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Association of Vision and Hearing Impairment on Cognitive Function and Loneliness: Evidence from the Mexican Health and Aging Study

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Abstract

Objectives: We investigated whether self-reported vision and hearing were associated with cognitive function and loneliness among Mexican adults aged 50 and older.

Methods: Mexican Health and Aging Study data. Vision/hearing status were self-reported (excellent-very good, good, fair-poor). Cognition was measured using nine tasks. Loneliness was measured using the UCLA Loneliness Scale. Analyses controlled for demographic and health characteristics.

Results: Among 12,353 participants (mean age = 67, 58% female), poor vision, but not hearing, was associated with lower global cognition ($\beta = -0.03$, $p < .05$). Poor vision (OR=1.57, 95% CI=1.30–1.91) and hearing (OR=1.35, 95% CI=1.14–1.61) were associated with higher odds of being lonely after adjusting for demographics and comorbidities, but not when adjusting for limitations in daily activities and depressive symptoms.

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Discussion: Poor vision is a potentially modifiable risk factor for lower cognition and loneliness among Mexican adults. These associations are partly due to functional characteristics of older adults with poor vision.

Introduction

Sensory impairments, such as hearing and vision impairment, are common problems that older adults experience in the United States (Crews & Campbell, 2004; Whitson et al., 2018), and there is mounting evidence that they significantly impact the health outcomes of older adults. Alone, visual impairment (visual acuity at near and distance) has been associated with lower cognitive function and incidence of dementia (Cao et al., 2023; Chen et al., 2017; Nagarajan et al., 2022; Shang et al., 2021; Zheng et al., 2018), and loneliness among older adults (Brunes et al., 2019; Davidson & Guthrie, 2019). Hearing loss, individually, has been associated with lower cognitive function (Loughrey et al., 2018; Powell et al., 2021; Wei et al., 2017; West et al., 2022), and older adults with hearing impairment have a significantly increased risk of experiencing loneliness (Cohen-Mansfield et al., 2016; Huang et al., 2021; Shukla et al., 2020; Sung et al., 2016).

Combined, older adults with *both* vision and hearing loss report the greatest number of disparities when compared to those with only vision or only hearing loss (Crews & Campbell, 2004; Davidson & Guthrie, 2019; Mick et al., 2018). Specifically, dual sensory impairment are more likely to have cognitive impairment and be associated with loneliness (Davidson & Guthrie, 2019; Mick et al., 2018) and have even worse cognition when experiencing both dual sensory impairment when compared to those with just one type of sensory impairment (Huang et al., 2020). Others have shown that the risk of loneliness is compounded in those with dual sensory impairment, compared to either impairment alone (Wang et al., 2022).

Much of the current evidence describing the link between sensory impairment and cognitive function or loneliness is based on data from non-Hispanic populations and/or small cohorts of Hispanics in the United States. For example, a study examining differences in trajectories of loneliness by ethnicity showed that loneliness both starts and remains higher over time among Hispanic versus non-Hispanic White adults in the United States, and that Hispanic adults also have an increased risk of sensory impairment (Davidson & Guthrie, 2019). Another study found that U.S.-based Hispanic adults had lower levels of cognitive performance than non-Hispanic White adults across multiple age groups (Díaz-Venegas et al., 2016). While it is informative to understand the experience of Hispanic populations living in the U.S., a more comprehensive understanding of sensory impairment, cognitive function, and loneliness may be gathered by examining this topic in other contexts.

