



## OPEN ACCESS

## EDITED BY

Ondrej Bezdicek,  
Charles University, Czechia

## REVIEWED BY

Chunbo Li,  
Shanghai Jiao Tong University, China  
Shiwei Duan,  
Zhejiang University City College, China  
Xiaoniu Liang,  
Fudan University, China

## \*CORRESPONDENCE

Ying Yu  
yuying@sumhs.edu.cn  
Qi Guo  
guoqijp@gmail.com

†These authors have contributed  
equally to this work and share first  
authorship

## SPECIALTY SECTION

This article was submitted to  
Alzheimer's Disease and Related  
Dementias,  
a section of the journal  
Frontiers in Aging Neuroscience

RECEIVED 20 March 2022

ACCEPTED 15 August 2022

PUBLISHED 01 September 2022

## CITATION

Liu Y, Yu X, Han P, Chen X, Wang F,  
Lian X, Li J, Li R, Wang B, Xu C, Li J,  
Zheng Y, Zhang Z, Li M, Yu Y and  
Guo Q (2022) Gender-specific  
prevalence and risk factors of mild  
cognitive impairment among older  
adults in Chongming, Shanghai, China.  
*Front. Aging Neurosci.* 14:900523.  
doi: 10.3389/fnagi.2022.900523

## COPYRIGHT

© 2022 Liu, Yu, Han, Chen, Wang, Lian,  
Li, Li, Wang, Xu, Li, Zheng, Zhang, Li, Yu  
and Guo. This is an open-access  
article distributed under the terms of  
the [Creative Commons Attribution  
License \(CC BY\)](#). The use, distribution  
or reproduction in other forums is  
permitted, provided the original  
author(s) and the copyright owner(s)  
are credited and that the original  
publication in this journal is cited, in  
accordance with accepted academic  
practice. No use, distribution or  
reproduction is permitted which does  
not comply with these terms.

# Gender-specific prevalence and risk factors of mild cognitive impairment among older adults in Chongming, Shanghai, China

Yuewen Liu<sup>1,2†</sup>, Xing Yu<sup>1†</sup>, Peipei Han<sup>1</sup>, Xiaoyu Chen<sup>1</sup>,  
Feng Wang<sup>3</sup>, Xuan Lian<sup>3</sup>, Jiayu Li<sup>3</sup>, Ruijin Li<sup>3</sup>, Beibei Wang<sup>3</sup>,  
Chunliu Xu<sup>3</sup>, Junxue Li<sup>4</sup>, Yaqing Zheng<sup>5</sup>, Ziwei Zhang<sup>5</sup>,  
Ming Li<sup>2</sup>, Ying Yu<sup>1\*</sup> and Qi Guo<sup>2\*</sup>

<sup>1</sup>Shanghai University of Medicine and Health Sciences, Shanghai, China, <sup>2</sup>Shanghai University of Medicine and Health Sciences Affiliated Zhoupu Hospital, Shanghai, China, <sup>3</sup>Shanghai University of Traditional Chinese Medicine, Shanghai, China, <sup>4</sup>Shanghai Health Rehabilitation Hospital, Shanghai, China, <sup>5</sup>Fujian Provincial Hospital, Fuzhou, China

**Objective:** This study explores the gender differences in the prevalence of mild cognitive impairment (MCI) and the correlation between multiple influencing factors.

**Materials and methods:** The sample was comprised of 1325 relatively healthy participants aged  $\geq 60$  years in a Shanghai community-dwelling (557 males and 768 females). Cognitive function was assessed by Mini-Mental State Examination (MMSE). The Instrumental Activities of Daily Living (IADL) scale was used to assess the activities of daily living.

**Results:** The overall prevalence of MCI was 15.2%, with 10.2% in men and 18.9% in women. In older male subjects, those with higher the Geriatric Depression Scale (GDS) scores [odds ratio (OR) = 1.07, 95% confidence interval (CI) = 1.01–1.14] and hypertension (OR = 2.33, 95% CI = 1.15–4.73) had a higher risk of MCI. female subjects who were illiterate (OR = 2.95, 95% CI = 1.82–4.78), had a farming background (OR = 1.69, 95% CI = 1.05–2.72), and a history of stroke (OR = 1.96, 95% CI = 1.07–3.59) had a higher risk of MCI, but this was not true for males. However, Male subjects who never smoked were less likely to have MCI (OR = 0.22, 95% CI = 0.09–0.54). Additionally, the prevalence of MCI was lower in older women with high grip strength (OR = 0.96, 95% CI = 0.92–0.99) and hyperlipidemia (OR = 0.45, 95% CI = 0.22–0.96).

