Associations of Vision Impairment and Eye Diseases With Memory Decline Over 4 Years in China and the United States

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• PURPOSE: To examine whether vision impairment and eye diseases are independently associated with memory decline in older adults.
• DESIGN: Cohort study.
• METHODS: We included 8,315 participants aged 50-94 years in China Health and Retirement Longitudinal Study (CHARLS) from China and 8,939 participants aged 50-95 years in Health and Retirement Study (HRS) from the United States in our analysis.
• RESULTS: During 4.0 years' follow-up, the composite memory decreased by 0.16 points in CHARLS. During 3.9 years' follow-up, the composite memory decreased by 0.51 in HRS. Distance vision impairment was inversely associated with an annual change in composite memory (β [95% CI]: –0.07 [–0.12, –0.01]) and immediate memory (–0.04 [–0.07, –0.02]) in CHARLS, and the corresponding values in HRS were –0.19 (–0.34, –0.05) and –0.07 (–0.13, –0.00), respectively. Near vision impairment was inversely associated with an annual change in delayed memory in CHARLS and composite memory, immediate memory, and delayed memory in HRS. In HRS, the association between distance vision impairment and memory decline was observed in individuals aged <65 years (β [95% CI]: –0.54 [–0.78, –0.30]) but not in those aged $\geq$65 years (–0.01 [–0.20, 0.18]). Cataract surgery or glaucoma was not significantly associated with memory decline in either CHARLS or HRS.
• CONCLUSION: Distance vision impairment was independently associated with an accelerated rate of memory decline in both China and the United States. Near vision impairment was predictive of decline in delayed memory in China and of decline in composite, immediate, and delayed memory in the United States. (Am J Ophthalmol 2021;228: 16–26. © 2021 Elsevier Inc. All rights reserved.)

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The global number of people with dementia was 43.8 million in 2016, with 10.4 million in China and 4.0 million in the United States.[1] The estimated worldwide cost of dementia was US$818 billion in 2015, with an increase of 35% since 2010, and the cost will be approximately US$2 trillion in 2030.[2] The socioeconomic cost caused by dementia imposes a tremendous economic burden on both China and the United States.[3,4] The absolute number of people with dementia will still increase in the next decade owing to the increasing older population.[5,6] Therefore, modifiable determinants must be identified to prevent dementia and cognitive decline.[7-9]

Both cognition and vision decrease with ageing, and vision is an important indicator of cognition in older adults.[10] Loss of vision input may decrease activation in central sensory pathways, thus resulting in an increased risk of cognitive load, brain structure damage, and cognitive decline.[10,11] Previous studies have linked vision impairment to dementia, but the results are inconsistent.[12-16] Recently, several longitudinal studies have investigated the association between vision impairment and cognitive decline;[17-19] however, these studies are limited by focusing on distance vision impairment only or near vision impairment only or small sample sizes. Additionally, several studies have also examined the association of eye diseases, such as cataract and glaucoma, with cognition with inconsistent results.[20,21] Education, social support, environment, and culture may play important roles in maintaining and improving cognitive function.[6,22] Therefore, whether vision impairment and eye diseases are independently associated with cognitive decline in populations with different backgrounds and ethics remains to be explored.

The present study aimed to examine whether vision impairment and eye diseases were predictive of memory decline in China and the United States using data with

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representative population-based samples from each country and almost the same survey methods. We assumed that distance vision impairment, near vision impairment, cataract surgery, and glaucoma at baseline were each associated with a higher decrease in memory in both countries.

METHODS

• **PARTICIPANTS:** The present analysis was based on 2 nationally representative publicly available sister survey data sets: the China Health and Retirement Longitudinal Study (CHARLS) from China and the Health and Retirement Study (HRS) from the United States.[23,24]

The China Health and Retirement Longitudinal Study

CHARLS is a nationally representative longitudinal survey of adults aged ≥45 years in China initiated in 2011 and followed up in 2013 and 2015.[23] Multistage sampling stratified by region (urban districts and rural counties) and per capita statistics on the gross domestic product was performed to identify participants for study inclusion. In total, 150 district/county-level units were randomly selected using a probability-proportional-to-size sampling technique from a sampling frame containing all county-level units in 28 provinces across China. A face-to-face computer-assisted personal interview was conducted on 10,257 households, with a response rate of 80.5% at baseline. The participants were then followed up every 2 years.

The study protocol was approved by the Ethical Review Committee at Peking University. Written informed consent was obtained from all the participants.

