

GRAZIELA ALMEIDA FONSECA

Faculdade Unyleya, Unyleya, São Paulo, SP, Brasil.

ELAINE CRISTINA COSTA LOPES

*Universidade Cesumar, UniCesumar, Maringá, PR,
Brasil.*

IZABELA VITÓRIA PEREIRA MARQUES

*Universidade Cesumar, UniCesumar, Maringá, PR,
Brasil.*

DANIEL VICENTINI DE OLIVEIRA

*Universidade Estadual de Maringá, UEM,
Maringá, PR, Brasil.*

Recebido em fevereiro de 2025.

Aprovado em julho de 2025.

RELATIONSHIP BETWEEN HEARING LOSS AND COGNITIVE IMPAIRMENT IN OLDER ADULTS: A SCOPING REVIEW

ABSTRACT

Population aging has increased the incidence of common health issues in older adults, such as hearing loss and cognitive decline. Studies indicate that hearing loss is a significant risk factor for dementia, suggesting that its treatment may help reduce cases of cognitive impairment. Recent research explores this relationship from a neurophysiological perspective, investigating cochlear metabolic pathways and connections with the hippocampus. This scoping review analyzed 35 articles published between 2018 and 2024 in the SciELO and PubMed databases. The studies examined the impact of hearing loss on different cognitive domains, such as language and praxis. The findings suggest that hearing loss negatively affects cognitive function, highlighting the importance of early intervention strategies to mitigate its effects on brain aging.

Keywords: hearing loss; cognitive decline; aging.

RELAÇÃO ENTRE PERDA AUDITIVA E COMPROMETIMENTO COGNITIVO EM PESSOAS IDOSAS: UMA REVISÃO DE ESCOPO

RESUMO

O envelhecimento populacional aumentou a incidência de problemas comuns aos idosos, como perda auditiva e declínio cognitivo. Estudos indicam que a perda auditiva é um fator de risco relevante para demência, sugerindo que seu tratamento pode contribuir para reduzir casos de comprometimento cognitivo. Pesquisas recentes investigam essa relação sob a perspectiva neurofisiológica, explorando vias metabólicas cocleares e conexões com o hipocampo. Esta revisão narrativa analisou 35 artigos publicados entre 2018 e 2024 nas bases SciELO e PubMed. Os estudos abordaram o impacto da perda auditiva em diferentes domínios cognitivos, como linguagem e praxias. Conclui-se que a perda auditiva influencia negativamente o funcionamento cognitivo, reforçando a necessidade de estratégias de intervenção precoce para minimizar seus efeitos no envelhecimento cerebral.

Palavras-Chave: perda auditiva; declínio cognitivo, envelhecimento.



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INTRODUCTION

Brazil is undergoing a demographic transition characterized by an increasing elderly population and a reduction in younger age groups (BORGES; RESENDE; COUTO, 2020; BORBA FILHO, 2017). As life expectancy rises and the population ages (MONTEIRO; COUTINHO, 2020), the incidence of diseases and disabilities common among older adults has also increased (BORGES; RESENDE; COUTO, 2020).

Among these conditions, hearing loss affects approximately two-thirds of the population aged 60 and older and is considered the fourth leading global cause of disability. Additionally, several studies have demonstrated an association between hearing loss and cognitive impairment (CARDOSO et al., 2023; IRACE et al., 2022; DIAO et al., 2019; LEE et al., 2021; GOLUB et al., 2020; SHARMA; LALWANI; GOLUB, 2020; LOUGHREY et al., 2018).

Cognitive impairment, in turn, may represent an early stage of different types of dementia, such as Alzheimer's disease or vascular dementia (PEREIRA et al., 2020). According to Alzheimer's Disease International (ADI, 2020), more than 55 million people worldwide live with some form of dementia. Research suggests that hearing loss is a significant modifiable risk factor for cognitive impairment and dementia, as it may predict or accelerate cognitive decline (LOUGHREY et al., 2018; IRACE et al., 2022; HARDY et al., 2016).

