Dementia and hearing loss briefing

A rapid scoping review of published systematic reviews and/or scoping reviews to explore and map the literature in relation to a) dementia and hearing loss/deafness and b) hearing loss and cognitive impairment

Authors: Prof. Gill Windle and Kiara Jackson, DSDC Wales Research Centre, School of Medical and Health Sciences, Bangor University and Prof. Andrea Tales, Centre for Innovating Ageing, Swansea University.

Supported by the Wales Centre for Ageing and Dementia Research by Health and Care Research Wales (Prof. Andrea Tales co-director; Prof. Gill Windle associate director).

For further information please contact g.windle@bangor.ac.uk

Final version 30th May 2022
Prepared for the Welsh Government Dementia Oversight of Implementation and Impact Group (DOIIG)
Background
A report prepared by the Welsh Government Task and Finish Group on Dementia, Hearing Loss and Deafness (2021) identified four priorities for action:

- **Priority 1 Prevention**: to reduce the number of people in Wales at risk of dementia due to undiagnosed and unmanaged hearing loss (hearing loss as a modifiable risk factor).
- **Priority 2 Assessment and diagnosis**: to improve the identification of individuals with hearing loss or deafness and suspected or diagnosed dementia (assessment) to ensure accurate dementia diagnosis (diagnosis).
- **Priority 3 Rehabilitation (of hearing)**: To ensure that hearing rehabilitation is accessible for those living with dementia and meets their specific individual needs.
- **Priority 4 The Deaf BSL community and dementia**: To improve understanding about the specific cultural, linguistic identity and needs of the Deaf British Sign Language (BSL) community across professionals working in health, social care and dementia services and drive cultural change in the provision of services (inclusivity and access).

The report from the group contains a number of recommendations. In relation to research it states: ‘The Welsh Government, via Health and Care Research Wales, should promote and fund world-leading, cross sector research into dementia and hearing loss as a priority for improving the health and care of people living with hearing loss, dementia and D/deafness.’

Aims
To assist in identifying priorities for future research funding by the Welsh Government and other funders, the objectives of this work are to:

- Undertake a scoping review to identify published systematic reviews or scoping reviews of primary research in relation to a) dementia and hearing loss/deafness and b) hearing loss and cognitive impairment.
- Descriptively map the identified literature in relation to the main topic themes to aid the future formulation of targeted research priorities and research questions for new research programmes.
Research question: What are the main topic themes emerging from published research on dementia, hearing loss or deafness?

The scoping exercise is restricted to published systematic reviews and/or scoping reviews of existing primary research. This type of secondary research is useful as reviews seek to find as much evidence as possible and synthesise the results from a wide range of individual research studies. Consequently identifying existing reviews on this topic is a useful first step in establishing the state of existing knowledge. The methods and results are documented in Appendix 1. Here we summarise the key points from this process.

Main findings
Twenty-four reviews were identified. On full appraisal nine did not have a replicable methodology explaining how their sources were identified consequently fifteen review papers were included in this final mapping exercise. The full details for each review (authors; countries studies conducted; type and # studies included; participant characteristics; critical appraisal methods, main findings and implications) are presented in the table in the Appendix 2. There are a number of clinical implications suggested by the authors of the included reviews which could be useful for supporting learning and development (see Appendix 3 for brief overview).

Table 1 presents an overview of the main six topic themes covered by the reviews and the corresponding review paper. These are classified as:

- Clinical methods for undertaking hearing assessments
- Effects of hearing rehabilitation
- Biological/brain relationship with hearing loss and dementia
- Effects of hearing loss on risk for dementia, cognitive impairment, MCI
- Cognitive screening tests for use in the clinical evaluation of MCI or dementia in people with hearing loss.
- Psychosocial therapeutic engagement approaches

The total number of primary research studies included in the reviews identified for this paper is 528. There was a lack of information about the specific type of dementia diagnosed. Where reported, studies tended to mainly be conducted in European or Western countries (‘developed’ nations).
Table 1: Main themes identified in the reviews and their sources.

<table>
<thead>
<tr>
<th>Authors of included evidence reviews</th>
<th>Clinical methods for undertaking hearing assessments</th>
<th>Effects of hearing rehabilitation</th>
<th>Biological/brain relationship with hearing loss and dementia</th>
<th>Effects of hearing loss on risk for dementia, cognitive impairment, MCI</th>
<th>Cognitive screening tests for use in the clinical evaluation of MCI or dementia in people with hearing loss.</th>
<th>Psychosocial therapeutic engagement approaches</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bott et al. (2019)</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cross et al. (2021)</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dawes et al. (2019)</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Di Stadio et al. (2021)</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ford et al. (2018)</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hobler et al. (2021)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lau et al. (2021)</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loughrey et al. (2018)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mamo et al. (2018)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pye et al. (2013)</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sanders et al. (2021)</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Taljaard et al. (2015)</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thomson et al. (2017)</td>
<td></td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Young et al. (2020)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Zheng et al. (2017)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Summary points from the findings of the reviews to help shape future research questions

The effects of hearing loss

The reviews identified in this paper suggest hearing loss is associated with:

- Incident dementia (Ford et al., 2018; Thompson et al., 2018)
- Mild cognitive impairment (Lau et al., 2021; Zheng et al., 2017)
- Decline in cognitive function and increased risk of cognitive impairment (Loughrey et al., 2018)
- Decline in cognitive function (Taljaard et al., 2015; Thompson et al., 2018)

However some of the reviews lacked information about the types of dementia in their study populations. There are many different types of dementia which will likely present with different deficits and require tailored hearing assessments, especially as it is suggested “we hear with our brains” (Johnson et al., 2021).