Mexico offers a unique opportunity to examine the impact of aging on health outcomes for multiple reasons. In 2022, adults 60 years and older in Latin America represented 13.4% of the population, with this number expected to increase to 16.5% by 2030 and 22% by 2050 (Parra-Rodríguez et al., 2020; Salazar-Xirinachs et al., 2022). The population in Latin America is aging at a rate that is much faster than high-income nations, resulting in many Latin American countries struggling to meet the healthcare needs of their aging population (Salazar-Xirinachs et al., 2022). Evidence from the Mexican Health and Aging Study indicates that the prevalence of cognitive dysfunction among adults aged 60 and older increased from 6.1% in 2001 to 7.3% in 2015 (Mejia-Arango et al., 2021). Also using this dataset, a cross-sectional study describing older Mexican individuals' mental and physical capacity, found that 88% of individuals had dysfunction in at least one of six domains (cognition, depression, hearing, vision, vitality, and mobility; World Health Organization, 2019), suggesting a need for additional research examining the links between conditions such as sensory impairment, cognition, and loneliness (Gutiérrez-Robledo et al., 2021).

The current study examined whether self-reported vision and hearing were associated with cognitive function and loneliness in a nationally representative study of Mexican adults aged 50 and older. We hypothesized that worse self-rated vision and hearing would be significantly associated with a) lower cognition and b) greater loneliness.

Data and Methods

The Mexican Health and Aging Study (MHAS) is an ongoing, nationally representative, longitudinal study of adults aged 50 years and older and their spouses regardless of age, who are living in Mexico (Wong et al., 2017). Detailed descriptions of the sampling techniques and data collection methods have previously been reported (Wong et al., 2017). In this study, we used data from Wave 4 (year 2015). A total of 14,206 people aged 50 and older were interviewed at Wave 4. We excluded 915 participants who received a proxy interview. We also excluded individuals if they had missing data for our outcome variables and covariates, resulting in a final analytic sample of 12,353 participants. Full details of the inclusion/exclusion criteria for the analytic sample are provided in Figure 1. Participants who were excluded from the analysis were older, completed fewer years of education, and were more likely to live in a rural community.

The IRB at the University of Texas Medical Branch determined this project was exempt because these data are de-identified, publicly available online at the study website in English (www.MHASweb.org) and in Spanish (www.ENASEM.org).

Vision status

Participants were asked to rate their overall eyesight with glasses, if they wear them. The response options were excellent, very good, good, fair, poor, and legally blind. We, like others, combined the "excellent and very good" categories and the "fair and poor" categories to minimize the number of comparisons (Hreha et al., 2021; Rogers & Langa, 2010). We excluded participants who reported being legally blind because of the small sample size (n=44).

Hearing status

Participants were asked to rate their overall hearing/auditory range (while using a hearing aid or device, if applicable) on a six-point scale (excellent, very good, good, fair, poor, and legally deaf). We categorized responses as "excellent-very good," "good," and "fair-poor" to minimize the number of comparisons. The legally deaf category was dropped from the analysis because only one person fell into this category.

Loneliness

Participants were assessed using the Revised UCLA Loneliness Scale (UCLA-LS), which has three items (Russell et al., 1980) and has been used in large data survey studies (Hughes et al., 2004). On a 3-point scale ("almost never"=1, "sometimes"=2, "frequently"=3), participants were asked to rate 1) how often do you feel like you lack companionship?; 2) how often do you feel left out?; and 3) how often do you feel isolated, distant from others? We classified participants who responded "often" to one or more question as experiencing loneliness.

Cognitive function:

The 2015 MHAS Cognitive Battery includes the following nine cognitive tasks: (1) immediate recall of an eight-word list; (2) delayed recall of an eight-word list; (3) stating the current day, month, and year; (4) naming animals for 60 seconds; (5) copying a figure; (6) drawing the figure from memory; (7) circling a target figure (60 total) in a visual array of other figures (visual scanning); (8) counting backward from 20 to 10 by 1 (numeracy); and (9) counting backward from 100 by 7 for a total of five subtractions (serial 7s). We used the MHAS datafiles that include imputed values for participants with missing values or non-response on one or more cognitive tests (Downer et al., 2021). Additionally, prior to attempting the cognitive tasks, participants are asked if they usually wear glasses to see things close-up or if they have difficulty seeing things close-up without using glasses. Participants who do not have glasses and report having difficulty seeing objects close-up are given magnifying lenses to use while completing the cognitive tasks or the item was marked not completed due to vision impairment.

