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Types of sensory disability are differentially associated with mental health in older US adults over time

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Abstract

Background: Sensory disability in older adults is associated with increased rates of depressive symptoms and loneliness. Here, we examined the impact of hearing, vision, and olfaction disability on mental health outcomes in older US adults.

Methods: We studied respondents from the first three rounds (2005/6, 2010/11, and 2015/16) of the National Social Life, Health and Aging Project, a nationally representative, longitudinal study of older US adults. Sensory function was assessed by structured interviewer ratings (hearing and vision) and objective assessment (olfaction). Cox proportional hazards models and one degree of freedom tests for trend were utilized to analyze the relationships between sensory disability and self-rated mental health, frequent depressive symptoms, frequent perceived stress, frequent anxiety symptoms, and frequent loneliness symptoms over time, adjusting for demographics, health behaviors, comorbidities, and cognitive function.

Results: We analyzed data from 3940 respondents over 10 years of follow-up. A greater number of sensory disabilities was associated with greater hazard of low self-rated mental health, frequent depressive symptoms, frequent perceived stress, and frequent loneliness symptoms over time ($p \leq 0.003$, all). After adjusting for covariates, older adults with a greater number of sensory disabilities had greater hazard of low self-rated mental health (HR = 1.22, CI = [1.08, 1.38], $p = 0.002$) and loneliness symptoms (HR = 1.13, CI = [1.05, 1.22], $p = 0.003$) over time in our tests for trend. In our Cox proportional hazards model, older adults with vision disability had greater hazard of low self-rated mental health (HR = 1.34, 95% CI = [1.05, 1.72], $p = 0.02$) and loneliness symptoms (HR = 1.21, CI = [1.04, 1.41], $p = 0.01$).

Conclusions: Older US adults with greater numbers of sensory disabilities face worse subsequent mental health. Future longitudinal studies dissecting the relationship of all five classical senses will be helpful in further understanding how improving sensory function might improve mental health in older adults.

KEYWORDS
disability, hearing, mental health, olfaction, vision

INTRODUCTION

The World Health Organization estimates that the world's population over age 60 will nearly double by 2050.[1] Therefore, one critical burden that will be increasingly challenging for clinicians is the care of large numbers of older adults with impaired sensory function. In the United States, approximately 94% of older adults experience impairment in at least one of the five classic senses and 67% experience this in two or more senses.[2] These sensory disabilities can often be regarded as "invisible" disabilities, potentially subjecting these older adults to further stigma and ableism.[3–6] This will be even more significant because sensory disability in older adults has been associated with increased rates of depressive symptoms and loneliness.[7,8] Estimates suggest that nearly 20% of people over the age of 55 will experience some sort of mental health concern.[9] Currently, we have an incomplete understanding of how sensory function affects mental health in older adults more broadly. However, impaired sensory function has been linked with morbidity and mortality, indicating its importance for older adults.[10]

Recently, there have been increased efforts to study the relationship between mental health in older adults and "sensory disability," a term for impaired sensory function that some prefer to the potentially stigmatizing term "sensory impairment."[11] Much of this work focuses on a limited range of sensory disabilities and/or mental health outcomes.[12–15] However, caring for a population with an increasing number of older adults with multiple sensory systems in decline requires that we develop a more nuanced understanding of the complex relationship between sensory function and mental health. Early data from England have examined this relationship[16]; a comparable study has not been conducted in the United States.

Here, we seek to address this gap in research by examining the association of three types of sensory disability (hearing, vision, and olfaction) with a broad spectrum of subsequent mental health outcomes in a nationally representative sample of older US adults.

Key points

- Older US adults with greater numbers of sensory disabilities face worse subsequent mental health.
- The types of sensory disability had specific associations with different aspects of mental health, providing generalizable results from a nationally representative sample.

Why does this paper matter?

Increased awareness of how sensory disabilities affect long-term mental health in older adults may help physicians and other healthcare professionals provide targeted assessment of specific mental health conditions based on sensory disabilities and provide personalized care.

METHODS

Sample

The National Social Life, Health and Aging Project (NSHAP) is a longitudinal, nationally representative study of older US adults living at home.[17–20] Baseline data collection occurred in 2005–2006 and included adults aged 57–85 years of age.[17,18] In 2010–2011, data collection included all original respondents who were alive (with proxy interviews of those too sick to interview), as well as their spouses or co-resident partners.[19] In 2015–2016, the project included returning respondents from prior rounds.[20] Thus, in these analyses, each respondent could provide up to 10 years of follow-up.

