alzheimer*:ti,ab,de or dement*:ti,ab,de) AND ('auditory rehabilitation'/exp or 'habilitation':ti,ab,de or 'audiologic rehabilitation':ti,ab,de or 'aural habilitation':ti,ab,de

Appendix (p. 2 of 3)

Search Strategies

or 'aural rehabilitation':ti,ab,de or 'clear speech':ti,ab,de or 'communication method':ti,ab,de or 'communication methods':ti,ab,de or 'communication'/de or 'communication':ti,ab,de or 'Correction of Hearing Impairment'/exp or 'correction':ti,ab,de or 'correction':ti,ab,de or 'corrections':ti,ab,de or 'correction of hearing loss':ti,ab,de or 'hearing aid':ti,ab,de or 'hearing aid'/exp or 'hearing aids':ti,ab,de or 'hearing rehabilitation':ti,ab,de or 'hearing loss correction':ti,ab,de or 'lip reading':ti,ab,de or 'lipreading':ti,ab,de or 'manual communication':ti,ab,de or 'manual communications':ti,ab,de or 'rehabilitation of hearing impaired':ti,ab,de or 'rehabilitation of hearing impaired':ti,ab,de or 'rehabilitation of hearing impairment':ti,ab,de or 'sign language':ti,ab,de or 'sign languages':ti,ab,de or 'speech reading':ti,ab,de or 'speechreading':ti,ab,de or amplif*:ti,ab,de or device*:ti,ab,de or gestur*:ti,ab,de or intervent*:ti,ab,de or manag*:ti,ab,de or treat*:ti,ab,de) NOT ('animal'/exp NOT ('animal'/exp AND 'human'/exp)) **NOT** (child*:ti or newborn*:ti or neonat*:ti or pediatric*:ti or paediatric*:ti or infant*:ti)

2,223 results as of August 20, 2015

87 results from August 1, 2015, to January 11, 2016

501 results from January 1, 2016, to September 11, 2017

Cochrane

- #1 MeSH descriptor: [Auditory Threshold] this term only 261
- #2 MeSH descriptor: [Hearing Disorders] explode all trees 1424
- #3 MeSH descriptor: [Hearing Loss] explode all trees 920
- #4 MeSH descriptor: [Hearing Loss, Noise-Induced] explode all trees 76
- #5 MeSH descriptor: [Persons With Hearing Impairments] explode all trees 25
- #6 MeSH descriptor: [Presbycusis] explode all trees 19
- #7 ("auditory comprehension":ti,ab,kw or "auditory defect":ti,ab,kw or "auditory defects":ti,ab,kw or "auditory deficit":ti,ab,kw or "auditory deficits":ti,ab,kw or "auditory threshold":ti,ab,kw or "auditory thresholds":ti,ab,kw or "hard of hearing":ti,ab,kw or "hearing acuities":ti,ab,kw or "hearing acuity":ti,ab,kw or "hearing deficit":ti,ab,kw or "hearing deficits":ti,ab,kw or "hearing disorder":ti,ab,kw or "hearing disorders":ti,ab,kw or "hearing dysfunction":ti,ab,kw or "hearing dysfunctions":ti,ab,kw or "hearing impaired":ti,ab,kw or "hearing impairment":ti,ab,kw or "hearing impairments":ti,ab,kw or "hearing loss":ti,ab,kw or "noise injury":ti,ab,kw or "noise injuries":ti,ab,kw or "hearing losses":ti,ab,kw or "impaired hearing":ti,ab,kw or "loss of hearing":ti,ab,kw or presbycus*:ti,ab,kw or presbyacus*:ti,ab,kw or hypoacus*:ti,ab,kw) 2245
- #8 #1 or #2 or #3 or #4 or #5 or #6 or #7 2654
- #9 MeSH descriptor: [Alzheimer Disease] explode all trees 2264
- #10 MeSH descriptor: [Cognition] this term only 5044
- #11 MeSH descriptor: [Communication Barriers] this term only 86
- #12 MeSH descriptor: [Dementia] this term only 1462
- #13 MeSH descriptor: [Mental Disorders] this term only 2361
- #14 cogniti*:ti,ab,kw or "communication barrier":ti,ab,kw or "communication barriers":ti,ab,kw or "language barrier":ti,ab,kw or "language barriers":ti,ab,kw or "mci":ti,ab,kw or "mcis":ti,ab,kw or "memory deficit":ti,ab,kw or "memory deficits":ti,ab,kw or "memory disorder":ti,ab,kw or "memory disorders":ti,ab,kw or "mental disorder":ti,ab,kw or "mental disorders":ti,ab,kw or alzheimer*:ti,ab,kw or dement*:ti,ab,kw 41606
- #15 #9 or #10 or #11 or #12 or #13 or #14 41606
- #16 MeSH descriptor: [Correction of Hearing Impairment] explode all trees 88
- #17 MeSH descriptor: [Communication] this term only 1478
- #18 MeSH descriptor: [Hearing Aids] explode all trees 370
- #19 "auditory rehabilitation":ti,ab,kw or "habilitation":ti,ab,kw or "audiologic rehabilitation":ti,ab,kw or "aural habilitation":ti,ab,kw or "aural rehabilitation":ti,ab,kw or "clear speech":ti,ab,kw or "communication method":ti,ab,kw or "communication methods":ti,ab,kw or "communication":ti,ab,kw or "correction":ti,ab,kw or "correction":ti,ab,kw or "corrections":ti,ab,kw or "correction of hearing loss":ti,ab,kw or "hearing aid":ti,ab,kw or "hearing aids":ti,ab,kw or "hearing rehabilitation":ti,ab,kw or "hearing loss correction":ti,ab,kw or "lip reading":ti,ab,kw or "lipreading":ti,ab,kw or "manual communication":ti,ab,kw or "manual communications":ti,ab,kw or "rehabilitation of hearing impaired":ti,ab,kw or "rehabilitation of hearing impaired":ti,ab,kw or "rehabilitation of hearing impairment":ti,ab,kw or "sign language":ti,ab,kw or "sign languages":ti,ab,kw or "speech reading":ti,ab,kw or "speechreading":ti,ab,kw or amplif*:ti,ab,kw or device*:ti,ab,kw or gestur*:ti,ab,kw or intervent*:ti,ab,kw or manag*:ti,ab,kw or treat*:ti,ab,kw 515552
- #20 #16 or #17 or #18 or #19 515635
- #21 #8 and #15 and #20 129
- #22 (child*:ti or newborn*:ti or neonat*:ti or pediatric*:ti or paediatric*:ti or infant*:ti) 63278
- #23 #21 not #22 108