There was a lack of information around subjective cognitive decline, a potential risk factor for dementia, and hearing loss.

It is not clear as to whether there are differences in congenital vs acquired hearing loss/deafness on cognitive function and decline.

It is not clear as to how sudden hearing loss vs gradual decline may differentially affect cognitive function and decline.

It is not clear when the best time to intervene may be e.g. should public health checks be undertaken on all middle age adults to assess for hearing loss.

Hearing rehabilitation

The reviews acknowledge differences in the results of studies in terms of whether or not hearing aids prevent deterioration of cognitive function in people without a diagnosis of dementia or MCI. Consequently further work could examine if hearing rehabilitation devices/techniques reduce the risk of developing cognitive impairment and/or prevent or
change any deterioration of cognitive function in people with hearing difficulties who do not have a diagnosis of dementia or MCI at the outset.

Similarly, the reviews present mixed results from studies as to whether or not hearing aids/hearing rehabilitation can improve cognition and slow cognitive decline in people with a diagnosis of dementia.

We suggest the specific evidence identified in this review could be further investigated initially as a single topic and explored in more depth, as there are a number of factors that could influence outcomes, including the need for a long-follow up assessment. Going forward, existing population cohort surveys that span many years may be a good basis for secondary data analysis, should they contain cognitive and hearing assessments e.g. MRC Dementia Platform.

Much of the evidence reviewed here focussed on hearing aids as the main form of hearing rehabilitation, however further research could explore how different techniques are effective in enhance communication for the person living with dementia.

**Biology/brain relationship**

Further understanding of the underlying biological/physiological/psychosocial mechanisms that explain ‘why’ there is a link between hearing loss and cognitive impairment/decline and dementia, (Sanders et al. 2021 present a good overview of the different hypotheses around mechanisms, as do some of the other reviews which examined the link between hearing loss, cognition or cognitive impairment/dementia).

**Assessments**

There are difficulties with cognitive assessments as applied to people with hearing difficulties, and further work could usefully look at how assessments can be adapted (e.g. Pye et al., 2013 suggest low background noise, and use of sensory corrective devices).

Similarly there are issues with clinical hearing assessments as applied to people with a known diagnosis, and further work could explore how this could be improved and adapted to an individuals needs.
In addition to hearing loss, the impact of other health conditions should be considered. Co-morbidities on hearing and subsequent cognitive function.

Other aspects of brain function in addition to ‘cognition’ that can be abnormal in dementia may also be affected by hearing loss and could be investigated.

There is a lack of evidence which has sought the direct voice of the person with hearing loss who may also be experiencing actual or perceived symptoms of cognitive decline or have a diagnosis of dementia. Further work is needed to enable the ‘lived experience’ to be represented. What is important to them?

Appendix 1 Methods and results

Aim: To undertake a scoping review of published systematic reviews and/or scoping reviews to explore and map the literature in relation to a) dementia and hearing loss/deafness and b) hearing loss and cognitive impairment.

Question: What are the main topic themes emerging from published research on dementia, hearing loss or deafness?

A protocol for searching and retrieval of the evidence was developed by GW and implemented by KJ (searches run January and February 2022). No double reviewing at abstract screening took place. Double reviewing took place at full text data extraction and appraisal (KJ and GW). All authors contributed to the interpretation of the results.

Primary databases:
1. Medline (EBSCO)
2. CINAHL (EBSCO)
3. PsychINFO and Social Science Premium Collection (ProQuest)

Searches to be built as:
1. String [a] topic
2. String [a] title & abstract
4. String [b] topic
5. String [b] title & abstract
7. String [c] topic
8. String [c] title & abstract
Population: string [a]
Dementia OR cognitive impairment OR Alzheimer’s Disease OR Frontotemporal Dementia OR OR vascular dementia OR PPA OR PCA OR familial Alzheimer’s Disease OR mild cognitive impairment OR MCI
Concept: string [b]
Hearing loss OR deaf OR deafness

Context: string [c]
Systematic review OR scoping review OR literature review

### Inclusion and Exclusion Criteria

<table>
<thead>
<tr>
<th>Inclusion criteria</th>
<th>Exclusion criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Published systematic reviews; scoping reviews or literature reviews with a replicable methodology.</td>
<td>Book chapters, conference papers, grey literature, discussion papers, opinion pieces and literature overviews.</td>
</tr>
<tr>
<td>Published in English in any country.</td>
<td>Not published in English.</td>
</tr>
</tbody>
</table>

