



# Self-reported dual sensory impairment, dementia, and functional limitations in Medicare beneficiaries

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## Abstract

**Background:** Vision and hearing impairments often co-exist with dementia, and all are independently associated with limitations in daily activities. Our aim was to examine the association of dual sensory impairment with functional limitations, and further examine the combined estimated association of sensory impairment and dementia with these functional limitations.

**Methods:** Cross-sectional analysis of the National Health and Aging Trends Study (NHATS), a population-based cohort of Medicare beneficiaries, was performed. Participants were selected from the 2015 round. Survey weighted Poisson regression models adjusted for dementia, demographics, and health status variables examined the association of self-reported dual sensory impairment (no sensory impairment, single sensory impairment, dual sensory impairment) with scores of limitations in mobility, self-care, and household activities. Models were repeated to take into account the combined effects of dual sensory impairment and dementia.

**Results:** Overall, 7124 participants representative of Medicare beneficiaries 65 years or older were included. Of them, 43.9% were 75 years or older and 55.3% were female. Older adults with dual sensory impairment had greater limitations

with mobility (prevalence rate ratio [PRR] = 1.45, 95% CI = 1.28–1.63), self-care (PRR = 1.41, 95% CI = 1.25–1.59), and household activities (PRR = 1.54, 95% CI = 1.37–1.72) compared with those without sensory impairment. They also had greater limitations than those with a single sensory impairment across the different activity categories. In models taking into account the combined estimated effect of both sensory impairment and dementia, those with dual sensory impairment and dementia had greater limitations than those without sensory impairment or dementia in each category (mobility: PRR = 1.85, 95% CI = 1.59–2.14, self-care: PRR = 1.86, 95% CI = 1.59–2.18, household: PRR = 2.41, 95% CI = 2.09–2.77).

**Conclusions:** Older adults with dual sensory impairment had greater functional limitations compared with those without sensory impairment and those with a single sensory impairment. Strategies to improve visual and/or hearing function (e.g., sensory aids, rehabilitation) could potentially help prevent or minimize disability, even among those with dementia.

#### KEYWORDS

dementia, disability, mobility, self-care, sensory impairment

## INTRODUCTION

In the United States (U.S.), approximately 18 million adults over the age of 65 have difficulty or receive help with self-care, mobility, or household activities.<sup>1</sup> Most older persons with disability receive assistance from family or friends, and use of formal care increases with disability severity.<sup>2</sup> Activity limitations also are associated with a broad range of negative outcomes including reduced social engagement,<sup>3,4</sup> nursing home entry,<sup>5,6</sup> and higher risk of death.<sup>7</sup>

Sensory impairments, both hearing and vision, are independently associated with functional limitations.<sup>8–11</sup> In the U.S., of adults 65 years and older, 9% are estimated to have vision impairment or blindness,<sup>12</sup> while more than 50% are estimated to have hearing impairment.<sup>13</sup> Vision and hearing impairment prevalence increases with age, and concurrent vision and hearing impairment, or dual sensory impairment, is estimated to affect 11% of adults aged 80 years and older.<sup>14</sup> Those with dual sensory impairment may be particularly vulnerable to the negative outcomes of sensory impairment as they may be unable to use sensory substitution strategies that rely on vision or hearing. However, few studies have investigated the association of dual sensory impairment with functional limitations. The few studies that have been conducted used data limited to specific populations such as French women,<sup>15</sup> Dutch adults with frailty,<sup>16</sup> residents in Beaver Dam, Wisconsin,<sup>17</sup> and New York City residents 95 years and older,<sup>18</sup> or old national U.S. data dated from 1984.<sup>19</sup>

### Key Points

- Adults with dual sensory impairment have more functional limitations than those with one or no impairment.
- Those who also have dementia have even greater limitations in daily activities.

### Why Does this Paper Matter?

Strategies to improve sensory functioning could minimize disability among older adults.

Dual sensory impairment is also associated with cognitive impairment and dementia.<sup>20–24</sup> The Aging, Demographics, and Memory Study (ADAMS) estimates that 22% of adults 71 years or older in the U.S. have cognitive impairment not dementia (CIND),<sup>25</sup> and 14% have dementia from any cause (including Alzheimer disease, vascular dementia, and other causes of dementia).<sup>26</sup> Cognitive impairment and dementia are also independently associated with functional decline,<sup>27</sup> and people with both dual sensory and cognitive impairments could be even more likely to have functional limitations.