The Health and Retirement Study

HRS is a nationally representative longitudinal survey of more than 37,000 individuals aged >50 years in 23,000 households in the United States.[24] The participants were identified through a stratified, multistage, probability-sampling design, with African American and Hispanic households oversampled. Before 2004, follow-up interviews via telephone were offered to individuals aged ≤80 years and face-to-face follow-up interviews with those aged >80 years. Since 2006, half of the sample was assigned a face-to-face follow-up interview, and the other half was assigned a telephone interview. The half-samples alternated in waves, so longitudinal information from the face-to-face interview was available every 4 years at the individual level. The survey has been fielded every 2 years since 1992. The response rate for the baseline was 81.6%.

The HRS has been approved by the institutional review board at the University of Michigan. In addition, the HRS obtained informed verbal consent from the voluntary participants and followed strict procedures to protect study participants from disclosure (including maintaining a Federal Certificate of Confidentiality).

• **VISION IMPAIRMENT AND EYE DISEASES:** In both CHARLS and HRS, distal vision impairment was assessed by asking the participants whether their eyesight was excellent, very good, good, fair, or poor when seeing things at a distance, analogous to recognizing a friend from across the street (with glasses or corrective lenses, if applicable). Reporting poor eyesight was classified as distal vision impairment and reporting excellent, very good, good, or fair eyesight was used as the reference group. Near vision impairment was assessed by asking participants whether their eyesight was excellent, very good, good, fair, or poor when seeing things up close, such as reading ordinary newspaper print (with glasses or corrective lenses, if applicable). Reporting poor eyesight was classified as near vision impairment and reporting excellent, very good, good, or fair eyesight was used as the reference group. Cataract surgery was defined if participants reported that they ever had cataract surgery. Glaucoma was defined if participants reported that a physician ever treated them for glaucoma. In HRS, the data on vision impairment and eye diseases were collected in 1998, 2006, and 2012. Because corresponding data were collected between 2011 and 2015 in CHARLS, the data between 2012 and 2016 in HRS were used in the analysis.

• **COGNITIVE ASSESSMENT:** In CHARLS, 5 cognitive screening tasks included the immediate and delayed recall of a 10-word list (one 4-word list was randomly selected), serial 7 subtraction from 100 five times, date orientation, and picture drawing.[25] In HRS, the tests used to assess cognitive functioning included immediate and delayed recall, the serial 7 subtraction test, counting backward, object naming test, and recall of the date and president and vice president to assess orientation.[24] The sensitivity and specificity of cognitive screening tasks used in screening for dementia in HRS was 0.78 and 0.88, respectively.[26] Three memory tasks, including the 10-word immediate and delayed recall tests and serial 7 subtraction test of working memory that was assessed in all waves of surveys in both CHARLS and HRS, were analysed in our study.

The total score for immediate recall ranged from 0 to 10 with each correctly recalled word assigned a score of 1 and so did delayed recall. The total score for serial 7 subtraction ranged from 0 to 5 with a score of 1 assigned to each of the 5 subtractions. Composite memory scores were computed by summing the scores of all 3 memory tasks and ranged from 0 to 25 with a higher score representing better memory. Annual changes in memory scores were computed by subtracting the scores at baseline from those at follow-up divided by the follow-up duration using the following formula: annual change = (memory at follow-up – memory at baseline) / follow-up duration.

• **PHYSICAL EXAMINATION:** In CHARLS, height was measured using a stadiometer (Seca 213; Seca Trading Co, Hangzhou, China), and weight was measured using a digital scale (Omron HN-286; Omron Corporation, Kyoto, Japan). In HRS, height and weight were self-reported between 1992 and 2004 and then measured using a stadiometer and a digital scale since 2006. Body mass index (BMI) was computed as weight in kilograms divided by the square of height in meters.

• **CONFOUNDERS:** The data on age, gender, education (≤8 years, 9-12 years, and ≥13 years), smoking (never smoked, former smoking, and current smoking), hypertension (yes, no), diabetes (yes, no), heart disease (yes, no), stroke (yes, no), lung disease (yes, no), psychiatric disorders (yes, no), cancer (yes, no), and arthritis (yes, no) were collected using the same questions in both CHARLS and HRS. Alcohol consumption was divided into 3 groups: never, <1 drink/mo, and ≥1 drink/mo in CHARLS and <1 drink/wk, 1-6 drinks/wk, and 7 drinks/wk in HRS. In CHARLS, physical activity was assessed based on the duration and frequency spent in different physical activities, from which the metabolic equivalent of task (MET) was calculated.[25] MET from moderate and vigorous physical activity was computed by multiplying the length (minutes per week) by an assigned MET value (4 MET for moderate physical activity and 7.5 MET for vigorous physical activity).[25] In HRS, participants were divided into quintiles according to moderate physical activity or vigorous physical activity. Living area (rural or urban area) was also collected in CHARLS.