### Management in reference manager software:

<table>
<thead>
<tr>
<th>Step</th>
<th>Actions</th>
<th>Included retrievals</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Total imports</td>
<td>224</td>
</tr>
<tr>
<td>2</td>
<td>De-duplicating (63)</td>
<td>161</td>
</tr>
<tr>
<td>3</td>
<td>Manual de-duplication (1)</td>
<td>160</td>
</tr>
<tr>
<td>4</td>
<td>Title screening (75 excluded)</td>
<td>85</td>
</tr>
<tr>
<td>5</td>
<td>Abstract screening (45 excluded)</td>
<td>40</td>
</tr>
<tr>
<td>6</td>
<td>Full texts unavailable (4)</td>
<td>36</td>
</tr>
<tr>
<td>7</td>
<td>Full text screening (12 excluded)</td>
<td>24</td>
</tr>
<tr>
<td>8</td>
<td>Included in final appraisal (9 excluded)</td>
<td>15</td>
</tr>
</tbody>
</table>
Records identified from Databases (n=224)
  - Medline (n=73)
  - CINAHL (n=32)
  - PsychINFO (n=76)
  - SSPC (n=43)

Records removed before screening:
  - Duplicate records removed (n=64)

Records screened (n=160)

Records excluded (n=75)

Reports sought for retrieval (n=85)

Reports not retrieved (n=3)
  - (Abstract only, unable to find full text)

Reports assessed for eligibility (n=82)

Reports excluded: 58
  - (Primary research, different population group e.g. deaf children, theses, book chapters; N=9 no replicable methodology reported)

Papers included in review (n=15)


http://www.prisma-statement.org/
### Appendix 2: Review papers included in the scoping review

<table>
<thead>
<tr>
<th>Bott et al. (2019)</th>
<th>Clinical methods to undertake hearing assessments.</th>
<th>Canada N=1, France N=1, Italy N=1</th>
<th>3 studies (2014-2017)</th>
<th>Total no of participants = 64 Gender % female = 58.1, 32, 50. Most of the participants with dementia had Alzheimer’s Disease.</th>
<th>No. of participants with dementia = 31, 25, 8.</th>
<th>Cross-sectional, observational</th>
<th>Across these three studies, the proportion of adults with dementia who could successfully complete PTA (pure-tone audiometry) ranged from 56% to 59%. Suggesting that PTA can be an effective tool in hearing evaluation for the majority of adults with dementia.</th>
<th>Further research is needed in this area, it should focus on homogeneous research design and the inclusion of adults with moderate and severe stages of dementia. Future research should also consider the feasibility of alternative non-behavioural hearing tests, such as AEP tests.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cross et al. (2021)</td>
<td>Effects of hearing rehabilitation</td>
<td>‘high-income countries’ USA N=8, Canada N=4, Australia N=3, Japan N=1</td>
<td>16 studies (1986-2020)</td>
<td>Total no. of participants 861 + (1 study no. of participants unknown), Participants living in residential aged care facilities, with any degree of hearing loss, with cognitive impairment (any subtype of dementia or MCI)</td>
<td>Participant numbers ranged from 1-279</td>
<td>Controlled trials, single-group pretest-post-test designs, interviews, surveys, and single-subject case designs.</td>
<td>Mixed Methods Appraisal Tool (MMAT) 27-item checklist (study methodology). Revised Criteria for Reporting the Development and Evaluation of Complex Interventions in healthcare checklist (CReDEC2), 13-item checklist (interventions).</td>
<td>Residents with dementia can benefit from hearing rehabilitation (including hearing devices, communication techniques, and visual aids (e.g., flashcards). Identifying and implementing efficient, individualized hearing rehabilitation is necessary for those with complex cognitive needs. Increased funding and support for the social care sector is required to address systemic issues that pose barriers to hearing rehabilitation, including time pressures, lack of training for staff and access to audiology services for residents.</td>
</tr>
</tbody>
</table>
Dawes et al. (2019) To synthesize the evidence base regarding the effect of treatment of hearing and vision impairment in people living with dementia on the following outcomes: (i) cognition; (ii) rate of cognitive decline; (iii) behavioural and psychological symptoms of dementia; (iv) hearing or vision-related quality of life; (v) general quality of life; (vi) ADL; and (vii) caregiver burden for adults with dementing conditions. [WE FOCUS ONLY ON THE FINDINGS IN RELATION TO THE TREATMENT OF HEARING].

Di Stadio et al. (2021) 1) To discuss the radiological and biomolecular findings shared by hearing loss and dementia and the pathological basis that are common to both conditions. 2) To discuss the current available treatment options for hearing loss and the effects of hearing devices on cognition.