A study using a population-based cohort of community-dwelling adults in North Carolina found that the combinations of dual sensory or vision impairment alone and cognitive impairment were most strongly associated with difficulty performing ADLs and IADLs,<sup>28</sup> and another one conducted

in a long-term facility in Canada reported that those with both dual sensory and cognitive impairment were the most likely to report activity limitations.<sup>29</sup> Recent work has shown that older Americans with both vision impairment and dementia are at higher risk for limitations in mobility and daily activities than those with vision impairment or dementia alone.<sup>30</sup> To our knowledge, no studies have examined the interaction of dual sensory impairment and dementia in a national study of community-dwelling adults.

With the aging of the population, understanding older adults' risk of having functional limitations is important for health care planning to ensure optimal aging and appropriate accommodations in the community and health care settings for people with sensory impairment. The present study aims to examine the association of dual sensory impairment with functional limitations in a nationally representative sample of older Medicare beneficiaries in the U.S., and then the combined estimated effects of sensory impairment and dementia.

## METHODS

### Study population

The National Health and Aging Trends Study (NHATS) is an ongoing cohort study of a nationally representative

sample of Medicare beneficiaries over the age of 65 years that aims to study late-life functioning through annual in-person interviews. Approximately 96% of older adults in the U.S. are covered by the Medicare insurance program.<sup>31</sup> The NHATS sample was initially drawn from the Medicare enrolment file in 2011. In these analyses, we used cross-sectional data from the 2015 NHATS round, when the sample was replenished to make it representative of the Medicare population 65 years or older once again. In total, 8334 participants were included in the NHATS in 2015. Of the 8334 participants, 758 did not complete or were ineligible for the sample person interview in Round 5 (e.g., deceased with proxy interview only), leaving 7576 participants eligible for inclusion in this study. Of them, 452 were excluded due to missing data (102 missing outcome information, 116 missing sensory impairment or dementia information, and 234 missing covariate information). The final analytic sample was 7124 (7124 of 7576; 94.0%). In general, those who were included in the study were more likely to be younger, non-Hispanic white, with a college degree, and with higher income than those who were excluded due to missing information. The NHATS study protocol was approved by the Johns Hopkins' Bloomberg School of Public Health's Institutional Review Board. Signed informed consent was obtained from the study participants or their proxy respondents at the time of enrollment in the study.<sup>32</sup>

