DOI: 10.1590/1413-81232023289.17452022EN

Association between self-perceived hearing status and cognitive impairment in the older Brazilian population: a population-based study

Alessandra Bayer de Oliveira (https://orcid.org/0000-0003-2199-2048) [1]
Paula Anderle (https://orcid.org/0000-0001-6216-5060) [2]
Bárbara Niegia Garcia de Goulart (https://orcid.org/0000-0002-2502-5883) [2]

Abstract *Cognitive health plays an important role in the quality of life and autonomy of older adults. and it is influenced by hearing ability. This article aims to analyze the association between self-perceived hearing status and cognitive impairment in Brazilian older adults. This cross-sectional population-based study was conducted with 4,977 older adults who participated in ELSI Brazil 2015. The cognitive impairment status (outcome. categorized as "yes" and "no") and variable of interest (self-perceived hearing status. categorized as "good" "fair" and "poor") were obtained using a self-report method. The following domains were considered for cognition: temporal orientation. memory (short and long term). and language (recent and late). Poisson regression with robust variance estimation was used to assess the self-perceived hearing status–cognitive impairment association in the crude and adjusted analyses. Sociodemographic. lifestyle. and medical history variables were used to adjust the analyses. We found that 31.8% of the participants reported fair or poor hearing and 42% had cognitive impairment. In the adjusted analysis. older adults with poor hearing were revealed to have a stronger association with cognitive impairment than their peers with good hearing. Therefore. in older Brazilian adults. lower self-perceived hearing status is associated higher levels of cognitive impairment.*
Key words *Hearing impairments, Hearing disorders, Cognitive impairment, Older adults*

[1] Curso de Fonoaudiologia, Universidade Federal do Rio Grande do Sul. Av. Paulo Gama 110, Farroupilha. 90040-060 Porto Alegre RS. alessandrabayer@hotmail.com
[2] Programa de Pós-Graduação em Epidemiologia, Universidade Federal do Rio Grande do Sul. Porto Alegre RS Brasil.

Introduction

Cognition refers to the individual mental process of acquiring, understanding and storing information through one's senses and experiences. Cognitive functions are the mental abilities that enable the correct interpretation and management of environmental information. These skills are essential to perform everything from the simplest tasks of everyday life to the most complex ones[1,2].

Cognitive impairment is when an individual has difficulty remembering or memorizing information, learning new skills, concentrating, or making decisions that affect their daily life, and it can range from mild impairment to dementia[3]. In all situations, cognitive impairment can have a major impact on the individual's general health and well-being[4]. Epidemiologic studies have shown that older adults with cognitive impairment have a higher risk of developing Alzheimer's disease (AD)[5-7].

The Global Burden of Disease study determined that between 1990 and 2016, dementia cases increased by 117%, from 20.2 million in 1990 to 43.8 million in 2016[8]. In Brazil, about 1.2 million people live with some form of dementia, and 100.000 new cases are diagnosed yearly[9], probably due to the intense and rapid aging process caused by the demographic transition[10]. Currently, more than 29 million Brazilians are over the age of 60[11].

In this context, an important fact is that cognition and hearing are closely related and influence each other. Neurocognitive functions influence speech understanding, especially in challenging acoustic situations[12]. According to the Global Burden of Disease study – GBD 2019, hearing loss (HL) is the third leading cause of age-related disability[13]. Presbycusis, namely, age -related hearing loss, is the most common sensory impairment observed in older adults[14]. The causes of HL include physiological and degenerative changes in hearing-related structures and modifications in cognitive cortical areas[15]. The onset of symptoms is gradual and subtle, since it primarily affects the detection of high-pitched sounds, interfering with speech understanding in noisy environments but not in quiet environments. Hence, this type of HL is often diagnosed late, thus delaying the onset of treatment[16].

Therefore, self-reported hearing impairment should be considered and investigated as soon as possible to avoid further long-term damage. Population-based epidemiological studies have used self-reported measures in this field since they are valid tools for screening large populations. Studies indicate that although self-reported hearing health assessment cannot replace an objective audiometric measurement, it is useful for data collection, providing important information on hearing loss among older adults[17-19].

Importantly, a systematic review and meta-analysis aimed to analyze the association between cognitive function, cognitive impairment, and dementia. In this meta-analysis, the associations between cognitive impairment and dementia were small but significant. These results highlight the importance of further research and randomized controlled trials to examine the implications of treatment for cognition impairment and to explore the possible causal mechanisms underlying this relationship[20].

Hearing acuity assessment has been widely studied; however, we couldn't find studies investigating the association between self-perceived hearing and cognitive function. Self-perceived hearing is a good screening tool for HL, as it identifies people who need specific and objective assessments to treat hearing disorders[21].

Since there is a gap in the literature on the association between self-perceived hearing status and cognitive impairment and hearing loss significantly affects the individual's social participation, which can lead to impairment in cognitive functions[3], this study aims to analyze the association between self-perceived hearing status and cognitive impairment in a sample of older Brazilian adults.

