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Research Report

The Association Between Hearing Impairment, Vision Impairment, Dual Sensory Impairment, and Serious Cognitive Impairment: Findings from a Population-Based Study of 5.4 million Older Adults

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Abstract.
Background: Sensory impairments and cognitive impairment are increasing in scope due to the aging population.
Objective: To investigate the association between hearing impairment, vision impairment, and dual sensory impairment with cognitive impairment among older adults.
Methods: Secondary analysis of a combination of ten consecutive waves (2008–2017) of the nationally representative American Community Survey. The sample included 5.4 million community-dwelling and institutionalized older adults aged 65 and older. Bivariate and logistic regression models were conducted to examine the association hearing impairment, vision impairment, and dual sensory impairment with cognitive impairment.
Results: After controlling for age, race, education, and income, older adults with only hearing impairment had more than double the odds of cognitive impairment (OR = 2.66, 95% CI = 2.64, 2.68), while older adults with only vision impairment had more than triple the odds of cognitive impairment (OR = 3.63; 95% CI = 3.59, 3.67). For older adults with dual sensory impairment, the odds of cognitive impairment were eight-fold (OR = 8.16; 95% CI = 8.07, 8.25). Similar trends were apparent in each sex and age cohort.
Conclusion: Hearing and vision impairment are both independently associated with cognitive impairment. However, dual sensory impairment is associated with substantially higher odds of cognitive impairment, even after controlling for

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sociodemographic characteristics. Practitioners working with older adults may consider treatment for sensory impairments and cognitive impairment concurrently. Future research is needed to determine if the association is causal, and to investigate the effectiveness of common methods of treatment for sensory impairment for reducing the prevalence of cognitive impairment.

Keywords: Blindness, cognitive dysfunction, deafness, dementia, hearing disorders, hearing loss, vision disorders

INTRODUCTION

Dementia is a major public health concern with an increasing social and economic burden due to population aging [1–3]. Two forms of sensory impairment – hearing impairment and vision impairment – also increase substantially with age. An estimated one third of adults aged 65–74 and roughly one half of adults aged 75 and older have some degree of hearing loss [4]. In the United States (US), the lifetime cost to society for each individual with age-related hearing impairment is $43,000 [5]. Vision impairment affects approximately 4% of adults aged 65–74 and 16% of adults aged 80 to 84 in the US [6]. Among adults aged 40 and above in the US, the annual cost of vision disorders is an estimated $35.4 billion due to direct costs and lost productivity [7].

Some older adults concurrently experience hearing and vision impairment, which is called dual sensory impairment. This prevents them from compensating for the loss of one sense through use of the other [8]. Between 1999 and 2006 an estimated 1.5 million adults had dual sensory impairment. While only 1% of adults aged 70 years or less had dual sensory impairment, this increases to 11.3% among adults aged 80 and older [9].

As the size of the older adult population grows from 56 million in the US in 2020 (17%) to 95 million in 2060, representing 23% of the population [10], it is anticipated that the number of older adults with hearing impairment, vision impairment, dual sensory impairment, and cognitive impairment will increase dramatically. Thus, it is essential to consider how these conditions may be related to one another.

Hearing impairment and cognitive impairment

A burgeoning literature has examined the relationship between hearing impairment and cognitive impairment among older adults. A recent review by Livingston and colleagues [11] on preventable causes of dementia found midlife peripheral hearing loss to be the largest preventable cause of dementia, causally associated with 9% of dementia cases. Similarly, a meta-analysis by Yuan and colleagues [12] found that moderate to severe peripheral hearing loss was associated with a 29% higher risk of cognitive impairment in the studies with 6 or fewer years of follow-up, and a 36% higher risk for studies with longer follow-up. They also found that those with severe central hearing loss had triple the risk of cognitive impairment compared to those without hearing problems [12]. Lin and colleagues [13] found that over a 6-year period, older adults with hearing loss at baseline had a 41% higher average annual rate of cognitive decline when compared to those with normal hearing.