• **STATISTICAL ANALYSIS:** The data are expressed as frequencies (percentage) and means ± standard deviations (SDs) for baseline characteristics according to country. *t* test was performed for continuous variables, and χ^2 test was performed for categorical variables to compare the difference in the baseline characteristics between individuals with and without distance vision impairment.

General linear regression models were used to obtain coefficients (β and 95% confidence interval [CI]) for the change in memory scores associated with vision impairment as well as eye diseases. We tested the following models: (1) age and gender; (2) model 1 plus education, smoking, alcohol intake, physical activity, and memory score (the living area was additionally adjusted in CHARLS) at baseline; and (3) model 2 plus BMI, hypertension, diabetes, heart disease, stroke, lung disease, psychiatric disorders, arthritis, and cancer at baseline. This analysis was conducted for CHARLS and HRS separately.

Moderation analysis was conducted to examine whether the association between vision impairment and memory decline was modified by important determinants for cognition, including age, gender, education, BMI, diabetes, hypertension, and psychiatric disorders.

Data analyses were conducted using SAS 9.4 for Windows (SAS Institute Inc, Cary, North Carolina, USA), and 2-sided *P* values <.05 were considered statistically significant.

RESULTS

• **PARTICIPANT CHARACTERISTICS:** After excluding individuals with missing data on age, sex, vision impairment, or cognition, our study sample comprised 8,315 participants aged 50.0-94.5 years in China (Supplemental Figure S1) and 8,939 participants aged 50.0-95.8 years in the United States (Supplemental Figure S2). Table 1 shows the baseline characteristics. The mean age was 61.1 ± 7.1 years (49.8% female) in CHARLS and 66.3 ± 9.4 years (50.6% female) in HRS. In both CHARLS and HRS, individuals with distance vision impairment were more likely to be older, to be less educated, to be non–alcohol drinkers, and to have a higher prevalence of hypertension, diabetes, heart disease, stroke, psychiatric disorders, lung disease, and arthritis than those without distance vision impairment (all *P* values <.05). Distance vision impairment was associated with lower immediate memory, delayed memory, working memory, and composite memory in both CHARLS and HRS.

• **VISION IMPAIRMENT AND EYE DISEASES:** The prevalence of distance and near vision impairment in CHARLS was 22.0% and 23.8%, respectively. The corresponding number in HRS was 2.3% and 5.3%, respectively. The prevalence of cataract surgery and glaucoma in CHARLS was 2.0% and 0.9%, respectively, whereas the corresponding number in HRS was 13.8% and 5.9%, respectively.

• **MEMORY CHANGE:** During a median follow-up of 4.0 (range: 1.9-4.4) years, the composite memory decreased from 10.18 at baseline to 10.03 at follow-up, with an annual change of –0.04 in CHARLS. During a median follow-up of 3.9 (range: 1.5-4.9) years, the composite memory decreased from 13.85 at baseline to 13.44 at follow-up, with an annual change of –0.13 in HRS.

• **DISTANCE VISION IMPAIRMENT AND MEMORY DECLINE:** In multivariable analysis, distance vision impairment was inversely associated with an annual change in composite memory (β [95% CI]: –0.07 [–0.12, –0.01]) and immediate memory (–0.04 [–0.07, –0.02]) in CHARLS. The corresponding number in HRS was –0.19 (–0.34, –0.05) and –0.07 (–0.13, –0.00), respectively. Distance vision impairment was associated with a higher rate of delayed memory decline (–0.04 [–0.07, –0.02]) after adjusting for confounders in CHARLS. This association was attenuated and found to be nonsignificant (–0.07 [–0.14, 0.01]) after adjusting for chronic diseases in HRS. An inverse association was found between distance vision impairment and annual change in working memory (–0.08 [–0.13, –0.02]) in HRS but not in CHARLS (Table 2).

• **NEAR VISION IMPAIRMENT AND MEMORY DECLINE:** In CHARLS, near vision impairment was inversely associated

TABLE 1. Baseline Characteristics of Study Participants in China and the United States

