



BMJ Open Relationship of age-related hearing loss with cognitive decline and dementia in Sinitic tonal language-speaking populations: protocol for a systematic review and meta-analysis

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ABSTRACT

Introduction Existing research on the potential association between age-related hearing loss (ARHL) and cognitive decline and dementia in tonal language-speaking populations is limited and inconsistent. There is psychophysiological evidence suggesting a tonal language background may be linked to enhanced general cognitive functions. We aim to systematically review the current evidence on the association between hearing loss and cognitive impairment/decline and dementia in older adults who speak a Sinitic tonal language, the most commonly spoken tonal language.

Methods and analysis This systematic review will consider peer-reviewed articles that employ objective or subjective hearing measurement and cognitive impairment or diagnosis of dementia. All relevant research publications in English or Chinese and published up to March 2022 will be considered for inclusion. Embase, MEDLINE, Web of Science, PsycINFO Google Scholar, SinoMed and Chinese Biomedical Database will be used, using both medical subject heading terms and keywords. The quality of evidence of an association between ARHL and cognitive impairment and/or dementia will be evaluated by the Grading of Recommendations, Assessment, Development and Evaluation (GRADE) system. A random-effects meta-analysis will be carried out with the Comprehensive Meta-Analysis software.

Ethics and dissemination Ethical approval will not be required for this systematic review. The results will be disseminated through peer-reviewed publications and conferences.

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INTRODUCTION

Hearing loss is one of the most common chronic conditions affecting ageing individuals. An estimated 2.5 billion people globally will be living with hearing loss by 2050.¹ In 2019, of all people with a hearing loss, more than 62% were older than 50 years.² Unaddressed hearing loss will bring far-reaching consequences, including challenges to

Strengths and limitations of this study

- This systematic review protocol follows the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) Protocols guidelines and the findings will be reported in accordance with the PRISMA reporting guidelines.
- The combination of keywords and medical subject heading terms will offer a comprehensive search strategy to identify relevant studies in the field of hearing loss and cognitive impairment.
- This review will focus only on Sinitic tonal languages, so evidence from speakers of other tonal languages will not be considered.

communicate effectively, contributing to social isolation and loneliness³ and mental health problem.^{4 5} Further evidence from both cross-sectional^{6–8} and longitudinal^{8–10} studies has reported an association between untreated hearing loss and cognitive impairment or decline. However, almost all studies mentioned above that reported an association between untreated hearing loss and cognitive impairment or decline had been conducted on non-tonal language speakers. There is an increasing number of reports on research studies with tonal language speakers.^{11–16} For example, Luo *et al*¹¹ in 2018 reported the prevalence of dementia with hearing impairment; sensory impairments were associated with a greater risk of dementia in Chinese older adults. Ren *et al*¹³ in 2019 reported the association between hearing loss and cognitive function in a Han Chinese older adult cohort using a standardised neurocognitive battery, finding that decreased cognitive function was significantly associated with hearing loss. Fu *et al*¹⁴ showed a significant association between age-related hearing loss and

cognitive impairment in a group of Mandarin-speaking older adults living in China.

A tonal language is defined as a language where variations of pitch (tone) at the monosyllabic level transmit lexical meaning. For example, the Mandarin word normally has four tonal values: high-level (often labelled as 1), rising (2), low-falling-rising (3) and high-falling (4). The syllable /ma/ in Mandarin can have four totally different meanings: /ma/1- (mother), /ma/2- (fibre), /ma/3- (horse) and /ma/4- (curse).¹⁷ However, there are no tone variations in a non-tonal language, for example, in English or French. Tonal languages are spoken by around half of the world's population. The perception of tonal language can be equated with the perception of music, which is supported by evidence that speaking tonal language leads to enhanced pitch perception in music, and in either domain improving processing in the other.¹⁸ Furthermore, evidence shows that playing a musical instrument may enhance the different cognitive functions of the brain, including memory and executive functions.¹⁹ According to existing psychophysiological research, a tonal language background may also be linked to improved general cognitive capacities. Bidelman *et al*²⁰ found that Cantonese speakers had better working memory than English speakers, using the Corsi blocks tapping measurements. As a result, it is feasible to speculate that tonal language speakers are more likely to have greater cognitive reserves that they can tap into later in life, and also for auditory functions such as listening. Therefore, determining whether there is a link between age-related hearing loss and cognitive abilities in tonal language-speaking populations, as there is in non-tonal language speakers, is important.