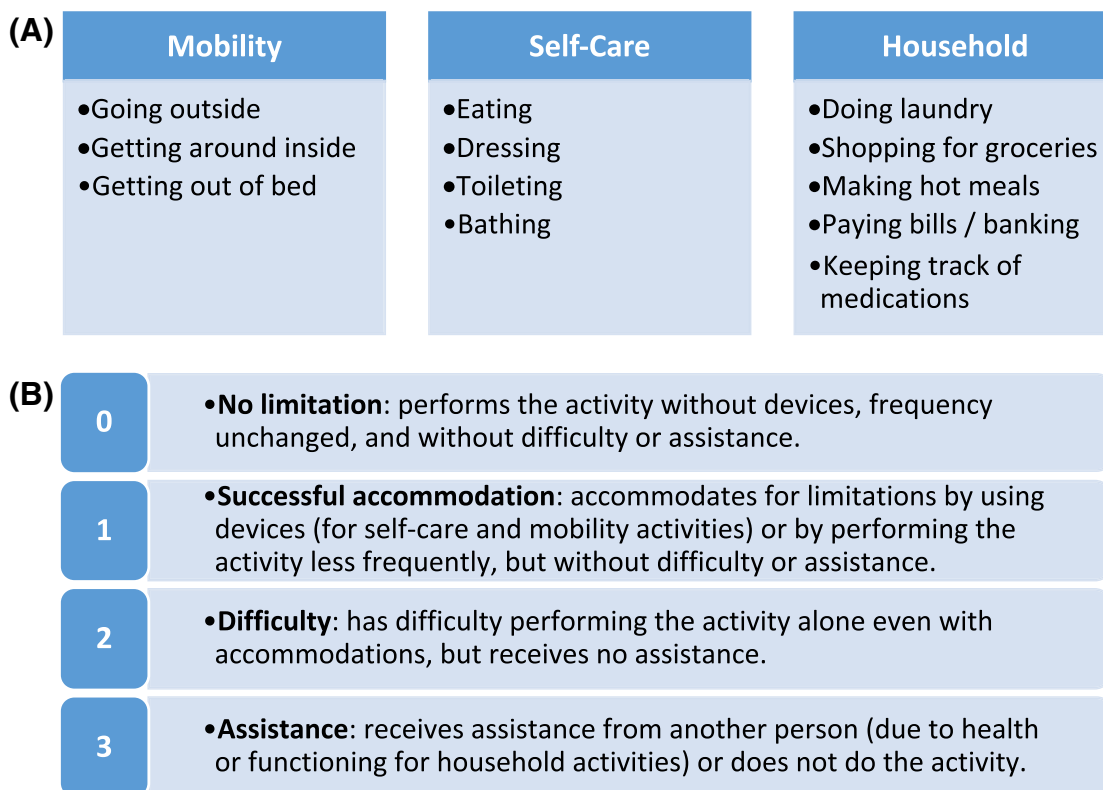


FIGURE 1 Functional limitation outcomes in the National Health and Aging Trends Study. (A) Mobility, self-care, and household activities. (B) Hierarchical scores of functional limitations

## Functional limitations

The NHATS late-life disability scale was used to assess functional limitations.<sup>33</sup> Limitations in 3 mobility activities (going outside, going around inside, getting out of bed), 4 self-care activities (eating, dressing, toileting, bathing), and 5 household activities (doing laundry, shopping for groceries, making hot meals, paying bills and banking, keeping track of medications) were the primary outcomes of this study (Figure 1A). For each mobility and self-care activity, participants were asked whether anyone helped with the activity and if not, whether they had difficulty doing it on their own. For household activities, participants were asked whether it was performed in the past month, how it was performed (by themselves, with someone else or whether someone else did the activity for them; if someone else helped was it for health or functioning reasons), if any equipment/devices were used, and whether they had difficulty performing it (using equipment/devices when applicable). For all activities except getting out of bed, using the toilet, and eating, participants were asked about changes in the prevalence of performing the activity by themselves since the past year.

Functional limitation scores for each category of activities (i.e., mobility, self-care, household) were computed based on a 4-category hierarchical scale previously described in this cohort (Figure 1B).<sup>34</sup> Each activity was assigned a score from 0 to 3, where 0 indicates no limitations performing the activity (no assistance, device use, or reduced prevalence), 1 indicates performing the activity with accommodation (device use or reduced prevalence, but no difficulty or assistance from others), 2 indicates difficulty performing the activity (with or without accommodation), and 3 indicates receiving assistance from someone to do the activity (for health or functioning reasons for household activities) or not doing it at all. Assessing functional limitation outcomes with the 4-category hierarchical scale used may better capture the continuum of disability than only including information about difficulty or ability to perform activities,<sup>34</sup> which were used by previous studies that examined the association between dual sensory impairment and functional limitations.<sup>15,16,18</sup> Summary measures for mobility, self-care, and household activities were computed by summing together the scores for individual activities within each category. Scores ranged from 0 to 9 for mobility activities, 0 to 12 for self-care activities, and 0 to 15 for household activities, where 0 indicates no limitations in any of the activities and higher scores indicating greater limitations in activities.

## Sensory impairment

The primary exposure was self-reported dual sensory impairment status. Self-reported sensory measures capture the day-to-day burden of sensory impairment by incorporating participants' perception and compensation mechanisms. They measure a valuable component of sensory impairment that impacts health independent of objective sensory impairment. Although different from clinically assessed sensory function, the two constructs are related. For example, compared with audiometric measures, self-reported hearing measures generally have high specificity but low sensitivity.<sup>35</sup> Most notably, older adults tend to underestimate their hearing impairment.<sup>36</sup> Self-reported vision measures are comparable to objectively assessed vision measures when they evaluate vision impairment and blindness together.<sup>37</sup>

Vision impairment was defined as self-reported blindness, or not being able to see across the street and/or newspaper print (despite using glasses or contacts if applicable). Hearing impairment was defined as any of the following: self-reported deafness, using a hearing aid or other hearing device, or not being able to hear well enough to use the telephone or to carry on a conversation in a room with a radio or TV playing (using a hearing device if applicable). Dual sensory impairment status was categorized as having no sensory impairment (reference), a single sensory impairment (i.e., vision or hearing impairment), or dual sensory impairment.