	Distance Vision Impairment: China			Distance Vision Impairment: United States		
	No	Yes	*P* Value[a]	No	Yes	*P* Value
Age (y), mean ± SD	60.7 ± 7.0	62.6 ± 7.4	<.0001	66.2 ± 9.4	69.9 ± 10.0	<.0001
Gender			<.0001			.71
Men	3,442 (53.1)	731 (39.9)		4,184 (48.0)	101 (49.3)	
Women	3,039 (46.9)	1,101 (60.1)		4,540 (52.0)	104 (50.7)	
Education			<.0001			<.0001
<9 y	4,253 (65.6)	1,458 (79.6)		486 (5.6)	33 (16.1)	
9-12 y	2,075 (32.0)	352 (19.2)		980 (11.2)	37 (18.0)	
>12 y	153 (2.4)	21 (1.1)		7,258 (83.2)	135 (65.9)	
Missing	2 (0.0)	1 (0.1)				
Living area			<.0001			
Urban	3,752 (57.9)	1,217 (66.4)				
Rural	2,731 (42.1)	615 (33.6)				
Alcohol consumption			<.0001			
≥1 drink/mo	1,795 (27.7)	392 (21.4)				
<1 drink/mo	503 (7.8)	113 (6.2)				
Never	4,185 (64.6)	1,327 (72.4)				
Alcohol consumption						.0001
7 drinks/wk				610 (7.0)	14 (6.8)	
1-6 drinks/wk				3,066 (35.1)	46 (22.4)	
<1 drink/wk				5,032 (57.7)	145 (70.7)	
Smoking			<.0001			.0632
Current	2,159 (33.3)	505 (27.6)		946 (10.8)	33 (16.1)	
Former	627 (9.7)	163 (8.9)		3,741 (42.9)	86 (42.0)	
Never	3,697 (57.0)	1,164 (63.5)		4,037 (46.3)	86 (42.0)	
Moderate and vigorous physical activity (MET-min/wk), mean ± SD	1,894.7 ± 4,520.2	2,038.5 ± 4,622.2	.23			
Moderate physical activity						<.0001
Every day				205 (2.3)	9 (4.4)	
>1 time/wk				2,327 (26.7)	35 (17.1)	
1 time/wk				1,095 (12.6)	25 (12.2)	
1-3 times/mo				945 (10.8)	21 (10.2)	
Never				4,131 (47.4)	113 (55.1)	
Missing				21 (0.2)	2 (1.0)	
Vigorous physical activity						<.0001
Every day				698 (8.0)	13 (6.3)	
>1 time/wk				4,141 (47.5)	86 (42.0)	
1 time/wk				1,605 (18.4)	31 (15.1)	
1-3 times/mo				1,034 (11.9)	31 (15.1)	
Never				1,240 (14.2)	43 (21.0)	
Missing				6 (0.1)	1 (0.5)	
BMI, mean ± SD	23.51 ± 3.47	23.38 ± 3.49	.15	29.67 ± 6.05	29.33 ± 5.62	.65
Hypertension			<.0001			.0022
Yes	1,634 (25.2)	553 (30.2)		4,775 (54.7)	127 (62.0)	
No	4,823 (74.4)	1,271 (69.4)		3,934 (45.1)	78 (38.0)	
Missing	26 (0.4)	8 (0.4)		15 (0.2)		
Diabetes			.0004			.0214
Yes	379 (5.8)	153 (8.4)		1,844 (21.1)	56 (27.3)	
No	6,053 (93.4)	1,663 (90.8)		6,873 (78.8)	148 (72.2)	
Missing	51 (0.8)	16 (0.9)		7 (0.1)	1 (0.5)	
Heart disease			<.0001			.0529
Yes	782 (12.1)	303 (16.5)		1,801 (20.6)	54 (26.3)	
No	5,672 (87.5)	1,517 (82.8)		6,915 (79.3)	151 (73.7)	

(*continued on next page*)

TABLE 1. (*continued*)

	Distance Vision Impairment: China			Distance Vision Impairment: United States		
	No	Yes	*P* Value[a]	No	Yes	*P* Value
Missing	29 (0.4)	12 (0.7)		8 (0.1)		
Stroke			.0022			.0104
Yes	108 (1.7)	52 (2.8)		520 (6.0)	18 (8.8)	
No	6,360 (98.1)	1,776 (96.9)		8,198 (94.0)	187 (91.2)	
Missing	15 (0.2)	4 (0.2)		6 (0.1)		
Psychiatric disorders			.0446			.0314
Yes	38 (0.6)	21 (1.1)		1,207 (13.8)	37 (18.0)	
No	6,416 (99.0)	1,803 (98.4)		7,507 (86.0)	168 (82.0)	
Missing	29 (0.4)	8 (0.4)		10 (0.1)		
Lung disease			<.0001			.0142
Yes	628 (9.7)	259 (14.1)		624 (7.2)	23 (11.2)	
No	5,833 (90.0)	1,566 (85.5)		8,094 (92.8)	181 (88.3)	
Missing	22 (0.3)	7 (0.4)		6 (0.1)	1 (0.5)	
Arthritis			<.0001			.0011
Yes	2,056 (31.7)	854 (46.6)		4,690 (53.8)	129 (62.9)	
No	4,417 (68.1)	972 (53.1)		4,026 (46.1)	76 (37.1)	
Missing	10 (0.2)	6 (0.3)		8 (0.1)		
Cancer			.10			.51
Yes	53 (0.8)	21 (1.1)		1,149 (13.2)	30 (14.6)	
No	6,402 (98.8)	1,806 (98.6)		7,560 (86.7)	175 (85.4)	
Missing	28 (0.4)	5 (0.3)		15 (0.2)		
Immediate memory, mean ± SD	4.19 ± 1.60	3.71 ± 1.51	<.0001	5.59 ± 1.57	4.94 ± 1.84	<.0001
Delayed memory, mean ± SD	3.23 ± 1.89	2.74 ± 1.80	<.0001	4.61 ± 1.89	3.87 ± 2.13	<.0001
Working memory, mean ± SD	3.09 ± 1.93	2.52 ± 1.97	<.0001	3.69 ± 1.55	3.19 ± 1.86	<.0001
Composite memory, mean ± SD	10.52 ± 4.13	8.97 ± 4.02	<.0001	13.90 ± 3.94	12.00 ± 4.45	<.0001