**Conclusion:** The prevalence of MCI was higher in the population of elderly women compared to men. Moreover, it was found that members with MCI tended to having higher GDS scores, smoking, and hypertension; whereas a history of farming, illiteracy, stroke, grip strength, and hyperlipidemia were correlated with MCI in women.

## KEYWORDS

mild cognitive impairment, prevalence, risk factors, gender differences, older adults

## Introduction

China has 249 million people aged 60 and over, which accounts for 17.9% of the total population (National Bureau of Statistics of China, 2021), indicating a high prevalence of mild cognitive impairment (MCI). With the increase in the aging population worldwide, the number of patients with cognitive impairment is also increasing, putting a heavy burden on families, communities, and health care systems. Accordingly, cognitive impairment has become a global public health problem.

Due to the lack of effective treatment, early intervention is considered the most cost-effective way to manage dementia (Livingston et al., 2017). Since MCI is considered the transition stage between undamaged cognitive function and dementia (Winblad et al., 2004), there has been a consensus to focus the main intervention on this population to prevent dementia. However, a few studies investigating the prevalence of MCI in China have inconsistent results, which are estimated to range from 4.5 to 21.5% (Li et al., 2011; Song et al., 2021). These inconsistencies require further study to arrive at more accurate estimates. Although previous studies have analyzed the association between modifiable risk factors and MCI stratified by gender (Zhang et al., 2019; Fu et al., 2020), this may affect the exposure of MCI risk factors and the prevalence of MCI due to China's vast territory, people's complex lifestyles, extended life span, different diagnostic criteria, and various screening methods. It is estimated that more than 70% of the elderly in China live in suburban communities. Shanghai is one of the most populous megacities in China. Studying the prevalence and influencing factors of MCI in its suburban counties can provide supporting data for the prevention, diagnosis, care, and treatment of MCI. Moreover, the current research conclusions on the gender differences in the prevalence and influencing factors of MCI are still inconsistent. No gender difference in the prevalence of MCI was present in other countries (Ganguli et al., 2013; Au et al., 2017; Overton et al., 2019). The difference is that the data of China show that the prevalence of MCI in women is higher than that in men (Fu et al., 2020). Understanding the gender differences of MCI may further understand the etiology and prevention of dementia. Attention to the prevalence of MCI and effective risk factor prevention strategies will help reduce the incidence rate of MCI and subsequent dementia.

The authors' previous studies have shown that both sarcopenia (Chen et al., 2021) and obesity (Ma et al., 2021) are associated with cognitive impairment. Therefore, this study explores the gender differences in the prevalence of MCI and the correlation between multiple influencing factors. By strengthening the identification of MCI, its related influencing factors can be examined in depth to provide a theoretical basis

for the early prevention and identification of MCI to establish an early warning model of MCI.

## Materials and methods

### Study population

The final analytic sample consisted of 1,325 participants ( $\geq 60$  years old) after excluding 38 individuals (3 had incomplete MMSE data; 4 were unable to perform the physical performance test; 31 participants had missing data on covariates or outcomes.). All subjects were invited to participate in a comprehensive geriatric assessment and cognitive function assessment in Chongming District of Shanghai in 2019 and 2020. The exclusion criteria were as follows: (1) severe cognitive impairment, dementia, mental illness or other neurodegenerative diseases; (2) Inability to communicate with researchers or unwillingness to give informed consent; (3) people with deafness or blindness and cannot complete the assessment; (4) those who cannot complete the grip strength, Timed Up and Go Test (TUGT), and 4-meter walking test. All participants provided informed consent prior to participation. If the participant was illiterate, the informed consent of its legal representative would be sought.