Our primary cognitive outcome was a measure of global cognition. We standardized each cognitive task using the sample mean and standard deviation. We then averaged the nine z-scores to obtain an overall score of global cognition. We also created scores for memory and non-memory tasks. We calculated the memory score by averaging the z-scores for immediate recall, delayed recall, and drawing a figure from memory. We calculated the non-memory score by averaging the z-scores for the animal naming, copying a figure, visual scanning, numeracy, and serial-7s. As a sensitivity analysis, we also created cognitive scores that excluded the cognitive items that most heavily relied on hearing (immediate and delayed word list recall) and vision (copying a figure, drawing a figure from memory, and visual scanning).

Covariates

Based on the literature and plausible associations with the outcome variables, we included several covariates, including age, sex (male/female), education (number of years of education), urban/rural location, and marital status (single, married, divorced). Health status included the number of self-reported health conditions (hypertension, diabetes, respiratory illness, heart attack, congestive heart failure, stroke, arthritis, and depression), number of depressive symptoms according to the nine-item Center of Epidemiological Studies – Depression scale, limitations in one or more activities of daily living (ADLs; bathing, eating, dressing, walking across the room, getting in/out of bed), and limitations in one or more instrumental ADLs (IADLs; using a telephone, taking medications, managing money, shopping, cooking).

Statistical Analysis

Descriptive characteristics of the study participants according to self-rated vision and hearing were presented as mean and standard deviations for continuous variables, and frequencies and proportions for categorical variables. We used multivariate linear regression models to test the association between vision, hearing, and cognitive function. We used multivariate logistic regression to test the association between vision, hearing, and loneliness. Model 1 presents unadjusted results, model 2 adjusted for demographic characteristics (age, sex, education, and location) and number of health conditions, and model 3 adjusted for depressive symptoms, ADL limitations, and IADL limitations. We included these three characteristics (functional limitations, depressive symptoms, and comorbidities) in a separate model because we considered them to be potential mediators in the relationship between sensory deficits, cognition, and loneliness. We also conducted analyses that included a statistical interaction term between fair-poor vision (yes / no) and fair-poor (yes / no) hearing to determine whether participants with dual sensory impairment had lower cognition and higher odds for loneliness than participants with fair-poor hearing or fair-poor vision, only. A $p < .05$ was considered significant for all statistical inferences. Data management and analyses were conducted using R version 3.1 (R Development Core Team, 2014).

Results

The sample distributions are shown by vision and by hearing status in Table 1 (n=12,353). Overall, the majority of the sample was female (58.00%), and the mean age was 67 years. Almost half of the sample (47.62%) reported fair/poor vision while 10.51% reported excellent/very good vision. Slightly more than half of participants (51.16%) reported fair/poor hearing compared to 13.80% reporting excellent/very good hearing. Participants with fair-poor vision or fair-poor hearing were older, had fewer years of formal education, were more likely to live in rural communities, and were in poorer health than participants with good or excellent-very good vision or hearing. Finally, 2,799 (22.7%) participants had fair-poor vision and fair-poor hearing (i.e., dual sensory impairment), 1,529 (12.4%) had fair-poor hearing only, and 3,083 (25.0%) had fair-poor vision only.

Table 2 presents the results from the regression models showing the association between the sensory impairments and the two study outcomes: cognition and loneliness. Participants with fair-poor vision had lower global (β= −0.03, p <.05) and memory cognition (β= −0.04, p <.05) than participants with excellent-very good vision, after adjusting for covariates (Model 3). In addition, participants with fair-poor hearing had worse non-memory cognition (β=−0.03, p <.05), adjusting for covariates (Model 3). While the unadjusted models (Model 1) examining hearing and global cognition and memory were statistically significant in the unadjusted models, the association did not remain statistically significant once demographic variables were included in the models. Fair-poor vision (OR=1.57, 95% CI=1.30–1.91) and fair-poor hearing (OR=1.35, 95% CI=1.14–1.61) were both associated with higher odds of being lonely net of demographic characteristics (Models 1 and 2); However, the association was not statistically significant once health characteristics were included (Model 3).