Method

Study design

This cross-sectional study was based on the Brazilian Longitudinal Study of Aging database conducted in 2015-2016 (ELSI-Brazil). ELSI -Brazil is a household-based survey conducted on a nationally representative Brazilian population aged 50 and above. ELSI-Brazil complies with National Health Council resolutions, such as 196/96, and its complementary resolutions, including 292/99, 340/2004, 346/2005, 347/2005, and 466/2012. This study was approved by the Research Ethics Committee (CEP) of the René Rachou Research Center of the Oswaldo Cruz Foundation, and the process is registered in Plataforma Brasil (Protocol no. 886.754)[22].

Ciência & Saúde Coletiva, 28(9):2653-2663, 2023

Participants and eligibility criteria

The ELSI-Brazil survey included 9,400 individual respondents from 70 municipalities in different regions of Brazil. The inclusion criterion for the current study was individuals aged 60 and above who answered the question, "How do you rate your hearing – even if you wear a hearing aid?"[22]. Participants with incomplete data were excluded. Thus, the final study sample comprised 4,977 participants.

Cognitive impairment

Cognitive impairment data came from the ELSI – Brazil Study, which uses a battery of tests applied in longitudinal studies conducted in different countries on the health of older adults, an initiative known as "The Health and Retirement Study"[23].

The Health and Retirement Study (HRS) is a nationally representative longitudinal survey of more than 37,000 individuals in the USA over 50. The survey, conducted every two years since 1992, was created to provide a national resource for data on the changing economic and health circumstances associated with aging, both at the individual and population levels. Its multidisciplinary approach focuses on four broad topics: income and wealth; health, cognition, and use of health services; work and retirement; and family connections[24].

The cognition section of the HRS is categorized into self-rated metamemory, memory, and mental processing (immediate and delayed recall, timed backward counting, serial subtraction of seven, date/object/president/vice-president naming, vocabulary, numeration, retrieval fluency, number series, and verbal reasoning), and depressive symptoms, with proxy classification of global memory (present and past) and respondent memory change[24].

For the cognitive function variable, three domains from the ELSI-Brazil questionnaire[22] were considered: temporal orientation, memory (short-term and long-term), and language.

Temporal orientation: refers to the individual's ability to orient oneself in time and process information related to time, day, month, year, and seasons[25]. Therefore, ELSI-Brazil participants were asked about the date, month, year, and day of the week, and the accuracy of the answers was checked (question codes q6, q7, q8, and q9 of the individual questionnaire of ELSI-Brazil)[22].

Memory: short-term memory is the ability to receive and store newly acquired information within a short time[26]. In the ELSI-Brazil study, short-term memory was measured by asking the individual to repeat ten words immediately after reading them (question code q13 of the individual questionnaire)[22]. Long-term memory is the ability to retain fundamental information, either understanding importance or repetition[26]. In the ESLI-Brazil study, it was measured by asking the individual to repeat ten words five minutes after reading them. Scores were computed separately from 0 to 10 for the number of evoked words (immediate and delayed) (question code q17 of the individual questionnaire)[22].

Language: language comprises a system of signs used to establish communication[27]. For this variable, individuals were asked to name two objects by their characteristics (scissors and banana) and call the current president and vice -president of Brazil at the time of the survey. The answers were computed as correct, incorrect, and do not know (question codes q18, q19, q20, and q21 of the individual questionnaire)[22].

After the tests were verified, analyses were conducted by obtaining the z scores for each domain. For memory analysis, the z score was considered for both tests (short-term and long-term memory). For the temporal orientation and language domains, each correct answer was considered equivalent to 1 point, with a total of 4 points. The z score of each test was calculated from the values obtained, and measures were used in standardized formats: "observed value – mean/average". Finally, a global z score was generated covering the three domains of cognitive function. The average of the three parameters (temporal orientation, memory, and language) was used for this measure. This was subsequently standardized according to the mean and standard deviation (SD) of the sample studied. Thus, cognitive impairment was defined for participants with a global z score equal to or less than -1SD[23].

Exposure variable

Data on the variable of interest, self-perceived hearing, were obtained from self-reported answers to the question: "How do you rate your hearing – even if you wear a hearing aid?" (question 16 of the individual questionnaire). For this question, the original questionnaire offers the following response options: very good or excellent, good, fair, poor, and very poor. For this

study, the responses were categorized as good (including very good or excellent and good), fair, and poor (including poor and very poor)[22].

Adjustment variables

To adjust the models used, we used sociodemographic variables, such as sex (female and male), age (60-69 years, 70-79 years, and ≥ 80)[28], education (never studied, elementary school, high school, undergraduate or more)[29], cognitive impairment (yes and no); lifestyle variables, such as physical activities (practice of physical exercises categorized as none, occasionally, regularly, and daily)[30], alcohol consumption (yes and no)[31], smoking (yes and no)[32]; use of individual sound amplification device (ISAD) (self-reported as no and yes); and clinical history variables, such as depression, diabetes, hypertension, heart failure, and stroke. These were assessed through self-reports; the participants were asked if they were diagnosed with any of these conditions, and yes and no answers were considered[22].

