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IZA DP No. 15934

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ISSN: 2365-9793

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ABSTRACT

Cognitive Misperception and Chronic Disease Awareness: Evidence from Blood Biomarker Data

Cognitive misperception contributed to poor decision-making; yet their impact on health-related decisions is less known. We examined how self-perceived memory was associated with chronic disease awareness among older Chinese adults. Data were obtained from the China Health and Retirement Longitudinal Study. Nationally representative blood biomarkers identify participants' dyslipidemia and diabetes status. Among participants with biomarker identified dyslipidemia or diabetes, disease awareness was defined as self-reported diagnosis of the conditions. The proportions of disease awareness were lower for individuals with better self-perceived memory and those with more impaired cognitive ability, showing opposite patterns. Controlling for cognitive ability and covariates, self-perceived memory was negatively associated with the dyslipidemia and diabetes awareness. In particular, older adults with the highest level of self-perceived memory had significantly lower disease awareness as compared to those with the lowest level of self-perceived memory. Our findings were robust to alternative cognitive measures and were stronger for less educated rural residents or those living without children. Cognitive misperception poses great challenges to chronic disease management. Targeted interventions and supports are needed, particularly for the disadvantaged.

JEL Classification: I12, J14, D91, I18

Keywords: cognitive impairment, self-perceived memory, chronic disease awareness, dyslipidemia, diabetes

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1. Introduction

Cognitive functioning is critical as in our daily life a host of complex and high-stakes decisions and a wide spectrum of activities rely on cognitive health (Agarwal and Mazumder, 2013; Livingston et al., 2020; Smith et al., 2010; Winblad et al., 2016). As population ages, deterioration in cognition can substantially impact individuals, families, and societies (Alzheimer's Disease International, 2019; Liverman et al., 2015; Winblad et al., 2016). Today, an estimated 55 million people worldwide live with dementia, with annual total costs above 1 trillion US dollars (Alzheimer's Disease International, 2021). Other less tangible costs, such as those related to decision-making, are rarely accounted for especially in the preclinical stages of dementia (Agarwal and Mazumder, 2013; Alzheimer's Association, 2019; Livingston et al., 2020; Smith et al., 2010; Winblad et al., 2016).

Given the crucial role of decision-making in people's well-being, it is of great value to understand how cognition may affect impactful decisions and planning. This is particularly important for older adults, who often make life-altering financial and health decisions that can be greatly influenced by cognitive aging (Agarwal et al., 2009; Griffith et al., 2005). Existing literature suggests that impaired cognitive intelligence and cognitive misperception can lead to poor decision-making in older ages (Agarwal et al., 2009; Amaral et al., 2022; Feil et al., 2012; Griffith et al., 2005; Jessen et al., 2014; Nicholas et al., 2021; Shin, 2021; Yu et al., 2022). Research has increasingly shown that cognitive impairment is linked to a lack of capacity in abstract thinking and executive function and may have large impact on decision-making (Feil et al., 2012; Nicholas et al., 2021). Cognitive misperception, on the other hand, may also greatly contribute to suboptimal decisions but has been discussed to a lesser extent (Centers for Disease Control and Prevention, 2019; Jessen et al., 2014), with most studies focusing on financial decisions (Nicholas et al., 2021; Shin, 2021; Widera et al., 2011; Yu et al., 2022). In particular, there is limited evidence linking the cognition (especially cognitive misperception) with health decision-making and planning. The lack of evidence on health-related decision-making is concerning as conceptually the declining cognitive function and misperception may challenge individuals' ability to manage health conditions through barriers to detect their health changes and seek proper health services (Centers for Disease Control and Prevention, 2019; Feil et al., 2012; Jessen et al., 2014).

To this end, chronic disease awareness, which involves many health-related decisions, is worth thorough investigation because it has very profound impacts on older adults' long-term wellbeing and might be greatly influenced by cognitive misperception in older ages (Amaral et al., 2022; Gautam et al., 2015). In particular, while other health misperceptions is found to hinder individuals from preventing heart disease (Brnstrm and Brandberg, 2010; Radcliffe and Klein, 2002), visiting the doctor for preventive care (Spitzer and Shaikh, 2022), or choosing a healthy lifestyle (Brewer et al., 2007), no evidence has linked cognitive misperception with a lack of awareness of chronic diseases. Assessing this relationship may provide novel and valuable insights into policy and interventions, especially for developing countries with inadequate disease control and prevention like China. Therefore, using nationally representative blood biomarkers and cognition data from China, this study aimed to understand how cognitive misperception was associated with chronic disease awareness among older adults.

The link between cognitive misperception and chronic disease awareness can be particularly salient in China as it faces notable challenges in both these two aspects. Chinese older adults generally have large risks of cognitive aging and great shortage in cognitive screening, which result in severe underdiagnosis issue. About 15 million older adults age 60 years or older have dementia and 39 million older adults have mild cognitive impairment in China (Jia et al., 2020a), with only a small proportion of them realizing their decline or impairment in cognition (Jia et al., 2020b). In our study, we showed that such cognitive misperception is evident among Chinese older adults: the actual cognitive ability (including memory) and self-perceived memory diverge greatly over age, with an increasingly enlarged gap between actual and self-perceived memory among older adults. On the other hand, chronic disease awareness is of serious concern in China. More than 180 million Chinese older adults have chronic diseases (National Health Commission of the People's Republic of China, 2019); however, a large proportion of them are unaware of their underlying diseases and conditions (Li and Lumey, 2019). Previous studies mostly attributed the low disease awareness to health system deficits (Xu et al., 2013; Zhao et al., 2016), yet little is known about the contribution of cognitive impairment and its misperception.

Our study fills this gap by examining how self-perceived memory is associated with dyslipidemia and diabetes awareness conditional on cognitive ability. We focus on these two chronic conditions because they are highly prevalent but inadequately controlled in China with very low awareness rates (<50%) (Li and Lumey, 2019; Song et al., 2019; Xu et al., 2013; Zhao et al., 2016). Their high prevalence also ensures adequate sample size for investigation. Moreover, as the diagnosis and management of these two conditions only require regular blood tests and doctor visits, the awareness of the diseases may rely less on health resources but more heavily on individuals' ability or willingness to detect health changes and seek proper health services. In other words, cognitive misperception likely impacts the dyslipidemia and diabetes awareness to a large extent, especially for those who have more disadvantaged socioeconomic conditions with greater vulnerability in disease management and control. Previous studies proposed that overconfidence might contribute to greater disease unawareness for diseases like diabetes (Gautam et al., 2015), but the association between cognitive misperception and disease awareness remains undetermined. Therefore, in our study, we tested and corroborated the hypotheses that, adjusting for cognitive ability, self-perceived memory is negatively associated with dyslipidemia and diabetes awareness; and the association is stronger for older adults in more disadvantaged sociodemographic groups.

2. Research Design and Methods

2.1 Data and Study Participants

Data were obtained from the China Health and Retirement Longitudinal Study (CHARLS), a nationally representative study of Chinese adults aged 45 or older. A comprehensive set of sociodemographic and health information was collected for over 20,000 individuals and 11,000 households, covering 150 counties and 28 provinces randomly sampled in China. The CHARLS national baseline survey was fielded in 2011-2012, and the follow-up surveys were conducted in 2013, 2015, and 2018, respectively. Detailed information on ethical approval, sampling design, informed consent, response rates and survey content of CHARLS can be found elsewhere (Zhao et al., 2020).

In CHARLS, venous blood samples were collected in 2011/2012 (11,847 participants) and in 2015 (13,013 participants) by medically trained staff from the Chinese Center for Disease Control and Prevention (CDC), after obtaining informed consent from study participants (Zhao et al., 2020, 2016). Cognitive function was assessed in each wave primarily using the Telephone Interview for Cognitive Status (TICS) and the CERAD immediate and delayed word recall. Starting in 2018, CHARLS conducted an expanded set of cognitive tests for older adults aged 60 years and over, including Mini-Mental State Exam (MMSE) and other cognitive instruments. These tests have been well validated and widely used to assess individuals' cognitive functioning and stages of cognitive impairment or dementia (Borenstein and Mortimer, 2016). Self-perceived memory was also measured in the survey.

Our study sample was constructed using CHARLS 2015 blood biomarkers data and CHARLS 2018 survey data. Specifically, we linked blood biomarkers that evaluate participants' risks of diabetes and dyslipidemia with their self-perceived memory and chronic disease awareness. We obtained 4,578 persons aged 60 or older with complete assessments of disease risks (via blood biomarkers), awareness, cognition, and covariates. We further identified 1,442 persons with dyslipidemia and 759 persons with diabetes based on blood biomarkers. They were respectively included as the dyslipidemia sample and the diabetes sample in our analysis. The detailed sample selection process is presented in **Figure 1**.

