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Exploring the Relationship Between Alzheimer's Disease and Age-Related Hearing Loss: A Literature Review

Raika Bourmand, BSc Student [1]*

[1] Department of Kinesiology, McMaster University, Hamilton, Ontario, Canada L8S 4L8

*Corresponding Author: bourmanr@mcmaster.ca

Abstract

Introduction: By 2050, the international prevalence of Alzheimer's disease (AD) is expected to triple, resulting in immense healthcare costs and personal effect. In recent years, researchers have identified age-related hearing loss (ARHL) as one of the most prevalent causes in older adults to be associated with the predisposition for mild cognitive impairment (MCI) and AD. However, the relationship between the two remains unclear. Several plausible mechanisms explaining this hearing-cognition relationship have been suggested, such as social isolation, auditory activation, and neurobiological factors. This review seeks to investigate the literature examining the relationship between ARHL and dementia, how ARHL as a modifiable risk factor plays a role in the severity of cognitive decline in the AD and MCI population, and advocate for why further research on this topic is essential to help create a cognitively healthier and more informed older adult population.

Methods: A comprehensive literature review of fifteen peer-reviewed articles was conducted using a predetermined protocol and inclusion criteria, such as keywords and databases. The search was limited to published articles in the English language from 2010 – present.

Results: No associations were found between brain cortical thickness and those with AD and ARHL in comparison to those with SCD where an association was present. A moderate correlation was found between neurobiological factors such as ApoE4 to explain the relationship between AD and ARHL. The use of active hearing aids did not contribute to a cognitive benefit in those with moderate AD and ARHL compared to the use of placebo hearing aids, or after the secondary activation of hearing aids in the placebo group.

Discussion: The literature shows inconclusive results about the mechanism linking ARHL and AD. The pattern of findings did not show consistent results between studies supporting a particular domain to explain the mechanism behind this relationship.

Conclusion: Through conducting this review, a greater understanding and awareness about the role of ARHL as a risk factor of MCI and AD is provided. Ultimately, this is important in individual lifestyle changes to prevent the onset of ARHL, and subsequently dementia in order to live healthier and with higher quality as they age.

Keywords: Alzheimer's disease; mild cognitive impairment; hearing loss; aging

Introduction

By the year 2050, over 152 million people are expected to be living with dementia [1]. Alzheimer's disease (AD) is the most common cause of dementia, which has been shown to develop progressively and often go unnoticed until the symptoms become debilitating. AD is associated with declines in cognitive abilities such as memory, executive functioning, and activities of daily living [2]. Early stages of AD are reflected in the precursor syndrome termed mild cognitive impairment (MCI). Individuals with MCI have not yet been diagnosed with dementia, and often have regular activities of daily living, but demonstrate memory and other cognitive impairments that are greater than expected for their age group [2]. People with MCI are at greater risk for progressing to AD than their healthy counterparts, as MCI is, commonly described as an intermediate stage between normal cognitive aging and AD. Over the span of three years, 20% of MCI cases end up progressing to dementia, of which 78% were attributed to AD [2]. These rates of progression to AD in those with MCI have been further estimated to be even higher, ranging between 20% and 40% [3].

In looking at the most common attributable factors for dementia, a recent meta-analysis found that hearing loss was the highest factor [1]. This meta-analysis was done while examining individuals with normal baseline cognition and hearing loss present at a threshold of 25 decibels (dB) or above, which is the World Health Organization threshold for hearing loss. For those over the age of 65, approximately 10% of these individuals develop AD, while around 40% develop age-related hearing loss (ARHL) [4]. Meanwhile, more than 90% of individuals who have been diagnosed with AD have some kind of hearing

loss [5]. Moreover, another meta-analysis found an increased risk of dementia per 10 dB of decline in hearing loss [1]. Although a relationship exists between ARHL and AD, the underlying mechanism remails unknown. However, the mechanisms underlying this relationship are unknown.