Data analysis

Data were presented as absolute and relative frequencies, considering the complex sample weights. Thus, the relative frequencies and other analyses were weighted, considering the characteristics of the sample, non-responses, and calibration. Poisson regression models with robust variance estimation were fitted independently for each adjustment variable.

Considering cognitive impairment as a reference category, crude and adjusted prevalence ratios were estimated for sociodemographic variables (Model 1: sex, age, and education), clinical history (Model 2: depression, diabetes, hypertension, heart failure, and stroke), and lifestyle (Model 3: physical activities, alcohol consumption, smoking, and use of ISAD). The adjustment variables were listed based on the literature and analyzed for correlation using the chi-square test. The final model, adjusted for all independent variables, was then used. The results were presented as prevalence ratios (PR) at 95% confidence intervals (95%CI); Tables 1 and 2 consider the weighted proportions obtained by multiplying each value by its respective weight and dividing it by the sum of the weights with a p-value of 0.05 at least for statistical significance. The Sandwich packages in R software[23] were used for all the analyses considering the study's complex sample design.

Results

The study sample comprised 4,977 older adults from the ELSI-Brazil cohort study baseline. Among these participants, 58% had no cognitive impairment, and 68.2% rated their hearing as good, 26.6% as fair, and 5.2% as poor. Regarding sociodemographic characteristics, 50.1% were female, 62.5% were aged 60-69 years, and 61.9% had completed elementary education (Table 1).

Regarding lifestyle, 42.8% of the sample reported not practicing physical activity, 85.2% reported not smoking, and 71.3% did not consume alcohol. Regarding clinical history, hypertension was the most prevalent chronic disease, affecting 61.6% of the sample. Furthermore, 97.7% reported not using an ISAD (Table 2).

The univariate analysis results of the association between the domains of cognitive impairment and self-perceived hearing status are in Table 3. We emphasize that altered memory, whether short- or long-term, seems to be associated with poor self-perceived hearing status.

In the crude analysis, the highest association between self-perceived hearing status and cognitive impairment was observed in individuals who reported poor auditory perception (PR = 1.53; 95%CI 1.52-1.56) about those who reported good auditory perception. In the final adjustment model, considering adjustments for sociodemographic and lifestyle variables and clinical history, individuals with poor hearing perception had a 22% higher strength of association for cognitive impairment compared with individuals with good hearing perception (PR = 1.22; 95%CI 1.22-1.25). Individuals with fair hearing perception had a 10% higher strength of association for cognitive impairment compared with individuals with good hearing perception (PR = 1.10; 95%CI% 1.08-1.12) (Table 4).

Discussion

The findings of this study indicate an association between self-perceived hearing status and cognitive impairment, as individuals who reported fair or poor auditory perception had a higher prevalence of cognitive impairment than individuals with good self-perceived hearing status. Furthermore, a higher association between hearing and cognitive impairment is shown when results related to lifestyle factors and clinical history are controlled by cofounders as sociodemographic factors, such as sex, age, education, lifestyle fac-

Table 1. Sociodemographic characteristics of the studied sample. according to self-perception of hearing – ELSI-Brazil 2015.

	Self-perception of hearing							
	Good		Fair		Poor		Total	
	n	% w	n	% w	n	% w	n	% w
	3299	**68.2**	**1363**	**26.6**	**315**	**5.2**	**4.977**	**100**
Age								
60-69	1.930	66.0	691	57.8	134	40.5	2.755	62.5
70-79	1.016	25.0	494	31.7	119	42.5	1.629	27.6
≥ 80	353	0.0	178	10.5	62	17.0	593	9.9
Sex								
Female	2.061	52.3	730	42.8	185	56.9	2.976	50.1
Male	1.238	47.7	633	57.2	130	43.1	2.001	49.9
Schooling								
Never studied	672	13.9	268	14.4	96	15.0	1.036	14.0
Primary education	1.940	60.0	845	65.1	182	70.6	2.967	61.9
Secondary education	484	16.8	182	15.8	27	12.4	693	16.3
Degree or more	203	9.3	68	4.7	10	2	281	7.8
Cognitive impairment								
Yes	1519	39.1	638	46.1	199	60.1	2356	42.0
No	1780	60.9	725	53.9	116	39.9	2621	58.0
Cognitive Functions								
Time orientation								
Normal	2768	85.5	1190	90.3	241	81.7	4199	86.6
Amended	531	14.5	173	9.7	74	18.3	778	13.4
Short-term memory								
Normal	2688	85.9	1086	80.9	216	68.5	3990	83.7
Amended	611	14.1	277	19.1	99	31.5	987	16.7
Long-term memory								
Normal	2597	82.7	1071	78.6	211	72.4	2879	81.0
Amended	702	17.3	292	21.4	104	27.6	1098	19.0
Language								
Normal	3155	75.3	1300	73.5	298	85.3	85.3	96.2
Amended	144	24.7	63	26.5	17	14.7	14.7	3.8

%w = weighted proportion.