Although other modifiable risk factors exist, such as diabetes, obesity, hypertension, and depression, the hearing loss represents one of the most significant attributable threats to dementia development (CARDOSO et al., 2023). Consequently, reducing hearing loss may help lower the incidence of dementia (IRACE et al., 2022).

Beyond health impacts, these conditions directly affect quality of life. Hearing loss impairs audibility and speech comprehension (CARDOSO et al., 2023), potentially leading to social isolation and depression (ROCHA; MARTINELLI, 2019). Cognitive impairment, in turn, hinders the ability to perform daily activities, resulting in a loss of autonomy and independence (PEREIRA et al., 2023).

From an economic perspective, according to Alzheimer's Disease International (ADI, 2020), the annual global cost of untreated hearing loss is estimated at nearly US\$1 trillion, while dementia-related cognitive decline costs approximately US\$1.3 trillion. Given this impact, numerous studies have been encouraged to explore further the causal relationship between hearing loss and cognitive impairment (GOLUB et al., 2020; BIKBOV et al., 2022; GAO et al., 2022; FENG et al., 2022).

Considering this scenario, the present study aimed to investigate the association between hearing loss and cognitive decline through a narrative literature review, seeking to answer the question: "How does hearing loss increase the risk of cognitive decline?"

METHOD

This narrative literature review was conducted using the Scientific Electronic Library Online (SciELO) and PubMed databases linked to the National Library of Medicine (NIH). Studies published in any year, in both Portuguese and English, were included. In addition to scientific articles, books, master's dissertations, and doctoral theses relevant to the topic were also considered.

The search strategy employed the following descriptors: "perda auditiva," "idosos," and "comprometimento cognitivo" in the SciELO database, and "hearing loss," "cognitive decline," and "old people" in the PubMed database.

RESULTS

The bibliographic search resulted in 35 articles, seven of which were retrieved from SciELO and the remaining 28 from PubMed. Most studies were from otorhinolaryngology (15 articles) and speech therapy (8 articles), while the rest were distributed among gerontology, psychology, and neuroscience.

The studies explored the possible relationship between hearing loss and cognitive decline, although they approached this correlation from different perspectives. Several studies, including those by Cardoso et al. (2023), Mukari et al. (2020), Drennan (2022), and Silva, Nigri, and Iorio (2018), investigated this connection in terms of speech recognition in noisy and quiet environments.

Others examined the impact of this relationship on motor task execution, such as the study by Gorecka et al. (2018). Some articles analyzed the social consequences of hearing loss and cognitive decline, exploring whether hearing impairment could lead to greater social isolation and, consequently, an increased risk of depression, as seen in studies by Kim et al. (2021), Gao et al. (2020), and Paiva et al. (2023).

Finally, certain studies aimed to understand the neurophysiological connection between hearing loss and cognitive decline, including those by Van't Hooft et al. (2023), Wan et al. (2023), and Li et al. (2023).

LITERATURE REVIEW

The Auditory System

Hearing is essential for socio-affective behavior and learning (MENDES FILHO, 2022). It functions as a complex system that captures, conducts, and interprets sound (COSTA et al., 2022). Sound, defined as a longitudinal mechanical wave (YOUNG; FREEDMAN, 2015), is transformed into a neural stimulus by the ears and processed by the auditory cortex (RODRIGUES, 2020).

The human ear is divided into three parts: external, middle, and inner (RUI, 2007). The external ear, consisting of the auricle and auditory canal, amplifies and directs sound waves to the tympanic membrane (DURAN, 2011). The middle ear contains the ossicles (malleus, incus, and stapes), which transmit and amplify sound. The auditory tube (Eustachian tube) balances pressure between the ear and nasopharynx (MENDES FILHO, 2022). The inner ear, composed of the cochlea and vestibular system, is responsible for hearing and balance (RODRIGUES, 2020).