[Figure 1 about here]

2.2 Cognitive ability and Self-perceived Memory

Participants were asked to rate their own memory at the time of the survey as a measure of self-perceived memory. The response was measured on a five-point Likert scale ranging from excellent (1) to poor (5) (Shin, 2021). We reverse-coded the variable with five levels, including poor (1), fair (2), good (3), very good (4), and excellent (5) (see **Supplementary Table 4**). As relatively few participants reported good, very good, or excellent, we combined the three categories as "good+" when treating self-perceived memory as a categorical variable.

Cognitive ability was treated as a control variable in the study and was primarily assessed by the Mini-Mental State Examination (MMSE), a 30-point scale with higher score indicating better cognitive performance (Folstein et al., 1975). As a validated cognitive instrument, MMSE is widely used in clinical settings to evaluate the global cognitive function and the status of cognitive impairment (CI) (Folstein et al., 1975). Following the literature, a small number of unanswered responses in MMSE were coded as zero to reduce sample attrition (Herzog and Wallace, 1997; Zhang et al., 2008); and participants were classified into three groups with well-established cut-offs: no-CI ($24 \leq MMSE \leq 30$); mild-CI ($18 \leq MMSE \leq 23$); and severe-CI ($0 \leq MMSE \leq 17$) (Tombaugh and McIntyre, 1992). Moreover, the memory component of MMSE (range: 0-6) and the CERAD immediate and delayed word recall assessed in CHARLS (range: 0-20) were included as alternative measures of cognitive ability, as they more directly measure individuals' memory function.

2.3 Chronic Diseases Awareness

This study investigated two chronic diseases, i.e., dyslipidemia and diabetes, that can be clearly assessed using CHARLS blood biomarkers collected in 2015. Based on established clinical guideline (World Health Organization, 2016; Zhu et al., 2018), a participant was considered to have dyslipidemia when total cholesterol (TC) ≥ 240 mg/dL (6.22 mmol/L), or low-density lipoprotein cholesterol (LDL- C) ≥ 160 mg/dL (4.14 mmol/L), or high-density lipoprotein cholesterol (HDL-C) < 40 mg/dL (1.04 mmol/L), or triglyceride (TG) ≥ 200 mg/dL (2.26 mmol/L) (Song et al., 2019); and was considered to have diabetes when fasting plasma glucose level ≥ 126 mg/dL (7.0 mmol/L), or HbA1c concentration ≥ 6.5 % (Zhao et al., 2016).

Awareness of the diseases was respectively defined as having ever been diagnosed of dyslipidemia (for dyslipidemia sample) and diabetes (for diabetes sample), as of the 2018 survey, i.e., three years after biomarker-based assessments in 2015. While the time gap between the assessment of biomarkers and survey responses prevents us from measuring instant disease awareness, it allowed survey subjects time to learn their chronic disease status.

2.4 Statistical Analysis

To compare the characteristics across older adults with different levels of disease awareness, cognitive ability and self-perceived memory, we performed χ^2 test for categorical variables, and Welch's t-test or one-way ANOVA for continuous variables (Lehmann et al., 2005).

Multivariate logistic regressions were employed to examine the relationship between self-perceived memory and the awareness of dyslipidemia (for dyslipidemia sample) and diabetes (for diabetes sample). The regressions adjusted for cognitive ability and a wide spectrum of covariates, including age, sex, education, rural/urban hukou registration status, rural/urban residence status, marital status, activities of daily living (ADL), instrumental activities of daily living (IADL), depressive symptoms, any other chronic diseases, health insurance, living arrangement, and the number of living children. Self-perceived memory was treated as continuous (i.e., 1-5) in our main specification; and the categorical specification of self-perceived memory (i.e., poor, fair, good+) was also tested to explore potential non-linear patterns. Individuals' cognitive ability was mainly controlled for using their cognitive impairment status (i.e., no-CI, mild-CI, severe-CI), as this classification has clearer clinical implications. As sensitivity analyses, we run the regressions adjusting for alternative measures of cognitive ability, including the total score of MMSE (range: 0-30), the memory score of MMSE (range: 0-6), and the total score of immediate and delayed word recall (range: 0-20). The results were robust to these alternative specifications and measurements.

The regressions were performed on the whole sample as well as subsamples stratified by individual sociodemographic characteristics. Stratifying characteristics included rural/urban hukou status (rural vs urban), education (below primary school vs primary school or above) and living arrangement (with vs without children). Regressions were weighted using inverse probability weights that correct for non-response to blood biomarker collection (Zhao et al., 2016); and standard errors were robust and clustered at the county level. All tests were two-sided with an alpha level of 0.05 for statistical significance and the analyses were carried out using STATA 17.0.

3. Results

The characteristics of study participants are presented in **Table 1**. Among older adults identified with dyslipidemia (N = 1,442) or diabetes (N = 759) by blood biomarkers (referred to hereafter as "patients"), the disease awareness rates were only 38.0% (n = 548) for dyslipidemia and 58.1% (n = 441) for diabetes as of 2018. Patients who reported better self-perceived memory were less likely to be aware of chronic diseases for both dyslipidemia ($P = 0.030$) and diabetes ($P = 0.041$). By contrast, patients with better cognitive ability were more likely to be aware of the diseases ($P < 0.001$ for dyslipidemia; $P = 0.007$ for diabetes). Additionally, patients who were female, more educated, urban residents, had other chronic diseases, or covered by more generous health insurance (e.g., urban employee medical insurance or public sector medical insurance) tended to have better disease awareness.

[Table 1 about here]

Characteristics stratified by self-perceived memory were also reported (**Supplementary Table 1**). Although patients with greater self-perceived memory tended to have better cognitive ability measured by MMSE ($P < 0.001$), over 45% of those who felt confident in their memory (i.e., Good+) had mild-CI or severe-CI (27.4 + 17.9 = 45.3% in the dyslipidemia sample; 19.6 + 25.8 = 45.4% in the diabetes sample), indicating a salient gap between cognitive ability and self-perceived memory. Additionally, the trends of self-perceived and cognitive ability across ages were also divergent (see **Supplementary Figure 1**). While the cognitive ability reduced markedly with age, the average level of self-perceived memory remained quite stable over age relative to the benchmark level at age 60, resulting in an increasingly enlarged gap.

Figure 2 illustrates the pattern of disease awareness by cognitive impairment status and by self-perceived memory. Overall, the proportions of disease awareness were higher for cognitively intact patients, while the proportions were lower for those with better self-perceived memory, showing an opposite pattern. The negative relationship between self-perceived memory and disease awareness persisted for each level of cognitive impairment. Most notably, among older adults with mild-CI, 42.3% of patients with poor self-perceived memory were aware of their dyslipidemia, while the proportion of disease awareness was much lower among patients with fair (33.1%) or good+ (17.4%) self-perceived memory (P = 0.007, chi-square test).

[Figure 2 about here]

The observed patterns were corroborated by our regression analyses when adjusting for covariates. As shown in **Table 2**, conditional on individuals' cognitive ability (cognitive impairment status), self-perceived memory was negatively associated with dyslipidemia awareness (Column 1). Relative to those with poor self-perceived memory, individuals who perceived their memory as fair (OR = 0.65; 95% CI = [0.47, 0.91]) or good+ (OR = 0.51; 95% CI = [0.28, 0.94]) were less likely to aware of their dyslipidemia condition (Column 1, Panel B). The effect of self-perceived memory on dyslipidemia awareness was not significant at 5% level (OR = 0.80; 95% CI = [0.63, 1.02]; P = 0.076) when using continuous specification (Column 1, Panel A), suggesting a non-linear pattern. On the other hand, with regard to diabetes, there was a strong and significant negative association between self-perceived memory and diabetes awareness (Column 5). Higher self-perceived memory was associated with lower diabetes awareness (OR = 0.71; 95% CI = [0.55, 0.92]) when using continuous specification (Column 5, Panel A). Particularly, diabetes awareness was significantly lower for patients who perceived their memory as good+ (OR = 0.42; 95% CI = [0.21, 0.84]) relative to those with poor self-perceived memory (Column 5, Panel B). The sensitivity analyses further indicate that the results for self-perceived memory were fairly robust to the alternative controls of cognitive ability, including the total score of MMSE (Columns 2 and 6), the memory score of MMSE (Columns 3 and 7), and the score of word recall (Columns 4 and 8). Lastly, consistent with our descriptive findings, older adults with lower cognitive ability were less likely to be aware of the diseases (Supplementary Figure 2 and 3), showing an opposite pattern to the self-perceived memory. All these findings were robust to the additional control of biomarkers and disease severity.