One perspective investigating this relationship assesses the impact of hearing aids in alleviating cognitive decline. For example, a 25-year-long prospective study of almost 4000 participants aged 65 years or older found a greater incidence of dementia in those who have self-reported hearing problems, excluding those who used hearing aids [6]. These findings are further supported by a cross–sectional study in the dementia population that found an association between hearing loss and worse cognition solely in those not using hearing aids [6]. However, the evidence for hearing aid use in alleviating cognitive decline specific to dementia or AD is also unclear. Aside from declines in peripheral hearing, central auditory processing (CAP), which also declines with age, has been proposed as the moderating factor that accounts for the relationship between AD and ARHL. For example, CAP dysfunction has been known to increase an individual's difficulty in interpreting central auditory tests (such as discriminating speech against background noise). CAP dysfunction influences one's ability to process auditory input. To support this, recent research has shown that central auditory function tests are effective in predicting the development of dementia. Specifically, when a cohort of older adults was tested, those who later developed AD had significantly poorer initial CAP function than those without AD [7].

ARHL is also associated with genetic and neural markers of AD, such as heightened volumes of cerebrospinal fluid (CSF), tau protein, and diminished hippocampal volume [3]. Meanwhile, the neurobiological perspective suggests that the relationship between AD and ARHL is also owed to structural changes in the brain. More specifically, this refers to the sensory deprivation hypothesis such that less sensory input to the brain as a result of ARHL ultimately results in structural decline and neurofunctional changes [3]. Moreover, ARHL has been correlated with lower gray matter volume in brain regions associated with auditory perception and cognition (e.g., hippocampus). Knowing this, however, the extent to which ARHL is associated with gray matter loss in those with varying degrees of cognitive impairment and neuropathology has not yet been examined.

It is evident that hearing loss plays an important role in the incidence of dementia, particularly due to AD. However, the underlying mechanisms in AD/MCI pathology and the extent to which hearing loss plays a bidirectional role in dementia risk remains unclear. This review seeks to investigate how ARHL plays a role in the severity of cognitive decline in the individuals with MCI or AD.

Methods

In conducting this literature review, relevant empirical articles were retrieved from the following search engines and databases: Scholars Portal Journals, PubMed, and Google Scholar. The articles were selected based on the following inclusion criteria: (1) being peer-reviewed and written in the English language, (2) being published after the year 2000, (3) pertaining to the relationship between Alzheimer's disease or mild cognitive impairment and hearing loss, and (4) participants being assessed for diagnosis using clinical criteria. Relevant research articles were obtained using search engine keywords of "Alzheimer's disease" OR "mild cognitive impairment AND "hearing loss". The first one hundred articles were screened for eligibility and brevity. A total of fifteen articles were found to be eligible and included in the present review. Articles were categorized according to themes/topics of clinical hearing tests, neuropathology, biomarkers, and assistive listening devices (such as hearing aids).

Results

As expected, some studies showed that those with ARHL did poorly on auditory tests of perceptual hearing acuity, where there was significantly worse performance in the AD group compared to MCI or participants with subjective memory complaint (and who otherwise demonstrate normal cognition for their age) [2]. This is supported by other studies who found that between these three groups, the AD group showed significant declines in the dichotic digit free recall test that assesses central auditory processing ability [7]. For example, in a study comparing older adults with and without dementia, the dementia group scored poorly on the dichotic sentence identification auditory test, with a mean score of 37% accuracy [8].

When assessing the neurobiological contributions of ARHL and AD, a recent study by Giroud and colleagues investigated the association between ARHL and brain atrophy in gray and white matter [3]. More ARHL can be related to less gray matter volume in the brain, particularly those areas responsible for auditory perception and cognition such as the hippocampus. The associations between ARHL and brain atrophy support a sensory deprivation hypothesis suggesting that long-term ARHL is associated with structural loss in the brain [3]. Using data from the Comprehensive Assessment of Neurodegeneration and Dementia study (COMPASS-ND), researchers analyzed older adult participants with subjective cognitive decline (SCD), MCI, and AD [3]. The study found that those with SCD who showed greater pure-tone hearing loss had lower gray matter volume in the right hippocampus; however, there were no such associations found within the MCI and AD groups. Moreover, significant associations were found between greater ARHL and greater cortical thickness in the SCD group, particularly in the superior temporal gyrus and the pars opercularis of the inferior frontal gyrus [3]. Likewise, there were no significant associations found between ARHL and cortical thickness in those with MCI or AD. This suggests that in older adults demonstrating a higher degree of cognitive impairment, these neurobiological underpinnings describing the association between ARHL