BMI = body mass index; MET = metabolic equivalent of task; MVPA = moderate and vigorous physical activity.
Unless otherwise noted, values are frequency (percentage).
[a] *t* test was used to test the difference between participants with and without distance vision impairment and χ^2 for categorical variables.

with annual changes in composite memory, immediate memory, and delayed memory after adjusting for age and gender, whereas only the association between near vision impairment and delayed memory remained significant after adjusting for other confounders (β [95% CI]: –0.03 [–0.01, –0.05]). In HRS, near vision impairment was inversely associated with an annual change in composite memory (β [95% CI]: –0.11 [–0.21, –0.01]), immediate memory (–0.06 [–0.10, –0.01]), and delayed memory (–0.05 [–0.11, –0.00]) after adjusting for confounders (Table 3).

• **EYE DISEASES AND MEMORY DECLINE:** As shown in Table 4, cataract surgery at baseline was not associated with changes in cognitive scores in either CHARLS or HRS. Table 5 shows that glaucoma at baseline was not associated with changes in cognition in either CHARLS or HRS.

• **MODERATION ANALYSIS:** In CHARLS, BMI was a significant moderator for the association between distance vision impairment and composite memory decline (*P* interaction = 0.0009). This association was stronger in individuals with normal weight (β [95% CI]: –0.15 [–0.21, –0.08] for BMI <25.0; 0.09 [–0.01, 0.19] for BMI ≥25.0). In HRS, the association between distance vision impairment and composite memory decline was observed in individuals aged younger than 65 years only (–0.54 [–0.78, –0.30] for individuals aged <65 years; –0.01 [–0.20, 0.18] for those aged ≥65 years) (eTable 1).

DISCUSSION

We demonstrated that distance vision impairment was independently associated with memory decline in both China and the United States. Near vision impairment was a risk factor for the decline in delayed memory in China and the decline in composite, immediate, and delayed memory in the United States. Cataract surgery or glaucoma was not significantly associated with memory decline in either China or the United States.

Previous studies have highlighted the importance of senses in cognitive decline.[10] The Lancet International Commission on Dementia Prevention and Care has

TABLE 2. The Change in Memory Scores Associated With Distance Vision Impairment

	Distance Vision Impairment: China		Distance Vision Impairment: United States	
	No, β (95% CI) (n=6,483)	Yes, β (95% CI) (n=1,832)	No, β (95% CI) (n=8,724)	Yes, β (95% CI) (n=205)
Composite memory				
Model 1[a]	0	–0.12 (–0.18, –0.07)	0	–0.28 (–0.42, –0.13)
Model 2[b]	0	–0.07 (–0.12, –0.02)	0	–0.19 (–0.34, –0.04)
Model 3[c]	0	–0.07 (–0.12, –0.01)	0	–0.19 (–0.34, –0.05)
Immediate memory				
Model 1	0	–0.07 (–0.09, –0.05)	0	–0.11 (–0.17, –0.04)
Model 2	0	–0.05 (–0.07, –0.02)	0	–0.07 (–0.13, –0.00)
Model 3	0	–0.04 (–0.07, –0.02)	0	–0.07 (–0.13, –0.00)
Delayed memory				
Model 1	0	–0.07 (–0.09, –0.04)	0	–0.11 (–0.18, –0.03)
Model 2	0	–0.04 (–0.07, –0.02)	0	–0.07 (–0.14, 0.01)
Model 3	0	–0.04 (–0.07, –0.02)	0	–0.07 (–0.14, 0.01)
Working memory				
Model 1	0	–0.01 (–0.04, 0.01)	0	–0.11 (–0.17, –0.06)
Model 2	0	0.01 (–0.02, 0.04)	0	–0.08 (–0.13, –0.02)
Model 3	0	0.01 (–0.02, 0.04)	0	–0.08 (–0.13, –0.02)

General linear regression models were used to obtain coefficients (β [95% CI]) for the change in memory scores for individuals with distance vision impairment vs those without.