In general, the results of the sensitivity analyses that excluded cognitive items that were highly dependent on hearing and vision were consistent with the primary analysis (Supplementary Table 1). In the fully adjusted models, we did not detect a statistically significant interaction between fair-poor vision and fair-poor hearing on any of the cognitive outcomes or for loneliness.

Discussion

The current study uses nationally representative data on Hispanic adults aged 50 and older in Mexico to examine the association between vision and hearing impairments and cognition and loneliness. Results from the current study suggest that sensory impairments have a complex association with health outcomes among Mexican older adults. Three major findings were observed.

First, it is important to note that we found that fair- poor vision is associated with worse global cognition and memory scores compared to individuals who reported excellent-very good self-rated vision. This association is not present for the non-memory tasks. Therefore, it seems that poor vision could be particularly deleterious to memory encoding, which is consistent with the pattern of findings that non-memory cognitive tasks were not associated with self-reported vision loss. Also, the observed association is important, particularly in light of prior evidence reporting that Hispanics have more visual impairments and have a higher prevalence of cognitive impairment than those who are not Hispanic (Kuo et al., 2021). Studies in non-Hispanic cohorts have shown vision impairment to be potentially modifiable and a target for interventions aiming to reduce risk for dementia (Ishii et al., 2008; Tamura et al., 2004).

Second, fair- poor hearing is significantly associated with poor global cognition, memory and non-memory scores in Model 1, but this association was no longer statistically significant when functional status and depressive symptoms were added and considered potential mediators. This is consistent with findings from a retrospective, epidemiological study of community- dwelling older adults, which also found that depressive symptoms can mediate the association between hearing loss and cognitive decline (Amieva et al., 2015). Additionally, fair-poor hearing is significantly associated with better non-memory scores in Model 3 (β=0.03, SE (0.01)). The last finding is not consistent with much of the literature documenting a link between hearing loss and cognitive decline (Wei et al., 2017; Whitson et al., 2018). One potential explanation is that hearing aid use may be particularly beneficial for Hispanic older adults, as those who wear hearing aids have been shown to experience a small improvement in cognitive functioning from ages 65–75 (West et al., 2022) and maintaining health (Garcia Morales et al., 2023). However it has been reported that Hispanics in the United States have a difficult time accessing hearing aids (Arnold et al., 2019). Another explanation is that prior research examining the impact of hearing loss on cognition has only controlled for race and/or ethnicity rather than considering how the association might vary between groups (Brenowitz et al., 2019; Curhan et al., 2019), resulting in limited evidence regarding the true nature of the link between hearing loss and cognition among individuals of Hispanic ethnicity. There is minimal information in MHAS about participants' hearing aid use; therefore, additional research is needed to better understand the association between hearing loss and cognition in this population.

Third, both sensory impairments (analyses run separately) were associated with increased loneliness in Mexican adults, after controlling demographic covariates, but the relationship was attenuated with further adjustment for health status covariates. Consistent with past research, this finding suggests that vision and hearing loss both place adults at increased risk of loneliness (Shah et al., 2020; Shukla et al., 2020). However, there is also evidence that Hispanic individuals reap health benefits due to their family-centered culture, which serves as a buffer against stress and loneliness (Corona et al., 2017; Davidson & Guthrie, 2019; Markides & Rote, 2019). The co-occurrence of other medical issues with sensory impairment may tend to activate these tight social support networks, thereby mitigating the likelihood of loneliness. Future research is needed to untangle the connection between sensory impairments and loneliness among Mexican older adults over time.