Source: Authors.

tors, and health conditions, variables known to be associated with cognitive impairment[1]. In addition, the gradual progress of presbycusis leads to restricted social participation since people with hearing loss adapt their daily activities to avoid situations of communicative difficulty; thus, the cognitive health of older adults is affected[33].

Aging is marked by the degeneration processes of several systems, with HL and cognitive impairment usually being the most evident[33]. The pathophysiology of presbycusis includes degenerative changes in the structures of the inner ear (e.g., loss of inner and outer hair cells, deterioration of spiral ganglion cells, and atrophy of the stria vascularis) and altered neural processing of auditory input[34]. One of the ways to reduce the damage caused by hearing loss is to use an individual sound amplification device (ISAD). However, most of the individuals in this study did not use the device (97.7%).

Moreover, studies have pointed out that clinical indications for hearing aid treatment, including hearing aids and cochlear implants (CI), raise expectations of their potential positive effects on cognitive functions and mood disorders among older individuals. Hearing rehabilitation can improve and restore the auditory perceptual skills needed for speech, thus contributing to

Table 2. Lifestyle and clinical health history of the studied sample according to self-perception of hearing – ELSI-Brazil 2015.

	Self-perception of hearing							
	Good		Fair		Poor		Total	
	n	%w	n	%w	n	%w	n	%w
	3299	**68.2**	**1363**	**26.6**	**315**	**5.2**	**4977**	**100**
Physical activity								
None	1,396	42.2	617	41.6	174	56.4	2,187	42.8
Occasionally	557	15.0	236	18.7	48	15.2	841	16.0
Regularly	642	21.4	240	19.6	48	12.9	930	20.4
Daily	704	21.4	270	20.1	45	15.5	1,019	20.8
Smoking								
Non-smoker	2,811	86.1	1,188	83.6	268	83.1	4,267	85.2
Smoker	488	13.9	175	16.4	47	16.9	710	14.8
Alcohol consumption								
No	2,559	72.8	1,054	66.0	259	79.6	3,872	71.3
Yes	740	27.2	309	34.0	56	20.4	1,105	28.7
Depression								
No	2,780	84.9	1,111	78.9	234	72.2	4,125	82.7
Yes	519	15.1	525	21.1	81	27.8	825	17.3
Hypertension								
No	1,284	38.1	527	39.8	99	53.3	1,910	38.4
Yes	2,015	61.9	836	60.2	216	64.7	3,067	61.6
Diabetes								
No	2,674	81.2	1,110	82.6	243	80.4	4,027	81.6
Yes	625	18.8	253	17.4	72	19.6	950	18.4
Stroke								
No	3,125	95.1	1,264	92.0	280	89.2	4,669	94.0
Yes	174	4.9	99	8.0	35	10.8	308	6.0
Heart failure								
No	3,044	92.0	1,225	92.0	269	84.1	4,538	91.6
Yes	255	8.0	138	8.0	46	15.9	439	8.4
Use of ISAD**								
No	3,245	98.5	1,319	96.3	298	94.0	4,862	97.7
Yes	54	1.5	44	3.7	17	6.0	115	2.3

%w = weighted proportion. ** Individual Sound Amplification Device.

Source: Authors.

social participation and, consequently, to this population's good functioning and cognitive maintenance[34,35].

The influence of years of schooling on cognitive processes should also be highlighted, as a higher level of education is positively associated with increased and maintained cognitive function throughout life[36,37]. A lengthy study time may delay the onset and rapid progression of symptoms of cognitive impairment since it does not influence the evolutionary process of aging but may affect the time at which accelerated declines occur[36]. An essential fact in this context is that individuals with HL have more significant learning difficulties and fewer years of study, a factor that may contribute to the loss of cognitive function in this population[38-40].

Additionally, low levels of schooling, which is a common phenomenon in different regions of Brazil and compromises access to health education – a strategy that enables the adoption of healthy behaviors and social mobilization to improve living conditions – influence adherence to the treatment of chronic diseases and may present difficulties in understanding the guidelines[41]. In addition to these issues, poverty is related to the health conditions of individuals; a study conducted in Brazil using data from the Brazil-

Table 3. Univariable analysis between dimensions of cognitive functions and self-perception of hearing in the study population.

Self-perception of hearing				
Good	Good	Fair	Poor	*p-value
	P(%ʷ)	P(%ʷ)	P(%ʷ)	
Time orientation				
Normal	67.2	27.7	5.0	0.015
Amended	73.6	19.3	7.1	
Language				
Normal	65.8	27.4	6.7	0.075
Amended	68.0	27.1	5.0	
Short-term memory				
Normal	70.0	25.7	4.3	0.006
Amended	58.8	31.2	10.0	
Long-term memory				
Normal	69.5	25.7	4.6	0.066
Amended	62.4	30.0	17.6	

P(%w): weighted prevalence. * Chi-square test.