## Covariates

Variables that may confound the association between sensory impairment and functional limitations were included. Sociodemographic characteristics included age (in 5 year intervals), sex (male, female), race/ethnicity (non-Hispanic white, non-Hispanic Black, non-Hispanic other, Hispanic), educational attainment (less than high school degree, high school degree, some college, college degree or more), and family income quartiles using multiple imputation values provided by the NHATS (less than \$17,000, \$17,000–31,000, \$31,000–60,000, \$60,000 or more).

Functional and health status variables included dementia, depression, count of self-reported physician diagnosed chronic conditions (arthritis, cancer, diabetes, heart attack, heart disease, hypertension, lung disease, osteoporosis, and stroke), self-reported history of cataract surgery, body-mass index (BMI) computed based on self-reported height and weight, and use of a proxy respondent (reasons included dementia, a major illness, speech

**TABLE 1** Population characteristics by sensory impairment status, the National Health and Aging Trends Study 2015 (*N* = 7124)

	Overall	No sensory impairment	Single sensory impairment	Dual sensory impairment	<i>p</i> -value <sup>a</sup>
<i>N</i> (weighted %)	7124 (100.0)	4843 (71.8)	1988 (25.2)	293 (3.1)	NA
Age in years, <i>N</i> (weighted %)					<0.001
65–69	991 (29.4)	805 (33.2)	167 (20.0)	19 (18.5)	
70–74	1681 (26.7)	1321 (28.8)	333 (22.2)	27 (13.6)	
75–79	1518 (19.0)	1097 (18.8)	392 (20.3)	29 (10.2)	
80–84	1329 (12.6)	866 (11.3)	408 (16.0)	55 (16.4)	
85–89	960 (8.0)	515 (5.9)	377 (12.9)	68 (19.5)	
≥90	645 (4.3)	239 (2.1)	311 (8.6)	95 (21.7)	
Female, <i>N</i> (weighted %)	4113 (55.3)	2901 (57.6)	1027 (48.1)	185 (61.7)	<0.001
Race/ethnicity, <i>N</i> (weighted %)					<0.001
Non-Hispanic white	4992 (80.7)	3292 (80.5)	1510 (82.9)	190 (67.7)	
Non-Hispanic black	1500 (8.4)	1166 (9.5)	283 (5.2)	51 (7.3)	
Non-Hispanic other <sup>b</sup>	207 (3.8)	144 (4.0)	52 (3.1)	11 (4.9)	
Hispanic	425 (7.2)	241 (6.1)	143 (8.7)	41 (20.0)	
Educational attainment, <i>N</i> (weighted %)					<0.001
Less than high school diploma	1544 (16.9)	958 (14.8)	472 (19.9)	114 (40.4)	
High school diploma	1916 (26.0)	1287 (25.4)	558 (27.9)	71 (26.4)	
Some college	1535 (23.2)	1085 (24.1)	398 (21.5)	52 (16.8)	
College degree or more	2129 (33.9)	1513 (35.8)	560 (30.7)	56 (16.3)	
Family income, <i>N</i> (weighted %)					<0.001
Less than \$17,000	1772 (19.3)	1133 (17.7)	517 (21.4)	122 (40.3)	
\$17,000–31,000	1775 (21.6)	1187 (20.9)	509 (23.0)	79 (24.7)	
\$31,000–60,000	1722 (25.8)	1181 (26.0)	481 (25.8)	60 (23.0)	
\$60,000 or more	1855 (33.3)	1342 (35.4)	481 (29.8)	32 (12.0)	
History of cataract surgery, <i>N</i> (weighted %)	3515 (41.4)	2153 (36.9)	1171 (52.0)	191 (59.1)	<0.001
Clinically significant depressive symptoms, <i>N</i> (weighted %)	956 (12.2)	538 (9.9)	319 (15.4)	99 (38.7)	<0.001
Proxy respondent, <i>N</i> (weighted %)	368 (3.5)	124 (1.8)	160 (5.9)	84 (25.0)	<0.001
BMI, mean (SD)	28.08 (5.82)	28.11 (5.73)	28.05 (5.90)	27.77 (7.28)	0.862
Number of comorbidities, mean (SD) <sup>c</sup>	2.55 (1.61)	2.42 (1.56)	2.79 (1.63)	3.68 (1.74)	<0.001
Dementia, <i>N</i> (weighted %)	1418 (14.6)	768 (11.1)	503 (21.0)	147 (45.1)	<0.001

Abbreviation: BMI, body mass index.

<sup>a</sup>Based on groupwise comparisons using survey-weighted chi-square tests.