### Covariates

Data on sociodemographic characteristics, behavioral characteristics, and disease history have previously been described (through face-to-face questions) (Liu et al., 2021). The questionnaire included questions about age, sex, height, body weight, marital status, illiteracy, living habits (alone or with others), sleep duration, smoking habits (current smoker, never smoking, and past smoker), drinking habits (drinking daily, occasional drinking, past drinking, and never drinking), and household income ( $< 1,000$ ,  $1,000$ – $3,000$ ,  $3,000$ – $5,000$ , and  $> 5,000$  RMB). Physical activity was assessed using the short form of the International Physical Activity Questionnaire (IPAQ) (Jiang et al., 2009). The depressive symptoms were evaluated by the Geriatric Depression Scale (GDS). Subjects with a score of  $\geq 11$  were considered to have depressive symptoms (Yesavage et al., 1982). Nutrition was evaluated by the Mini Nutritional Assessment-Short Form (MNA-SF) (Kaiser et al., 2009). Physical performance was assessed by grip strength, a 4-m walking test, and the Timed Up and Go Test (TUGT). The details of the measurement method have been described in the authors' previous research (Liu et al., 2021). Disease history included type 2 diabetes mellitus (T2DM), hypertension, hyperlipidemia, stroke, gout, anemia, pulmonary disease, biliary tract disease,

kidney disease, heart disease, osteoarthritis, cancer, and thyroid disease.

## Definition of mild cognitive impairment

This study adopted the MCI diagnostic criteria based on Petersen's definitions (Petersen et al., 1999): (1) memory complaint; (2) normal activities of daily living; (3) normal general cognitive function; (4) abnormal memory for age; (5) not demented.

## Assessment of cognitive function

Cognitive assessment was completed using the Mini-Mental State Examination (MMSE) (Folstein et al., 1975) by trained investigators. It includes 30 items, the score ranges from 0 to 30 points, with the higher scores indicating better cognitive performance. The use of MMSE to define MCI is consistent with previous studies (Liu et al., 2021), that is, The cut-off points used for cognitive impairment were as follow:  $\leq 17$  for illiterate people,  $\leq 20$  for people with primary school, and  $\leq 24$  for people with middle school or higher (Zhang et al., 1990). The above cut-off points have been proved to be sensitive and effective in the diagnosis of MCI in Chinese elderly population (Zhang et al., 2006).

## Assessment of daily activity ability

The daily activity ability was evaluated using the Instrumental Activities of Daily Living scale (IADL) (Lawton and Brody, 1969). It includes 8 items, the score ranges from 0 to 8 points, with the higher scores indicating better daily activity ability. IADL scores  $\geq 6$  indicates normal daily activity ability (Nagamatsu et al., 2013).

## Statistical analysis

The following analyses were performed to investigate the prevalence of MCI and the correlation between multiple influencing factors. Normally distributed data were presented as mean  $\pm$  standard deviation, while non-normally distributed data were presented as median, with the 25–75% interquartile range given in parentheses. Categorical variables were expressed as a percentage (%). The differences according to the characteristics of cognitive status were analyzed using the *t*-tests, Chi-square tests, and Mann-Whitney *U* tests. Logistic regression analysis was used to analyze the factors associated with MCI. Based on previous research, age, marital status, illiteracy, living conditions, farming, Smoking, BMI, IPAQ,

and comorbidity status (hypertension, hyperlipidemia, stroke, diabetes) were considered factors potentially associated with MCI. As such, these factors were included as independent variables in the models of the present study. All the statistical analyses were performed using SPSS version 21.0, and  $P < 0.05$  was considered statistically significant.