and brain structure in AD pathology may become more mixed as AD pathology progresses [3]. Likewise, Neff et al. conducted a study investigating the relationship between ARHL and ApoE4, a gene well-known for heightened risk for dementia, in those with AD [9]. Here, participants with AD were grouped into one of four groups based on their ApoE4 status and hearing status: normal hearing (NH)/ApoE4+, ARHL/ApoE4+, NH/ApoE4–, and ARHL/ApoE4–. Neff and colleagues found that the NH/ApoE4+ group had the greatest prevalence of AD neuropathology, and HL/ApoE4– group the lowest [9]. Ultimately, the findings reinforce a potential relationship between hearing loss and AD, while suggesting that neurobiological factors such as genetics (i.e., ApoE4) may play an important role in this association [9].

While the studies described focused on further understanding hearing loss, a great deal of research has also been directed towards understanding how technology alleviates the contributions of HL on AD. Most commonly, this has been investigated through the role of auditory medical devices such as hearing aids. A study conducted by Adrait and colleagues sought to assess the impact of hearing aids on those with ARHL and AD with respect to behavior, functional abilities, and quality of life [10]. Participants with AD were fitted with either a hearing aid (experimental group) or an inactive hearing aid (control group) and were followed up at six months and 12 months on cognitive measures. The researchers found no significant difference between groups in favor of active hearing aids [10]. Therefore, there were no benefits observed in participants' cognition, neuropsychiatric symptoms, or activities of daily living. However, there was a significant improvement of AD-related quality of life found in relation to good compliance with active hearing aids in the experimental group. Thus, the results are unclear in clinical significance and do not establish a clear influence of hearing aids in participants with AD and ARHL [10].

Similar results were found in a qualitative study interviewing participants with AD and ARHL who had already been using hearing aids [11]. The four major themes which were reported by participants were the perceived benefits, ambivalence, stigma, and practical difficulties of using hearing aids. For example, the benefits included improved communication with relatives and an increased sense of confidence. Furthermore, participants questioned the how effective the hearing aids really were, while comments about stigma ranged from not minding the appearance to how visible hearing aids reveal them as impaired. Participants reported that their memory loss is an obstacle in losing, using or misplacing their hearing aids [11]. Also, it was found that putting the hearing aids on, fiddling with them, and excessive loudness of noise were practicality issues. Overall, experiences and attitudes about the use of hearing aids among those with AD were found to be complex [11]. The device was not reported to benefit the severity of cognitive impairment; rather, their AD-related symptoms enhanced the difficulty of using the device. For example, many participants found it difficult to remember to use their hearing aid, how to properly insert it, or had problems misplacing and losing the device [11].

In terms of MCI, Buholc and colleagues recently conducted a retrospective analysis of a cohort of hearing-impaired adults with baseline dementia or MCI from an existing database [12]. It was found that participants with MCI who used hearing aids were found to have a significantly lower risk of developing dementia in comparison to those who did not use hearing aids [12]. Moreover, the median time to incident dementia was found to be two years for non–users of hearing aids users and four years for hearing aid users [12]. For participants with dementia, the median survival time for non-users of hearing aids was six years and seven years for hearing aid users [12]. Therefore, this suggests the potential preventative role of hearing aids to alleviate the progression of cognitive impairment at the MCI stage.

Discussion

Overall, this review found that in explaining the relationship between ARHL and AD, present findings show mixed results. It was shown that those with AD show poorer performance on auditory tests than those in MCI or control conditions, as expected [2,7]. Evidence suggesting the mechanism is owed to neurobiological factors and genetics are promising but require further exploration which addresses limitations of current literature [13]. Some literature on this topic discussed this underlying mechanism through the use of hearing aids. Surprisingly, it was generally found that using active hearing aids did not contribute to a cognitive benefit in those with moderate AD and ARHL compared to the use of placebo hearing aids, or after the secondary activation of hearing aids in the placebo group [10,14]. Additionally, no associations were found between brain cortical thickness and those with AD and ARHL in comparison to those with SCD where an association was present [3]. Nevertheless, researchers have found a moderate correlation between genetic factors (i.e., ApoE4 status) to explain the relationship between AD and ARHL [7]. Current research suggests that hearing aid use in those with ARHL serves a protective role in preventing the development and progression of early dementia and MCI, rather than having a treatment role for those with AD and ARHL [10].