[Table 2 about here]

Our stratified analyses further demonstrate that the negative association between self-perceived memory and disease awareness were stronger among patients with more disadvantaged sociodemographic characteristics (**Figure 3**). Specifically, controlling for cognitive ability and covariates, better self-perceived memory was significantly associated with lower dyslipidemia awareness only among older adults with rural hukou status (OR = 0.73; 95% CI = [0.57, 0.94]; P = 0.016) and those with lower education (OR = 0.61; 95% CI = [0.44, 0.85]; P = 0.003). Meanwhile, self-perceived memory had larger and more significant negative effects on diabetes awareness among older adults living without children (OR = 0.61; 95% CI = [0.45, 0.83]; P = 0.002) than those with children.

[Figure 3 about here]

4. Discussion and Implications

In addition to deteriorated cognitive functioning, biases in perceived cognitive ability may profoundly impact decision-making and wellbeing, imposing tremendous burden on individuals, families, and societies; yet, how they affect health-related decision-making and outcomes such as chronic disease awareness is largely under-studied. Using nationally representative data with blood biomarkers and cognitive assessments, this study provided initial evidence on how self-perceived memory was associated with the dyslipidemias and diabetes awareness. Several findings of this study warrant further discussion. First, we revealed that overconfidence in cognitive ability was an emerging issue among Chinese older adults; and individuals with higher self-perceived memory were less likely to be aware of their underlying dyslipidemias and diabetes conditional on cognitive ability (i.e., negative association). Moreover, we found that the negative associations between self-perceived memory and disease awareness were stronger among older adults with lower education, rural Hukou status and living without children relative to others. Lastly, we showed that the disease awareness was lower among older adults with poorer cognitive ability, showing an opposite pattern to self-perceived memory.

First of all, we showed that older adults often overestimate their cognitive abilities, which can lead to a lack of awareness of their chronic health problems. In line with previous studies (Haavisto, 2017; Rickenbach et al., 2015), we found that unrealistic optimism towards cognitive ability are common, especially for individuals with poorer cognitive functioning. Existing literature implies that cognitive misperception can be an early sign of cognitive impairment (Roberts et al., 2009), which often leads to poor financial decisions and outcomes (Grežo, 2020;

Shin, 2021; Yu et al., 2022). In this study, we advanced the literature by investigating the adverse effects of cognitive misperception on health-related decision-making and outcomes, and confirmed the hypothesis of its association with disease awareness (Amaral et al., 2022; Gautam et al., 2015). In particular, our finding of negative association between self-perceived memory and disease awareness is consistent with existing theories.

Conceptually, cognitive misperception might contribute to chronic disease unawareness via two channels: both motivational and informational. People who have too much confidence in their cognitive skills might be less likely to consider the potential health risks that could affect them, which in turn reduces their motivation to use health-related knowledge to take action or practice (Bénabou and Tirole, 2002). In addition, older adults who incorrectly process their memories initially might later largely disregard the new health-related information (Gottlieb, 2010). In Low and Middle Income Countries (LMIC), especially where health resources are scarce and often unequally distributed, people with cognitive misperception are more likely to disregard health information, thereby making it harder to be aware of chronic conditions (Heine et al., 2021). In China, older adults often self-diagnose or self-medicate instead of visiting formally trained doctors when confronted with non-acute pain or illness (Chang et al., 2017). It is likely that overestimating cognitive ability may lead to an overly optimistic opinion of their own health changes (Schwarzer and Fuchs, 1996), thus making them less likely to seek medical help. Additionally, cognitive misperception can lead to more use of heuristics in decision-making and lowers the accuracy of self-assessment and disease awareness (Besedeš et al., 2012). Many believe their health conditions are not serious enough for medical treatment or are simply unaware of their actual health risks, especially for those with poor cognitive abilities but are overly optimistic. Our findings on chronic disease awareness thus emphasize the importance of promoting regular assessment of cognitive abilities among older adults, improving the accuracy of their perceived cognitive abilities, and encouraging them to seek help and advice for decision-making.

Second, we demonstrated that the negative association between self-perceived memory and disease awareness were stronger among older adults with more disadvantaged sociodemographic characteristics. In particular, older adults with lower education, rural hukou status, or living without children were affected more by their self-perceived memory, leading to significantly lower levels of disease awareness than their more advantaged counterparts. As a major element of human capital, education plays a critical role in health investments and decision-making (Grossman, 2000). Older adults with a lower level of education often have poorer health literacy, and are less capable of making well-informed decisions than those more educated when confronted with diseases (Cho et al., 2008), lowering the chances of disease diagnosis and awareness (Clark et al., 1991). Low education may also increase individuals' susceptibility to self-directed ageism and stigma (Marques et al., 2020), impeding active and self-motivated health-seeking behaviors. Moreover, older adults with rural hukou or living without children generally receive less supports from communities and families, thereby experiencing greater risks of disease ignorance. Despite the critical role of social services and supports for chronic disease prevention, monitoring, and control, long-term care systems in China are still underdeveloped and unequally distributed (Feng et al., 2020), elevating vulnerability to chronic diseases for disadvantaged older adults (Mazzuco et al., 2017). Therefore, multidimensional and integrated supports from the healthcare system, community-based facilities, and families should be provided, with a special focus on the disadvantaged population.

Finally, this study provides novel evidence on the gradient relationship between cognitive impairment and disease awareness. We demonstrated that older adults with mild-CI or severe-CI were much less likely to be aware of dyslipidemia and diabetes than cognitively intact individuals. Disease management is often cognitively demanding and may rely on individuals' health literacy and judgments (Cho et al., 2008). The rates of chronic disease awareness among Chinses older adults were far from satisfactory (Li and Lumey, 2019; Song et al., 2019), especially for those cognitively impaired, which may create barriers for obtaining appropriate treatments (Dyer et al., 2007; Lin and Chen, 2022). Stigma related to CI may also hinder older adults from timely care and social services (Alzheimer's Disease International, 2019). Therefore, more targeted chronic disease screening programs are required, particularly for cognitively impaired individuals.

Some limitations should be noted. First, although nationally representative data were used to examine the relationship between self-perceived memory and chronic disease awareness, the blood biomarker sample may not be large enough for stratified analysis by additional sociodemographic characteristics (e.g., marital status). Future research may use larger datasets of biomarkers to test differences across key population groups. Second, while we hypothesize the association between cognitive misperception and chronic disease awareness might be partially explained by reduced clinical assessments, direct measures on this are lacking in the dataset. Future studies may seek to link with richer data (e.g., electric health records) to directly observe if respondents with cognitive misperception were indeed less likely assessed for diabetes or dyslipidemia and informed of diagnoses. Also, alternative mechanisms under which self-perceived memory could affect disease awareness worth further investigations. For example, self-perceived memory can be an early sign of the disease process or obstacle to recognition of diseases. Finally, this study only examined two prevalent and underdiagnosed diseases with identifiable biomarkers collected in CHARLS. Although it provides informative and suggestive evidence on the topic, the findings may not be generalized to other diseases and settings. Future studies may explore other diseases with larger datasets and richer biomarkers to validate our findings.

Despite these limitations, this study provided first evidence on the association of self-perceived memory with chronic disease awareness among Chinese older adults. Our findings suggest that older adults with greater self-perceived memory were less likely to be aware of their underlying chronic diseases. Additional supports from families and societies are required. Moreover, older adults with rural hukou status, low education or living without children were more vulnerable to cognitive impairment and biases in perceived memory, therefore policies and interventions should prioritize these disadvantaged populations.

Acknowledgements

The IZA Discussion Paper Series serves as a preprint server to deposit latest research for feedback. This work is supported by research awards from the U.S. National Institute on Aging (R01AG077529; K01AG053408); and Claude D. Pepper Older Americans Independence Center at Yale School of Medicine, funded by the National Institute on Aging (P30AG021342). Z.L. and M.F. are joint first authors. Z.L wrote the paper and performed the data analyses. M.F. wrote the paper. X.C planned the study, supervised the data analysis, and revised the paper. The funders had no role in the study design; data collection, analysis, or interpretation; in the writing of the report; or in the decision to submit the article for publication. The authors have no conflict of interest.

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Tables and Figures

Table 1. Characteristics of study population by disease awareness

Table 2. Effects of self-perceived memory on dyslipidemia and diabetes awareness

Figure 1. Flow chart of study participants

Notes: CHARLS=China Health and Retirement Longitudinal Study.

Figure 2. Dyslipidemia awareness and diabetes awareness by self-perceived memory and cognitive ability (cognitive impairment status)

Notes: Estimates in paratheses denote the average level of awareness in each group. For better illustration, 95% confidence interval were not plotted. Statistical differences between groups can be found in Table 1 (and Supplementary Table 1) for descriptive results, as well as in Table 2 (and Supplementary Figure 2) for regression estimates. Abbreviations: No-CI, no cognitive impairment; Mild-CI, mild cognitive impairment; Severe-CI, severe cognitive impairment. Good+ included "good", "very good", and "excellent".