| Effects of hearing rehabilitation | Not reported | 12 papers on 10 studies (1998 - 2017) | Total participants = 178 | Sample sizes ranged from 1 - 51 | Randomized controlled trial, case reports, single subject design, or pre-post test single group design. | Risk of bias was assessed using Downs and Black’s (1998) checklist (27 items). Data concerning the development, piloting, and evaluation of the sensory interventions were extracted and described according to the Criteria for Reporting the Development and Evaluation of Complex Interventions in healthcare: revised guideline (CReDeCI 2) (Möhler et al., 2015). | Six studies reported on hearing aid provision, one study on hearing aid “trouble shooting,” one study on provision of assistive listening devices, one study on provision of assistive listening devices plus information on hearing loss and communication training, and one study on cochlear implantation interventions. Results were variable: hearing aid provision improved hearing related disability and behavioural and psychological symptoms but not ADL function or carer burden. No benefits reported for assistive listening devices, the cochlear implant led to immediate improvement in hearing related disability, but this was not sustained. All the reported studies of hearing aid interventions found good compliance with hearing aid use across a range of severities of dementia and which were comparable to levels of use reported among non-cognitively impaired new hearing aid users. | There is an urgent need for well-controlled intervention studies that include measures of hearing disability, behavioural and psychological symptoms of dementia, cognitive function and rate of decline, quality of life, ADL, and caregiver burden. It would be desirable to develop complex interventions that could be tailored to individual patterns of impairment and patient preference. Future research should include better quality reporting, consistent use of an inclusive range of relevant outcomes, and more robust study designs to establish the benefit of sensory interventions to improve outcomes for people with dementia. |

| Biological/brain relationship with hearing loss and dementia | Not reported (English language only) | 93 articles (2000-2020) | Not reported | Not reported | Epidemiological studies, case-control studies, prospective studies, and retrospective studies. (Review studies were included only if systematic or meta-analysis) | Not reported | Identified radiological and biomolecular findings that might confirm the association between HL and dementia, presence of brain atrophy and gliosis in both. Temporal lobe atrophy - common in HL - may increase the risk of developing dementia, and diffuse brain atrophy involving the temporal lobe may cause HI. Brain gliosis in the memory area/auditory cortex might cause hearing deficit or difficulty in speech discrimination, early symptom of cognitive decline. Auditory restoration by hearing devices could preserve brain functions by stimulating brain connectivity and improving the biomolecular effect link between hearing loss and dementia is still unknown. | Suggests a role for auditory correction in elderly patients to preserve cognitive abilities. Cause-effect link between hearing loss and dementia is still unknown. |
mechanisms responsible of the synaptogenesis (microglia), thus stimulating a reparative process.

CLINICAL IMPLICATIONS: auditory restoration by hearing devices could preserve brain functions by stimulating brain connectivity and improving the biomolecular mechanisms responsible of the synaptogenesis (microglia), stimulating a reparative process. The results suggest a role for auditory correction in elderly patients to preserve cognitive abilities.

Ford et al. (2018) To investigate the association of hearing loss and incident dementia in the older age demographic that is at highest risk for both of these conditions through a) a prospective cohort study and b) a systematic review and meta-analysis of prospective studies. [WE FOCUS ON THE FINDINGS OF THE SYSTEMATIC REVIEW]

Effects of hearing loss on incident dementia
USA N=9, UK N=1, Wales N=1, Germany N=1, Singapore N=1, Taiwan N=1, Australia N=1

15 studies (1996 - 2017) 13 of these were included in the meta-analysis

227,614 total participants, 72,831 were included in the meta-analysis. Aged 39+ 'diverse populations of both genders'

Participant numbers ranged from: 274 -154,783

Eligible studies were rated for quality in five areas: (1) the assessment of exposure (hearing) was objective i.e. through direct testing (yes/no), (2) the diagnosis of dementia was made through direct clinical contact (yes/no), (3) confounding was taken into account (yes/no/uncertain), (4) the statistical analysis was appropriate (yes/no/uncertain) and (5) other sources of bias were considered in the analysis of the data; e.g. selection bias, unacceptable loss to follow-up (yes/no/uncertain)

Increased risk of incident dementia with hearing impairment. Dementia-type did not substantially change these findings.

"Efforts to reduce the impact of mild-life hearing loss + dementia should continue to be explored. Increased dementia risk in association with hearing loss could have important public health implications, should future studies prove this link to be causal. An unanswered question raised by our studies though is whether this effect may be modifiable in any way i.e. would hearing aids reduce risk or change the trajectory of cognitive decline."

"Well designed randomized controlled trials targeting older people with hearing loss who are at risk of cognitive impairment are needed to determine if the link between hearing loss and cognitive impairment is causal and can be reversed with appropriate treatment."
Hober et al. (2021) To identify valid and reliable screening measures that are effective for the identification of hearing loss and are suitable for use by nursing staff providing care to residents with dementia in long-term care homes.

Clinical methods for undertake hearing assessments. Included studies in French, German, Spanish, Dutch, Portuguese, Italian, and Mandarin 193 papers (1995 - 2020) aged 65+; A mixture of dementia types, unspecified dementia or cognitive impairment indicative of dementia was most frequently reported, across almost half the reviewed studies (n = 86), but the most common diagnosis among participant groups was dementia of the Alzheimer’s type (n = 59). If severity reported, this was mild to severe (n = 51) or mild to moderate cognitive impairment (n = 41).

Not reported Peer reviewed as well as non-peer reviewed publications were captured, including conference proceedings and academic dissertations not conducted (scoping review)

"The review found that a wide range of measurement approaches have been used to measure aspects of hearing and auditory functioning in individuals living with dementia, including subjective measures (based on self- or other-reports), behavioural measures (requiring a patient response to tones or speech), and physiological measures (examining the ear canal for cerumen [wax], immittance to assess middle ear function, otoacoustic emissions to evaluate inner ear status, or evoked response potentials to examine auditory brain responses). Pure-tone audiometry was the most frequently reported hearing test."