Given the potential effect of tonal language-speaking on cognition, and considering the growing number of studies on age-related hearing loss and cognitive decline in tonal language-speaking population, a systematic review and meta-analysis of publications with tonal language speakers is required.

The objective of this research is to systematically review the current evidence on the association between age-related hearing loss and cognitive function, cognitive impairment and/or dementia in Sinitic tonal language speakers aged 40 years old and above. A meta-analysis of published evidence will also be conducted. To the best of our knowledge, this will be the first systematic review to explore this topic.

METHODS AND ANALYSIS

The reporting of the systematic review will conform with the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) statement.²¹ The present review protocol follows the provisions of the PRISMA Protocols checklist.²² This systematic review has been registered with the International Prospective Register of Systematic Reviews (PROSPERO). Any deviations from this protocol

Table 1 Eligibility criteria

Eligibility criteria	Inclusion criteria	Exclusion criteria
Publication type	<ul style="list-style-type: none"> ▶ Peer-reviewed publications with original data. ▶ Publications written in English or Chinese. ▶ All articles on the topic published before October 2021. Update to be conducted in March 2022. 	<ul style="list-style-type: none"> ▶ Non-original studies; editorials, reviews and letters.
Population type	<ul style="list-style-type: none"> ▶ Studies on adults aged 40 years and above. ▶ Studies on populations speaking a Sinitic tonal language, for example, Mandarin and Cantonese. 	<ul style="list-style-type: none"> ▶ Studies on children or adults aged under 40 years. ▶ Studies on populations speaking a non-Sinitic tonal language, for example, Thai and Vietnamese.
Assessment type	<ul style="list-style-type: none"> ▶ Studies that use objective or subjective hearing measurement. ▶ Studies that use cognitive impairment or diagnosis of dementia: (1) global cognition assessment tools including MoCA or MMSE; (2) specific domains by both verbal and non-verbal measurements (including any of attention, delayed recall, fluency, immediate recall, processing speed, reasoning, semantic memory, visuospatial ability and working memory) to evaluate cognitive function; and (3) clinical diagnosis of dementia. 	<ul style="list-style-type: none"> ▶ Studies that do not include auditory assessments. ▶ Studies that do not include any cognitive assessments.

MMSE, Mini-Mental State Examination; MoCA, Montreal Cognitive Assessment.

will be listed in the published results paper, and any additional analyses conducted will be listed as post-hoc.

Eligibility criteria

Both quantitative and qualitative measurements on cognitive function or diagnosis of dementia will be included. The included publications will be assessed in three categories: publication type, population type and assessment type (table 1).

All study designs will be considered for inclusion in this review (eg, randomised controlled trials, non-randomised clinical trials, cohort studies, case-control

studies, repeated measures studies). Case report studies and reviews will be excluded. Studies that documented the cognitive processes or diagnosis changes on dementia of adults aged 40 years and over will be included. The exclusion criteria were animal studies; individuals under the age of 40 years; no control group available, that is, individuals without cognitive impairment; and individuals with a previous cognitive/neurological disorder, for example, pre-existing intellectual disability and acquired brain injury.

The primary measures of cognitive function or cognitive impairment or diagnosis of dementia will be (1) global cognition assessment tools including the Montreal Cognitive Assessment or the Mini-Mental State Examination; (2) both verbal and non-verbal measurements of specific cognitive domains, including attention, immediate or delayed recall, speech fluency, processing speed, reasoning, visuospatial ability, and working or semantic memory; or (3) clinical diagnosis of dementia. The primary measures of hearing will be objective hearing assessment, specifically pure tone audiometry, and subjective hearing loss assessment, including self-report.

Information sources

The search will be carried out in the following databases: Embase, MEDLINE, Web of Science and PsycINFO, and specifically for Chinese language reports: SinoMed and Chinese Biomedical Database (CBM). A further grey literature search will also be conducted by Google Scholar to identify any relevant articles that were not found through the database search. References and citations of relevant publications already identified for inclusion, as well as reviews on this topic, will also be scrutinised. Publications in English and Chinese will be included.

Search strategy

Both medical subject heading terms and keywords will be used to retrieve as many relevant articles as possible in the Embase and MEDLINE databases. Keywords and their synonyms, abbreviations, and truncations will also be used in Web of Science, PsycINFO and Google Scholar,

as listed in table 2. A similar strategy will be used for the two Chinese databases, SinoMed and CBM. The search terms will be divided into three domains: (1) hearing loss, (2) cognitive decline and (3) Sinitic tonal language. Two independent reviewers will be deployed to undertake the search and the processes of identification of studies to diminish personal errors and system biases. An independent librarian has reviewed the search strategy.