Figure 3. Effects of self-perceived memory on disease awareness for the entire sample as well as for the sample stratified by rural/urban hukou status, education, and living arrangement

Notes: Logistic regressions were performed to examine the association between self-perceived memory on dyslipidemia and diabetes awareness. Plotted points denote the estimated odds ratio of self-perceived memory; horizontal lines denote the 95% confidence interval (95% CI). X axis is plotted at log scale. All the regressions controlled for cognitive ability and covariates. The model and variable specification followed Panel A of Table 2 Column 1 and 5. Full estimation results are shown in Supplementary Table 2 and 3.

Table 1. Characteristics of study population by disease awareness

Variable	Dyslipidemia Sample			p-value	Diabetes Sample			p-value
	All (N = 1,442)	Unaware (n = 894)	Aware (n = 548)		All (N = 759)	Unaware (n = 318)	Aware (n = 441)	
Self-perceived memory								
Poor, No. (%)	429 (29.8)	254 (28.4)	175 (31.9)	0.030	252 (33.2)	95 (29.9)	157 (35.6)	0.041
Fair, No. (%)	845 (58.6)	521 (58.3)	324 (59.1)		410 (54.0)	172 (54.1)	238 (54.0)	
Good+, No. (%)	168 (11.7)	119 (13.3)	49 (8.9)		97 (12.8)	51 (16.0)	46 (10.4)	
Cognitive ability								
No-CI, No. (%)	728 (50.5)	403 (45.1)	325 (59.3)	<0.001	361 (47.6)	138 (43.4)	223 (50.6)	0.007
Mild-CI, No. (%)	465 (32.2)	304 (34.0)	161 (29.4)		262 (34.5)	107 (33.6)	155 (35.1)	
Severe-CI, No. (%)	249 (17.3)	187 (20.9)	62 (11.3)		136 (17.9)	73 (23.0)	63 (14.3)	
Age, mean (SD)	67.5 (5.8)	67.7 (6.0)	67.0 (5.4)	0.014	68.3 (6.0)	68.6 (6.0)	68.1 (6.0)	0.361
Education in years, mean (SD)	5.0 (4.6)	4.5 (4.4)	5.7 (4.8)	<0.001	4.9 (4.7)	4.5 (4.5)	5.2 (4.8)	0.052
Female, No. (%)	705 (48.9)	406 (45.4)	299 (54.6)	0.001	379 (49.9)	148 (46.5)	231 (52.4)	0.112
Rural hukou status, No. (%)	1000 (69.3)	662 (74.0)	338 (61.7)	<0.001	515 (67.9)	239 (75.2)	276 (62.6)	<0.001
Rural residence status, No. (%)	771 (53.5)	525 (58.7)	246 (44.9)	<0.001	399 (52.6)	203 (63.8)	196 (44.4)	<0.001
Married, No. (%)	1187 (82.3)	722 (80.8)	465 (84.9)	0.048	623 (82.1)	254 (79.9)	369 (83.7)	0.178
Depressive symptoms, No. (%)	520 (36.1)	312 (34.9)	208 (38.0)	0.241	282 (37.2)	112 (35.2)	170 (38.5)	0.349
Any ADL limitation, No. (%)	291 (20.2)	160 (17.9)	131 (23.9)	0.006	198 (26.1)	79 (24.8)	119 (27.0)	0.507
Any IADL limitation, No. (%)	350 (24.3)	216 (24.2)	134 (24.5)	0.900	224 (29.5)	79 (24.8)	145 (32.9)	0.017
Any other chronic diseases, No. (%)	1264 (87.7)	737 (82.4)	527 (96.2)	<0.001	693 (91.3)	280 (88.1)	413 (93.7)	0.007
Urban employee MI, No. (%)	294 (20.4)	139 (15.5)	155 (28.3)	<0.001	165 (21.7)	56 (17.6)	109 (24.7)	0.019
Urban-rural residence MI, No. (%)	1087 (75.4)	715 (80.0)	372 (67.9)	<0.001	558 (73.5)	244 (76.7)	314 (71.2)	0.089
Public sector MI, No. (%)	20 (1.4)	7 (0.8)	13 (2.4)	0.012	20 (2.6)	7 (2.2)	13 (2.9)	0.526
Living with children, No. (%)	479 (33.2)	305 (34.1)	174 (31.8)	0.355	231 (30.4)	104 (32.7)	127 (28.8)	0.249
No. of living children, mean (SD)	3.0 (1.5)	3.2 (1.6)	2.9 (1.4)	<0.001	3.1 (1.5)	3.2 (1.5)	3.0 (1.5)	0.054

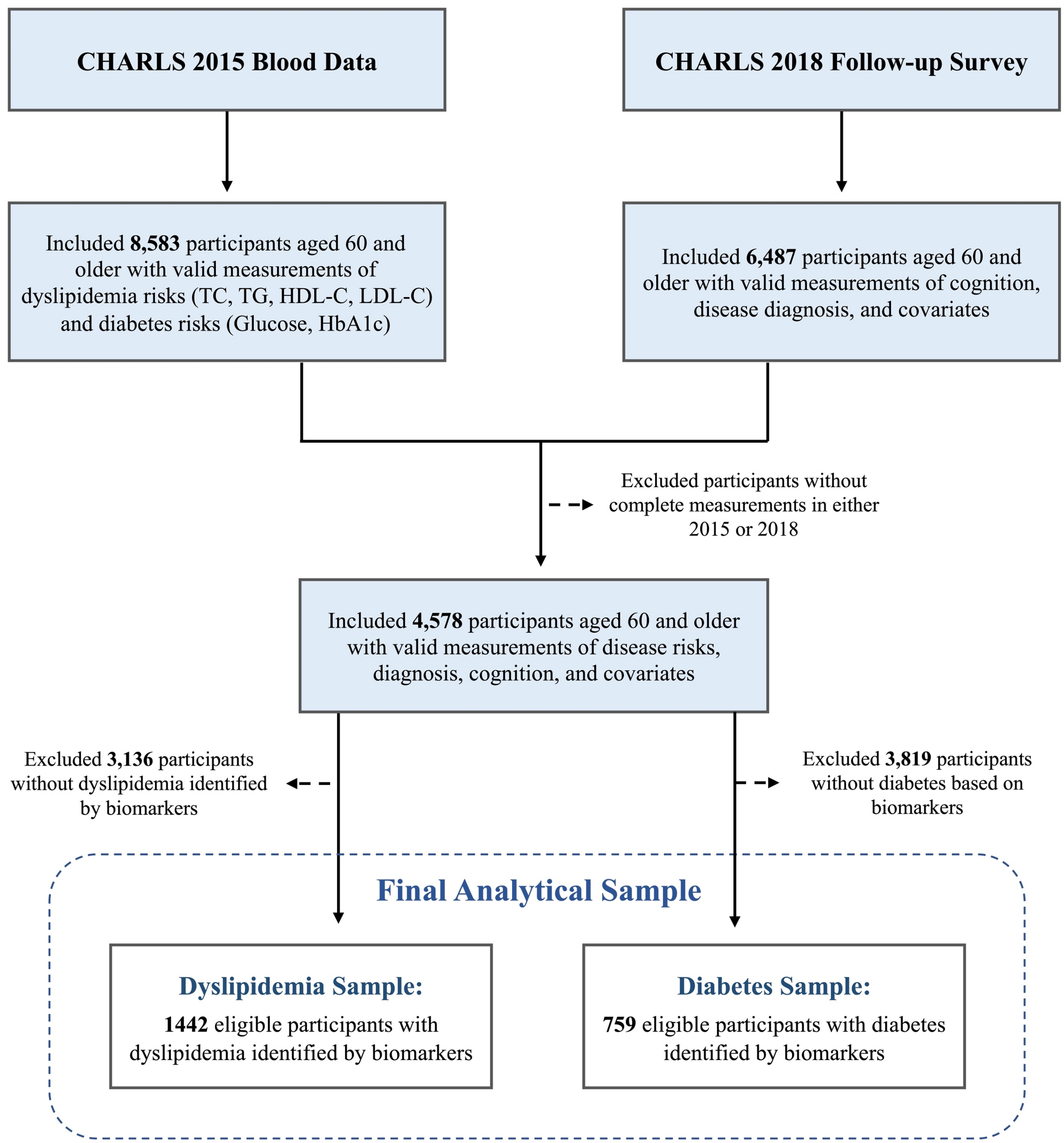
Notes: Cognitive ability was classified based on Mini-Mental State Exam. No-CI=no cognitive impairment; Mild-CI=mild cognitive impairment; Severe-CI=severe cognitive impairment; SD=standard deviation; MI=medical insurance; ADL=activities of daily living; IADL=instrumental activities of daily living. For self-perceived memory, Good+ included "good", "very good", and "excellent".