An analysis of dual sensory impairments was completed since others have reported on the impact they have together on cognition and loneliness (Crews & Campbell, 2004; Davidson & Guthrie, 2019; Kuo et al., 2021; Mick et al., 2018; Wang et al., 2022), and interestingly we did not find a statistically significant interaction, which is inconsistent with the literature. One potential reason for this result is that the sample's mean age was 67 years, which is younger on average than most research reporting on individuals with dual sensory impairment (e.g., participants in two studies were 80 or more years old;Mick et al., 2021; Swenor et al., 2013). We found that 22.7% of this cohort had dual sensory impairment, which was similar to what a few other studies reported (Crews & Campbell, 2004; Davidson & Guthrie, 2019).

Loneliness rates have sharply increased in the last decades and are now considered to be an epidemic that results in higher rates of cardiovascular mortality and dementia (US Surgeon General, 2023). Sensory impairments, particularly vision and hearing loss, have received increasing attention as potentially modifiable risk factors for cognitive decline and loneliness that could contribute to the development of effective interventions (Davidson & Guthrie, 2019; Deal & Rojas, 2022; Lin et al., 2023; Livingston et al., 2017). Although this has prompted much research activity, empirical evidence has mostly focused on the non-Hispanic White population, despite known disparities experienced by Hispanic individuals. Also, our findings are novel as we used data from a nationally representative longitudinal study of aging in Mexico and therefore should not be generalized to other Hispanic populations.

Limitations

This study had several limitations. First, the measures of sensory impairment were self-reported. While self-report is subjective, we recognize that there are advantages to collecting these data such as capturing the full range of the daily impact of sensory impairments. An example of this is that the gold standard for clinically assessing hearing sensitivity is pure-tone audiometry (West et al., 2020); however, researchers have noted that this measure may not fully capture the lived experience of hearing disability. Therefore self-report may be an important complement to objective measures (Demeester et al., 2012; Gatehouse & Noble, 2004; Kramer et al., 1996). For visual impairment, self-report was also used. Older adults could have multiple types of visual impairments such as a loss of a part of their field of vision or have a scotoma; therefore, this dataset is limited and may not capture the full range of potential visual impairments an older adult could have. A second limitation is the methodology used for this work. We recognize the nature of a cross-sectional analysis precludes our ability to draw causal interpretations of the findings. However, our research question was to learn more about the relationship between multiple independent variables on our outcome to determine if any associations exist and therefore a cross-sectional method was necessary, not longitudinal. Third, many of the cognitive measures used for this study rely directly on one's ability to hear or see. We did complete a sensitivity analysis after creating modified scores, which excluded the tasks that relied most heavily on hearing and vision. However it may be best to instead use measures that do not rely on these senses, such as the Montreal Cognitive Assessment-H (for acquired hearing impairment) and Montreal Cognitive Assessment- V (for vision impairment) in order to have all cognitive domains represented (Al-Yawer et al., 2019; Dawes et al., 2019).

Future research should investigate the longitudinal association between vision, hearing, cognition, and loneliness, using the MHAS dataset to determine causal interpretations. Also, it would potentially be useful to add cognitive assessments adapted and validated for hearing and vision impaired individuals (Dawes et al., 2019) in order to potentially eliminate bias in cognitive testing (Nichols et al., 2022). Another future research project could be to learn about the role of sensory deficits in cognitive testing in a Mexican older adult population (Abraham et al., 2023) and determine how sensory associations with loneliness may mediate performance on cognitive tests.