It is important to note that in assessing the role of hearing aids, many researchers suggest that hearing aid use is protective, rather than the alternative that those progressing to dementia are less likely to use hearing aids [1]. The use of hearing aids has been associated with better quality of life and less social isolation or depression in older adults, which would be of particular importance for those with dementia. This is thought to be a result of increased social stimulation with hearing aid use. For example, one would assume that ARHL would contribute to decreased social interaction which would ultimately decrease one's

cognitive performance as a result of a lack of stimulation [11,12]. Indeed, the use of hearing aids has been correlated with higher cognitive performance, beyond the effects of moderating variables like social isolation or depression. One explanation for the present study not finding significant slowing down of cognitive decline with active hearing aid use compared to a placebo may be owed to older adults beginning hearing rehabilitation later. Specifically, older adults have been found to begin auditory rehabilitation such as the use of hearing aids, around eight to twelve years after first noticing a hearing impairment. Despite this literature, limited longitudinal research exists on the cognitive benefits of hearing aids, and the evidence for this mechanism remains inconclusive [11,12]. Hence, future research should explore whether the long-term absence of auditory inputs may or may not be reversible with hearing aid adaptation [13,14].

An important note of discussion is the assessment of hearing loss using subjective reports from the participants. For example, objective and subjective hearing loss show concordance values of 65–77%, which is lower than one may expect. In particular, older participants have also been shown to underestimate their degree of hearing loss. Hence, the results may have been biased as a subset of those with ARHL may have been miscategorized as normal hearing, rather than being placed in the HL group of participants [4,11]. Limitations of this review include the idea that other domains of research such as additional physiological factors, influence the relationship between ARHL and AD. For example, ARHL and AD are both associated with metabolic stress and diminished mitochondrial function [4]. Plasma lipid profiles, specifically those rich in phosphatidylcholine and phosphatidylethanolamine have been shown to be inversely correlated with AD-related biomarkers [4]. Therefore, lipid dysregulation and other neurobiological factors might also play a role in this relationship. Future reviews should seek to analyze this topic with a more holistic viewpoint, assessing research from all domains.

Conclusions

Present scientific literature has found that ARHL is associated with increased risk of AD, particularly in those over 65 years of age [15]. This review is important in identifying the past and present work examining the relationship between AD and ARHL. Understanding the mechanism behind this relationship will help researchers to develop treatments and interventions which can potentially target and mitigate this mechanism for people at all stages of dementia. This information is essential particularly for clinicians, who can use their understanding of potential mechanisms to better assess and advocate for better hearing health with their patients. With greater awareness from clinicians about the potentially protective role of hearing aids in dementia development, they would be better able to encourage active hearing aid use earlier with a patients' experience of hearing loss symptoms.

Future directions in research should seek to investigate the relationship between ARHL and dementia risk by using gold-standard hearing assessment measures, seeking the impact of audiological interventions other than hearing aids (or with improved hearing-assistive devices), and examining other changes in older adults' cognitive and physical health during the progression of their condition. It is also crucial that public health campaigns are adequate in order to translate the scale and impact of ARHL and increase awareness of prevention strategies, the significance of inaction, and benefits of audiological intervention.

List of Abbreviations Used

AD: Alzheimer's disease
MCI: mild cognitive impairment
ARHL: age-related hearing loss
NH: no-hearing
SCD: subjective cognitive decline

Conflicts of Interest

The author declares that they have no conflict of interests.

Ethics Approval and/or Participant Consent

No ethics approvals or participant consent was needed in conducting this literature review.

Authors' Contributions

RB: made contributions to the design of the study, collected and analyzed data, drafted and revised the manuscript, and gave final approval of the version to be published.

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