The spiral-shaped cochlea consists of three compartments: the vestibular and tympanic scalae, filled with sodium-rich perilymph, and the middle scale, filled with potassium-rich endolymph (ITO, 2020). These chambers are separated by Reissner's and basilar membranes, where the organ of Corti is located, converting sound waves into neural impulses (KANDEL, 2014).

The hair cells within the organ of Corti are divided into inner cells, responsible for sound transduction, and outer cells, which modulate auditory signals (MENDES FILHO, 2022). The basilar membrane and hair cells are tonotopically organized and respond to different sound frequencies: high-pitched sounds stimulate the rigid base, while low-frequency sounds reach the flexible apex (BEAR et al., 2017).

The sound pathway begins with wave capture by the auricle, directing it to the tympanic membrane, which vibrates in resonance and transmits the stimulus to the ossicles. The ossicles amplify the signal and transfer it to the inner ear, where perilymph propagates the waves, activating hair cells (MENDES FILHO, 2022). The stereocilia displacement opens mechanosensitive ion channels, allowing potassium and calcium influx, triggering action potentials in the cochlear nerve (PURVES, 2010; KANDEL, 2014).

The auditory pathways extend from the cochlear nerve to the cochlear nuclei, then through the superior olivary complex and inferior colliculus, before reaching the medial geniculate body in the thalamus and finally the auditory cortex (MENDES FILHO, 2022). Sound localization recruits the superior olivary complex and inferior colliculus, while frequency and intensity are decoded in the thalamus (PAULUCCI, 2005). In the auditory cortex, located in the temporal lobe, sound characteristics such as timbre, intensity, and frequency are processed. In contrast, the emotional tone of speech is interpreted in the parietal lobe (PAULUCCI, 2005).

Hearing loss

The human ear is sensitive to a range of frequencies, approximately 20 Hz to 20 kHz, with a minimum sound pressure level that can be perceived, known as the auditory threshold. Hearing loss is characterized by a decline in auditory sensitivity, meaning an increase in the auditory threshold (RODRIGUES, 2020).

Three types of hearing loss may result from mechanical or neural damage: conductive, central, and sensorineural. Conductive hearing loss occurs due to disturbances in sound conduction from the external to the inner ear (BEAR et al., 2017). In other words, it results from conditions affecting the external and middle ear, such as occlusion of the auditory canal by earwax or foreign objects, tympanic membrane rupture, or arthritic ossification of the middle ear bones (PURVES, 2010), as well as inflammatory processes like otitis externa and media (SILVA, 2020).

Central hearing loss is caused by damage along the auditory pathways, including injuries between the cochlear nerve or nuclei and the auditory cortex or cortical damage resulting from cerebrovascular accidents (strokes). Sensorineural hearing loss, the most common type, results from the degeneration of hair cells in the organ of Corti, with presbycusis, or age-related hearing loss, being a primary example (PACIELLO et al., 2022; MENDES FILHO, 2020).

Hearing loss can affect the auditory system at the peripheral or central levels. Peripheral hearing loss primarily involves sensory impairment, while central hearing loss affects auditory processing, meaning that although individuals perceive sound, they struggle to decode its informational content (BROTTO et al., 2023).

In cases of peripheral hearing loss, diagnosis is commonly performed using pure-tone and speech audiometry (BROTTO et al., 2023). Pure-tone audiometry is a psychoacoustic test where

the patient signals when they hear a tone through headphones in a soundproof booth. If the test is conducted using a free-field speaker, it is called free-field pure-tone audiometry (BROTTO, 2023).

In speech audiometry, words are presented at different intensity levels instead of pure tones, and the patient must repeat them. The score is based on the percentage of correct responses (BROTTO et al., 2023). Another approach is the International Matrix Sentence Test, which, unlike traditional audiometry, simulates real-world noisy environments by presenting speech stimuli along with background noise at varying signal-to-noise ratios (BROTTO, 2023).