Source: Authors.

ian Household Sample Survey (PNAD in Portuguese) from 1998 found that social inequalities affect health conditions and the use of health services among older adults[41,42].

It is essential to highlight the impact of medical history and lifestyle on individuals and the risks of developing cognitive impairment, both observed in this study sample. Lifestyle factors such as regular physical exercise[43-45], reduced smoking[46], and alcohol consumption[47] affected HL and, consequently, cognitive function.

According to the Brazilian Ministry of Health, approximately 57.4 million people nationwide have at least one chronic non-communicable disease (NCD). Biological factors, such as genetic load, sex, age, and habits and behaviors that affect health, such as physical inactivity, inadequate diet, obesity, smoking, and alcohol abuse, facilitate their development[48]. Diseases such as hypertension, depression, stroke, and heart failure were notably prevalent in the sample, significantly affecting the results of this study.

Furthermore, in terms of NCDs, hypertension, and diabetes are known to influence cardiovascular changes, such as stroke, which in turn is a risk factor for cognitive impairment[49-51]. There is strong epidemiological evidence of the relationship between diabetes and cognitive impairment. Furthermore, the study also examined the correlation between hearing impairments and identified various contributing factors[52-54].

This study was limited to a cross-sectional analysis of the association between self-perceived hearing status and cognitive impairment, exposing prevalence results in the population studied at the population level. Hence, the causal relationships between the factors under study as well as their incidence in the elderly population were not analyzed. However, this study brings a relevant approach to the analysis of human aging processes, being an essential source of information for public health actions for older adults.

In addition, this study is relevant because it is the first thus far to analyze the association between self-perceived hearing status and cognitive impairment using a complex population-based sample representative of the older Brazilian population. In addition, the data used for the analyses were obtained from the ELSI-Brazil study, concurring with the literature on the reliability and validity of self-report studies[22,55] since self-reporting is an easy and practical way to apply population-based surveys[55].

Conclusion

This study highlights the association between cognitive impairment and fair and poor self-perceived hearing in older Brazilian adults compared to older Brazilian adults with good self-perceived hearing. These findings support the need for hearing screenings, self-perception assessments, and hearing treatment programs at the national level in this population since these measures and actions can prevent changes in cognitive health.

Furthermore, we emphasize that the results obtained in this study point to the need for longitudinal studies on the subject to analyze the causal relationship between hearing and cognitive changes among older adults in Brazil and the potential effects of auditory rehabilitation interventions on the cognitive aspect, with emphasis on early intervention for short- and medium-term memory functions. In addition, other studies that deepen the understanding of the etiopathogenesis of HL and cognitive decline are also necessary so that the mechanisms of their association are elucidated.

Table 4. Crude and adjusted association (by Poisson regression with robust variance) between self-perception of hearing and occurrence of cognitive impairment in older Brazilian adults.

	Cognitive impairment		
	PR_{crude}(95% CI)	**$PR_{adjusted}$(95% CI)**	**p-value**
Model 1 | Variables			
Auditory perception			
Good	1.00	1.00	< 0.001
Fair	1.17(1.15-1.20)	1.08(1.06-1.10)	< 0.001
Poor	1.53(1.52-1.56)	1.25(1.22-1.28)	< 0.001
Age			
60-69	1.00	1.00	< 0.001
70-79	1.55(1.51-1.59)	1.51(1.48-1.56)	< 0.001
80 ≥	2.40(2.32-2.48)	2.35(2.27-2.43)	< 0.001
Sex			
Female	1.00(0.98-1.03)	1.01(0.99-1.04)	0.225
Schooling			
Lower education	4.98(4.55-5.44)	1.76(1.74-1.78)	< 0.001
Model 2 | Variables			
Auditory perception			
Good	1.00	1.00	< 0.001
Fair	1.17(1.15-1.20)	1.15(1.12-1.17)	< 0.001
Poor	1.53(1.52-1.56)	1.47(1.44-1.50)	< 0.001
Hipertension			
Yes	1.06(1.04-1.08)	1.05(1.04-1.07)	< 0.001
Depression			
Yes	1.10(1.08-1.13)	1.07(1.05-1.10)	< 0.001
Stroke			
Yes	1.48(1.45-1.51)	1.43(1.40-1.46)	< 0.001
Diabetes			
Yes	1.14(1.12-1.17)	1.14(1.12-1.16)	< 0.001
Heart failure			
Yes	0.94(0.91-0.97)	0.92(0.90-0.95)	< 0.001
Use of hearing aids			
Yes	1.58(1.53-1.64)	1.48(1.43-1.54)	< 0.001
Model 3 |Variables			
Auditory perception			
Good	1.00	1.00	< 0.001
Fair	1.17(1.15-1.20)	1.21(1.19-1.23)	< 0.001
Poor	1.53(1.52-1.56)	1.46(1.43-1.48)	< 0.001
Smoking	0.91(0.89-0.93)	0.90(0.88-0.92)	< 0.001
Yes			
Alcohol use			
Yes	0.66(0.64-0.69)	0.66(0.64-0.68)	< 0.001
Physical activity			
Lower levels of physical activity	0.75(0.73-0.77)	0.71(0.69-0.74)	< 0.001

Source: Authors.