Vision impairment and cognitive impairment

Vision impairment is another sensory impairment that may increase one's risk of cognitive impairment. A recent population-based longitudinal study of older adults found that worsening vision was associated with declining cognition [14]. Swenor and colleagues [15] examined the relationship between vision impairment and cognitive outcomes and found that specific aspects of vision impairment were associated with an increased risk of cognitive decline based on digital symbol tests and Modified Mini-Mental State Exam (3MS) scores. In particular, impairments in visual acuity, contrast sensitivity, and stereo acuity were associated with a 55%, 33%, and 28% increased risk of cognitive impairment, respectively [15]. A longitudinal study of 2,087 older adults by Anstey and colleagues [16] found that declines in visual acuity were strongly associated with memory decline. Similarly, a longitudinal analysis by Reyes-Ortiz and colleagues [17] found near vision impairment in particular was associated with cognitive decline, while distance vision impairment was not.

Dual sensory impairment and cognitive impairment

Several studies have also identified an association between dual sensory impairment and cognitive impairment. In a longitudinal analysis of 6,520 older adults, Byeon and colleagues [18] found that dual sensory impairment was significantly associated with a higher prevalence of dementia at baseline, as well as a higher incidence of dementia at the 6-year follow-up when compared to those with a single sensory impairment and those with normal sensory functioning. An additional longitudinal study of 1,989 nursing home residents by Yamada and colleagues [19] found that participants with dual sensory impairment experienced greater cognitive decline over a one-year period. However, this effect was moderated by social engagement; socially engaged participants with dual sensory impairment did not have a faster rate of cognitive decline. In a study of older women, Lin and colleagues [20] found that hearing impairment, vision impairment, and dual sensory impairment were all associated with increased odds of cognitive impairment, with higher odds of cognitive impairment occurring among those with dual sensory impairment compared to those with hearing or vision impairment alone.

The objective of the current study is to investigate the association between serious cognitive impairment and hearing impairment, vision impairment, and dual sensory impairment using a large, nationally representative sample of community-dwelling and institutionalized older American adults.

METHODS

Data

As has been described elsewhere [21], the current study used merged data from 10 consecutive waves (2008 to 2017) of the American Community Survey (ACS). The ACS is an annual survey conducted by the US Census Bureau which replaces the long form of the decennial census. A large, nationally representative sample of 3.5 million American addresses were randomly selected each year for ACS interviewing. The ACS sample includes those living in the community and institutions, such as nursing homes.

The response rate was excellent and ranged from a low of 89.9% in 2013 to a high of 98.0% in 2009 for respondents in the community. The response rate for individuals in institutional settings ranged from 94.7% in 2017 to 98.0% in 2008 [22].

The sample size of those aged 65 and older ranged from 467,736 in 2008 to 610,327 in 2017, resulting in a total sample size of 5,405,135 respondents.

Measures

For each of the 10 years of data collection, the same questions were used in the ACS for cognitive impairment, hearing impairment, and vision impairment [23]. Serious cognitive impairment was based upon the question, “Because of a physical, mental, or emotional condition, does this person have serious difficulty concentrating, remembering, or making decisions?” (yes/no). Hearing impairment was based upon the question, “Is this person deaf or does he/she have serious difficulty hearing?” (yes/no). Vision impairment was based upon the question, “Is this person blind or does he/she have serious difficulty seeing even when wearing glasses?” (yes/no). The questions were based on self-report for those who were able to answer, but among those were incapable of answering, a proxy such as a family member or nursing home staff member provided the information. Age was entered into the logistic regression analyses categorically by year with top coding at 97. For the prevalence tables, age was presented in 10-year groups (i.e., 65–74, 75–84, 85 and older). Race/ethnicity was categorized into Hispanic (of any race), non-Hispanic white, non-Hispanic Black, non-Hispanic American Indian Alaskan Native, non-Hispanic Asian-American, Native Hawaiian Pacific Islander, Non-Hispanic mixed, or other. Sex was based on self-report or proxy report of male or female. Education was categorized as no schooling, some schooling but less than grade 3 completed, then each year of education completed from grade 3 through grade 11, grade 12 but no diploma, grade 12 regular high school diploma, General Education Diploma (GED), some college but less than 1 year, 1 or more years of college but no diploma, associate’s degree, bachelor’s degree, master’s degree, professional degree, and doctorate. Household income was based on a measure of household income as a percentage of the poverty threshold for households of a similar size and composition with the following categories: under poverty line, 100–199%, 200-–299%, 300–399%, 400–499%, and 500% or more.