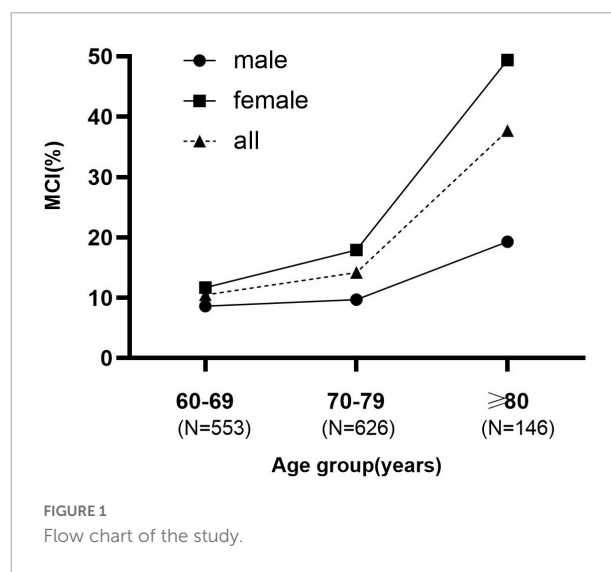
## Ethics

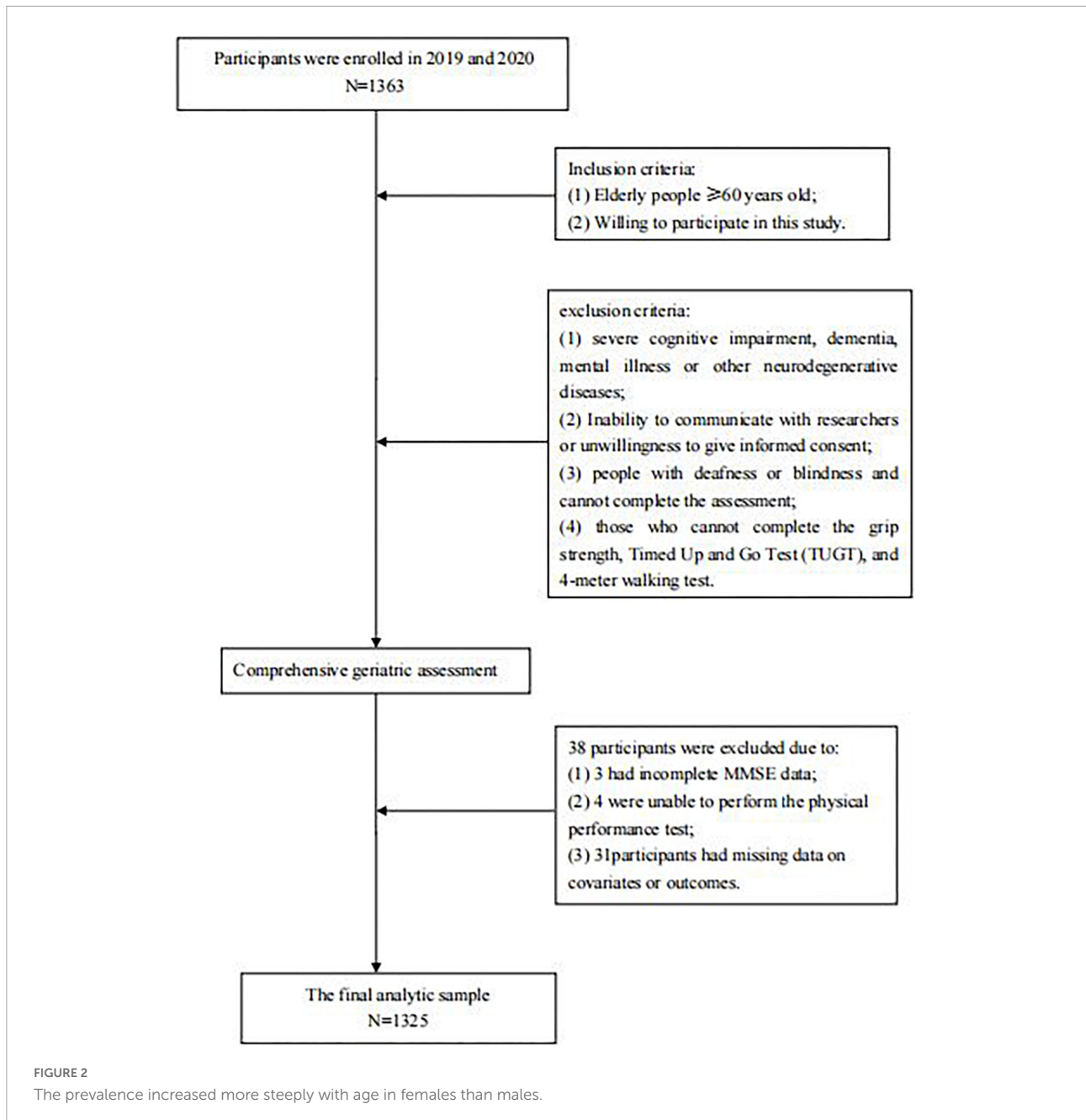
The study was approved by the Ethics Committee of Shanghai University of Medicine and Health Sciences and the methods were carried out in accordance with the principles of the Declaration of Helsinki.