Ciência & Saúde Coletiva, 28(9):2653-2663, 2023

Collaborations

AB Oliveira, P Anderle e BNG Goulart contributed to the conception and design of the study, data analysis and interpretation, writing of the article, and review and final approval of the content.

References

1. Forte G, Favieri F, Casagrande M. Heart rate variability and cognitive function: a systematic review. *Front Neurosci* 2019; 13:710.
2. Murman DL. The impact of age on cognition. *Semin Hear* 2015; 36(3):111-121.
3. Lv X, Li W, Ma Y, Chen H, Zeng Y, Yu X, Hofman A, Wang H. Cognitive decline and mortality among community-dwelling Chinese older people. *BMC Med* 2019; 17(1):63.
4. Centers for Disease Control and Prevention (CDC). Subjective Cognitive Decline – A Public Health Issue [Internet]. 2019. [cited 2019 jul 30]. Available from: https://www.cdc.gov/aging/data/subjective-cognitive-decline-brief.html
5. Charchat-Fichman H, Caramelli P, Sameshima K, Nitrini R. Declínio da capacidade cognitiva durante o envelhecimento. *Rev Bras Psiquiatr* 2005; 27(1):79-82.
6. Davis M, O Connell T, Johnson S, Cline S, Merikle E, Martenyi F, Simpson K. Estimating Alzheimer's disease progression rates from normal cognition through mild cognitive impairment and stages of dementia. *Curr Alzheimer Res* 2018; 15(8):777-788.
7. Kirova AM, Bays RB, Lagalwar S. Working memory and executive function decline across normal aging, mild cognitive impairment, and Alzheimer's disease. *BioMed Res Int* 2015; 2015:748212.
8. Launer LJ. Statistics on the burden of dementia: need for stronger data. *Lancet Neurol* 2019; 18(1):25-27.
9. Ministérios da Saúde (MS). Conhecer a demência, conhecer o Alzheimer: o poder do conhecimento – setembro, Mês Mundial do Alzheimer [Internet]. 2021. [acessado 2022 dez 19]. Disponível em: https://bvsms.saude.gov.br/conhecer-a-demencia-conhecer-o-alzheimer-o-poder-do-conhecimento-setembro-mes-mundial-do-alzheimer/
10. Centro de Estudos Estratégicos da Fiocruz (CEE). O envelhecimento populacional compromete o crescimento econômico no Brasil? [Internet]. 2020. [acessado 2022 dez 19]. Disponível em: https://cee.fiocruz.br/?q=envelhecimento-populacional-compromete-o-crescimento-economico
11. Instituto Brasileiro de Geografia e Estatística (IBGE). População [Internet]. 2020. [acessado 2021 out 20]. Disponível em: https://www.ibge.gov.br/estatisticas/sociais/populacao.html
12. Völter C, Götze L, Dazert S, Wirth R, Thomas JP. Impact of hearing loss on geriatric assessment. *Clin Interv Aging* 2020; 15:2453-2467.
13. GBD 2016 Disease and Injury Incidence and Prevalence Collaborators. Global, regional, and national incidence, prevalence, and years lived with disability for 328 diseases and injuries for 195 countries, 1990-2016: a systematic analysis for the Global Burden of Disease Study 2016. *Lancet* 2017; 390(10100):1211-1259.
14. Caruso MFB, Mármora CHC, Delgado FEF. Prevalência de perda auditiva autorrelatada em idosos e fatores associados em Juiz de Fora. *Rev Hosp Univ Pedro Ernesto* 2019; 17(2):35-42.
15. Davis A, McMahon CM, Pichora-Fuller KM, Russ S, Lin F, Olusanya BO, Chadha S, Tremblay KL. Aging and hearing health: the life-course approach. *Gerontologist* 2016; 56(Suppl. 2):S256-S267.