Statistical analysis

Descriptive statistics were generated using cross-tabs and chi-square tests for cognitive impairment, age cohort (65–74, 75–84, 85+), sex, education level (<High school, high school graduate, university graduate) and poverty level by sensory impairment (no impairment, hearing only, seeing only, dual sensory

Table 1
Characteristics of respondents with no sensory impairment, hearing impairment only, vision impairment only, and dual sensory impairment ($n = 5{,}405{,}135$)

	Total (%)	Sensory Impairment				
		No Sensory Impairment (%) ($n = 4{,}360{,}981$)	Hearing Impairment (%) ($n = 666{,}275$)	Vision Impairment (%) ($n = 198{,}998$)	Both Hearing and Vision Impairment (%) ($n = 178{,}881$)	p-value from χ^2
Cognitive Impairment						
No	89.2	93.0	80.0	71.9	49.5	<0.001
Yes	10.8	7.0	20.0	28.1	50.5	
Sex						
Male	43.6	42.0	56.9	34.4	43.6	<0.001
Female	56.4	58.0	43.1	65.6	56.4	
Age						
65–74	55.9	60.8	36.2	42.3	25.3	<0.001
75–84	30.8	29.6	37.1	34.6	32.7	
85+	13.3	9.6	26.7	23.1	42.0	
Education						
<High schoolgraduate	19.5	17.6	23.4	32.1	35.9	<0.001
High school graduate (includes associate's degree & GED)	56.7	57.0	57.2	53.5	51.5	
University degree	23.8	25.4	19.4	14.4	12.6	
Poverty level						
0–99%	9.1	8.6	8.7	15.0	13.7	<0.001
100–199%	20.4	19.4	22.5	28.1	27.3	
200–299%	18.1	18.0	19.4	17.8	17.3	
300–399%	13.8	14.1	14.0	11.1	10.7	
400–499%	9.9	10.2	9.6	7.0	6.5	
500+	25.6	27.4	21.5	13.9	12.5	
Missing	3.1	2.3	4.2	7.1	11.9	

impairment). The prevalence of cognitive impairment by hearing impairment, vision impairment, and dual sensory impairment for age groups (i.e., 65–74, 75–84, 85 and older, 65 and older) and both sexes was generated for both genders together and for each gender by the age cohorts. For both genders together, logistic regression analyses of cognitive impairment were conducted that included sensory loss, age, race, income, and education. Additional logistic regression analyses of cognitive impairment were conducted for each gender and for each age cohort that included sensory loss, age, race, income, and education.

All data were weighted to adjust for non-response and differential selection probabilities. All sample sizes are represented in their unweighted form. All analyses were conducted using IBM SPSS 25.

RESULTS

When those with cognitive impairment were compared to those without cognitive impairment, the prevalence of hearing impairment only (22.2% versus 10.8%), vision impairment only (9.9% versus 3.1%), and dual sensory impairment (16.0% versus 1.9%) was much higher, and the prevalence of those without any sensory impairment was much lower (51.9% versus 84.3%; $p < .001$). The prevalence of dual sensory impairment increased from 1.5% among those aged 65 to 74, to 2.6% among those aged 75–84, to 10.8% among those aged 85 and older. There was a dose response relationship between poverty level and dual sensory loss, ranging from 1.7% of those at 500% or higher of the poverty line to 5.2% of those living below the poverty line. Older adults who had not completed high school had a higher prevalence of dual sensory impairment than high school graduates or university graduates (6.3%, 3.1%, 1.8%, respectively). Those with missing data on income, many of whom may have been in nursing homes where their information was provided by proxies such as nursing staff, had particularly high levels of dual sensory impairment (13.3%).