Conclusion

Sensory impairments, and particularly poor vision, may be a potentially modifiable risk factor for lower cognition and loneliness among older Mexican adults. Also, the associations are partly due to functional characteristics of older adults with poor vision. The results from the sensitivity analysis were similar but the coefficients were slightly smaller. The reduced coefficients could reflect the limitations of using traditional cognitive items for older adults with vision and hearing impairment, because performance can be confounded by vision and hearing status. Nonetheless, this study is foundational and has important findings that help to fill a gap in the literature on associations among sensory loss, cognition, and loneliness for older Mexican adults.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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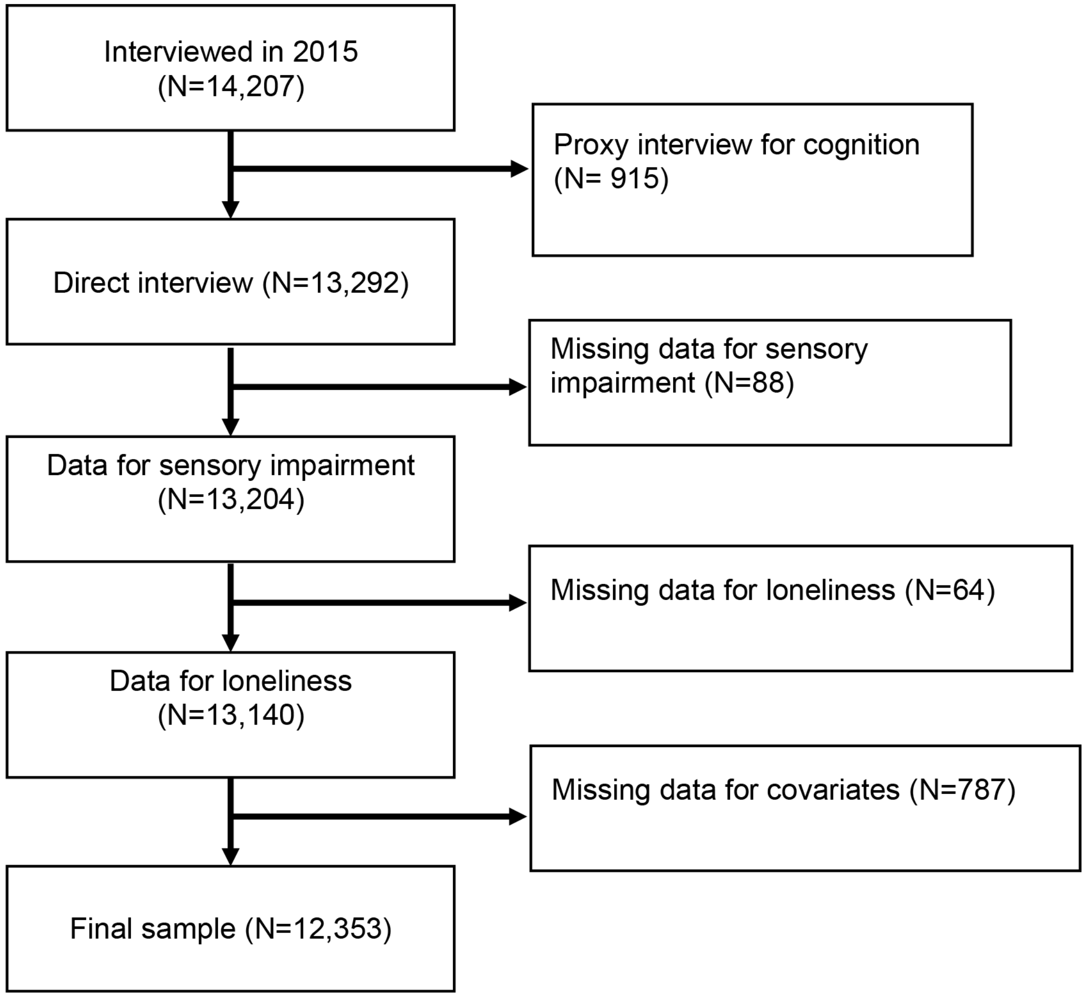

Figure 1:
Sample selection

Table 1:

Demographic and health characteristics of the final sample according to self-rated vision and hearing status.