[a]Model 1 was adjusted for age and gender.

[b]Model 2 was adjusted for Model 1 plus education, smoking, alcohol intake, physical activity, and memory score (living area was additionally adjusted for in CHARLS) at baseline.

[c]Model 3 was adjusted for model 2 plus body mass index, hypertension, diabetes, heart disease, stroke, lung disease, psychiatric disorders, arthritis, and cancer at baseline.

TABLE 3. The Change in Memory Scores Associated With Near Vision Impairment

	Near Vision Impairment: China		Near Vision Impairment: United States	
	No, β (95% CI) (n=6,337)	Yes, β (95% CI) (n=1,978)	No, β (95% CI) (n=8,461)	Yes, β (95% CI) (n=469)
Composite memory				
Model 1[a]	0	–0.05 (–0.10, 0.00)	0	–0.19 (–0.29, –0.09)
Model 2[b]	0	–0.02 (–0.07, 0.03)	0	–0.12 (–0.21, –0.02)
Model 3[c]	0	–0.02 (–0.06, 0.03)	0	–0.11 (–0.21, –0.01)
Immediate memory				
Model 1	0	–0.02 (–0.05, –0.00)	0	–0.10 (–0.14, –0.05)
Model 2	0	–0.01 (–0.03, 0.01)	0	–0.06 (–0.11, –0.02)
Model 3	0	–0.01 (–0.03, 0.01)	0	–0.06 (–0.10, –0.01)
Delayed memory				
Model 1	0	–0.04 (–0.07, –0.02)	0	–0.10 (–0.15, –0.05)
Model 2	0	–0.03 (–0.05, –0.01)	0	–0.06 (–0.11, –0.01)
Model 3	0	–0.03 (–0.05, –0.01)	0	–0.05 (–0.11, –0.00)
Working memory				
Model 1	0	0.00 (–0.02, 0.03)	0	–0.05 (–0.09, –0.01)
Model 2	0	0.02 (–0.01, 0.04)	0	–0.02 (–0.06, 0.02)
Model 3	0	0.02 (–0.01, 0.04)	0	–0.02 (–0.06, 0.02)

General linear regression models were used to obtain coefficients (β [95% CI]) for the change in memory scores for individuals with near vision impairment vs those without.

[a]Model 1 was adjusted for age and gender.

[b]Model 2 was adjusted for Model 1 plus education, smoking, alcohol intake, physical activity, and memory score (living area was additionally adjusted for in CHARLS) at baseline.

[c]Model 3 was adjusted for model 2 plus body mass index, hypertension, diabetes, heart disease, stroke, lung disease, psychiatric disorders, arthritis, and cancer at baseline.

TABLE 4. The Change in Memory Scores Associated With Cataract Surgery

	Cataract Surgery: China		Cataract Surgery: United States	
	No, β (95% CI) (n=8,148)	Yes, β (95% CI) (n=167)	No, β (95% CI) (n=3,828)	Yes, β (95% CI) (n=613)
Composite memory				
Model 1[a]	0	–0.02 (–0.17, 0.14)	0	0.05 (–0.05, 0.15)
Model 2[b]	0	–0.07 (–0.22, 0.08)	0	0.07 (–0.03, 0.17)
Model 3[c]	0	–0.07 (–0.22, 0.08)	0	0.08 (–0.02, 0.17)
Immediate memory				
Model 1	0	–0.02 (–0.09, 0.04)	0	0.01 (–0.03, 0.06)
Model 2	0	–0.04 (–0.11, 0.02)	0	0.02 (–0.02, 0.06)
Model 3	0	–0.04 (–0.11, 0.02)	0	0.02 (–0.02, 0.06)
Delayed memory				
Model 1	0	–0.00 (–0.07, 0.07)	0	0.01 (–0.04, 0.06)
Model 2	0	–0.02 (–0.09, 0.05)	0	0.02 (–0.03, 0.07)
Model 3	0	–0.02 (–0.09, 0.05)	0	0.02 (–0.03, 0.07)
Working memory				
Model 1	0	–0.01 (–0.09, 0.07)	0	0.03 (–0.01, 0.07)
Model 2	0	–0.02 (–0.10, 0.06)	0	0.04 (–0.00, 0.07)
Model 3	0	–0.02 (–0.10, 0.06)	0	0.04 (–0.00, 0.08)

General linear regression models were used to obtain coefficients (β [95% CI]) for the change in memory scores for individuals with cataract surgery vs those without.