Table 2. Effects of self-perceived memory on dyslipidemia and diabetes awareness

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Dyslipidemia Awareness OR (95% CI)				Diabetes Awareness OR (95% CI)			
Panel A. Continuous Specification								
Self-Perceived Memory (1-5)	0.80†	0.79†	0.80†	0.79†	0.71**	0.70**	0.70**	0.71**
	(0.63 - 1.02)	(0.62 - 1.01)	(0.63 - 1.02)	(0.60 - 1.03)	(0.55 - 0.92)	(0.54 - 0.91)	(0.54 - 0.90)	(0.55 - 0.92)
MMSE Cog Impairment	YES	NO	NO	NO	YES	NO	NO	NO
MMSE Score 0-30	NO	YES	NO	NO	NO	YES	NO	NO
MMSE Memory Score 0-6	NO	NO	YES	NO	NO	NO	YES	NO
Word Recall Score 0-20	NO	NO	NO	YES	NO	NO	NO	YES
Panel B. Categorical Specification								
Self-Perceived Memory (Ref. Poor)								
Fair	0.65*	0.65*	0.68*	0.60**	0.77	0.77	0.78	0.80
	(0.47 - 0.91)	(0.47 - 0.90)	(0.49 - 0.95)	(0.43 - 0.84)	(0.53 - 1.12)	(0.53 - 1.11)	(0.54 - 1.13)	(0.53 - 1.21)
Good+	0.51*	0.50*	0.52*	0.49*	0.42*	0.40*	0.40**	0.42*
	(0.28 - 0.94)	(0.27 - 0.92)	(0.29 - 0.96)	(0.26 - 0.93)	(0.21 - 0.84)	(0.20 - 0.82)	(0.20 - 0.80)	(0.21 - 0.86)
MMSE Cog Impairment	YES	NO	NO	NO	YES	NO	NO	NO
MMSE Score 0-30	NO	YES	NO	NO	NO	YES	NO	NO
MMSE Memory Score 0-6	NO	NO	YES	NO	NO	NO	YES	NO
Word Recall Score 0-20	NO	NO	NO	YES	NO	NO	NO	YES

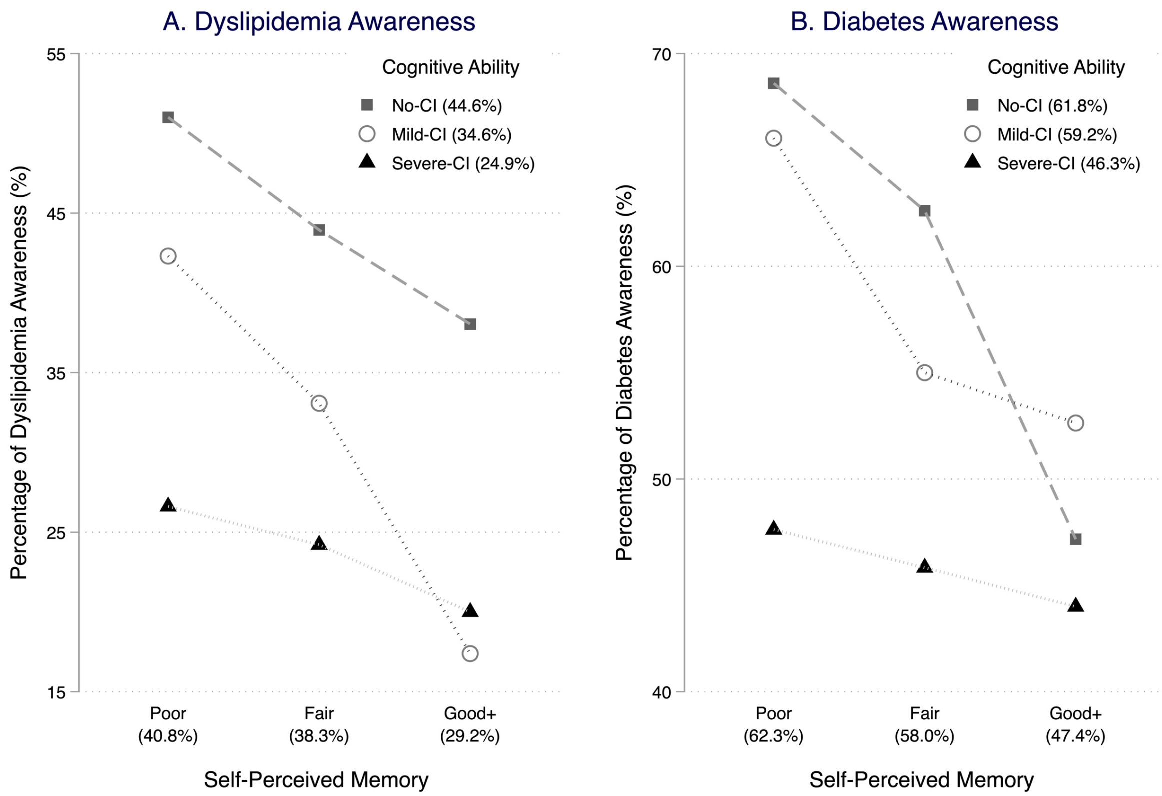
Notes: Logistic regression was performed for each of the two outcome variables, controlling for cognitive impairment with different assessment across columns. Panel A used continuous specification of self-perceived memory (i.e., 1-5), while Panel B used categorical specifications of self-perceived memory (i.e., poor, fair, good+). All the regression models controlled for age, gender, education, rural/urban hukou status, rural/urban residence status, marital status, depressive symptoms, ADL, IADL, other chronic diseases, health insurance, living arrangement, and number of living children. Regressions were weighted, with sample weights that have corrections for blood non-response using inverse probability weights. Standard errors were robust and clustered at county level. Abbreviations: OR, odds ratio; 95% CI, 95% confidence interval; No-CI, no cognitive impairment; Mild-CI, mild cognitive impairment; Severe-CI, severe cognitive impairment. MMSE, Mini Mental State Exam. Statistical significance: *** $p<0.001$, ** $p<0.01$, * $p<0.05$, $^{\dagger}p<0.10$.

Figure 1. Flow chart of study participants



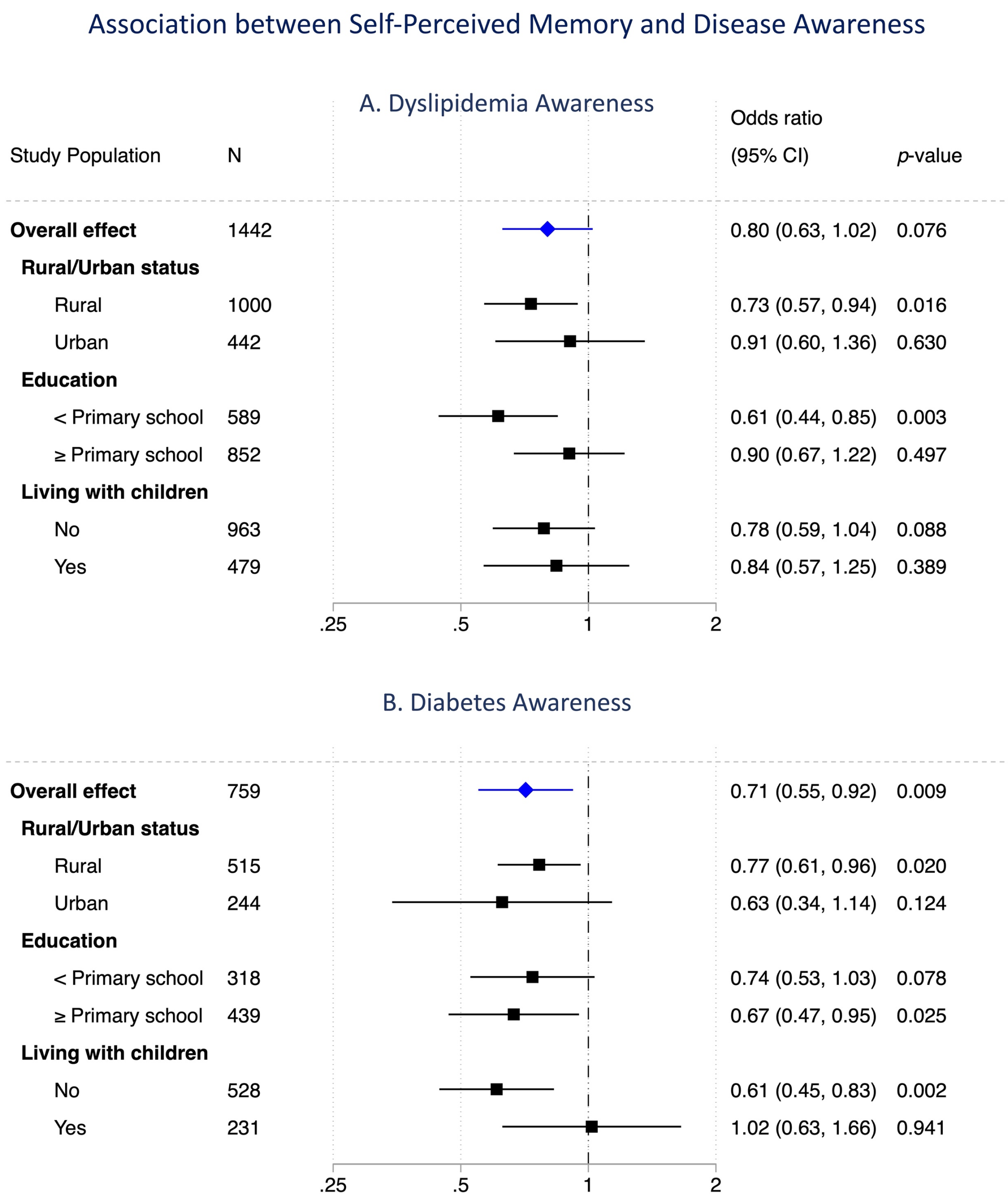
Notes: CHARLS=China Health and Retirement Longitudinal Study.