Table 1 provides a profile of the characteristics of respondents by level of sensory impairment (i.e., no sensory impairment, hearing impairment only, vision impairment only, and dual sensory impairment). Overall, 56.4% of the sample were female and 43.6% were male. However, men were over-represented in the hearing impairment only category (56.9% male versus 43.1% female). In the total sample, 13.3% were age 85 and older, but this age group comprised 42% of those with dual sensory impairment. Overall, 19.5% had not completed high school, but more than one third (35.9%) of those with dual sensory impairment were without a high school diploma. In the total sample, 9.1% were below the poverty line. This increased to 13.7% in those with dual sensory impairment.

Table 2 provides the prevalence of cognitive impairment by age group and sex. A dose-response was evident across all age and sex groups, such that those with no sensory impairments had the lowest prevalence of cognitive impairment, followed by those with only hearing impairment and those with only visual impairment, with a markedly higher prevalence of cognitive problems among those with dual sensory impairment. For example, among both men and women aged 65 and over, the prevalence of cognitive impairment ranged from 7.0% among those with no sensory impairment to 50.5% among those with dual sensory impairment. The prevalence of cognitive impairment among those with dual sensory impairment ranged from a low of 42.5% among men aged 65–74 to a high of 58.1% among women aged 85 and above.

There is an additive relationship between the prevalence of cognitive impairment for those with hearing impairment alone, and vision impairment alone, such that the sum of those two prevalence equals the prevalence of cognitive impairment among those with dual sensory impairment. For example, for both genders aged 65 and over, the prevalence of cognitive impairment for those with hearing impairment alone (20.0%) plus the prevalence of cognitive impairment for those with vision impairment alone (28.1%) equals 48.1%, which is remarkably close to the observed prevalence of cognitive impairment among those with dual sensory loss (i.e., 50.5%). This additive relationship occurs for each sex group and both age cohorts under age 85.

Table 3 provides the odds of cognitive impairment by sensory loss among those aged 65 and older. For both sexes aged 65 and older, in comparison to those with no sensory loss, there was a dose-response in the odds of cognitive impairment among those with hearing impairment only (OR = 2.66; 95% CI = 2.64, 2.68) and vision impairment only (OR = 3.63; 95% CI = 3.59, 3.67) having markedly lower odds than those with dual sensory impairment (OR = 8.16; 95% CI = 8.07, 8.25). Similar findings were evident for both men (hearing impairment only: OR = 2.77; 95% CI = 2.74, 2.80; vision impairment only: OR = 3.89; 95% CI = 3.81, 3.96; dual sensory impairment: OR = 9.02; 95% CI = 8.88, 9.17) and women (hearing impairment only: OR = 2.58; 95% CI = 2.55, 2.61; vision impairment only: OR = 3.50; 95% CI = 3.45, 3.55; dual sensory impairment: OR = 7.55; 95% CI = 7.44, 7.66). Table 3 also examines both sexes combined by 10-year age cohorts. The magnitude of the odds of cognitive impairment by sensory impairment was greatest for the youngest cohort (age 65–74) and lowest for the oldest cohort (age 85+). Among those aged 65–74, in comparison to those with no sensory impairment, there was a dose-response relationships for those with hearing impairment only (OR = 3.45; 95% CI = 3.40, 3.50), vision impairment only (OR = 5.16; 95% CI = 5.06, 5.25), and dual sensory impairment (OR = 14.24; 95% CI = 13.94, 14.53). In the sample of men and women aged 75–84, the odds of cognitive impairment for those with hearing impairment only (OR = 2.53; 95% CI = 2.50, 2.57), vision impairment only (OR = 3.46; 95% CI = 3.39, 3.52), and dual sensory impairment (OR = 8.52; 95% CI = 8.36, 8.67) showed a similar trend, although with lower magnitude than among those aged 65 to 74. When the sample was restricted to those age 85 and older, the odds of cognitive impairment showed a similar dose-response, although the odds were lower than in the two younger age cohorts. In comparison to respondents aged 85 and older with no sensory impairment, the odds of cognitive impairment were higher for those with hearing impairment only (OR = 1.95; 95% CI = 1.92, 1.98), vision impairment only (OR = 2.06; 95% CI = 2.02, 2.11), and dual sensory impairment (OR = 4.57; 95% CI = 4.49; 4.65).