[a]Model 1 was adjusted for age and gender.

[b]Model 2 was adjusted for Model 1 plus education, smoking, alcohol intake, physical activity, and memory score (living area was additionally adjusted for in CHARLS) at baseline.

[c]Model 3 was adjusted for model 2 plus body mass index, hypertension, diabetes, heart disease, stroke, lung disease, psychiatric disorders, arthritis, and cancer at baseline.

TABLE 5. The Change in Memory Scores Associated With Glaucoma

	Glaucoma: China		Glaucoma: United States	
	No, β (95% CI) (n=8,240)	Yes, β (95% CI) (n=75)	No, β (95% CI) (n=4,183)	Yes, β (95% CI) (n=262)
Composite score				
Model 1[a]	0	–0.06 (–0.29, 0.16)	0	–0.03 (–0.18, 0.11)
Model 2[b]	0	–0.11 (–0.33, 0.10)	0	–0.01 (–0.15, 0.13)
Model 3[c]	0	–0.11 (–0.33, 0.10)	0	–0.01 (–0.16, 0.13)
Immediate memory				
Model 1	0	0.02 (–0.07, 0.12)	0	–0.02 (–0.09, 0.04)
Model 2	0	–0.00 (–0.09, 0.09)	0	–0.01 (–0.07, 0.05)
Model 3	0	0.00 (–0.09, 0.09)	0	–0.01 (–0.07, 0.05)
Delayed memory				
Model 1	0	–0.07 (–0.18, 0.03)	0	–0.00 (–0.08, 0.07)
Model 2	0	–0.10 (–0.19, 0.00)	0	0.01 (–0.07, 0.08)
Model 3	0	–0.10 (–0.19, 0.00)	0	0.01 (–0.07, 0.08)
Subtraction calculation				
Model 1	0	0.01 (–0.11, 0.12)	0	–0.03 (–0.08, 0.03)
Model 2	0	–0.01 (–0.12, 0.10)	0	–0.02 (–0.08, 0.03)
Model 3	0	–0.01 (–0.13, 0.10)	0	–0.02 (–0.08, 0.03)

General linear regression models were used to obtain coefficients (β [95% CI]) for the change in memory scores for individuals with glaucoma vs those without.

[a]Model 1 was adjusted for age and gender.

[b]Model 2 was adjusted for Model 1 plus education, smoking, alcohol intake, physical activity, and memory score (living area was additionally adjusted for in CHARLS) at baseline.

[c]Model 3 was adjusted for model 2 plus body mass index, hypertension, diabetes, heart disease, stroke, lung disease, psychiatric disorders, arthritis, and cancer at baseline.

reported that hearing loss in midlife is the most important modifiable risk factor for dementia,[7] but vision, as another important sense, is linked to dementia in fewer longitudinal studies. The vasculature of the eye and brain shares several common characteristics,[27,28] and the retina is a reliable marker of dementia and mild cognitive impairment,[29] partly explaining the association between vision impairment and cognitive decline. Vision impairment may be associated with an increased risk of cognitive load, brain structure damage, social isolation, and reduced activity,[10] resulting in an accelerated rate of cognitive decline.

We found that distance vision impairment is associated with a larger decrease in memory, especially immediate and delayed memory, in both China and the United States. Our analysis showed individuals with distance vision impairment were more likely to have a lower education and a higher prevalence of psychiatric disorders, diabetes, and hypertension, which are well-known risk factors for dementia. Adjustment for these covariates did not substantially change the association between distance vision impairment and change in memory, suggesting the potential effects of vision impairment on memory decline may be via other pathways. Consistent with our study, the data from the Singapore Epidemiology of Eye Diseases study of 2478 individuals (1073 Chinese, 768 Indian, and 637 Malay adults) with a mean age of 67.6 years demonstrated that distance vision impairment at baseline was associated with a decrease in cognition over 6 years (β [95% CI]: −0.27 [−0.37, −0.17]).[19] Another longitudinal study of 2520 community-residing US adults aged 65-84 years reported that distance vision impairment was associated with declining cognitive function over time.[18] However, those studies focused on global cognition but not key memory domains such as immediate, delayed, and working memory. Our findings were supported by a longitudinal study showing that distance vision impairment was associated with memory decline over 2 years.[30] Our further analysis of the HRS cohort showed a significant interaction between age and distance vision impairment for memory decline, with an inverse association between distance vision impairment and memory decline observed in those aged <65 years. This finding is consistent with a longitudinal study of 8,253 individuals demonstrating that the inverse association between vision impairment and incident dementia was significant in those aged 50-69 years (hazard ratio [95% CI]: 3.60 [1.10-11.78]) but not in those aged ≥ 70 years (1.24 [0.69-2.22]).[14] Distance vision impairment was associated with a higher decrease in working memory in the United States but not in China. The age difference between 2 cohorts might partly explain the inconsistent findings, but exact mechanisms need to be explored in future research.