Figure 2. Dyslipidemia awareness and diabetes awareness by self-perceived memory and cognitive ability (cognitive impairment status)



Notes: Estimates in paratheses denote the average level of awareness in each group. For better illustration, 95% confidence interval were not plotted. Statistical differences between groups can be found in Table 1 (and Supplementary Table 1) for descriptive results, as well as in Table 2 (and Supplementary Figure 2) for regression estimates. Abbreviations: No-CI, no cognitive impairment; Mild-CI, mild cognitive impairment; Severe-CI, severe cognitive impairment. Good+ included "good", "very good", and "excellent".

Figure 3. Effects of self-perceived memory on disease awareness for the entire sample as well as for the sample stratified by rural/urban hukou status, education, and living arrangement



Notes: Logistic regressions were performed to examine the association between self-perceived memory on dyslipidemia and diabetes awareness. Plotted points denote the estimated odds ratio of self-perceived memory; horizontal lines denote the 95% confidence interval (95% CI). X axis is plotted at log scale. All the regressions controlled for cognitive ability and covariates. The model and variable specification followed Panel A of Table 2 Column 1 and 5. Full estimation results are shown in Supplementary Table 2 and 3.

Supplementary Material

Supplementary Figure 1. Age trends of self-perceived memory and cognitive ability

Supplementary Figure 2. Association between cognitive ability (cognitive impairment status) and chronic disease awareness by diseases and model specifications

Supplementary Figure 3. Association between cognitive ability (alternative cognitive measures) and chronic disease awareness by diseases and model specifications

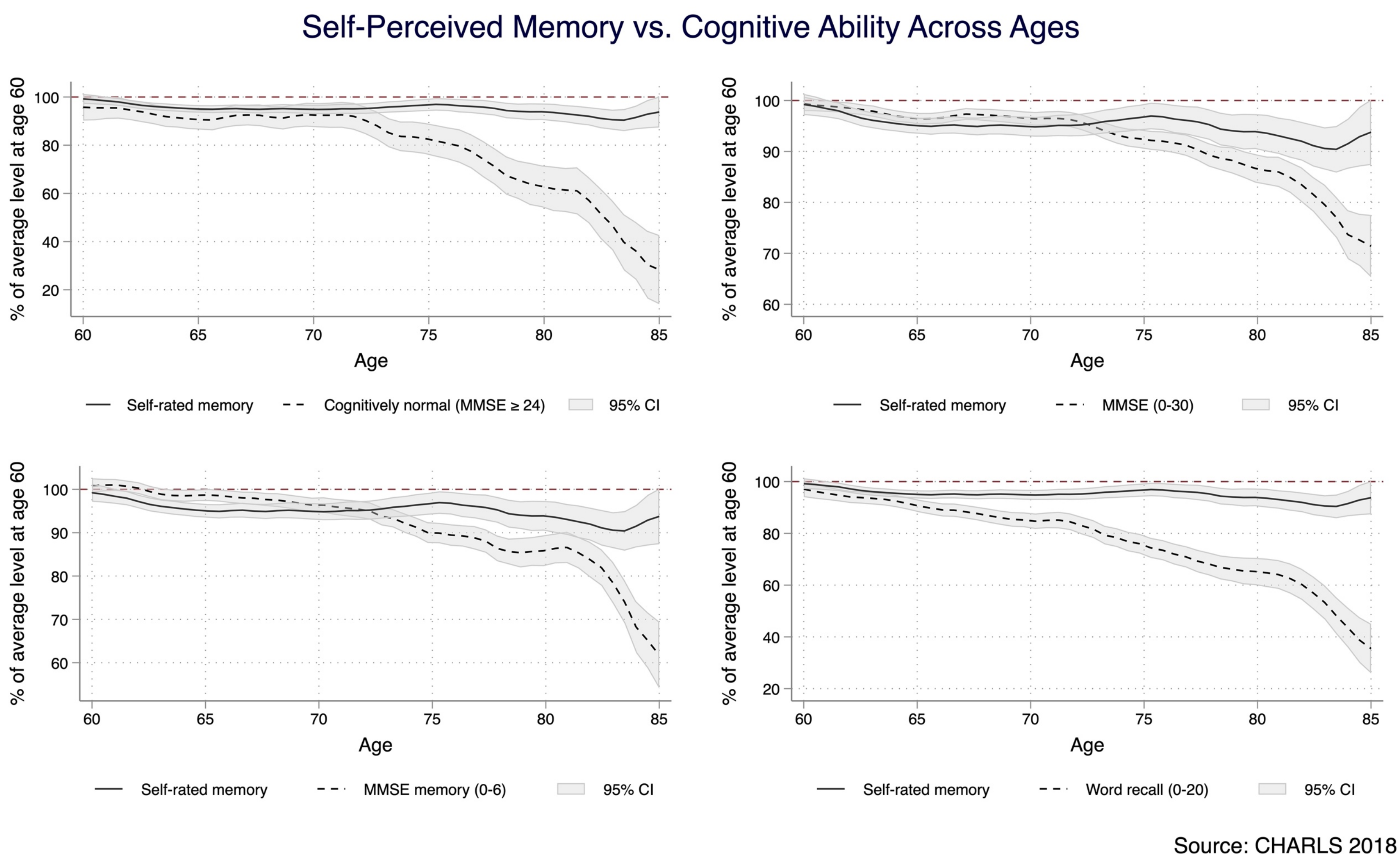
Supplementary Table 1. Characteristics of study population by diseases and self-perceived memory

Supplementary Table 2. Effects of self-perceived memory and cognitive ability on dyslipidemia awareness by rural/urban hukou status, education, and living arrangement

Supplementary Table 3. Effects of self-perceived memory and cognitive ability on diabetes awareness by rural/urban hukou status, education, and living arrangement

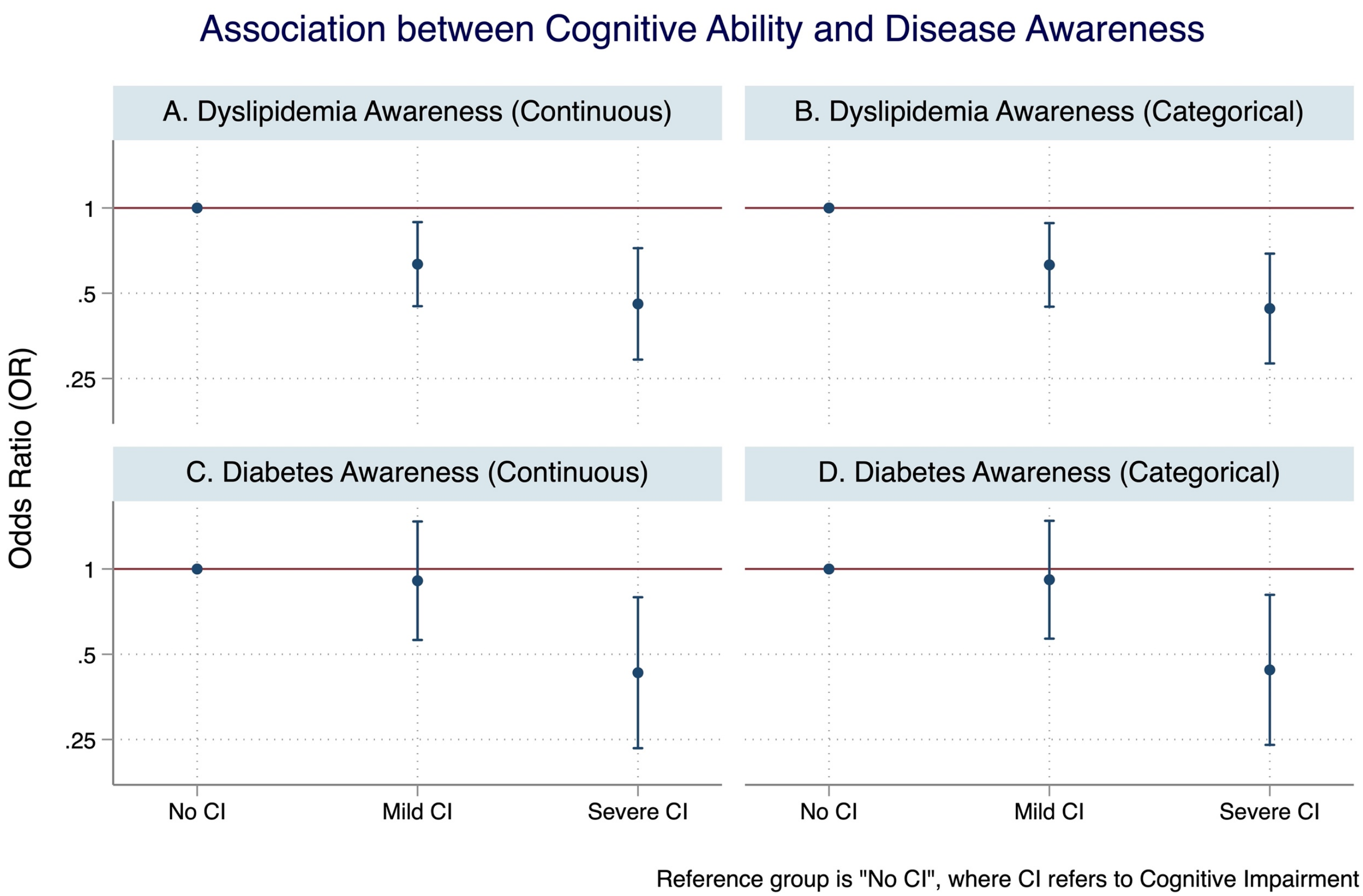
Supplementary Table 4. Distributions of self-perceived memory and cognitive ability