Characteristics	Total Sample (N=12,353)	Self-rated Vision: Excellent – very good (n=1,298)	Self-rated Vision: Good (n=5,173)	Self-rated Vision: Fair – poor (n=5, 882)		Self-rated Hearing: Excellent – very good (n=1,705)	Self-rated Hearing: Good (n=6,320)	Self-rated Hearing: Fair – poor (n=4,328)
Age, mean (SD)	66.7 (9.4)	65.2 (8.82)	66.3 (9.11)	67.4 (9.71)		64.3 (8.68)	65.8 (8.96)	69.0 (9.83)
Sex, n (%)								
Men	5,189 (42.0)	544 (41.9)	2,098 (40.6)	2,547 (43.3)		686 (40.2)	2,029 (46.9)	2,474 (39.1)
Women	7,164 (58.0)	754 (58.1)	3,075 (59.4)	3,335 (56.7)		1019 (59.8)	2,299 (53.1)	3,846 (60.9)
Education, mean (SD)	5.70 (4.68)	7.62 (5.26)	6.32 (4.96)	4.72 (4.01)		7.05 (5.10)	5.95 (4.81)	4.80 (4.10)
Marital status, n (%)								
Married	8,201 (66.4)	878 (67.6)	3,471 (67.1)	3,852 (65.5)		1,141 (66.9)	4,253 (67.3)	2,807 (64.9)
Not married	1,785 (14.4)	219 (16.9)	754 (14.6)	812 (13.8)		290 (17.0)	939 (14.9)	556 (12.8)
Widowed	2,367 (19.2)	201 (15.5)	948 (18.3)	1,218 (20.7)		274 (16.1)	1,128 (17.8)	965 (22.3)
Community size, n (%)								
100,000+	7,063 (57.2)	936 (72.1)	3,124 (60.4)	3,003 (51.1)		1,109 (65.0)	3,592 (56.8)	2,362 (54.6)
99,000 – 15,000	1,660 (13.4)	148 (11.4)	671 (13.0)	841 (14.3)		212 (12.4)	836 (13.2)	612 (14.1)
14,999 – 2,500	1,188 (9.6)	64 (4.9)	459 (8.9)	665 (11.3)		144 (8.4)	615 (9.7)	429 (9.9)
< 2,500	2,442 (19.8)	150 (11.6)	919 (17.8)	1,373 (23.3)		240 (14.1)	1,277 (20.2)	925 (21.4)
ADL limitations, n (%)								
0	10,517 (85.1)	1,172 (90.3)	4,576 (88.5)	4,769 (81.1)		1,528 (89.6)	5,551 (87.8)	3,438 (79.4)
1	1,008 (8.2)	70 (5.4)	347 (6.7)	591 (10.0)		97 (5.7)	453 (7.2)	458 (10.6)
2+	828 (6.7)	56 (4.3)	250 (4.8)	522 (8.9)		80 (4.7)	316 (5.0)	432 (10.0)
IADL limitations, n (%)								
0	10,841 (87.8)	1,194 (92.0)	4,707 (91.0)	4,940 (84.0)		1,566 (91.8)	5,676 (89.8)	3,599 (83.2)
1	943 (7.6)	71 (5.5)	324 (6.3)	548 (9.3)		87 (5.1)	423 (6.7)	433 (10.0)
2+	569 (4.6)	33 (2.5)	142 (2.7)	394 (6.7)		52 (3.0)	221 (3.5)	296 (6.8)
Health conditions, n (%)								
0	4,277 (34.6)	484 (37.3)	1,934 (37.4)	1,859 (31.6)		688 (40.4)	2,364 (37.4)	1,225 (28.3)