Beyond standard clinical assessments, electrophysiological tests, such as auditory brainstem response, and radiological imaging, such as computed tomography and magnetic resonance imaging, can be used. The auditory brainstem response evaluates auditory pathway function, from the auditory nerve to the midbrain, based on characteristic waveform peaks following a sound stimulus (KONRAD-MARTIN et al., 2012).

Audiological tests assess different auditory processing domains for central hearing loss, including temporal processing, spectral resolution, and binaural integration. Temporal processing refers to detecting brief interruptions in continuous sound, which is crucial for speech perception. One commonly used test is the gap-in-noise test, where subjects are asked to identify short silent gaps within continuous noise (BROTTO et al., 2023). Spectral resolution involves distinguishing between different frequencies and their compositions. This ability is assessed using the spectral ripple test, in which patients are exposed to a sound composed of a broad frequency range with modulated amplitude (BROTTO et al., 2023).

Binaural integration relates to dysfunctions in the central auditory system that disrupt how auditory signals from both ears are processed together, leading to impaired sound perception. The dichotic listening test is commonly used, where the patient listens to two sounds presented simultaneously to each ear and is required to reproduce them (BROTTO et al., 2023).

Cognitive Decline

Cognitive decline can manifest at any age due to various conditions, such as genetic syndromes and metabolic disorders, and is characterized by impaired reasoning, concentration, learning, and memory. Additionally, with aging, cognitive decline is often associated with a pre-dementia stage (MENDES FILHO, 2022).

According to Mendes Filho (2022), in addition to reducing life expectancy, dementia progressively limits individuals' ability to perform daily tasks and engage in social interactions. In advanced stages, severe neuropsychiatric symptoms, spatial-temporal disorientation, amnesia, and consequent loss of autonomy occur.

Cognitive decline can affect multiple cognitive domains, including memory, language, gnosis, praxis, executive function, and visuospatial abilities (KLIMOVA; VALIS; KUCA, 2017). Different brain regions may be involved, particularly the hippocampus. This structure considered an extension of the temporal cortex and a key component of the limbic system, plays a crucial role in learning, memory formation, spatial navigation, emotional behavior, hypothalamic function regulation, and neurogenesis (MENDES FILHO, 2022).

The hippocampus is essential for cognitive function, and its morphological and physiological alterations are often linked to mental disorders. Additionally, it is connected to the central auditory pathway through afferents from the medial prefrontal cortex, insula, and amygdala. As a result, hippocampal function can be influenced by both sound exposure and auditory deprivation (BILLIG et al., 2022).

One method for assessing cognitive decline is the Mini-Mental State Examination (MMSE), which evaluates spatial and temporal orientation, memory, attention, calculation ability, visuospatial skills, and language (PEREIRA et al., 2020). In addition, biomarker detection for neurodegeneration and aberrant proteins may be used for diagnosis (MENDES FILHO, 2022). For instance, structural magnetic resonance imaging (MRI) can identify hippocampal and bilateral entorhinal cortex atrophy, while functional neuroimaging can detect reduced glucose metabolism in temporal and parietal regions. Molecular neuroimaging techniques are also available to identify amyloid peptide retention in brain parenchyma (RADANOVIC; STELLA; FORLENZA, 2015).

Association Between Hearing Loss and Cognitive Decline

Presbycusis, or age-related hearing loss, develops gradually, initially affecting the perception of high-frequency sounds and later impairing sensitivity to mid-frequency sounds and speech comprehension (MENDES FILHO, 2022). Additionally, it is associated with reduced brain volume, suggesting an accelerated atrophy process (RIGTERS et al., 2017; LIN et al., 2014). Thus, presbycusis is considered a biomarker and a modifiable risk factor for cognitive decline and dementia (MENDES FILHO, 2022).

Three main theories have been proposed to explain this association. The common cause hypothesis suggests that hearing loss and cognitive decline result from a shared neurodegenerative process in the aging brain without directly causing the other (STAHL, 2017). Possible causes include vascular diseases affecting both the central nervous and auditory systems, alterations in metalloproteinase 9 (MMP-9) levels in the auditory cortex and hippocampus, and a decline in insulin-like growth factor (IGF-1). Magnetic resonance imaging studies indicate that presbycusis is independently associated with temporal lobe atrophy, with more significant hippocampal reduction observed in cases of severe hearing loss (MENDES FILHO, 2022).