<sup>b</sup>Includes American Indian, Asian, Native Hawaiian, Pacific Islander, and “other” race.

<sup>c</sup>Comorbidity count includes self-reported physician diagnoses of arthritis, cancer, diabetes, heart attack, heart disease, hypertension, lung disease, osteoporosis, and stroke.

or hearing impairment, language barrier, and being temporarily unavailable). Dementia was defined as having probable dementia or possible dementia (i.e., cognitive impairment) using the broad definition previously described in the NHATS cohort.<sup>38</sup> As such, participants were considered to have dementia if they had a self- or

proxy-reported physician diagnosis of dementia or Alzheimer’s disease, a score of 2 or greater on the AD8 Dementia Screening Interview administered to proxy respondents, or a score less than or equal to 1.5 standard deviations below the mean on at least 1 cognitive performance test (memory, orientation, or executive function).

Clinically significant depressive symptoms were defined as a score of 3 or greater on the 2-item Patient Health Questionnaire.<sup>39</sup>

## Statistical analysis

Cross-sectional analyses examined the association between dual sensory impairment status and limitations in mobility, self-care, and household activities. Analyses accounted for the NHATS complex survey design using the recommended approach and weights provided by the NHATS User Guide.<sup>40</sup> Weighted percentages and means of population characteristics were presented for the overall population and by dual sensory impairment group. Generalized linear models with a Poisson distribution and log-link function were used to examine the association between sensory impairment and scores on the mobility, self-care, and household activities, adjusting for sociodemographic characteristics and health/functional status. Models were repeated with a combined sensory impairment and dementia status variable (no sensory impairment and no dementia [reference], single sensory impairment and no dementia, dual sensory impairment and no dementia, no sensory impairment and dementia, single sensory impairment and dementia, and dual sensory impairment and dementia) to examine the estimated joint effects of sensory impairment and dementia on the functional limitation scores. Sensitivity analyses excluding participants with proxy respondents were conducted. The *p*-values were two-tailed with statistical significance level set at 0.05. Analyses were conducted using R, version 3.6.1 (R Foundation for Statistical Computing, Vienna, Austria).

## RESULTS

### Study population

Overall, 7124 participants were included, representing about 38.5 million Medicare beneficiaries 65 years or older (Table 1). The majority were female (55.3%), non-Hispanic white (80.7%), and had at least a high school diploma (83.1%). Seventy-two percent reported no sensory impairment, 25.2% reported a single sensory impairment, and 3.1% reported dual sensory impairment. Overall, 1418 (14.6%) had dementia; dementia prevalence was 11.1% among those with no sensory impairment (*N* = 768), 21.0% among those with a single sensory impairment (*N* = 503), and 45.1% among those with dual sensory impairment (*N* = 147). A greater proportion of those with dual sensory impairment than without

TABLE 2 Multivariable-adjusted prevalence rate ratios of functional limitations by sensory impairment and dementia status, the National Health and Aging Trends Study 2015 (*N* = 7124)

	Mobility activities		Self-care activities		Household activities	
	PRR (95% CI)	<i>p</i> -value	PRR (95% CI)	<i>p</i> -value	PRR (95% CI)	<i>p</i> -value
<b>Sensory impairment</b>						
No sensory impairment	1 [Reference]	NA	1 [Reference]	NA	1 [Reference]	NA
Single sensory impairment	1.19 (1.10, 1.30)	<0.001	1.14 (1.06, 1.22)	0.001	1.19 (1.11, 1.28)	<0.001
Dual sensory impairment	1.45 (1.28, 1.63)	<0.001	1.41 (1.25, 1.59)	<0.001	1.54 (1.37, 1.72)	<0.001
<b>Dementia</b>						
No dementia	1 [Reference]	NA	1 [Reference]	NA	1 [Reference]	NA
Dementia	1.49 (1.38, 1.61)	<0.001	1.46 (1.35, 1.57)	<0.001	1.79 (1.63, 1.97)	<0.001

Note: Models adjusted for age (65–69, 70–74, 75–79, 80–84, 85–89, ≥90 years), sex (male, female), race/ethnicity (non-Hispanic white, non-Hispanic black, non-Hispanic other, Hispanic), education (<high school diploma, high school diploma, some college, ≥college degree), income (<\$17,000, \$17,000–\$31,000, \$31,000–\$60,000, ≥\$60,000), history of cataract surgery (yes, no), clinically-significant depressive symptoms (yes, no), proxy response (yes, no), body mass index, and number of comorbidities.