DISCUSSION

The results of this nationally representative study of 5.4 million American older adults support an independent association between cognitive impairment and hearing impairment and vision impairment alone, as well as dual sensory impairment. One in six older adults with cognitive impairments (16.0%) had dual sensory loss compared to only one in 53 (1.9%) of their peers without cognitive impairment. When compared to older adults aged 65 and older without any sensory impairment, older adults with hearing impairment only or vision impairment only had 2.66 and 3.63 higher odds of cognitive impairment, respectively. Among older adults with dual sensory impairment, the odds of cogni-

Table 2
Prevalence of cognitive impairment by hearing impairment, vision impairment, and dual sensory impairment for three age groups and both sexes

Sensory Impairment	Age 65–74			Age 75–84			Age 85 and above			Total (age 65 and above)		
	Total ($n = 3,004,467$)	Men ($n = 1,404,814$)	Women ($n = 1,599,653$)	Total ($n = 1,681,964$)	Men ($n = 723,892$)	Women ($n = 958,072$)	Total ($n = 718,704$)	Men ($n = 242,303$)	Women ($n = 476,401$)	Total ($n = 5,405,135$)	Men ($n = 2,371,009$)	Women ($n = 3,034,126$)
No impairment ($n = 4,360,981$)	4.1%	4.0%	4.1%	8.5%	7.2%	9.3%	20.5%	15.7%	22.7%	7.0%	5.7%	7.8%
Hearing impairment only ($n = 666,275$)	13.0%	12.2%	14.6%	18.3%	16.1%	21.3%	31.8%	26.9%	35.1%	20.0%	16.5%	24.6%
Vision impairment only ($n = 198,998$)	23.6%	22.4%	24.4%	28.1%	26.1%	29.1%	36.3%	31.7%	37.9%	28.1%	25.2%	29.6%
Both hearing and vision impairment ($n = 178,881$)	45.1%	42.5%	48.6%	48.1%	44.1%	51.7%	55.8%	50.9%	58.1%	50.5%	45.7%	54.3%
p-value for differences in cognitive impairment by sensory impairment	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

Source: American Community Survey (2008–2017) ($n = 5,405,135$).

Table 3
Odds Ratio of Cognitive Impairment by Sensory Impairment (no sensory impairment, hearing only, seeing only, both hearing and seeing problems) for sex specific analyses of those aged 65 and older and for both sexes by age cohort (65–74, 75–84, 85+) ($n = 5,405,135$)

Variable Name	Total 65+ ($n = 5,405,135$)	Male 65+ ($n = 2371009$)	Female 65+ ($n = 3034126$)	Both Sexes 65–74 ($n = 3004467$)	Both Sexes 75–84 ($n = 1681964$)	Both Sexes 85+ ($n = 718704$)
NEITHER hearing nor seeing problems (ref)	1.00 (Ref)	1.00 (Ref)	1.00 (Ref)	1.00 (Ref)	1.00 (Ref)	1.00 (Ref)
only HEARING not seeing problems	2.66 (2.64, 2.68)	2.77 (2.74, 2.81)	2.58 (2.55, 2.61)	3.45 (3.40, 3.50)	2.53 (2.50, 2.57)	1.95 (1.92, 1.98)
only SEEING problems not hearing	3.63 (3.59, 3.67)	3.89 (3.81, 3.96)	3.50 (3.45, 3.55)	5.16 (5.06, 5.25)	3.46 (3.39, 3.52)	2.06 (2.02, 2.11)
BOTH hearing and seeing problems	8.16 (8.07, 8.25)	9.02 (8.88, 9.17)	7.55 (7.44, 7.66)	14.24 (13.94, 14.53)	8.52 (8.36, 8.67)	4.57 (4.49, 4.65)