Data management and study selection

All the results from database and grey searches will be imported into Rayyan (www.rayyan.ai). Rayyan will be used as a systematic review publication organisational online tool. The selection of the articles will be carried out in two phases: first, the titles and abstracts will be screened by independent reviewers based on the eligibility criteria for further review; and second, the full text of eligible articles will be analysed based on the eligibility criteria. The search and screening of the publication will be conducted independently by two researchers (XF and RT) for both English and Chinese articles. A discussion will resolve any disagreement until consensus is reached or in consultation with other authors (DMPJ, RHE and SW).

Data extraction

Information extracted from the included studies will include the following: (1) authors and year of publications; (2) location of the study (countries and cities); (3) demographics of the subjects, for example, age, sex and language; (4) method of primary measures of hearing or cognitive function; (5) outcomes of primary measures; and (6) significant findings (main results). Correlation coefficients or ORs between age-related hearing loss and cognitive decline or dementia will be recorded.

Quality assessment

The screened studies will be assessed to address the different risks of bias and the findings will be analysed. A table of evidence will be formed to grade the recommendations based on the American Society of Plastic Surgeons Evidence Rating Scale for Prognostic/Risk Studies.²⁵ The quality of

Table 2 Keywords and medical subject heading (MeSH) terms for database search

Domains	Keywords	MeSH terms
Hearing loss	Hearing loss OR hearing impairment OR Deafness OR presbycusis OR hearing deficit 听力损失 OR 听力损伤 OR 耳聋 OR 老年性聋 OR 听力下降	Hearing loss OR Hearing impairment OR Hearing disorders 听觉丧失
Cognitive decline	Cognition OR Cognitive decline OR cognitive impairment OR dementia OR Alzheimer's disease OR AD OR mild cognitive impairment OR MCI OR subjective cognitive decline OR SCD OR subjective memory complaints OR SMC OR memory OR attention OR executive function OR processing speed 认知 OR 认知下降 OR 认知损伤 OR 老年痴呆 OR 阿尔兹海默症 OR 轻度认知功能损伤 OR 轻度认知功能障碍 OR AD OR MCI OR SMC OR 记忆力 OR 注意力 OR 执行功能 OR 处理速度	Cognition disorders OR Cognitive defect OR Cognitive impairment OR dementia 认知障碍 OR 痴呆
Sinitic tonal language	Chinese OR Mandarin OR Cantonese	



evidence in clinical trials will be assessed using the Cochrane Risk of Bias 2.²⁴ The Newcastle-Ottawa Scale will be used to determine bias in case-control and cohort studies.²⁵

Meta-analytic approach

The meta-analysis will be conducted using the software package Comprehensive Meta-Analysis (<https://www.meta-analysis.com/>). For continuous variables, the Pearson r correlation coefficient will be chosen as the effect size of the linear association between hearing loss and cognitive impairment. For categorical variables, OR with 95% CI will be exported as the synthesised measure of effect size. The I² statistics will be used to assess the heterogeneity of the studies. P<0.05 will be considered significant.

Meta-bias(es)

Publication bias will be assessed through a funnel plot. Selective reporting will be assessed by a sensitivity analysis.

Synthesis of results

The data extracted from the articles will be listed to show the overall quality, the main findings and the level of evidence of all the enrolled studies.²⁶ To synthesise the evidence, the results will be analysed based on hearing loss, cognitive decline and impairment.

Patient and public involvement

Patients or the public will not be involved in the study.

ETHICS AND DISSEMINATION

This systematic review will involve analyses of available literature and therefore ethical approval will not be required. Findings will be disseminated through peer-reviewed publications and conferences.

This systematic review and meta-analysis will explore the current evidence on the association between age-related hearing loss and cognitive decline or dementia in populations speaking prominent tonal languages. By discussing and summarising information about potential moderating factors that can explain whether or how hearing loss is related to cognitive decline or dementia, the findings from this review could provide directions for interventional studies and provide hearing care practitioners with an understanding of the impact and implications of age-related hearing loss.

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Contributors DMPJ, RHE, BL and XF designed this systematic review. XF initialised the protocol draft with guides from DMPJ, RHE and RT. XF, SW and RT ran the pilot search strategy. All authors contributed to the preparation of this systematic review and meta-analysis and approved the submitted version.

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