108 results as of August 20, 2015

4 results August 1, 2015, to January 11, 2016

35 results from January 1, 2016, to September 11, 2017

Appendix (p. 3 of 3)

Search Strategies

CINAHL

("auditory comprehension" OR "auditory defect" OR "auditory defects" OR "auditory deficit" OR "auditory deficits" OR MH "auditory threshold" OR "auditory threshold" OR "auditory thresholds" OR "hard of hearing" OR "hearing acuities" OR "hearing acuity" OR "hearing deficit" OR "hearing deficits" OR "hearing disorder" OR MH "hearing disorders + " OR "hearing disorders" OR "hearing dysfunction" OR "hearing dysfunctions" OR "hearing impaired" OR "hearing impairment" OR "hearing impairments" OR "hearing loss" OR "noise injury" OR "noise injuries" OR "hearing losses" OR "impaired hearing" OR "loss of hearing" OR MH "presbycusis" OR presbycus* OR presbyacus* OR hypoacus*) AND (MH "alzheimer's disease" OR MH "cognition" OR cogniti* OR "communication barrier" OR MH "communication barriers" OR "communication barriers" OR MH "dementia" OR "language barrier" OR "language barriers" OR "mci" OR "mcis" OR "memory deficit" OR "memory deficits" OR "memory disorder" OR "memory disorders" OR "mental disorder" OR MH "mental disorders" OR "mental disorders" OR alzheimer* OR dement*) AND ("auditory rehabilitation" OR "habilitation" OR "audiologic rehabilitation" OR "aural habilitation" OR "aural rehabilitation" OR "clear speech" OR "communication method" OR "communication methods" OR MH "communication" OR "communication" OR MH "Rehabilitation of Hearing Impaired + " OR "correction" OR "correction" OR "corrections" OR "correction of hearing loss" OR "hearing aid" OR MH "hearing aids + " OR "hearing aids" OR "hearing rehabilitation" OR "hearing loss correction" OR "lip reading" OR "lipreading" OR "manual communication" OR "manual communications" OR "rehabilitation of hearing impaired" OR "rehabilitation of hearing impaired" OR "rehabilitation of hearing impairment" OR "sign language" OR "sign languages" OR "speech reading" OR "speechreading" OR amplif* OR device* OR gestur* OR intervent* OR manag* OR treat*) NOT TI(child* OR newborn* OR neonat* OR pediatric* OR paediatric* OR infant*)

851 results as of August 20, 2015

29 results from August 1, 2015, to January 11, 2016

147 results from January 1, 2016, to September 11, 2017

PsycINFO

("auditory comprehension" OR "auditory defect" OR "auditory defects" OR "auditory deficit" OR "auditory deficits" OR DE "auditory thresholds" OR "auditory threshold" OR "auditory thresholds" OR "hard of hearing" OR "hearing acuities" OR "hearing acuity" OR "hearing deficit" OR "hearing deficits" OR "hearing disorder" OR DE "Hearing Disorders" OR "hearing disorders" OR "hearing dysfunction" OR "hearing dysfunctions" OR "hearing impaired" OR "hearing impairment" OR "hearing impairments" OR "hearing loss" OR "noise injury" OR "noise injuries" OR "hearing losses" OR "impaired hearing" OR "loss of hearing" OR "presbycusis"[Mesh] OR presbycus* OR presbyacus* OR hypoacus*) AND (DE "alzheimer disease" OR DE "cognition" OR cogniti* OR "communication barrier" OR DE "communication barriers" OR "communication barriers" OR DE "dementia" OR "language barrier" OR "language barriers" OR "mci" OR "mcis" OR "memory deficit" OR "memory deficits" OR "memory disorder" OR "memory disorders" OR "mental disorder" OR DE "mental disorders" OR "mental disorders" OR alzheimer* OR dement*) AND ("auditory rehabilitation" OR "habilitation" OR "audiologic rehabilitation" OR "aural habilitation" OR "aural rehabilitation" OR "clear speech" OR "communication method" OR "communication methods" OR DE "communication" OR "communication" OR "correction" OR "correction" OR "corrections" OR "correction of hearing loss" OR "hearing aid" OR DE "Hearing Aids" OR DE "Cochlear Implants" OR "hearing aids" OR "hearing rehabilitation" OR "hearing loss correction" OR "lip reading" OR "lipreading" OR "manual communication" OR "manual communications" OR "rehabilitation of hearing impaired" OR "rehabilitation of hearing impaired" OR "rehabilitation of hearing impairment" OR "sign language" OR "sign languages" OR "speech reading" OR "speechreading" OR amplif* OR device* OR gestur* OR intervent* OR manag* OR treat*) NOT TI(child* OR newborn* OR neonat* OR pediatric* OR paediatric* OR infant*)

947 results as of August 20, 2015

14 results from August 1, 2015, to January 11, 2016

117 results from January 1, 2016, to September 11, 2017