NSHAP was approved by the institutional review boards of NORC and the University of Chicago and written, informed consent was provided by all respondents. Deidentified NSHAP data are publicly available.[18–20]

Sensory function

Sensory function was assessed during each round of data collection. Professional, trained interviewers rated respondents' hearing and vision on a scale from 1 (defined as "practically deaf" and "practically blind") to 5 ("normal hearing" and "normal vision").[18–20] Respondents were permitted to use the assistive devices they typically use, such as glasses and hearing aids, as the goal was to determine "functional" ability in daily life. These subjective ratings serve as a useful stand-in when objective measures of vision and hearing are unavailable.[21] Previous work has found respondent hearing and vision to be

associated with interviewer-rated scores in the expected direction, even after controlling for other covariates.[22,23] Respondents with interviewer-rated scores of 3 or lower were characterized as having "sensory disability" for that sense. This dichotomizing strategy was used to capture the tail of the skewed distribution, as previous work has suggested this strategy may capture respondents with "functional vulnerabilities."[22]

Objective assessment of olfaction was conducted by trained interviewers using a validated odor identification test involving five scented felt tip pens.[9,24] Respondents who correctly identified three or fewer scents were characterized as having "olfactory disability."

We also tabulated respondents' number of co-occurring sensory disabilities (hearing, vision, and olfaction).

Mental health outcomes

Our primary outcomes were self-rated mental health, depressive symptoms, perceived stress, anxiety, and loneliness using validated instruments. Self-rated mental health is a useful single-item measure of mental health as it correlates with a variety of mental health measures.[25] Interviewees were asked to rate their own emotional or mental health as being poor, fair, good, very good, or excellent.[18–20] To create our Cox proportional hazards models, we dichotomized self-rated mental health due to the skewed distribution of self-rated mental health in our sample. We chose to characterize any respondents rating their self-rated mental health as "poor" or "fair" as having "low self-rated mental health." Similar to our dichotomization of hearing and vision ratings, this strategy allowed us to capture the tail of our skewed distribution, highlighting individuals particularly at risk.[22]

The remaining mental health measures were dichotomized as has been described by Payne et al.[26] previously, which yielded prevalence estimates comparable to other epidemiological studies of mental health, and is briefly summarized here. Depressive symptoms were measured using a short form of the Center for the Epidemiologic Studies Depression Scale (CES-D). Scores range from 0 to 22, with higher scores reflecting more frequently occurring depressive symptoms. Individuals with scores ≥9 were characterized as having "frequent depressive symptoms."[26]

Perceived stress was measured using a shortened four-question version of the Perceived Stress Scale.[27] Scores can range from 0 to 8, with higher scores representing more frequent symptoms of perceived stress. Interviewees who scored ≥1 were characterized as experiencing "frequent perceived stress."[26]

Anxiety symptoms were measured using the Hospital Anxiety and Depression Scale's Anxiety Subscale. Scores range from 0 to 21, with higher scores reflecting more frequently occurring anxiety symptoms. Individuals with scores ≥8 were characterized as having "frequent anxiety symptoms."[26]

Feelings of loneliness were measured using a three-question version of the well-established Revised UCLA Loneliness Scale. Scores can range from 0 to 6, with higher scores correlating to more frequent symptoms of loneliness. Interviewees who scored ≥1 were characterized as having frequent feelings of loneliness.[26] Throughout this paper, we will refer to frequent feelings of loneliness as simply "loneliness symptoms."

Covariates

We included age, sex, race and ethnicity, education, marital status, heavy alcohol use, smoking status, comorbidities, and cognitive function in our analyses because they have been previously associated with sensory disability or mental health.[9,16,28–31]

Race and ethnicity were defined as White, Black, Hispanic non-Black, and other, according to standard National Institute of Health (NIH) categories. Highest level of education was included as a measure of socioeconomic status and divided into four categories: no high school diploma, high school diploma or equivalent, some college completed, bachelor's degree, and beyond. Marital status was characterized as married/living with a partner or not. The Charlson comorbidity index (CCI) was modified for survey use (range 0–16) to describe overall physical health, with higher scores representing more comorbid conditions.[32,33] Heavy alcohol use was defined as four or more drinks on any day for men or three or more for women as recommended by the National Institute on Alcohol Abuse and Alcoholism.[34] Smoking status was characterized as current or not based on the response at the time of interview and only included smoking via cigarettes, cigars, or a pipe. The distribution of these variables is presented in Table 1.