A number of adults with cognitive impairment were unable to complete standard test protocols or required the tester to modify the procedures used to administer tests. "These findings highlight the importance of the testing environment (i.e., a quiet location), as well as the training required to successfully administer screening tests with knowledge of how to adapt standard procedures to the cognitive capacities and abilities of the individuals being screened. Almost two-thirds of hearing tests identified in the present review were not found to be suitable for nurses to administer in LTCHs."

Although frequently used, the suitability of pure-tone audiometry for use by nursing staff in LTCHs is limited, as standardized audiometry presents challenges for many.

An urgent need to develop new approaches to screen hearing in long-term care homes. Identifying reliable, valid, and feasible hearing screening tools for nurses is a necessary step in this quest to develop new approaches and implement informed policies to identify hearing loss in residents living with dementia in LTCHs by the most appropriate, responsive, and practicable means, so that the sensory and communicative needs of affected residents can also be addressed.
Lau et al. (2021)  
To identify any relationship between hearing loss and a prodromal state of dementia or mild cognitive impairment.

| Establish the relationship between hearing loss, cognition and dementia or mild cognitive impairment. | America N=19, Europe N=6, Asia N=5, Africa N=2, Australia N=2 | 34 studies (1986/89 – 2019) 18 studies included in the meta-analysis | 48,017 total participants. Patient population: adults with hearing loss and/or mild cognitive impairment/early dementia. Homogeneous populations (e.g. white people, well-educated, health-aware). | Patients N=15,086 (range = 5-4820). Control N=32,931 (range = 10-8911). Range = 20 - 13,731 recruited for each study. | Cohort N = 10, Cross-sectional N = 23, Cohort and Cross-sectional N = 1 | Newcastle–Ottawa Scale (cohort studies), minimum 6/9 stars. None mentioned for cross-sectional. | 23/34 studies observed a significant association between hearing loss and mild cognitive impairment. Significantly more people with MCI had peripheral hearing loss compared with those without. Significantly more people with peripheral hearing loss had mild cognitive impairment compared with those without. There was a correlation between hearing loss and incidence of early dementia or cognitive decline. | Future research should focus on identifying the underlying mechanisms linking hearing loss with dementia and developing rehabilitation strategies to delay or prevent its occurrence. Clinical recommendations: routine cognitive assessment for people who present with hearing loss in an audiology clinic. Referral for hearing assessment when diagnosed with mild cognitive impairment in primary care. Early intervention and rehabilitation to improve QoL and reduce morbidity associated with hearing loss could be investigated through a) routine cognitive assessment for people who present with hearing loss in an audiology clinic; b) referral for hearing assessment when diagnosed with mild cognitive impairment in primary care. Prospective cohort studies could examine whether early diagnosis of cognitive impairment improves important patient or caregiver outcomes. Examine the mechanisms linking hearing loss and cognitive decline (e.g., cognitive reserve and cognitive processes, social |
Loughrey et al. (2018)  
To examine and estimate the association between Age Related Hearing Loss (ARHL) and cognitive function, cognitive impairment, and dementia through a systematic review and meta-analysis.

| Establish the relationship between hearing loss, cognition and mild cognitive impairment. | 12 countries: United States N=14, Australia N=13, Germany N=5, The Netherlands N=5, United Kingdom N=3, Canada N=1, Finland N=1, Denmark, Finland, and Sweden N=1, Spain N=1, Italy N=1, Japan N=1. | 40 studies, 36 included in meta-analysis | 34,471 total. 20,264 participants included in meta-analysis. Gender: 100% Female N=2, 0% Female N=2, NA N=3, Remaining N=39 range 35.2% – 66.7% Female. | Range = 47 – 4221 recruited for each study | 36 epidemiologic studies included in quantitative synthesis (meta-analysis). 26 Cross-sectional cognition, 9 Cohort cognition, 5 Cross-sectional impairment, 3 Cohort impairment, 3 Cohort dementia, 2 Cross-sectional dementia. Studies restricted to those using pure-tone audiometry hearing assessments. | Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) instrument | Age-related hearing loss was significantly associated with decline in all main cognitive domains and with increased risk for cognitive impairment and incident dementia. A small but significant association between ARHL and 10 cognitive function domains in cross-sectional studies, and 7 of the 8 available cognitive function domains in cohort studies. A significant association between ARHL and cognitive impairment was found across cross-sectional and cohort studies. A significant association was found between ARHL and vascular dementia, but not specifically between ARHL and vascular dementia or Alzheimer’s Disease. "Randomised clinical trials exploring the cognitive benefits of hearing loss treatment are required, as is more research as to whether treatment alone or as part of a wider approach to risk factors, modifies dementia outcomes. Neuroimaging studies could examine modification of cortical changes and neurocognitive compensation with hearing aid use in speech tasks. Future epidemiologic research might assess whether ARHL is associated with cognitive decline independently of neuropathologic hallmarks of dementia and whether a mediator of this association exists (e.g., loneliness). Also of interest would be whether cognitive reserve moderates cognitive decline in the population with ARHL." Understanding the causal mechanisms between ARHL and cognitive decline or dementia (‘how’ this happens, the biological, physiological basis etc). |}