Supplementary Figure 1. Age trends of self-perceived memory and cognitive ability



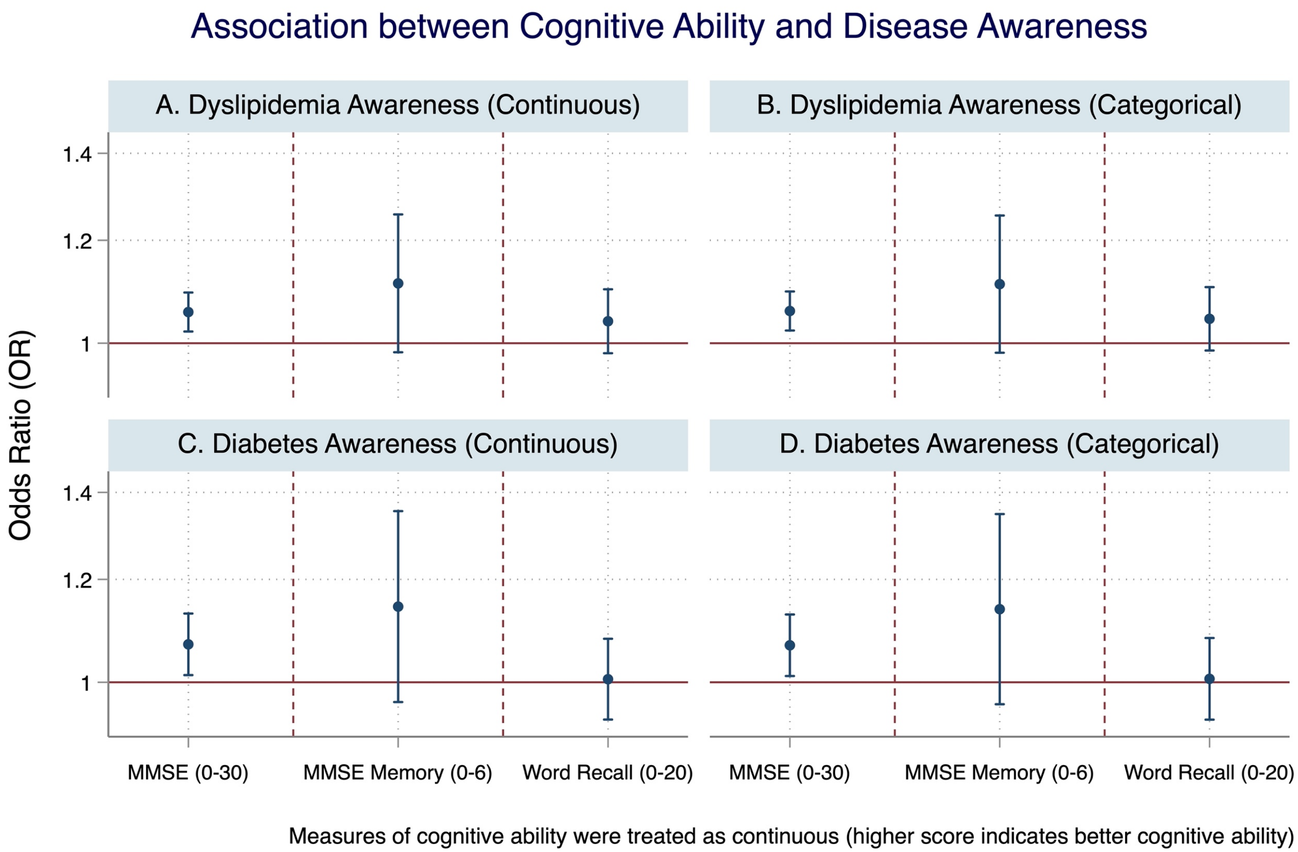
Notes: CHARLS=China Health and Retirement Longitudinal Study, 95% CI=95% confidence interval. For each age cohort, we calculated the relative proportion of their average perceived memory and cognitive performance relative to the benchmark average levels at age 60. The lines were fitted by local average smoothing.

Supplementary Figure 2. Association between cognitive ability (cognitive impairment status) and chronic disease awareness by diseases and model specifications



Notes: This figure illustrates the association between cognitive ability and dyslipidemia awareness (Panel A and B) and diabetes awareness (Panel C and D) estimated by logistic regressions controlling for self-perceived memory and covariates. The cognitive ability was measured by individuals' cognitive impairment status (i.e., No-CI, Mild-CI, Severe-CI). Self-perceived memory was treated as continuous (i.e., 1-5) in Panel A and C, and categorical (i.e., poor, fair, good+) in Panel B and D. Plotted points represent the odds ratios, and vertical lines represent 95% confidence intervals.

Supplementary Figure 3. Association between cognitive ability (alternative cognitive measures) and chronic disease awareness by diseases and model specifications



Notes: This figure illustrates the association between cognitive ability and dyslipidemia awareness (Panel A and B) and diabetes awareness (Panel C and D) estimated by logistic regressions, controlling for self-perceived memory and covariates. In each panel, the cognitive ability was treated as continuous and measured by either the total score of MMSE (range: 0-30), the memory score of MMSE (range: 0-6), and the total word recall (range: 0-20), with higher score indicating better cognitive ability; and the estimates for each measure are separated by dotted lines. Self-perceived memory was treated as continuous (i.e., 1-5) in Panel A and C, and categorical (i.e., poor, fair, good+) in Panel B and D. Plotted points represent the odds ratios, and vertical lines represent 95% confidence intervals.

Supplementary Table 1. Characteristics of study population by diseases and self-perceived memory