At baseline, the Short Portable Mental Status Questionnaire (SPMSQ) was used to assess cognitive function.[35] At 5- and 10-year follow-up, NSHAP enhanced the cognitive assessment by implementing an adaptation of the Montreal Cognitive Assessment (MoCA) validated for use in a survey setting.[35] On both scales, higher scores indicate better overall cognitive function. To make comparisons between rounds, cognitive function scores were standardized using *z*-scores.

Statistical analysis

Differences in demographic, covariate, and mental health characteristics based on number of sensory disabilities at

TABLE 1 Weighted demographics and health characteristics for respondents in analytic sample by number of sensory disabilities at study entry.

	Number of sensory disabilities				
	0	**1**	**2**	**3**	
	2131 respondents	**1109 respondents**	**541 respondents**	**159 respondents**	***p*-value***
Age (mean ± SD)	73.7 ± 6.4	75.9 ± 7.5	78.6 ± 8.0	80.4 ± 8.9	**<0.001**
Sex—*n* (%)					**<0.001**
Male	917 (43.2)	574 (52.7)	299 (57.5)	95 (62.3)	
Female	1214 (56.8)	535 (47.3)	242 (42.5)	64 (37.7)	
Race and Ethnicity—*n* (%)					0.06
White	1573 (83.1)	759 (78.9)	376 (79.5)	97 (74.1)	
Black	288 (8.1)	192 (10.4)	96 (11.2)	43 (16.8)	
Hispanic, non-Black	209 (6.3)	129 (7.9)	57 (6.5)	15 (7.1)	
Other	53 (2.4)	25 (2.8)	11 (2.8)	3 (2.1)	
Education—*n* (%)					**<0.001**
<High school	355 (13.8)	256 (19.1)	196 (31.0)	59 (31.5)	
High school/equivalent	535 (25.8)	313 (27.9)	130 (26.1)	51 (34.8)	
Some college	700 (33.8)	295 (27.6)	138 (25.7)	27 (17.2)	
Bachelor's or more	541 (26.6)	245 (25.4)	77 (17.1)	22 (16.5)	
Married/living with partner—*n* (%)	1381 (67.2)	641 (61.5)	291 (57.0)	82 (53.3)	**<0.001**
Current smoker—*n* (%)	243 (11.6)	137 (12.5)	66 (13.5)	20 (11.3)	0.68
Heavy alcohol use—*n* (%)	185 (9.0)	66 (6.9)	41 (8.2)	11 (7.3)	0.49
Charlson comorbidity index (CCI) (mean ± SD)	1.26 ± 1.41	1.58 ± 1.60	1.88 ± 1.79	1.72 ± 1.80	**<0.001**
Cognitive function (*z*-score) (mean ± SD)	0.28 ± 0.74	−0.03 ± 1.00	−0.29 ± 1.14	−0.94 ± 1.42	**<0.001**
Type of sensory disability—*n* (%)					
Hearing	0 (0)	335 (30.2)	452 (85.2)	159 (100.0)	**<0.001**
Vision	0 (0)	223 (21.2)	387 (72.6)	159 (100.0)	**<0.001**
Olfaction	0 (0)	606 (56.2)	279 (53.1)	159 (100.0)	**<0.001**
Self-rated mental health (mean ± SD)	3.86 ± 0.90	3.69 ± 1.01	3.45 ± 1.13	3.34 ± 1.11	**<0.001**
Self-rated mental health rated as "poor" or "fair"—*n* (%)	173 (7.2)	133 (11.1)	97 (17.0)	31 (18.8)	**<0.001**
Depressive symptoms score (mean ± SD)	4.45 ± 3.75	4.69 ± 4.06	5.84 ± 4.82	6.29 ± 4.76	**<0.001**
Frequent depressive symptoms—*n* (%) (depressive symptoms score > =9)	357 (16.3)	212 (18.4)	137 (26.8)	46 (29.6)	**<0.001**
Perceived Stress Scale (mean ± SD)	1.75 ± 1.78	1.86 ± 1.81	2.01 ± 2.00	2.49 ± 2.47	**<0.001**
Frequent perceived stress—*n* (%) (Perceived Stress Scale > = 1)	1114 (60.5)	556 (66.9)	271 (69.1)	81 (73.5)	**0.003**
Anxiety symptoms score (mean ± SD)	4.36 ± 3.42	4.49 ± 3.63	4.60 ± 4.36	5.15 ± 4.40	0.41
Frequent anxiety symptoms—*n* (%; anxiety symptoms score > =8)	322 (18.4)	166 (20.0)	86 (22.7)	24 (26.4)	0.14
Loneliness Scale (mean ± SD)	0.97 ± 1.33	1.03 ± 1.44	1.33 ± 1.66	1.67 ± 1.86	**<0.001**
Frequently felt lonely—*n* (%) (Loneliness Scale > = 1)	820 (43.8)	397 (45.1)	208 (53.8)	69 (65.8)	**<0.001**

Note: Bolded values represent statistically significant associations ($p \leq 0.05$).
*Chi-square test or ANOVA.