We found that near vision impairment was associated with a decline in delayed memory in China and a decline in composite, immediate, and delayed memory in the United States. The association between near vision impairment and cognition has been reported in a few previous studies. A cross-sectional study of 190 older Israeli adults aged ≥ 75 years showed that near vision impairment was associated with worse cognitive function.[31] In the analysis of the National Health and Nutrition Examination Survey of 2975 respondents aged ≥ 60 years, near vision impairment was associated with worse cognitive function but not higher odds of vision impairment.[32] A longitudinal analysis of 2140 Mexican Americans aged ≥ 65 years reported that near vision impairment was associated with an annual cognitive decrease of 0.13 points.[33] Again, these studies did not analyze whether near vision impairment was associated with memory at different domains. Near vision impairment was associated with a higher decrease in immediate and delayed memory but not in working memory. This may be due to the fact that immediate and delayed memory tasks are more likely to depend on sensory stimulus that is sensitive to changes with age.[34,35] Our study based on nationally representative populations in China and the United States provides evidence on the association between near vision impairment and immediate and delayed memory decline.

Participants in China were more likely to report poor vision but less likely to report a diagnosis of glaucoma or cataract surgery than those in the United States. The participants in China may have had lower education and economic and social support to screen and treat vision problems. The magnitude of the inverse association between vision impairment and change in memory was larger in the United States than in China. This may be attributed to the older age of participants in the United States than in China, resulting in a larger decrease in memory in the United States. Participants in the United States who reported vision impairment might have more severe eye problems than those in China. Therefore, vision impairment had a stronger association with memory in the United States than in China. As 81.2% of people blind or vision impaired in 2015 had a preventable or treatable cause, our findings suggest screening and treating for vision impairment in older adults may help prevent or delay memory decline and the development of dementia.

Some previous studies have demonstrated the potential benefits of cataract surgery for cognitive function.[36] More recently, several studies did not find a significant association between cataract surgery and cognition.[37,38] We found that cataract surgery was not associated with memory decline in either China or the United States. The memory decline in individuals with cataract surgery was compared to those without cataract surgery in our study, but memory decline between cataract patients with and without surgery may be more comparable. However, this analysis cannot be conducted in our study because the data on cataract are not available. We found that glaucoma was not significantly associated with cognitive decline over time in either China or the United States. Several cross-sectional studies with small sample sizes have shown an inverse association between glaucoma and cognitive function,[39] and the effect may be stronger for executive function[40] and verbal working memory.[41] Cross-sectional analysis of our study showed that glaucoma was inversely associated with cognitive function, especially subtraction calculation, in the United States but not in China (data not shown). Our findings based on 2 populations with different backgrounds demonstrated that glaucoma might not be a reliable predictor for the change in memory.

The strengths of the present study included the large sample size of 2 nationally representative populations in China and the United States. This study also uniquely examined whether the association between vision impairment and memory decline was modified by age, gender, smoking, and education. The present study has potential limitations. First, self-reported vision impairment in our study might result in measurement errors, although a significant association between self-reported and objectively measured eyesight has been reported.[42] Second, it is also possible that cognitive decline may exacerbate vision impairment as previous studies have shown that sensory and motor regions of the central nervous system are affected by Alzheimer disease pathology.[43,44] Third, a large proportion of individuals with cataract who were not surgically treated in China, especially among rural areas, and those who underwent cataract surgery might have higher income and education,[45,46] which might bias the association between cataract surgery and cognition. More than half of glaucoma cases remained undiagnosed, even in developed countries such as the United States.[47] This may bias the association between glaucoma and cognitive decline towards the null. Third, the data on vision impairment and eye diseases were collected in several waves (1998, 2006, and 2012) in HRS, which did not allow us to perform repeated measures associations.

In conclusion, distance vision impairment was independently associated with a higher decrease in memory in both China and the United States. Near vision impairment was predictive of the decline in delayed memory in China and the decline in composite, immediate, and delayed memory in the United States.

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Distance vision impairment was associated with a higher decrease in composite and immediate memory in both China and the United States. Near vision impairment was inversely associated with an annual change in delayed memory in China and in composite, immediate, and delayed memory in the United States. Cataract surgery or glaucoma was not significantly associated with memory decline in either country. Screening and treating vision impairment may help delay/prevent memory decline in older adults.

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