## Results

### Characteristics of the participants

A total of 1,363 participants were evaluated. Of these, 38 were excluded: 3 had incomplete MMSE data; 4 were unable to perform the physical performance test; 31 participants had missing data on covariates or outcomes (Figure 1). The final analytic sample consisted of 1,325 participants in the study (mean age,  $71.79 \pm 5.77$  years; 58.0% women), of whom 202 (15.2%) were diagnosed with MCI (57 males and 145 females). Participants were divided into three age groups, 60–69, 70–79, and  $\geq 80$  years, with 58 (10.5%), 89 (14.2%), and 55 (37.7%) people, respectively. The prevalence increased more steeply with age in females than males (Figure 2). Table 1 presents the characteristics of these participants. Compared to participants with normal cognition, participants with MCI were older, had lower daily activity





ability, higher GDS scores, sleep longer, less physical activity, and a higher proportion of illiteracy, widows, living alone, agriculture, low income, and worse physical performance. However, there were some differences when stratified by gender. Males with MCI had a higher proportion of hypertension (77.2% versus 61.8%;  $P = 0.022$ ) and a higher score of GDS ( $6.54 \pm 4.81$  versus  $5.50 \pm 4.55$ ;  $P = 0.003$ ), but these results were not statistically significant in females ( $P > 0.05$ ). Females with MCI had longer sleep time, lower daily activity levels, and were more likely to be farmers and illiterate.

## Univariate and multivariate analysis of associated factors for mild cognitive impairment

Results from univariate and multivariate logistic regression models for factors related to MCI in 557 males and 768 females are reported in **Tables 2** and **3**, respectively. After adjusting for potential confounders, in older male subjects, those with higher GDS scores [odds ratio (OR) = 1.07, 95% confidence interval (CI) = 1.01–1.14] and hypertension (OR = 2.33, 95% CI = 1.15–4.73) were associated with

TABLE 1 Baseline characteristics of study participants with normal cognition vs. mild cognitive impairment.