- Isolation, environmental ‘deafferentation’.
Mamo et al. (2018) To evaluate the evidence for hearing loss treatment in older adults with hearing loss and cognitive impairment and determine if there was evidence for novel treatment approaches/clinical adaptations that may be used to tailor hearing loss treatment to older adults.

| Effects of hearing rehabilitation | Not reported. | 13 studies (1998 - 2017) | Total participants = 328. Participant age ranged from 57 to 100 years old. | Sample sizes ranged from 1 - 100 | Randomized controlled trial design, quasi-experimental studies, case studies, randomized placebo-controlled trial, two treatment arm randomized trial, pre/post quasi-experimental and cross-sectional survey. | American Speech-Language-Hearing Association’s levels of evidence and the National Institutes of Health Quality Assessment Tools. | The authors grouped their results by 3 outcome areas. 1) cognitive outcomes; 2) dementia related symptom outcomes: 3) hearing and communication outcomes. No significant findings with regard to change in cognitive function post-hearing rehabilitation in the studies reviewed. Treating hearing loss in persons with cognitive impairment can have benefits to communication and quality of life, it was beneficial in improving dementia-related behavioural symptoms (described as verbal disruptions and outbursts) and reduces stressful communication for caregivers. Clinical implications: 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. Two studies used non-custom personal amplification, one study used communication training, one employed computer-based auditory training and one case study established a care plan for maintenance of existing hearing aids. 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 non-custom personal sound amplifiers within a memory disorders clinic (Mamo et al., 2017). One study relied on speech therapy and communication training to improve communication between the person and future research should implement experimental designs with control groups and objective measures related to change in dementia-related behavioural 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.

“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 behaviours. In addition, case studies from LTC facilities indicate opportunities for more alternative approaches to care (e.g., communication training, non-custom headset amplifiers), and randomized trials could test different approaches (i.e., factorial designs) that provide custom and non-custom hearing loss treatment plans across multiple LTC settings.” |
Cognitive screening tests for use in the clinical evaluation of MCI or dementia in people with hearing loss.

Not reported.

N=13 (4 specifically looked at cognitive assessments adapted for hearing impairment)

Not reported

Not described but suggest feasibility/pilot type designs.

N/A scoping review

Two cognitive assessments were identified as adapted and applied in 4 studies. The Mini Mental Status Exam (MMSE): in one study questions from the standard MMSE were administered on individual flashcards, phrased as per standard verbal administration. In the other, items were written in large font and three items were administered verbally (repeating a sentence), serial sevens and spelling "world" backwards). Serial sevens item was not included in the final score. Montreal Cognitive Assessment (MoCA): In one study verbal instructions were translated into visual instructions and presented via a computerized visual slide show. In the other, auditory items were deleted from the standard MoCA (Language repetition, Clinical: It would be clinically important to know what level of sensory impairment renders standard measures of cognitive performance invalid, necessitating the use of alternative assessments. There is a particular need for the development of reliable cognitive assessments for individuals with hearing impairment.)
Sanders et al. (2021) To systematically review the existing longitudinal literature to examine the evidence for using hearing aids intervention as a treatment for deteriorating cognitive function (in people without dementia at the onset of the study)

| Effects of hearing rehabilitation - preventing cognitive decline on people without dementia or MCI. Clinical methods of undertaking cognitive assessments. | 'High income countries', USA N=8, Italy N=2, Germany N=1, Netherlands N=1, Japan N=1, Korea N=1, Turkey N=1, Brazil N=1, Australia N=1 | 17 studies (1990 - 2020) | 3526 participants total | range = 6 to 2040 participants | 4 RCTs, 13 prospective cohort studies | The Cochrane Risk of Bias tool was used to assess randomized controlled trials (RCTs), while the Newcastle-Ottawa Scale was used for non-randomized prospective cohort studies. | Conclude that there is controversy about the effects of hearing aids on cognition. If beneficial effects of hearing aids on cognition exists, they particularly seem to affect the executive function domain. Additionally, using hearing aids might not have an effect on the language domain and little, if any, effect on complex attention and learning and memory. The authors note difficulties to precisely measure cognitive ability, with cognition being such a broad concept. There are many different tests available, which measure different aspects of cognition, as evidenced in this review. They also note "the validity of these tests in a population with hearing impairment is questionable and cognitive tests relying on auditory stimuli could potentially overestimate the effects of hearing aids on cognition". [This paper contains a good discussion on the different hypotheses for the hearing loss-dementia relationship]. Need for long-term, large-scale observational studies to better understand the effects of hearing aids on cognitive decline, in the form of longitudinal randomised clinical trial. There is a need for standardisation of well-justified cognitive measures. Elucidation of underlying mechanisms, and stratification of the results according to subtypes of dementia. Evaluate the effects of hearing aids on social and emotional cognition. It is known that hearing loss starts around mid-life, so studies should commence in slightly younger adults. |
To examine the evidence-base regarding the relationship between hearing and cognition in adults with and without hearing impairment.