Abbreviations: CI, confidence interval; NA, not applicable; PRR, prevalence rate ratio.

sensory impairment were 80 years and older (57.6 vs. 19.3%), female (61.6 vs. 57.6%), Hispanic (20.0 vs. 6.1%), had a family income less than \$17,000 (40.3 vs. 17.7%), and had clinically significant depressive symptoms (38.7 vs. 9.9%).

### Prevalence rate of functional limitations by sensory impairment status

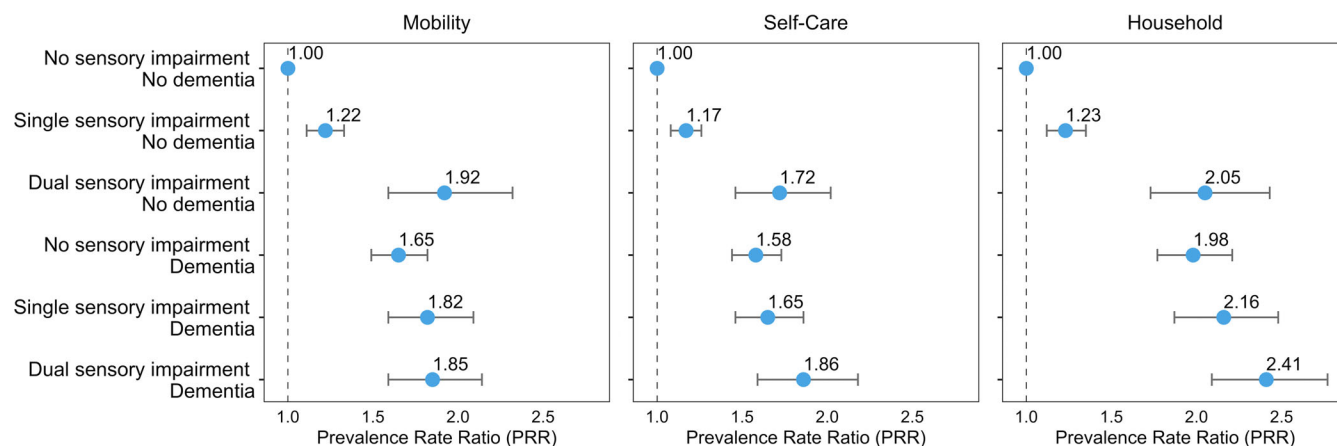
In fully adjusted models, those with dual sensory impairment had higher prevalence rates of limitations with mobility, self-care, and household activities compared to those with no sensory impairment and those with a single sensory impairment (Table 2). The prevalence rate of greater mobility limitations was 1.19 times (95% confidence interval [CI] = 1.10–1.30) higher among those with a single sensory impairment and 1.45 times (95% CI = 1.28–1.63) higher among those with dual sensory impairment relative to those without sensory impairment (*p*-trend<0.001). Compared with those without sensory impairment, those with a single sensory impairment had 1.14 times (95% CI = 1.06–1.22) higher prevalence rate of greater limitations in self-care, and those with dual sensory impairment had 1.41 times (95% CI = 1.25–1.59) higher prevalence rate of limitations in self-care activities (*p*-trend < 0.001). The prevalence rate of greater limitations in household activities was 1.19 times (95% CI = 1.11–1.28) higher among those with a single sensory impairment and 1.54 times (95% CI = 1.37–1.72) higher among those with dual sensory impairment relative to those without sensory impairment (*p*-trend < 0.001).

Inferences were unchanged when excluding study participants with proxy respondents (Table S1).

### Prevalence rate of functional limitations by the combined estimated effects of sensory impairment and dementia

There was an independent association of dementia with functional limitations (Table 2). Specifically, dementia was also associated with greater limitations in mobility (PRR = 1.49, 95% CI = 1.38–1.61), self-care (PRR = 1.46, 95% CI = 1.35–1.57), and household activities (PRR = 1.79, 95% CI = 1.63–1.97).