Source: American Community Survey pooled data from the 2008–2017 waves. All data are adjusted for age, education, income, and race.

tive impairment increased eight-fold. For older men specifically, those with hearing impairment only or vision impairment only had 2.77 and 3.89 higher odds of cognitive impairment, respectively. Among older women, those with hearing impairment only or vision impairment only had 2.58 and 3.50 higher odds of cognitive impairment, respectively. The odds of cognitive impairment increased nine-fold among men and more than seven-fold among women among those with dual sensory impairment. These findings indicate a robust independent association between hearing impairment and vision impairment with cognitive impairment, with the highest odds of cognitive impairment occurring among older adults with dual sensory impairment.

In examining the relationship between hearing impairment only and cognitive impairment, the results of the current study indicate an independent association between hearing loss and cognitive impairment. The bivariate analyses suggested women with hearing impairment were more likely to report cognitive impairment (24.6%) than were men with hearing impairment (16.5%). However, logistic regression analyses, which took into account age, race, income, and education, indicated the adjusted odds of cognitive impairment among those with hearing impairment is comparable across sexes, with men having 2.77 higher odds of cognitive impairment, and women having 2.58 higher odds of cognitive impairment. There are mixed results on sex variation in hearing loss and dementia, with some studies showing women are more likely to experience cognitive impairment in the context of hearing loss [8], and others finding that sex is not a significant predictor of cognitive impairment in older adults with hearing impairment [24].

Older participants were more likely to report both hearing impairment and cognitive impairment. While 13.0% of older adults aged 65–74 with hearing impairment also reported cognitive impairment, this number increased to 31.8% among respondents aged 85 and older. These findings are consistent with the literature demonstrating an association between age-related hearing impairment and dementia [12]. Interestingly, logistic regression analyses indicate that the odds of cognitive impairment among those with hearing impairment were higher among younger older adults relative to the oldest older adults; respondents aged 65–74 with hearing impairment had 3.45 greater odds of cognitive impairment, while respondents aged 85+ had 1.95 greater odds of cognitive impairment. It may be that older adults aged 85+ are already more likely to experience cognitive impairment regardless of sensory impairment, and therefore the association is not as strong as among those aged under 75 when both hearing loss and memory problems are less common.

In looking at the relationship between vision impairment only and cognitive impairment, the current study supports an independent association between vision problems and cognitive impairment. Older adults with vision impairment had approximately four times higher odds of cognitive impairment when compared to older adults without any sensory impairment. These results are consistent with the emerging literature demonstrating an association between vision impairment and dementia [25, 26]. The relationship between vision impairment and cognitive impairment followed a similar pattern to hearing impairment and cognitive impairment, in which despite the higher prevalence of both conditions among the oldest older adults, the odds of cognitive impairment among those with vision impairment was highest in the youngest age group. While older adults aged 65–74 with vision impairment had five times the odds of cognitive impairment, the odds of cognitive impairment declined to approximately double among older adults aged 85 and older. These findings indicate that although vision impairment may be associated with higher odds of cognitive impairment for all older adults, there is a graded association suggesting adults aged 65–74 with vision loss have substantially higher odds of cognitive impairment compared to older respondents.