16. Glick HA, Sharma A. Cortical neuroplasticity and cognitive function in early-stage, mild-moderate hearing loss: evidence of neurocognitive benefit from hearing aid use. *Front Neurosci* 2020; 14:93.
17. Yang TH, Chu YC, Chen YF, Chen MY, Cheng YF, Wu CS, Huang H-M. Diagnostic validity of self-reported hearing loss in elderly Taiwanese individuals: diagnostic performance of a hearing self-assessment questionnaire on audiometry. *Int J Environ Res Public Health* 2021; 18(24):13215.
18. Tsimpida D, Kontopantelis E, Ashcroft D, Panagioti M. Comparison of self-reported measures of hearing with an objective audiometric measure in adults in the English Longitudinal Study of Ageing. *JAMA Netw Open* 2020; 3(8):e2015009.
19. Amieva H, Ouvrard C, Giulioli C, Meillon C, Rullier L, Dartigues JF. Self-reported hearing loss, hearing aids, and cognitive decline in elderly adults: a 25-year study. *J Am Geriatr Soc* 2015; 63(10):2099-2104.
20. Loughrey DG, Kelly ME, Kelley GA, Brennan S, Lawlor BA. Association of age-related hearing loss with cognitive function, cognitive impairment, and dementia: a systematic review and meta-analysis. *JAMA Otolaryngol Head Neck Surg* 2018; 144(2):115-126.
21. Fiamoncini JD, Silva AO, Sousa TR de, Satler CE, Silva IMC, Cera ML. Associação entre o desempenho linguístico-cognitivo e a autopercepção auditiva de idosos. *Audiol Commun Res* 2022; 27:e2597.
22. ELSI-BRASIL. Estudo Longitudinal da Saúde dos Idosos Brasileiros [Internet]. 2015. [acessado 2020 mar 14]. Disponível em: http://elsi.cpqrr.fiocruz.br/
23. Aliberti MJR, Szlejf C, Lima-Costa MF, de Andrade FB, Alexandre TS, Ferri CP, Suemoto CK. Frailty modifies the association of hypertension with cognition in older adults: evidence from the ELSI-Brazil. *J Gerontol A Biol Sci Med Sci* 2021; 76(6):1134-1143.
24. Sonnega A, Faul JD, Ofstedal MB, Langa KM, Phillips JWR, Weir DR. Cohort profile: the Health and Retirement Study (HRS). *Int J Epidemiol* 2014; 43(2):576-585.
25. Breska A, Ivry RB. The human cerebellum is essential for modulating perceptual sensitivity based on temporal expectations. *eLife* 2021; 10:e66743.
26. Norris D. Short-term memory and long-term memory are still different. *Psychol Bull* 2017; 143(9):992-1009.
27. Sá APS. Linguagem científica: características e importância [Internet]. 2017. [acessado 2021 nov 15]. Disponível em: https://ambitojuridico.com.br/edicoes/revista-166/linguagem-cientifica-caracteristicas-e-importancia/amp/
28. Baraldi GS, Almeida LC, Borges ACC. Evolução da perda auditiva no decorrer do envelhecimento. *Rev Bras Otorrinolaringol* 2007; 73(1):64-70.
29. Instituto de Pesquisa Econômica Aplicada (IPEA). Os níveis de escolaridade no setor público brasileiro [Internet]. 2017. [acessado 2021 nov 15]. Disponível em: https://www.ipea.gov.br/atlasestado/arquivos/rmd/4874-conjunto4v10.html
30. Organização Mundial de Saúde (OMS). Atividade física [Internet]. 2020. [acessado 2022 nov 16]. Disponível em: https://www.who.int/news-room/fact-sheets/detail/physical-activity