Results from the models examining the combined estimated effects of sensory impairment and dementia on the prevalence rate ratios of functional limitations are presented in Figure 2. Relative to those with no sensory impairment and no dementia, those with dual sensory impairment but not dementia had 1.92 (95% CI = 1.59–2.32) higher prevalence rate of limitations in mobility activities, 1.72 (95% CI = 1.46–2.02) higher prevalence rate of limitations in self-care activities, and 2.05 (95% CI = 1.73–2.43) higher prevalence rate of limitations in household activities, while those with both dual sensory impairment and dementia had 1.85 (95% CI = 1.59–2.14) higher prevalence rate of limitations in mobility activities, 1.86 (95% CI = 1.59–2.18) higher prevalence rate of limitations in self-care activities, and 2.41 (95% CI = 2.09–2.77) higher prevalence rate of limitations in household activities. Excluding participants with proxy respondents did not result in a change in the inferences (Table S2).



**FIGURE 2** Multivariable-adjusted prevalence rate ratios of functional limitations by combined sensory impairment and dementia status, the National Health and Aging Trends Study 2015 (N = 7124). Models adjusted for age (65–69, 70–74, 75–79, 80–84, 85–89, ≥90 years), sex (male, female), race/ethnicity (non-Hispanic white, non-Hispanic black, non-Hispanic other, Hispanic), education (<high school diploma, high school diploma, some college, ≥college degree), income (<\$17,000, \$17,000–31,000, \$31,000–60,000, ≥\$60,000), history of cataract surgery (yes, no), clinically-significant depressive symptoms (yes, no), proxy response (yes, no), body mass index, and number of comorbidities

## DISCUSSION

In a nationally representative sample of Medicare beneficiaries in the United States, we found that older adults with dual sensory impairment had greater limitations in mobility, household, and self-care activities compared with those without sensory impairment and those with a single sensory impairment, after adjusting for dementia, sociodemographic characteristics, and other functional and health status variables. Having both dual sensory impairment and dementia was associated with the highest levels of limitations in self-care and household activities.

Our finding that dual sensory impairment is associated with greater functional limitations is consistent with previous studies. In the French E3N sub-cohort of older adults, women with dual sensory impairment were found to have more limitations in IADLs (similar to household activities) compared to those without sensory impairment, and compared to those with hearing or vision impairment alone.<sup>15</sup> In a sample of community-living frail Dutch older adults,<sup>16</sup> and in a sample of adults aged 95 years or older in New York City,<sup>18</sup> those with dual sensory or vision impairment had similarly greater limitations in IADLs and ADLs (similar to mobility and self-care activities) compared to those with hearing or no sensory impairment. In these two studies, however, samples may have been limited to those with more severe forms of sensory impairment, including vision impairment, as they included only frail adults in one,<sup>16</sup> and only those aged 95 years and older in the other.<sup>18</sup> A study using the Longitudinal Study on Aging, a nationally representative sample of older adults in the U.S. in 1984, found that having dual sensory impairment was associated with greater limitations in ADLs or IADLs compared with not having sensory impairment.<sup>19</sup> Finally, a study using data from the Epidemiology of Hearing Loss Study and Beaver Dam Eye Study found that clinically assessed vision impairment was associated with lower physical functioning scores, but hearing impairment and the interaction between hearing and vision impairment were not significantly associated with physical functioning.<sup>17</sup>

We also found that having dual sensory impairment (relative to no sensory impairment) was associated with greater difficulty with mobility and self-care activities to a similar extent as to having dementia (relative to not having dementia) (similar magnitude of PRRs). The association with limitations in household activities was stronger with dementia (PRR = 1.79, 95% CI = 1.63–1.97) than with dual sensory impairment (PRR = 1.54, 95% CI = 1.37–1.72). Early cognitive decline is known to cause changes in daily function, especially IADLs,<sup>41</sup> which could explain the strong association with

household activities specifically. However, when accounting for the combined estimated effects of dementia and sensory impairment, there was a 20% increase in the PRR between having dementia and no sensory impairment, and having both dementia and dual sensory impairment (relative to no dementia and no sensory impairment). Therefore, dual sensory impairment may have a comparable association to dementia when it comes to less complex or cognitively demanding activities (mobility, self-care). With more cognitively demanding activities (household activities), the odds of difficulty performing them for those with dual sensory impairment increase when they also have dementia.