Characteristics	Total Sample (N=12,353)	Self-rated Vision Excellent – very good (n=1,298)	Self-rated Vision Good (n=5,173)	Self-rated Vision Fair – poor (n=5, 882)		Self-rated Hearing Excellent – very good (n=1,705)	Self-rated Hearing Good (n=6,320)	Self-rated Hearing Fair – poor (n=4,328)
1–2	6,940 (56.2)	711 (54.8)	2,862 (55.3)	3,367 (57.2)		886 (52.0)	3,510 (55.5)	2,544 (58.8)
3+	1,136 (9.2)	103 (7.9)	377 (7.3)	656 (11.2)		131 (7.7)	446 (7.1)	559 (12.9)
Depressive symptoms, mean (SD)	3.34 (2.64)	2.58 (2.42)	2.90 (2.47)	3.89 (2.71)		2.65 (2.49)	3.09 (2.55)	3.98 (2.69)
Global cognition, mean (SD)	−0.02 (0.65)	0.19 (0.61)	0.05 (0.65)	−0.12 (0.64)		0.14 (0.62)	0.01 (0.64)	−0.13 (0.65)
Memory, mean (SD)	−0.02 (0.79)	0.20 (0.74)	0.05 (0.79)	−0.12 (0.79)		0.15 (0.76)	0.03 (0.77)	−0.16 (0.81)
Non-memory, mean (SD)	−0.02 (0.67)	0.19 (0.63)	0.05 (0.67)	−0.13 (0.66)		0.14 (0.64)	0.002 (0.67)	−0.11 (0.66)
Any loneliness, n (%)								
No	10,512 (85.1)	1,160 (89.3)	4,572 (88.4)	4,780 (81.3)		1,493 (87.6)	5,497 (87.0)	3,522 (81.4)
Yes	1,841 (14.9)	138 (10.6)	601 (11.6)	1,102 (18.7)		212 (12.4)	823 (13.0)	806 (18.6)

Note: SD (standard deviation); ADLs (activities of daily living); IADLs (instrumental activities of daily living)

Table 2:

Self-rated vision and hearing in association with global cognition, memory, non-memory, and loneliness

	Model 1	**Model 2**	**Model 3**
	Global Cognition (b, SE)		
Self-rated vision			
Excellent – very good			
Good	−0.14 (0.02) **	−0.02 (0.01)	−0.02 (0.01)
Fair – poor	−0.31 (0.02) **	−0.06 (0.01) **	−0.03 (0.01) *
Self-rated hearing			
Excellent – very good			
Good	−0.13 0.02) **	−0.01 (0.01)	−0.01 (0.01)
Fair – poor	−0.27 (0.02) **	0.0002 (0.01)	0.02 (0.01)
	Memory (b, SE)		
Self-rated vision			
Excellent – very good			
Good	−0.15 (0.02) **	−0.05 (0.02)	−0.04 (0.02)
Fair – poor	−0.32 (0.02) **	−0.07 (0.02) **	−0.04 (0.02) *
Self-rated hearing			
Excellent – very good			
Good	−0.12 (0.02) **	−0.002 (0.02)	0.002 (0.02)
Fair – poor	−0.31 (0.02) **	−0.02 (0.02)	0.002 (0.02)
	Non-Memory (b, SE)		
Self-rated vision			
Excellent – very good			
Good	−0.14 (0.02) **	−0.02 (0.02)	−0.01 (0.02)
Fair – poor	−0.31 (0.02) **	−0.05 (0.02) **	−0.03 (0.02)
Self-rated hearing			
Excellent – very good			
Good	−0.13 (0.02) **	−0.02 (0.01)	−0.01 (0.01)
Fair – poor	−0.25 (0.02) **	0.01 (0.01)	0.03 (0.01) *
	Loneliness (OR, 95% CI)		
Self-rated vision			
Excellent – very good			
Good	1.10 (0.91–1.35)	0.99 (0.82–1.22)	0.91 (0.74–1.13)
Fair – poor	1.94 (1.61–2.35) **	1.54 (1.27–1.88) **	1.04 (0.85–1.29)
Self-rated hearing			
Excellent – very good			
Good	1.05 (0.90–1.24)	0.96 (0.81–1.13)	0.84 (0.70–1.01)

	Model 1	Model 2	Model 3
Fair – poor	1.61 (1.37–1.90) **	1.30 (1.10–1.54) **	0.87 (0.73–1.05)

Note:

* $p < 0.05$;

** $p < 0.001$

b (estimated beta coefficient); SE (Standard error); OR (odds ratio); CI (confidence interval)

Model 1: unadjusted model

Model 2: adjusted for demographic characteristics and number of health comorbidities.

Model 3: adjusted for demographic, number of health comorbidities, ADL limitations, IADL limitations, and depressive symptoms.