Meta-analyses examined evidence for and against seven questions. Is cognition poorer in individuals with normal hearing compared to (i) untreated or (ii) treated hearing impairment, is cognition associated with degree of hearing impairment in (iii) untreated and/or (iv) treated hearing, is cognition (v) different in untreated compared to treated hearing impairment, (vi) does cognition improve after intervention, and (vii) how is hearing impairment differentially associated with cognitive ability across six domains of cognition?

### Effects of hearing loss on cognitive function in adults with and without hearing impairment.

<table>
<thead>
<tr>
<th>Study</th>
<th>Design</th>
<th>Participants</th>
<th>Measures</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taljaard et al. (2015)</td>
<td>33 studies</td>
<td>5,735 participants total. Mean age of 57.7 (+27.0) years</td>
<td>Cognitive assessments</td>
<td>The authors did not appraise the quality of the papers included in their analysis but note that publication bias was inspected visually using funnel plots, and statistically through Egger’s test for asymmetry.</td>
</tr>
<tr>
<td>Thomson et al. (2017)</td>
<td>17 studies</td>
<td>Range = 200 - 1,338,462 recruited for each study.</td>
<td>12 prospective cohort studies, 4 cross-sectional, 1 case-control</td>
<td>All of the studies evaluated in this review found hearing loss is associated with dementia or cognitive decline.</td>
</tr>
</tbody>
</table>

### Benefits of hearing rehabilitation.

- Better hearing is associated with better performance across all cognitive domains examined, including attention and processing speed, short-term/working, and long-term memory, executive functioning, and semantic processing and word knowledge, although the effects were all small. These effects were not impacted by the age of the participants, the time with treatment, or whether the tasks were 'visual' or 'verbal' in nature.
- Large differences were observed in the selection of cognitive test measures and many of the studies used cognitive tasks produced and normed for a hearing population.

### Cognitive domains.

- Differences between studies: future examination of the possible influence of variables including pre- and post-lingual hearing impairment, verbal and non-verbal IQ, oral and manual communication, mood, cognitive reserve, education and the number of health conditions. Future research should also target the cognitive domains to be evaluated based on a proposed mechanism of action.

Researchers should be explicit about their theory-based argument for which cognitive domains are affected in hearing impairment, and why hearing affects these domains in order for research to agree on using the same, well-justified cognitive measures that are relevant and valid for people with hearing impairment.

Studies that investigate the proposed mechanisms by which impaired hearing is related to impaired cognition (e.g. social isolation) are urgently required. Differences between studies: future examination of the possible influence of variables including pre- and post-lingual hearing impairment, verbal and non-verbal IQ, oral and manual communication, mood, cognitive reserve, education and the number of health conditions. Future research should also target the cognitive domains to be evaluated based on a proposed mechanism of action.

Researchers should be explicit about their theory-based argument for which cognitive domains are affected in hearing impairment, and why hearing affects these domains in order for research to agree on using the same, well-justified cognitive measures that are relevant and valid for people with hearing impairment.
diminished the likelihood of cognitive decline. The authors suggest the hearing aid use assessment (a yes/no question) may be inadequate as it does not capture compliance/correct use.

Wayne et al. suggested that an effective way to identify why hearing loss precedes dementia is to intervene in various proposed causal pathways and observe their impact on cognition.

Evaluating family history in the context of studying hearing loss as a risk factor for dementia could provide valuable insight into the etiology behind the connection.

| Young et al. (2020) | Psychosocial therapeutic approaches. | Dates searched: 1980-2017, Stage 1: 12 references found, Stage 2: 24 references + 7 web resources, stage 3: 28 sources | Not reported. | Peer-reviewed articles, books, web-based resources (including 4 in sign-language) | Not used. | Life-story work has the potential to build on lifelong storytelling practices by Deaf people, the functions of which have included the (re)forming of cultural identity, the combating of ontological insecurity, knowledge transmission, the resistance of false identity attribution, and the celebration of language and culture. The life-story work must be carried out in a signed language, such as BSL. A Deaf person’s (sign) language is a fundamental marker of their identity and sense of self in the world, portrayed and reinforced by the content and modality of many stories. Deaf person to Deaf person communication plays a crucial role. The inter-subjective and collective opportunities stories present to assert those fundamental bonds of belonging and shared experience are valued. It is important to recognise that the personal and social history of Deaf people will not necessarily mirror the history of the hearing majority. Integral to storytelling practices is the visual, not just in the sense of signed languages being visual languages but in the ways in which stories use Deaf people’s | No previous research on the development of a life-story work intervention specifically for Deaf people who are sign language users and who experience dementia. There is currently no such intervention available that is linguistically and culturally tailored to Deaf people who experience dementia and no available resources on which to draw. |
visual orientation in both content, form and narrative effects. Much of this is familiarity with the expressive potential of space, positing of objects and visual expressions. For Deaf people with dementia, the challenge may not lie in the loss of words and speech, but potentially in the failure of others to enable their visuality, regardless of whether they have retained fluent sign language.