The current study indicates that dual sensory impairment had the strongest association with cognitive impairment, significantly greater than the association between hearing or vision impairment alone. In fact, the relationship appears to be additive, with those with dual sensory impairment having a prevalence of cognitive impairment comparable to the sum of the prevalence of cognitive impairment among those with hearing impairment alone and vision impairment alone. Half of older adults aged 65 + with both hearing and vision impairment also had cognitive impairment. Older adults with dual sensory impairment had 8 times higher odds of cognitive impairment when compared to older adults without sensory impairment. These findings align with research indicating that dual sensory impairment heightens the risk of developing dementia compared to a single sensory impairment [20, 27]. Although the oldest participants were the most likely to experience dual sensory impairment, the odds of cognitive impairment among those with dual sensory impairment in comparison to those with no sensory impairment were highest in the youngest age group. The odds of cognitive impairment were 14-fold among older adults aged 65–74. Among older adults aged 65–74 and 85+, the odds of cognitive impairment were approximately 8-fold and four-fold, respectively. Although it is evident from age 65 until 85+, the association between dual sensory impairment and cognitive impairment is strongest among older adults aged 65–74, which underlines the importance of targeted outreach to this population. If further research indicates the association is causal, there is an urgent need to introduce strategies to address sensory impairment in this population, such as affordable hearing aids and easily available operations for cataracts. In addition to improving functioning and quality of life, these strategies may potentially reduce preventable cases of cognitive impairment.

Unfortunately, this observational study does not provide sufficient information to determine the reasons behind the observed link between sensory loss and cognitive problems. There are several potential causal mechanisms that may underlie the association between sensory impairment and dementia that warrant future research. For example, cognitive deterioration within the brain may be the result of decreased auditory and visual input due to hearing and/or vision loss, as per the sensory deprivation hypothesis [28, 29]. According to the resource allocation hypothesis, hearing or vision impaired older adults may use more cognitive resources to accommodate for sensory deficits, allocating fewer cognitive resources for higher order memory processes [29]. Other possible explanations focus on external factors, such as hearing impairment leading to social disengagement among older adults, hastening cognitive decline due to isolation and lack of stimulation [30]. It is also possible that the direction of the relationship is opposite, as per the cognitive load on perception hypothesis, which proposes that a decline in cognition may result in declines in sensory performance due to decreased resources for sensory processing [29, 31].

It is also possible that the association between sensory loss and dementia is non-causal, in line with the common cause hypothesis which theorizes that sensory impairment and cognitive impairment may be due to shared age-related degeneration of the central nervous system [29]. Frailty may be the common cause underlying pathway by contributing to inflammatory, metabolic, nutritional, hormonal, vascular, and nutritional pathways [32]. Additionally, lifetime exposure to harmful environmental factors, such as lead, may contribute to shared pathology development [33, 34].

The findings of the present study may inform interventions that can support older people with concurrent sensory impairment and cognitive impairment. Special attention, in particular, should be given to those aged 65–74 who have serious hearing and/or vision impairment. If the relationship with dementia is found to be causal, such interventions may potentially mitigate the development of cognitive impairment. Sensory impairments and dementia are typically assessed and treated separately, but interventions concurrently targeting both conditions may be more beneficial [35]. Given the rapidly aging population and concomitant rising number of older adults with dementia and hearing impairment, practitioners should identify and treat dementia and age-related sensory impairment during their early stages [29, 36]. Early diagnosis and treatment can prolong an optimal quality of life for patients [8]. Practitioners can also provide patients with psychoeducation on the potential link between sensory loss and dementia, which may lead them to seek treatment earlier [25].

It is essential that practitioners and researchers consider the full impact of sensory impairment on cognitive testing methods, as both auditory and visual testing methods may fail to take hearing and vision impairment into account [37]. When performing cognitive tests on older adults with sensory impairments, practitioners should ensure they are communicating audibly and/or using visual speech cues for hearing impaired individuals, eliminating items from cognitive tests that rely on vision for those who are visually impaired, and using physical cues for individuals with hearing or dual sensory impairment, as this can help increase the accuracy of testing and prevent confounding [13, 25].