Sensory impairment can be addressed to potentially help maintain functional independence among older adults using relatively low-cost, accessible strategies. Improving access to hearing and vision care services in the community could help maintain older adults' sensory function. Screening for sensory impairment in health care settings could help to detect sensory impairment and address it earlier by referring for treatment (e.g., cataract surgery), prescribing sensory aids (e.g., glasses, hearing aids), or referring for visual and/or aural rehabilitation. Some strategies have also been shown to improve or maintain function (ADLs) among people with low vision, including improving indoor lighting,<sup>42</sup> and participation in a health-promotion program.<sup>43</sup>

Importantly, among people with dementia, interventions to address vision and hearing impairments are generally considered as effective, relatively low-cost, and accessible strategies to improve function.<sup>44</sup> This could be especially important in the subset of people with both dual sensory impairment and dementia. A systematic review<sup>44</sup> identified the Memory of Reasoning Enhanced Low Vision Rehabilitation (MORE-LVR) Program as one that improved cognitive and visual function, as well as performance on ADLs.<sup>45</sup> In the SENSE-Cog Field Trial, providing vision and hearing support (through assessment, provision of glasses and/or hearing aids with or without sensory support therapy) improved function in people with dementia.<sup>46</sup> Further research could assess more interventions for their impact on daily function, especially strategies that address both vision and hearing simultaneously, as those with dual sensory impairment may be the most vulnerable to disability.

Currently, the traditional Medicare program does not cover most vision and hearing services. Even among those enrolled in Medicare Advantage plans, out-of-pocket expenses still make up more than two-thirds of vision and hearing care costs.<sup>47</sup> Expanding Medicare coverage to include vision and hearing services could help optimize independence and functioning among older adults, including those with dementia. The regulation of



over-the-counter hearing aids sales for the treatment of mild to moderate hearing loss under the Over-the-Counter Hearing Aid Act of 2017 is another example of a policy that could have a positive impact on this issue. However, to date the Food and Drug Administration has not released regulations governing the samples of over-the-counter hearing aids.<sup>48</sup>

This study has limitations that should be taken into account when interpreting the results. First, the sampling frame used to draw the sample, the Medicare enrollment file, is inclusive of more than 95% of older adults in the U.S., but a small percentage of older adults are not represented. Moreover, older participants of non-white race or Hispanic ethnicity, and those with lower income and educational attainment maybe have been underrepresented due to missing data. However, those missing data represent only a small proportion (6%) of the study population. Second, the cross-sectional analyses do not allow for establishing temporality in the association of sensory or cognitive impairments with functional limitations. However, they allow to examine the co-existence of multiple impairments and functional limitations among a growing subset of the population. Third, the severity of sensory impairment was not accounted for in the exposure variable. The association of sensory impairment with functional limitations may be different for those with mild compared to severe impairments. Finally, self-reported sensory measures may represent a correlated but distinct construct compared to clinically assessed sensory measures, and may underestimate the prevalence of sensory impairment. Nonetheless, they provide important data on the day-to-day lived sensory experience.

In conclusion, we found that dual sensory impairment was associated with functional limitations in a nationally representative sample of older community-dwelling Medicare beneficiaries in the U.S. Those with both dual sensory impairment and dementia had the highest level of functional limitations across a range of activities regarded as important for independent daily living. Addressing sensory impairment through low-cost strategies could help improve or maintain function among older adults, including those with dementia. Further research is needed to evaluate interventions for people with dual sensory impairment specifically.

### CONFLICT OF INTEREST

Dr. Reed reports sitting on the scientific advisory boards without financial compensation of Shoebox Inc and Good Machine Studio. All other authors have no conflicts of interest.

### AUTHOR CONTRIBUTIONS

Lama Assi, Joshua R. Ehrlich, Yunshu Zhou, Nicholas S. Reed, and Jennifer A. Deal designed the study and

conducted the statistical analyses. Alison Huang, Judith Kasper, Frank R. Lin, Michael M. McKee, and Bonnielin K. Swenor contributed to the interpretation of the data. Lama Assi, Joshua R. Ehrlich, and Jennifer A. Deal drafted the manuscript. Yunshu Zhou, Alison Huang, Judith Kasper, Frank R. Lin, Michael M. McKee, Nicholas S. Reed, and Bonnielin K. Swenor revised it for critically important intellectual content. All authors approved the final version to be published.

### SPONSOR'S ROLE

Study sponsors had no role in study design; collection, analysis, and interpretation of data; writing the report; and the decision to submit the report for publication.

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## SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

**Table S1.** Multivariable-adjusted prevalence rate ratios of functional limitations by sensory impairment and dementia status excluding those with proxy respondents, the National Health and Aging Trends Study 2015 ( $N = 6756$ ).

**Table S2.** Multivariable-adjusted prevalence rate ratios of functional limitations by sensory impairment and dementia status excluding those with proxy respondents, the National Health and Aging Trends Study 2015 ( $N = 6756$ ).

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