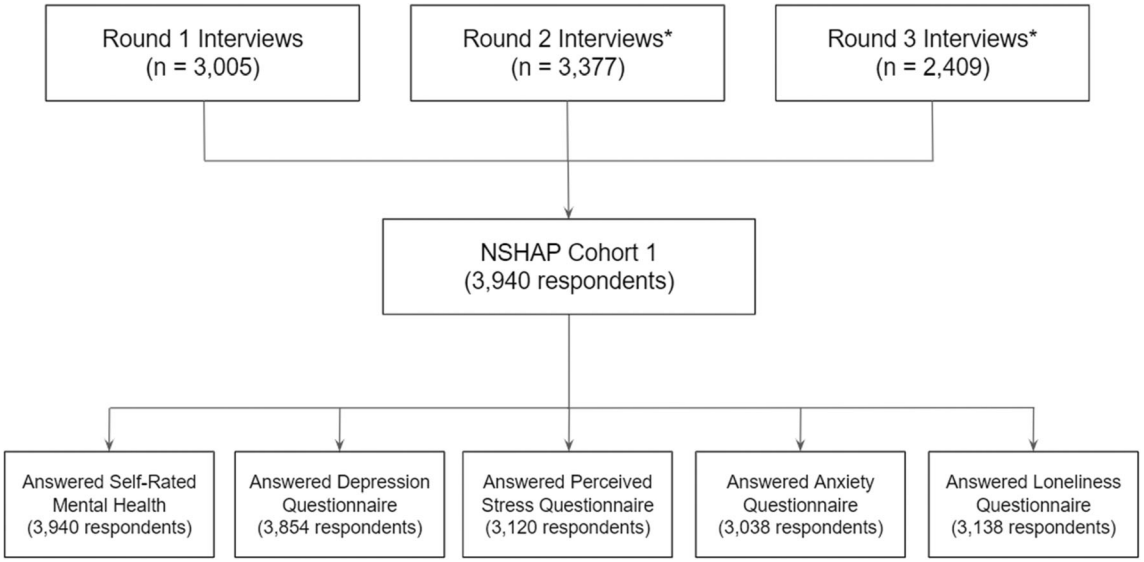

FIGURE 1 STROBE diagram for analytic sample. *Interviews in round 2 included all surviving round 1 respondents, as well as spouses or co-resident partners. Interviews conducted in rounds 2 and 3 included surviving respondents from previous rounds.

study entry were examined using Pearson's chi-square tests and one-way analyses of variance. A series of Cox proportional hazard models with time-varying covariates were used to examine the associations between (a) the number of sensory disabilities and each of the mental health outcomes and (b) each type of sensory disability and each of the mental health outcomes in separate models. For the former (a) series, one degree of freedom tests for trend was used to test if a greater number of sensory disabilities was associated with greater risk of poor mental health outcomes. Respondents were removed from the survival analysis after the first timepoint at which they experienced the mental health outcome of interest. All models adjusted for demographic factors, health behaviors, comorbidities, and cognitive function, which were allowed to vary with time. For missing covariate and sensory function data, respondents' last observed result was carried forward to the next timepoint. As an additional sensitivity analysis, we ran all previously described models without carrying last observation of covariates forward.

Results are reported as hazard ratios and 95% confidence intervals (CIs). Statistical significance was set at $p \leq 0.05$. Statistical analysis utilized weights to account for differences in nonresponse and in probability of selection to make the NSHAP study cohort nationally representative. Analyses were conducted using Stata Version 18 (StataCorp LLC, College Station, Texas, USA).

RESULTS

During the first three rounds of NSHAP data collection (2005/6, 2010/11, and 2015/6), there were 3940 unique respondents (Figure 1). Table 1 summarizes the weighted demographic and health characteristics for the analytic sample at study entry. The US adults with a greater number of sensory disabilities tended to be older ($p \leq 0.001$), have higher comorbidity scores (mean CCI; $p \leq 0.001$), and worse cognitive function (z-score; $p \leq 0.001$; Table 1).