There is also a need for further longitudinal research with large sample sizes to conclusively determine whether the relationship between hearing, vision, and dual impairment and dementia is causal [26, 38]. Future research is also needed to examine how standard treatments for hearing and vision impairment, such as hearing aids, may influence cognition. Some research indicates a positive relationship between hearing loss treatment and cognitive functioning; however, much of this literature is limited to case studies and other nonexperimental evidence, limiting the generalizability of the available evidence [39]. Although there is some higher quality evidence to support the relationship between hearing aid utilization and improved cognitive function, the focus of this research has been on short-term changes in cognitive function ranging from 4 weeks to 18 months [40–44], emphasizing the need for longitudinal research with follow-up over many years. The available longitudinal research has shown mixed results. A 25-year longitudinal study found that older adults with normal hearing and older adults using hearing aids showed a similar rate of cognitive decline, while hearing impaired older adults who did not use hearing aids experienced a significantly greater decline in cognitive status over time [45]. In contrast, a 6-year longitudinal study concluded the use of hearing aids had no effect on cognition [26]. Further research should explore the effectiveness of hearing loss and vision loss interventions in delaying or reducing the onset of dementia, and as well as in altering the progressive course of dementia among those experiencing concurrent sensory impairment [13, 46].

Limitations

The findings of this study should be considered in light of some limitations. First, this study uses self-reported data to measure hearing impairment, which is considered less accurate than audiometric measures such as pure tone audiometry. However, self-report data is easier to gather and far less expensive [45], facilitating data collection from this study's large sample size of more than 5.4 million older adults. Many studies of community-dwelling older adults have made use of self-reported medical conditions, and self-reported hearing has been found to be correlated to pure tone audiometry scores [17]. It is important to note that among those with serious cognitive problems, the questions would have been answered by a proxy respondent such as family member or nurse in long-term care. Second, cognitive impairment was based on the question, "Because of a physical, mental, or emotional condition, do you have serious difficulty concentrating, remembering, or making decisions?" This may not be equivalent to a standardized tool to measure cognitive impairment. However, this question may be less likely to be vulnerable to being biased by auditory or visual impairments than standardized tools requiring responses to a series of cognitive tasks. Third, the current analysis was missing information on important factors that may influence the relationship between sensory impairments and cognitive impairment, such as the presence of other chronic health conditions and general health status, health behaviors such as smoking or alcohol consumption, obesity, or relevant genetic information (e.g., *APOE4* status). It is possible that individuals without hearing or vision impairment were in better health overall than their peers with sensory impairment and were therefore at lower risk for cognitive impairment. Fourth, the current study did not have information on whether respondents with hearing impairment had hearing aids. Given that hearing impairment is a potentially modifiable condition, it is possible that individuals with hearing aids may be less socially affected by their hearing impairment and could also be less likely to have cognitive impairment. Finally, due to the cross-sectional nature of the analysis, there is no way to know the length of time that respondents have had hearing, vision, or cognitive impairment. It is possible that the relationship between sensory impairment and cognitive impairment may be influenced by the duration of the hearing and/or vision impairment.

Conclusion

Despite these limitations, the current study uses an extremely large nationally representative sample of more than five million older American adults to demonstrate a robust association of hearing impairment, vision impairment, and dual sensory impairment with cognitive impairment. After controlling for age, race, education, and income, we found that older adults with hearing impairment had more than double the odds of cognitive impairment, while older adults with vision impairment had more than triple the odds of cognitive impairment. For older adults with dual sensory impairment, the odds of cognitive impairment were eight-fold. These findings emphasize the importance of considering the concurrent experience of sensory impairment and cognitive impairment and of tailoring interventions accordingly. As discussed above, there is a need for future longitudinal research to determine if this relationship is causal, and to further examine possible mechanisms that may underlie the relationship between sensory impairment and cognitive impairment, including the sensory deprivation hypothesis, the resource allocation hypothesis, the cognitive load on perception hypothesis, and the common cause hypothesis. There is also a need for intervention studies to investigate the effectiveness of sensory impairment treatments for reducing cognitive impairment. Intervention research and policy should also consider the accessibility of available treatments, such as the affordability of hearing aids and cataract surgery, and how this may influence the relationship between sensory impairment and cognitive impairment. A deeper understanding of the mechanisms that underlie the relationship between sensory impairment and cognitive impairment, as well as the interventions that can support these concurrent issues, may help support the health and well-being of an aging population.

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CONFLICT OF INTEREST

The authors have no conflict of interest to report.

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