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The Role of Hearing Impairment in Cognitive Decline: Need for the Special Sense Assessment in Evaluating Cognition In Older Age

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In recent years, dementia research has focused on age-related hearing impairment (ARHI) or presbycusis as a possible risk factor for cognitive impairment and decline [1]. The special senses, particularly hearing and vision, are key elements among the possible modifiable risk factors in building up dementia prevention strategies. Recently, the National Institute on Aging held an exploratory workshop focused on age-related and neuropathological changes in the olfactory, visual, auditory and motor systems suggesting that sensory and motor changes may precede the cognitive symptoms of Alzheimer's disease (AD) by several years and may signify increased risk of developing AD [2]. At early stage, ARHI typically affects audibility of the higher frequencies (6,000 and 8,000 Hz), and part of the hearing problems are not related to the peripheral deficit of the auditory system but to the central auditory processing (CAP) dysfunction, with considerable difficulty in understanding speech in the presence of any background noise or in reverberant rooms but presenting no problem in a quiet environment. Both peripheral and central auditory dysfunctions are therefore relevant to assess a possible influence of ARHI on late-life cognitive disorders [1]. The prevalence of a hearing loss is particularly high among the elderly, and recent data showed that peripheral ARHI, measured with appropriate technique like pure tone audiometry (PTA), was present in about 2 out of 3 persons while CAP dysfunction was present in about 15% of the population [3].

In the current issue of *Neuroepidemiology*, Wu and Chiu [4] present the findings of an epidemiological study conducted in Taiwan exploring the possible association between self-reported hearing loss and age-related trajectories of memory function in a population-based cohort of about 5,000 adults aged ≥ 50 years who were followed for 11 years. In this study, hearing impairment increased the age-related differences in the intercept of the memory function by over 25%, and the association was significantly greater in older people than in younger people, but the authors found no significant difference in the slope of decline in memory score over

time based on hearing impairment status [4]. The self-reported assessment of hearing status performed in the study by Wu and Chiu [4] roughly evaluates the peripheral component of ARHI. In the last decade, the cumulative evidence coming from a number of longitudinal population-based studies suggested a strong link between peripheral ARHI and cognitive disorders in older age [1, 5, 6], with a single exception in a 2-year follow-up of the Australian Longitudinal Study of Ageing [7]. However, a weak association between hearing loss and memory decline was found in a re-evaluation of the same sample in a longer follow-up of 8 years [8]. Very recently, in the older Australian cohort of the Blue Mountains Eye Study, higher proportions of participants with visual, hearing or dual sensory impairment (hearing and vision) had a decline in global cognitive testing scores after 5 and 10 years compared to participants with no sensory impairment. However, no significantly greater risk of possible cognitive decline after adjusting for age and sex or further adjusting for more potential confounding variables was found [9]. Different operational definitions of hearing loss and cognitive function and adjustment for multiple potential confounders could partly explain these discrepant findings.

Strengths of the study by Wu and Chiu [4] included a large sample and a longer follow-up period with repeated observations. The main limitations were the self-reported assessment of hearing status with the impossibility to distinguish between peripheral and central auditory dysfunction and the auditory verbal memory test used. PTA remains the gold standard for clinical assessment of peripheral auditory dysfunction [10] and among positive population-based studies linking peripheral ARHI to cognition, only one used a self-reported measure of hearing loss [11]. Cognitive measurement tools vary across studies, ranging from global cognitive screening tests to domain-specific tests assessing memory, language and/or executive functioning. Global cognitive screening tools may capture only limited variability in a normally aging population, with ceiling effects that could potentially lead to an underestimation of the true relationship between ARHI and cognitive decline. On the other hand, although evidence suggested that the link between ARHI and cognitive decline persisted when auditory items are removed from cognitive screening tests [1, 10], and when non-auditory tests of cognition are used [12], such confounders may overestimate the strength of the association. Very recently, the first meta-analysis exploring the impact of hearing loss and hearing intervention on cognition suggested that that individuals with hearing loss had poorer cognition compared to individuals with normal hearing, whether or not that hearing loss is treated [13]. The degree of cognitive deficit is significantly associated with the degree of hearing impairment in both untreated and treated hearing impairment. Furthermore, hearing intervention significantly improves cognition and hearing impairment impacted on all domains of cognition [13]. However, although this meta-analysis suggested that hearing impairment was implicated in cognitive disorders, due to methodological differences within studies (samples, measurement of cognition, hearing intervention, etc.), small

sample sizes, and the failure to control for premorbid and other health factors, conclusion about causal relationships may be premature.

Although, at present, epidemiological evidence is still unable to confirm a causal relationship between ARHI and cognition, some factors may be involved in causal mechanistic pathways, while other factors may constitute shared pathological processes or etiological pathways underlying both ARHI and cognitive disorders in late life [1]. Hypothesized mechanisms to connect auditory and cognitive functions include the 'cognitive load on perception', 'sensory-deprivation', 'information degradation' and 'common-cause' hypotheses [1, 10]. Interestingly, in the study by Wu and Chiu [4], the association of hearing impairment with lower memory test scores was significantly more prominent at older age. The impact of ARHI on cognition appeared to be especially important among the oldest old suggesting a strong link of this connection with frailty [1], a geriatric multidimensional syndrome characterized by a nonspecific state of vulnerability, reduced multisystem physiological reserve and decreased resistance to stressors. Frailty is an independent risk factor for cognitive impairment and dementia [1]. Some recent population-based studies confirmed the link between hearing loss and frailty showing that ARHI was associated with increased risk of falling over time and developing frailty [14] and poorer objective physical functioning and incident disability in older adults [15].

A substantial body of epidemiological evidence linking ARHI with late-life cognitive disorders suggested the potential for correcting hearing loss so that elders can function better also from a cognitive point of view with appropriate treatment with important implications for quality of life, social involvement and lifetime cognitive health. A few randomized controlled trials (RCTs) showed improvement in cognitive function, social engagement or global measures of change in hearing aid users not cognitively impaired [16] or with dementia [17]; however, determining whether treating hearing loss could delay cognitive decline and dementia remains an open issue. For observational studies, in cross-sectional modeling in a large sample of UK adults ($n = 164,770$), hearing aid use was associated with better cognition [18]. For long-term outcomes of hearing aid use on cognition, in 2 longitudinal population-based studies with a 6-year follow-up period, no impact of sensory intervention (cataract surgery or hearing aids) on cognitive measures was found [19] and rates of cognitive decline were not significantly attenuated in individuals using hearing aids versus those without hearing aids [12]. However, in a recent population-based study with a 25-year follow-up, treating hearing loss with hearing aids attenuated cognitive decline [20], suggesting some evidence that hearing aids may have a long-term protective effect against cognitive decline.

In the next future, RCTs with more representative cohorts and technology (i.e., digital hearing aids or cochlear implants) and longer follow-up periods are needed, also estimating the effects of hearing rehabilitative interventions on cognitive and global functioning. However, hearing aids alone could be not enough to properly manage ARHI, and interventions should be broader, incorporating also concerted counseling, environmental accommodations and rehabilitative hearing training. The results of the study by Wu and Chiu [4] suggest challenging new questions for all areas of dementia research.

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