Mental health and number of sensory disabilities

In unadjusted analyses, there were significant differences among older US adults in self-rated mental health ($p \leq 0.001$), frequent depressive symptoms ($p \leq 0.001$), frequent perceived stress ($p = 0.003$), and loneliness symptoms ($p \leq 0.001$) based on their number of sensory disabilities. There was no significant difference in anxiety scores nor frequent anxiety symptoms ($p = 0.14$; Table 1). In our test for trend, older adults with a greater number of sensory disabilities had greater hazard of low self-rated mental health ($p = 0.002$) and loneliness symptoms ($p = 0.003$). A greater number of sensory disabilities was not significantly associated with an increased hazard of experiencing frequent depressive symptoms ($p = 0.12$), frequent perceived stress ($p = 0.89$), or frequent anxiety symptoms ($p = 0.98$) in adjusted analyses.

In our adjusted Cox proportional hazard models, older adults with two sensory disabilities had significantly greater hazard of low self-rated mental health (HR = 1.60, 95% CI = [1.14, 2.26], $p = 0.008$) and greater hazard of loneliness symptoms (HR = 1.30, 95% CI = [1.08, 1.56], $p = 0.006$) over time than those with no sensory disability. Those with three sensory disabilities had significantly

TABLE 2 Effect of the number of sensory disabilities on mental health measures when controlling for all covariates.[a]

	Self-rated mental health		Frequent depressive symptoms		Frequent perceived stress		Frequent anxiety symptoms		Frequently felt lonely	
	3013 respondents		2855 respondents		2253 respondents		2959 respondents		2396 respondents	
	HR (95% CI)	*p*	HR (95% CI)	*p*	HR (95% CI)	*p*	HR (95% CI)	*p*	HR (95% CI)	*p*
No. of sensory disabilities (vs. 0)										
1	1.22 (0.94, 1.57)	0.13	1.00 (0.76, 1.30)	0.98	1.07 (0.96, 1.19)	0.22	0.85 (0.71, 1.11)	0.28	1.13 (0.98, 1.30)	0.10
2	**1.60 (1.14, 2.26)**	**0.008**	1.11 (0.80, 1.56)	0.52	1.07 (0.88, 1.30)	0.51	1.17 (0.88, 1.55)	0.28	**1.30 (1.08, 1.56)**	**0.006**
3	1.52 (0.83, 2.81)	0.17	**1.75 (1.21, 2.54)**	**0.004**	0.67 (0.45, 1.00)	0.051	0.64 (0.32, 1.30)	0.21	1.40 (0.97, 2.01)	0.07
One degree of freedom trend test		**0.002**		0.12		0.89		0.98		**0.003**
Sensitivity analysis										
No. of sensory disabilities (vs. 0)										
1	1.22 (0.94, 1.57)	0.13	0.99 (0.76, 1.30)	0.95	1.07 (0.96, 1.19)	0.20	0.89 (0.71, 1.11)	0.29	1.13 (0.97, 1.30)	0.11
2+	**1.60 (1.18, 2.13)**	**0.003**	1.22 (0.91, 1.63)	0.18	1.01 (0.83, 1.24)	0.89	1.10 (0.83, 1.45)	0.51	**1.31 (1.10, 1.56)**	**0.003**
One degree of freedom trend test		**0.003**		0.27		0.62		0.86		**0.003**

Note: Bolded values represent statistically significant associations ($p \leq 0.05$).

[a]Including age, sex, race and ethnicity, education, marital status, heavy alcohol use, smoking status, Charlson comorbidity index, and cognitive function (*z*-score).