Variable	Dyslipidemia Sample					Diabetes Sample				
	All (N = 1,442)	Poor (n = 429)	Fair (n = 845)	Good+ (n = 168)	*p*-value	All (N = 759)	Poor (n = 252)	Fair (n = 410)	Good+ (n = 97)	*p*-value
Disease awareness	548 (38.0)	175 (40.8)	324 (38.3)	49 (29.2)	0.030	441 (58.1)	157 (62.3)	238 (58.0)	46 (47.4)	0.041
Cognitive ability										
No-CI, No. (%)	728 (50.5)	149 (34.7)	487 (57.6)	92 (54.8)	<0.001	361 (47.6)	86 (34.1)	222 (54.1)	53 (54.6)	<0.001
Mild-CI, No. (%)	465 (32.2)	156 (36.4)	263 (31.1)	46 (27.4)		262 (34.5)	103 (40.9)	140 (34.1)	19 (19.6)	
Severe-CI, No. (%)	249 (17.3)	124 (28.9)	95 (11.2)	30 (17.9)		136 (17.9)	63 (25.0)	48 (11.7)	25 (25.8)	
Age, mean (SD)	67.5 (5.8)	67.9 (5.6)	67.2 (5.8)	67.6 (6.1)	0.137	68.3 (6.0)	68.5 (6.5)	68.1 (5.8)	68.7 (5.7)	0.464
Education in years, mean (SD)	5.0 (4.6)	3.3 (4.1)	5.6 (4.5)	6.1 (5.0)	<0.001	4.9 (4.7)	3.5 (4.1)	5.5 (4.7)	6.1 (5.3)	<0.001
Female, No. (%)	705 (48.9)	266 (62.0)	372 (44.0)	67 (39.9)	<0.001	379 (49.9)	161 (63.9)	175 (42.7)	43 (44.3)	<0.001
Rural hukou status, No. (%)	1000 (69.3)	350 (81.6)	550 (65.1)	100 (59.5)	<0.001	515 (67.9)	195 (77.4)	261 (63.7)	59 (60.8)	<0.001
Rural residence status, No. (%)	771 (53.5)	288 (67.1)	415 (49.1)	68 (40.5)	<0.001	399 (52.6)	153 (60.7)	201 (49)	45 (46.4)	0.006
Married, No. (%)	1187 (82.3)	346 (80.7)	709 (83.9)	132 (78.6)	0.142	623 (82.1)	202 (80.2)	344 (83.9)	77 (79.4)	0.361
Depressive symptoms, No. (%)	520 (36.1)	221 (51.5)	268 (31.7)	31 (18.5)	<0.001	282 (37.2)	112 (44.4)	147 (35.9)	23 (23.7)	0.001
Any ADL limitation, No. (%)	291 (20.2)	140 (32.6)	133 (15.7)	18 (10.7)	<0.001	198 (26.1)	96 (38.1)	84 (20.5)	18 (18.6)	<0.001
Any IADL limitation, No. (%)	350 (24.3)	165 (38.5)	156 (18.5)	29 (17.3)	<0.001	224 (29.5)	109 (43.3)	95 (23.2)	20 (20.6)	<0.001
Any other chronic diseases, No. (%)	1264 (87.7)	399 (93.0)	731 (86.5)	134 (79.8)	<0.001	693 (91.3)	241 (95.6)	366 (89.3)	86 (88.7)	0.011
Urban employee MI, No. (%)	294 (20.4)	36 (8.4)	208 (24.6)	50 (29.8)	<0.001	165 (21.7)	30 (11.9)	110 (26.8)	25 (25.8)	<0.001
Urban-rural residence MI, No. (%)	1087 (75.4)	378 (88.1)	599 (70.9)	110 (65.5)	<0.001	558 (73.5)	210 (83.3)	282 (68.8)	66 (68)	<0.001
Public sector MI, No. (%)	20 (1.4)	4 (0.9)	12 (1.4)	4 (2.4)	0.393	20 (2.6)	4 (1.6)	12 (2.9)	4 (4.1)	0.358
Living with children, No. (%)	479 (33.2)	137 (31.9)	284 (33.6)	58 (34.5)	0.776	231 (30.4)	80 (31.7)	124 (30.2)	27 (27.8)	0.771
No. of living children, mean (SD)	3.0 (1.5)	3.4 (1.5)	2.9 (1.5)	2.8 (1.5)	<0.001	3.1 (1.5)	3.3 (1.5)	3.0 (1.4)	3.0 (1.5)	0.007

Notes: Cognitive ability was classified based on Mini-Mental State Exam. No-CI=no cognitive impairment; Mild-CI=mild cognitive impairment; Severe-CI=severe cognitive impairment; SD=standard deviation; MI=medical insurance; ADL=activities of daily living; IADL=instrumental activities of daily living. For self-perceived memory, Good+ included “good”, “very good”, and “excellent”.

Supplementary Table 2. Effects of self-perceived memory and cognitive ability on dyslipidemia awareness by rural/urban hukou status, education, and living arrangement

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	Dyslipidemia Awareness		Dyslipidemia Awareness		Dyslipidemia Awareness	
	Rural	Urban	<Primary School	≥Primary School	Not Living with Children	Living with Children
Self-Perceived Memory	0.73	0.91	0.61	0.90	0.78	0.84
	(0.57 - 0.94)	(0.60 - 1.36)	(0.44 - 0.85)	(0.67 - 1.22)	(0.59 - 1.04)	(0.57 - 1.25)
Cognitive Ability (Ref. No-CI)						
Mild-CI	0.80	0.47	0.92	0.51	0.59	0.66
	(0.58 - 1.10)	(0.24 - 0.92)	(0.52 - 1.64)	(0.34 - 0.77)	(0.38 - 0.92)	(0.36 - 1.23)
Severe-CI	0.43	0.46	0.53	0.24	0.43	0.39
	(0.27 - 0.71)	(0.11 - 1.83)	(0.31 - 0.92)	(0.08 - 0.69)	(0.24 - 0.78)	(0.17 - 0.91)
Observations	1,000	442	589	852	963	479
Covariates	YES	YES	YES	YES	YES	YES
Pseudo R-squared	0.137	0.161	0.139	0.178	0.148	0.234

Notes: Logistic regression was performed for each group. Standard errors were clustered at county level. All the regression models controlled for age, gender, education, rural/urban hukou status, rural/urban residence status, marital status, depressive symptoms, ADL, IADL, other chronic diseases, health insurance, living arrangement, and number of living children. The model and variable specification followed Table 2 Columns 1 and 5, where self-perceived memory was treated as continuous (i.e., 1-5), while cognitive ability was measured by cognitive impairment status (i.e., no-CI, mild-CI, severe-CI). Regressions were weighted, with sample weights that have corrections for blood non-response using inverse probability weights. Abbreviations: OR, odds ratio; 95% CI, 95% confidence interval; No-CI, no cognitive impairment; Mild-CI, mild cognitive impairment; Severe-CI, severe cognitive impairment. The estimates of self-perceived memory are visualized in Figure 3.

Supplementary Table 3. Effects of self-perceived memory and cognitive ability on diabetes awareness by rural/urban hukou status, education, and living arrangement

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	Diabetes Awareness		Diabetes Awareness		Diabetes Awareness	
	Rural	Urban	<Primary School	≥Primary School	Not Living with Children	Living with Children
Self-Perceived Memory	0.77	0.63	0.74	0.67	0.61	1.02
	(0.61 - 0.96)	(0.34 - 1.14)	(0.53 - 1.03)	(0.47 - 0.95)	(0.45 - 0.83)	(0.63 - 1.66)
Cognitive Ability (Ref. No-CI)						
Mild-CI	0.72	1.00	0.68	1.13	0.98	0.96
	(0.42 - 1.24)	(0.40 - 2.49)	(0.29 - 1.60)	(0.58 - 2.20)	(0.55 - 1.74)	(0.41 - 2.23)
Severe-CI	0.39	0.61	0.33	0.42	0.45	0.28
	(0.21 - 0.73)	(0.10 - 3.82)	(0.13 - 0.81)	(0.13 - 1.33)	(0.21 - 0.94)	(0.09 - 0.91)
Observations	515	244	318	439	528	231
Covariates	YES	YES	YES	YES	YES	YES
Pseudo R-squared	0.148	0.137	0.168	0.111	0.116	0.224

Notes: Logistic regression was performed for each group. Standard errors were clustered at county level. All the regression models controlled for age, gender, education, rural/urban hukou status, rural/urban residence status, marital status, depressive symptoms, ADL, IADL, other chronic diseases, health insurance, living arrangement, and number of living children. The model and variable specification followed Table 2 Columns 1 and 5, where self-perceived memory was treated as continuous (i.e., 1-5), while cognitive ability was measured by cognitive impairment status (i.e., no-CI, mild-CI, severe-CI). Regressions were weighted, with sample weights that have corrections for blood non-response using inverse probability weights. Abbreviations: OR, odds ratio; 95% CI, 95% confidence interval; No-CI, no cognitive impairment; Mild-CI, mild cognitive impairment; Severe-CI, severe cognitive impairment. The estimates of self-perceived memory are visualized in Figure 3.

Supplementary Table 4. Distributions of self-perceived memory and cognitive ability

Variable	**Dyslipidemia Sample (N=1,442)**	**Diabetes Sample (N=759)**
Self-perceived memory (5-levels)		
Poor (1), No. (%)	429 (29.8%)	252 (33.2%)
Fair (2), No. (%)	845 (58.6%)	410 (54.0%)
Good (3), No. (%)	94 (6.5%)	55 (7.3%)
Very Good (4), No. (%)	67 (4.7%)	37 (4.9%)
Excellent (5), No. (%)	7 (0.5%)	5 (0.7%)
Cognitive ability (MMSE: 3-levels)		
No-CI (24-30), No. (%)	728 (50.5%)	361 (47.6%)
Mild-CI (18-23), No. (%)	465 (32.3%)	262 (34.5%)
Severe-CI (0-17), No. (%)	249 (17.3%)	136 (17.9%)
Self-perceived memory (1-5), mean (SD)	1.9 (0.8)	1.9 (0.8)
Cognitive ability (MMSE: 0-30), mean (SD)	22.5 (5.1)	22.3 (5.1)

Notes: MMSE=Mini-Mental State Exam; No-CI=no cognitive impairment; Mild-CI=mild cognitive impairment; Severe-CI=severe cognitive impairment.