| Zheng et al. (2017) | Effects of hearing loss on dementia | America | 4 studies (2002 – 2014) | 7461 participants total | Range = 274 – 4463 recruited for each study. Hearing Impaired N= 2057 (15 – 1162). Control N= 5404 (220 – 3627) | Prospective cohort studies | The modified Newcastle–Ottawa scale | Hearing impairment significantly increases the risk of cognitive impairment while there is no significant difference with the risk of Alzheimer’s disease. | Future well-designed prospective cohort studies could confirm the association between hearing impairment and risk of Alzheimer’s disease. |
Appendix 3 Summary of clinical implications for workforce development suggested by the authors of the studies included in this review

Improving Hearing/Cognitive Testing

- Audiologists need to take dementia into account when assessing hearing. They may need to adapt the testing procedures or the testing environment to obtain accurate results. For example: using a more interesting tone, shortening the frequency ranges, adapting to individuals needs, a calm environment and/or using alternative tests (Bott et al., 2019).

- Evaluation of older patients presenting with hearing loss should include neurological, radiologic and auditory investigations focusing on the peripheral and central auditory pathways, with the aim of improving hearing. In patients presenting with cognitive loss, it is fundamental to rapidly identify any hearing loss, as early intervention aiming at hearing rehabilitation could be helpful to slow down the cognitive decline (Di Stadio et al., 2021).

- Screening tests identified for Nurses to use in long-term care settings: use of interview questions, collecting relevant hearing and ear disease history from medical charts, using questionnaires, screen for tinnitus and hyperacusis, behavioural measures such as ‘the whisper test’. Highlights the importance of the testing environment (i.e., a quiet location), as well as the training required to successfully administer screening tests with knowledge of how to adapt standard procedures to the cognitive capacities and abilities of the individuals being screened (Hobler et al., 2021).

- It is important for clinicians to be aware of the significant association between hearing loss and incident mild cognitive impairment and allow for early detection and intervention to try and delay onset of dementia. A role for routine cognitive assessment for people who present with hearing loss in an audiology clinic. Similarly, a referral for hearing assessment might be in the patient’s best interest when they are diagnosed with mild cognitive impairment in primary care. Early intervention to address both issues might prove crucial in improving quality of life and reducing morbidity associated with hearing loss and dementia (Lau et al., 2021).

- It is important to consider the environment in which the test is being taken: ensuring good light levels, low background noise, and use of sensory corrective devices would reduce the confounding effects of vision and hearing loss. Brief vision and hearing tests should be used in conjunction with cognitive tests. Additionally, greater emphasis could be given to other methods of assessment in individuals with sensory impairment such as informant-reported functional and cognitive changes and patient history (Pye et al., 2013).

The role of specific training and family involvement

- There is no mandatory training on hearing, or any regulated standards set for hearing care in the UK. Therefore, there is a lack of staff knowledge of hearing care or recognition of hearing needs, in addition there is a lack of time for staff to engage in hearing intervention due to their high workload (Cross et al., 2021).
• Additional education on observable indicators of hearing loss, as well as reporting biases, is warranted for healthcare professionals working with this patient population (Hobler et al., 2021).

• Hearing interventions and a communication training intervention (for resident and staff) both yielded a reduction in verbal disruptions and outbursts (Mamo et al., 2018).

• Family input may lead to more successful hearing interventions. Family involvement with care improves resident well-being, and their knowledge informs “shared decision making” and “family-centred dementia care,” which includes decisions about hearing rehabilitation (Cross et al., 2021).

The Benefits of Hearing Care

• Actively identifying and treating sensory impairments among people with dementia may be an easy, effective, and cost-efficient method of improving quality of life for people with dementia and their caregivers and reducing healthcare costs for people with dementia (Dawes et al. 2019).

• “Although the woman had been an hearing aid (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. 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 staff highlights a particular burden of hearing loss treatment in this population (Mamo et al., 2018).

• Patients who reported high compliance with hearing aid use showed a small benefit in quality of life. Participants who completed 7–8 weeks of auditory training that focused on frequency discrimination and consonant identification, reported a significant difference in working memory scores post–auditory training. The study argues that there is potential for sensory and cognitive changes after consistent training (Mamo et al., 2018).

• Close to 4/5 of persons with hearing loss do not use hearing aids. Hearing loss is easily diagnosable and treatable, clinicians should be aware of hearing loss and counsel patients on the benefits of hearing aids. Hearing aids benefit communication and social functioning, additionally, they are known to positively affect mood and quality of life (Sanders et al., 2021).

• Individuals with treated hearing impairment demonstrate superior cognition to those with untreated hearing impairment. Simplifying the programming of key hearing aid features for individuals with reduced cognitive ability is beneficial (Taljaard et al., 2015).
Earwax Removal

- Earwax removal is an easy and effective means of improving hearing (Cross et al., 2021).

- A suitable measure identified for nurses to use to screen the hearing of residents living with dementia in long-term care settings was otoscopy to determine the need for cerumen management. Importantly, removal of cerumen occluding the ear canal to restore sound transmission to the eardrum has many benefits; it can improve hearing in more than 10% of cases, as well as increasing the accuracy of audiometric testing, and enabling devices such as hearing aids to perform properly (Habler et al., 2021).
Appendix 4: References for reviews included in this scoping review


**Reviews without a clear methodology not included in this scoping review (but useful insights)**