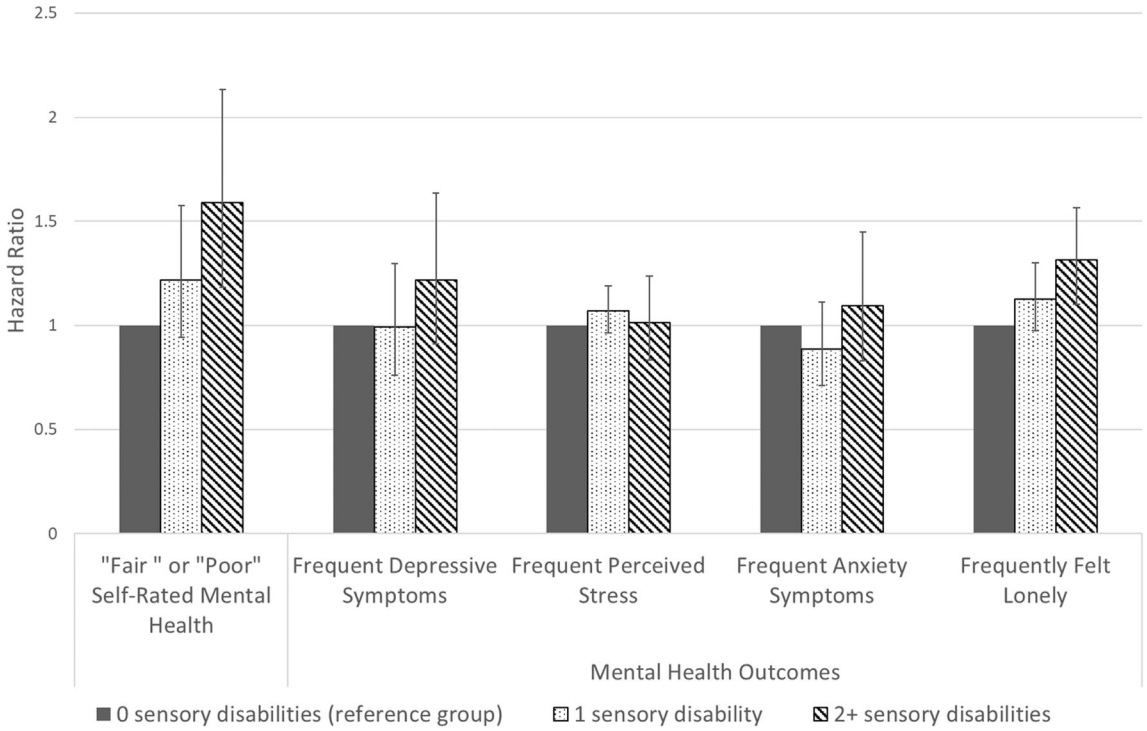

FIGURE 2 Hazard ratios of self-rated mental health, frequent depressive, perceived stress, anxiety, and loneliness symptoms by number of sensory disabilities. *Error bars represent 95% confidence intervals.

greater hazard of developing frequent depressive symptoms (HR = 1.75, 95% CI = [1.21, 2.54], $p = 0.004$) over time. Due to the low number of older adults with three sensory disabilities, we performed a sensitivity analysis to assess the impact of this group on results, in which we used only three categories for the number of sensory disabilities (0, 1, or 2+). The findings from our sensitivity analysis (Table 2 and Figure 2) were consistent with our other findings. Full model results are available in Supplementary Table S1. When using models without covariates carried forward from the last observation, results and conclusions did not change (results not shown).

Mental health by type of sensory disability

When looking at each type of sensory disability separately, older adults with vision disability had greater hazard of low self-rated mental health (HR = 1.34, 95% CI = [1.05, 1.72], $p = 0.02$) and loneliness symptoms (HR = 1.21, CI = [1.04, 1.41], $p = 0.01$; Table 3). There was no significant association between any hearing or olfactory disability and a specific mental health outcome, although hearing disability seemed to have the strongest association with self-rated mental health and loneliness symptoms (self-rated mental health: HR = 1.31, $p = 0.06$; loneliness: HR = 1.20, $p = 0.06$) and olfactory disability with self-rated mental health and frequent perceived stress (self-rated mental health: HR = 1.23, $p = 0.15$; frequent perceived stress: HR = 1.09, $p = 0.13$; Table 3). Full models are available in Supplementary Tables S2–S4.

DISCUSSION

Our study is the first to look at longitudinal relationships between concurrent sensory disabilities and a broad spectrum of mental health measures in a nationally representative sample of older US adults. Our findings are consistent with prior work showing that patients with sensory disabilities tend to have worse mental health (depression, perceived stress, anxiety, and loneliness).[13–16,36–40]

We also found that different types of sensory disability were associated with different aspects of mental health. These data suggest that awareness of these relationships may help physicians and other healthcare professionals to provide targeted assessment of specific mental health conditions for older adults based on their sensory disabilities. Primary care providers, otolaryngologists, and ophthalmologists who identify sensory loss in their patients may use their knowledge of specific sensory issues to screen for mental health conditions. Future work should investigate the utility of using assessment of sensory function in this way, perhaps as a complement to

TABLE 3 Effect of hearing, vision, and olfactory disability on mental health when controlling for all covariates.[a,b]