The information degradation hypothesis, or cognitive overload, suggests that cognitive decline results from the increased effort required to process auditory stimuli. Due to damage in peripheral auditory structures, more cognitive resources are needed for speech comprehension, reducing availability for other functions such as attention, memory, and executive control (STAHL, 2017; MENDES FILHO, 2022).

The third explanation, the sensory deprivation hypothesis, proposes that the continuous cognitive demand for auditory processing may lead to long-term neuroplastic alterations. Studies suggest auditory sensory deprivation causes widespread molecular changes throughout the cerebral cortex and subcortical structures (MENDES FILHO, 2022).

Cognitive aging can affect various domains, including memory, learning, language, executive function, attention, motor skills, and social cognition. Over time, a slowdown in information processing reduced working memory capacity, and difficulties in shifting attention and

learning new information are commonly observed (SARANT et al., 2023). Cognitive decline may progress to dementia when cognitive impairment becomes irreversible, affecting daily activities and leading to a loss of autonomy (SARANT et al., 2023).

Several recent studies have investigated the relationship between hearing loss and cognitive decline. Irace et al. (2022) demonstrated this association in the language domain, while Lee et al. (2022) identified a connection between bilateral hearing loss and memory impairment. Other studies, such as those by Gorecka et al. (2018) and Wang et al. (2023), explored the impact of hearing loss on motor tasks, including gait and the ability to sit and stand, assessing central auditory processing through dichotic listening and its relation to binaural integration (BROTTO et al., 2023).

Beyond confirming the association between hearing loss and cognitive decline, some studies have sought to understand the underlying neurophysiological mechanisms. Patel et al. (2022) examined the impact of noise-induced hearing loss on hippocampus-dependent cognitive functions (spatial learning and memory) and striatum-dependent functions (visuomotor associative learning), as well as microglial expression. Their findings indicated deficits in spatial associative learning and changes in hippocampal microglial expression, whereas striatum-dependent functions and microglial expression remained unaffected.

Li et al. (2023) suggested that cortical thickness in the left parahippocampal cortex, a region often affected in early-stage dementia, may link central auditory processing and cognitive performance in aging. Other studies have advanced the molecular understanding of this relationship: Wan et al. (2023) investigated cochlear metabolic pathways, while Van't Hooft et al. (2023) analyzed dementia-related biomarkers potentially associated with hearing loss. The latter study found a relationship between hearing loss and amyloid biomarker accumulation only in younger individuals and identified the hippocampus as a mediator between hearing loss and global cognition in older adults.

Although hearing loss is an independent risk factor for cognitive decline, its causal relationship remains unclear. While research suggests that the hippocampus mediates in this association, the exact mechanisms remain largely unexplored. In other words, much is still unknown about auditory pathways and their interactions with other brain regions.

CONCLUSION

This narrative review highlighted a significant association between hearing loss and cognitive decline, reinforcing the hypothesis that auditory function is crucial in maintaining cognitive abilities throughout aging. Various studies examined this relationship from different perspectives, including its impact on language, memory, motor skills, and global cognition, suggesting that hearing loss may be a modifiable risk factor for dementia.

The proposed theories explaining this connection point to both neurodegenerative processes standard to aging and mechanisms related to cognitive overload and sensory deprivation. Furthermore, neurophysiological findings indicate the involvement of the hippocampus and other brain structures in mediating this association, although the exact mechanisms remain poorly understood.

Given the increasing prevalence of hearing loss and cognitive disorders in the elderly population, early identification and appropriate intervention may serve as effective strategies to slow cognitive decline and reduce the impact of dementia. Expanding research into the neurophysiological aspects of this association is essential for developing more effective preventive and therapeutic approaches, ultimately improving the quality of life for older individuals.

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