31. Organização Mundial de Saúde (OMS). I Levantamento nacional sobre os padrões de consumo de álcool na população brasileira [Internet]. 2004. [acessado 2021 nov 17]. Disponível em: https://bvsms.saude.gov.br/bvs/publicacoes/relatorio_padroes_consumo_alcool.pdf
32. Campos MW, Serebrisky D, Castaldelli-Maia JM. Smoking and cognition. *Curr Drug Abuse Rev* 2016; 9(2):76-79.
33. Costa-Guarisco LP, Dalpubel D, Labanca L, Chagas MHN. Percepção da perda auditiva: utilização da escala subjetiva de faces para triagem auditiva em idosos. *Cien Saude Colet* 2017; 22(11):3579-3588.
34. Castiglione A, Benatti A, Velardita C, Favaro D, Padoan E, Severi D, Pagliaro M, Bovo R, Vallesi A, Gabelli C, Martini A. Aging, cognitive decline and hearing loss: effects of auditory rehabilitation and training with hearing aids and cochlear implants on cognitive function and depression among older adults. *Audiol Neurotol* 2016; 21(Suppl. 1):21-28.
35. Hear-it. Há muitos benefícios com o uso de aparelhos auditivos [Internet]. 2019. [acessado 2021 set 20]. Disponível em: https://www.hear-it.org/pt/ha-muitos-beneficios-com-o-uso-de-aparelhos-auditivos
36. Rutherford BR, Brewster K, Golub JS, Kim AH, Roose SP. Sensation and psychiatry: linking age-related hearing loss to late-life depression and cognitive decline. *Am J Psychiatry* 2018; 175(3):215-224.
37. Clouston SAP, Smith DM, Mukherjee S, Zhang Y, Hou W, Link BG, Richards M. Education and cognitive decline: an integrative analysis of global longitudinal studies of cognitive aging. *J Gerontol B Psychol Sci Soc Sci* 2020; 75(7):e151-e160.
38. Zaidman-Zait A, Most T. Pragmatics and peer relationships among deaf, hard of hearing, and hearing adolescents. *Pediatrics* 2020; 146(Suppl. 3):S298-S303.
39. Paatsch L, Toe D. The impact of pragmatic delays for deaf and hard of hearing students in mainstream classrooms. *Pediatrics* 2020;146(Suppl. 3):S292-S297.
40. Ziliotto DM, Souza DJ, Andrade FI. Quando a inclusão não se efetiva: a evasão de alunos surdos ou com deficiência auditiva no ensino superior. *Rev Educ Espec* 2018; 31(62):727.
41. Lima-Costa MF, Barreto S, Giatti L. A situação socioeconômica afeta igualmente a saúde de idosos e adultos mais jovens no Brasil? Um estudo utilizando dados da Pesquisa Nacional por Amostras de Domicílios PNAD/98. *Cien Saude Colet* 2002; 7(4):813-824.
42. Lima-Costa MF. A escolaridade afeta, igualmente, comportamentos prejudiciais à saúde de idosos e adultos mais jovens? Inquérito de Saúde da Região Metropolitana de Belo Horizonte, Minas Gerais, Brasil. *Epidemiol Serv Saude* 2004;13(4):201-208.
43. Brasure M, Desai P, Davila H, Nelson VA, Calvert C, Jutkowitz E, Butler M, Fink HA, Ratner E, Hemmy LS, McCarten JR, Barclay TR, Kane RL. Physical activity interventions in preventing cognitive decline and Alzheimer-type dementia: a systematic review. *Ann Intern Med* 2018; 168(1):30-38.
44. Guure CB, Ibrahim NA, Adam MB, Said SM. Impact of physical activity on cognitive decline, dementia, and its subtypes: meta-analysis of prospective studies. *BioMed Res Int* 2017; 2017:9016924.
45. Karssemeijer EGA, Aaronson JA, Bossers WJ, Smits T, Olde Rikkert MGM, Kessels RPC. Positive effects of combined cognitive and physical exercise training on cognitive function in older adults with mild cognitive impairment or dementia: a meta-analysis. *Ageing Res Rev* 2017; 40:75-83.
46. Wingbermühle R, Wen KX, Wolters FJ, Ikram MA, Bos D. Smoking, APOE genotype, and cognitive decline: The Rotterdam Study. *J Alzheimers Dis JAD* 2017; 57(4):1191-1195.
47. Koch M, Fitzpatrick AL, Rapp SR, Nahin RL, Williamson JD, Lopez OL, DeKosky ST, Kuller LH, Mackey RH, Mukamal KJ, Jensen MK, Sink KM. Alcohol consumption and risk of dementia and cognitive decline among older adults with or without mild cognitive impairment. *JAMA Netw Open* 2019; 2(9):e1910319.
48. Organização Mundial de Saúde (OMS). Doenças e agravos não transmissíveis [Internet]. 2019. [acessado 2021 out 3]. Disponível em: https://www.saude.pr.gov.br/Pagina/Doencas-e-agravos-nao-transmissiveis.
49. Menezes TN, Oliveira ECT, Fischer MATS, Esteves GH. Prevalência e controle da hipertensão arterial em idosos: um estudo populacional. *Rev Port Saude Publica* 2016; 34(2):117-124.
50. Livingston G, Sommerlad A, Orgeta V, Costafreda SG, Huntley J, Ames D, Ballard C, Banerjee S, Burns A, Cohen-Mansfield J, Cooper C, Fox N, Gitlin LN, Howard R, Kales HC, Larson EB, Ritchie K, Rockwood K, Sampson EL, Samus Q, Schneider LS, Selbæk G, Teri L, Mukadam N. Dementia prevention, intervention, and care. *Lancet* 2017; 390(10113):2673-734.
51. Kalaria RN, Akinyemi R, Ihara M. Stroke injury, cognitive impairment and vascular dementia. *Biochim Biophys Acta* 2016; 1862(5):915-925.
52. Konrad-Martin D, Reavis KM, Austin D, Reed N, Gordon J, McDermott D, et al. Hearing impairment in relation to severity of diabetes in a veteran cohort. *Ear Hear* 2015; 36(4):381-394.
53. David LZ, Finamor MM, Buss C. Possíveis implicações audiológicas do diabetes melito: uma revisão de literatura. *Rev CEFAC* 2015; 17(6):2018-2024.
54. Biessels GJ, Despa F. Cognitive decline and dementia in diabetes mellitus: mechanisms and clinical implications. *Nat Rev Endocrinol* 2018; 14(10):591-604.
55. Morimoto SS, Kanellopoulos D, Manning KJ, Alexopoulos GS. Diagnosis and treatment of depression and cognitive impairment in late life. *Ann N Y Acad Sci* 2015; 1345(1):36-46.

Article submitted 25/06/2022
Approved 31/01/2023
Final version submitted 02/02/2023

Chief editors: Romeu Gomes, Antônio Augusto Moura da Silva