	Self-rated mental health		Frequent depressive symptoms		Frequent perceived stress		Frequent anxiety symptoms		Frequently felt lonely	
	3013 respondents		2855 respondents		2253 respondents		2959 respondents		2396 respondents	
	HR (95% CI)	*p*	HR (95% CI)	*p*	HR (95% CI)	*p*	HR (95% CI)	*p*	HR (95% CI)	*p*
Hearing	1.31 (0.98, 1.74)	0.06	1.22 (0.95, 1.56)	0.13	0.99 (0.88, 1.12)	0.90	1.02 (0.82, 1.28)	0.84	1.20 (0.99, 1.44)	0.06
Vision	**1.34 (1.05, 1.72)**	**0.02**	1.06 (0.83, 1.37)	0.63	0.97 (0.83, 1.14)	0.74	1.00 (0.76, 1.31)	1.00	**1.21 (1.04, 1.41)**	**0.01**
Olfaction	1.23 (0.93, 1.62)	0.15	1.04 (0.84, 1.28)	0.73	1.09 (0.97, 1.23)	0.13	0.96 (0.81, 1.15)	0.68	1.05 (0.88, 1.26)	0.58

Note: Bolded values represent statistically significant associations ($p \leq 0.05$).
[a]Covariates included in models were age, sex, race and ethnicity, education, marital status, heavy alcohol use, smoking status, Charlson comorbidity index, and cognitive function (z-score).
[b]Separate models used for each type of sensory disability.

existing mental health screening tools. Moreover, future work may also investigate the use of minimally invasive sensory interventions (such as glasses, hearing aids, or aromatherapy) as ways to modulate specific aspects of mental health in older adults.

Often society delineates between "visible" and "invisible" disabilities, with sensory disabilities often being considered "invisible." Chloe Orkin, a UK physician with an invisible disability describes this phenomenon: "I [was] met with s[k]epticism. People ... seemed to think that my weird constellation of invisible problems must be exaggerated, psychological or both."[6] This quote highlights the judgment that those with invisible disabilities can experience, both in healthcare settings and in broader society, further underscoring the need to dispel this stigma within the medical community.

With this context, we speculate that the association between lower self-rated mental health and vision disability could be due to the problem of ableism in our medical system. Previous work has shown that patients with hearing and vision disability experience greater difficulty finding accessible and accommodating mental health services.[41–43] Disabled patients are frequently subject to bias, discrimination, and stigma in medical settings.[3–5] This trend is especially problematic, as disabled patients interact more frequently with the healthcare system.[44] These recurrent negative experiences may be contributing to decreased overall mental health not directly related to a particular mental health outcome. We note that we observed a trend toward an association between hearing disability and self-rated mental health (HR $= 1.31$, $p = 0.06$). In short, we feel that these data are consistent with previous work highlighting ableism in the healthcare system. Thus, our hypothesis is that the association between hearing disability, vision disability, and self-rated mental health may reflect challenges in accessing mental health service due to ableism. More broadly, this suggests the need for increased destigmatization around the topic of disability so that we can improve accessibility and quality of care for disabled, older patients. Indeed, self-rated mental health may also be capturing health-related factors like health service utilization and satisfaction with mental health services and future work should seek to understand these relationships.[25]

There are several possible reasons why hearing disability was not significantly associated with any particular mental health outcome, despite previous work showing hearing disability to be associated with one specific condition, anxiety.[13] One explanation could be related to our use of interviewer-rated hearing. Another explanation could be the strength and robustness of Deaf culture. The Deaf community has a long and rich history, which includes the struggle for recognition and rights following the American Civil Rights Movement.[45] In modern times, Deaf culture

continues to flourish, with over 300 different sign language dialects around the world[46] and higher education institutions, like Gallaudet University.[47] Previous work has found that a positive sense of community improves mental health in both older adults and disabled college students.[48,49] If we consider Deaf community, culture, and identity from this perspective, we can understand how this sense of community may serve as a protective factor against worsening mental health over time. Future work should seek to better understand the how engagement with the disabled and/or Deaf communities can improve mental health in older adults. Moreover, more work is needed by healthcare providers to understand these vibrant communities to improve culturally sensitive care, which may be currently inadequate.[50]

Similarly, olfactory disability was not significantly associated with any particular mental health outcome in our study, despite previous work finding olfactory disability to be associated with symptoms related to anxiety, depression, and loneliness.[12,15,37] As noted above, this may be related to the more "invisible nature" of olfactory disability in our society. However, another explanation may be the role of an underlying factor linking all types of aging-related sensory disability, previously described as "global sensory impairment (GSI)." Using a structural equation model to adjust for age, sex, and race, Correia et al. found that olfactory disability was one of the strongest components of GSI, suggesting that olfactory disability may be mediated by GSI to a greater extent than other senses.[2] In our study, we could not adjust for GSI because taste and touch were only measured at baseline in NSHAP by design. Future work is needed to explore the relationship between all five classic senses, GSI, and mental health in older adults. Nevertheless, these findings further underscore the potential value of the minimally invasive sensory interventions previously mentioned, as both potential modulators for specific aspects of mental health but improving sensory function overall via GSI.

Interestingly, we found no significant association between specific mental health outcomes and sensory disabilities when including all three types of sensory disabilities into a single model (not shown in results, see Supplementary Table S5). We suspect this was because patients with multisensory disability of three or more senses may be related to significant comorbidities that affect mental health to a greater extent than their sensory function. It also remains possible that there is correlation between the different senses via GSI, as we have discussed. Additional work in this area is needed.

Decreased physical health has been linked with worse overall mental health.[51] This is mirrored in sensory function, as we found that patients with a greater number of sensory disabilities also tended to have greater comorbidity and worse cognitive function (Table 1). Moreover, comorbidity was significantly associated with self-rated mental health, frequent depressive symptoms, frequent perceived stress, and frequent anxiety symptoms in nearly every model (Supplementary Tables S1–S5). Future studies are needed to explore the causal relationships between sensory function, mental health, and physical health.

While our work is generally consistent with the literature on sensory function and mental health, there are specific areas where our findings differ from existing work. Most notably, we did not find any specific sensory disabilities to be associated with increased anxiety symptoms. Previous work found hearing and visual disabilities to be associated with depressive and anxiety symptoms in older adults.[52,53] The differences in our studies may be attributable to the difference in time scale of our analyses. We studied the effect of sensory disability on mental health across 5- and 10-year follow-up periods, while the referenced studies used 1- or 2-year follow-up. Thus, we extend prior findings to suggest that clinicians must be vigilant across a longer timeframe to connect sensory disabilities with specific mental health conditions in older adults. We also note that our study by design is nationally representative, providing wide generalizability.

We acknowledge that our results do not capture all of the nuances of sensory disabilities, due to the design and scale of NSHAP, an omnibus study. We lack any information regarding what stage of life the older adults included in our analytic sample developed these sensory disabilities nor if the patients were engaged with the Deaf or hard of hearing, blind and low vision, smell impaired, or broader disabled communities or cultures, which have faced challenges in society and the healthcare system historically.[3–5,54] Our long-term goal is to improve the health of the disabled community.

Our study had some limitations. We lacked objective measurements for hearing at all timepoints and vision during 5- and 10-year follow-up. To maximize the comparability of sensory function across our analytic sample, subjective interviewer ratings from each round were used. The use of subjective ratings may have limited our ability to characterize small changes in hearing and vision that may have been identified by objective measures. This limitation is further compounded by the inherent subjectiveness (and thus variation) between different interviewers. This, along with power, may have contributed to the lack of clear dose–response for those with three sensory disabilities. Future studies using objective measures of sensory function are needed. One final limitation was that frequent depressive symptoms, frequent perceived stress, frequent anxiety symptoms, and loneliness symptoms are measures of symptom burden and do not directly relate to

specific clinical diagnoses. However, NSHAP focused on the lived experience of respondents and targeted a community sample rather than a clinical population, providing broad generalizability.

CONCLUSION

Increased numbers of sensory disabilities are associated with worse overall mental health in older US adults, with some specificity in the relationships between specific sensory modalities and particular mental health symptoms. Increased awareness about the role that sensory disabilities may have on mental health in older adults may help physicians and other healthcare professionals to provide targeted assessment of specific mental health conditions for older adults based on their sensory disabilities and provide more personalized care to patients. Future longitudinal studies dissecting the relationship of all five classical senses will be helpful in further understanding how improving sensory function might improve mental health in older adults.

AUTHOR CONTRIBUTIONS

Alexander Z. Wang: design, conduct, analysis, and presentation. Kristen E. Wroblewski: conduct, analysis, and presentation. Louise Hawkley: analysis and presentation. Jayant M. Pinto: design, analysis, supervision, and presentation.

CONFLICT OF INTEREST STATEMENT

Jayant M. Pinto reports speaker bureau and advisory board participation for Sanofi/Regeneron and Optinose. The authors report no other conflict of interest or disclosures.

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None in the design, conduct, analysis, presentation, or supervision of this paper.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

Supplementary Table S1. Complete models for effect of number of sensory disabilities on mental health measures when controlling for all covariates.

Supplementary Table S2. Complete models for effect of hearing disability on mental health.

Supplementary Table S3. Complete models for effect of vision disability on mental health.

Supplementary Table S4. Complete models for effect of olfactory disability on mental health.

Supplementary Table S5. Complete models for effect of hearing + vision + olfactory disability on mental health.

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