Variables	Total( <i>n</i> = 1325)			Male( <i>n</i> = 557)			Female( <i>n</i> = 768)		
	Normal cognition ( <i>n</i> = 1123)	Mild cognitive impairment ( <i>n</i> = 202)	<i>P</i> -value	Normal cognition ( <i>n</i> = 500)	Mild cognitive impairment ( <i>n</i> = 57)	<i>P</i> -value	Normal cognition ( <i>n</i> = 623)	Mild cognitive impairment ( <i>n</i> = 145)	<i>P</i> -value
Age (year)	71.27 ± 5.38	74.66 ± 6.96	<0.001	71.70 ± 5.48	73.72 ± 7.02	0.001	70.93 ± 5.28	75.03 ± 6.92	<0.001
BMI(kg/m <sup>2</sup> )	23.69 ± 3.45	23.68 ± 3.43	0.963	23.40 ± 3.33	23.39 ± 3.83	0.989	23.92 ± 3.53	23.79 ± 3.27	0.680
IADL (score)	7.79 ± 0.63	7,63 ± 0.67	0.001	7.82 ± 0.47	7.68 ± 0.61	0.039	7.77 ± 0.73	7.61 ± 0.69	0.021
MNA-SF (score)	12.79 ± 1.51	12.68 ± 1.44	0.327	12.82 ± 1.44	12.51 ± 1.66	0.127	12.76 ± 1.56	12.74 ± 1.34	0.886
GDS (score)	5.50 ± 4.55	6.81 ± 5.39	<0.001	4.85 ± 4.01	6.54 ± 4.81	0.003	6.02 ± 4.89	6.92 ± 5.61	0.053
Sleep duration(hour)	8.40 ± 1.43	8.79 ± 1.55	0.001	8.43 ± 1.39	8.61 ± 1.49	0.334	8.38 ± 1.45	8.85 ± 1.57	0.001
IPAQ (Met/wk)	5255(2226,10080)	3864(1647,8201)	0.003	4988(2079, 8966)	3222(1533, 8652)	0.167	5639(2373, 10920)	3990(1908, 7989)	0.003
Illiteracy (%)	98(8.7%)	68(33.7%)	<0.001	21(4.2%)	5(8.8%)	0.121	77(12.4%)	63(43.4%)	<0.001
Widowed(%)	191(17.0%)	75(37.1%)	<0.001	41(8.2%)	11(19.3%)	0.006	150(24.1%)	64(44.1%)	<0.001
Living alone (%)	166(14.8%)	61(30.2%)	<0.001	50(10.0%)	14(24.6%)	0.001	116(18.6%)	47(32.4%)	<0.001
Farming (%)	565(50.3%)	135(66.8%)	<0.001	198(39.6%)	23(40.4%)	0.913	367(58.9%)	112(77.2%)	<0.001
<b>Monthly income (%)</b>			<0.001			0.121			0.004
< 1000	70(6.2%)	29(14.4%)		23(4.6%)	6(10.5%)		47(7.5%)	23(15.9%)	
1000-3000	683(60.8%)	131(64.9%)		286(57.2%)	36(63.2%)		397(63.7%)	95(65.5%)	
3000-5000	160(14.2%)	18(8.9%)		80(16.0%)	7(12.3%)		80(12.8%)	11(7.6%)	
>5000	210(18.7%)	24(11.9%)		111(22.2%)	8(14.0%)		99(15.9%)	16(11.0%)	
<b>Smoking (%)</b>			0.014			0.075			0.495
Current smokers	178(15.9%)	28(13.9%)		174(34.8%)	28(49.1%)		4(0.6%)	0(0.0%)	
Never smokers	757(67.4%)	155(76.7%)		140(28.0%)	10(17.5%)		617(99.0%)	145(100%)	
Ever smokers	188(16.7%)	19(9.4%)		186(37.2%)	19(33.3%)		2(0.3%)	0(0.0%)	
<b>Drinking (%)</b>			0.065			0.168			0.126
Daily drinkers	171(15.2%)	29(14.4%)		150(30.0%)	18(31.6%)		21(3.4%)	11(7.6%)	
Occasional drinkers	152(13.5%)	27(13.4%)		91(18.2%)	16(28.1%)		61(9.8%)	11(7.6%)	
Former drinkers	135(12.0%)	12(5.9%)		111(22.2%)	7(12.3%)		24(3.9%)	5(3.4%)	
Never drinkers	665(59.2%)	134(66.3%)		148(29.6%)	16(28.1%)		517(83.0%)	118(81.4%)	
<b>physical performance</b>									
Grip strength (kg)	23.95 ± 8.91	19.10 ± 8.88	<0.001	30.31 ± 8.22	27.01 ± 9.65	0.005	18.85 ± 5.50	15.99 ± 6.28	<0.001
4-meter walking test (m/s)	1.11 ± 0.23	0.94 ± 0.25	<0.001	1.15 ± 0.25	1.02 ± 0.25	0.001	1.07 ± 0.21	0.92 ± 0.25	<0.001
TUGT (s)	9.63 ± 3.31	11.9 ± 4.76	<0.001	9.56 ± 3.36	11.04 ± 3.70	0.002	9.68 ± 3.28	12.24 ± 5.09	<0.001
<b>Diseases (%)</b>									

(Continued)

TABLE 1 (Continued)

Variables	Total( <i>n</i> = 1325)			Male( <i>n</i> = 557)			Female( <i>n</i> = 768)		
	Normal cognition ( <i>n</i> = 1123)	Mild cognitive impairment ( <i>n</i> = 202)	<i>P</i> -value	Normal cognition ( <i>n</i> = 500)	Mild cognitive impairment ( <i>n</i> = 57)	<i>P</i> -value	Normal cognition ( <i>n</i> = 623)	Mild cognitive impairment ( <i>n</i> = 145)	<i>P</i> -value
Diabetes (%)	178(15.9%)	32(15.8%)	0.997	78(15.6%)	9(15.8%)	0.970	100(16.1%)	23(15.9%)	0.955
Hypertension (%)	683(60.8%)	139(68.8%)	0.031	309(61.8%)	44(77.2%)	0.022	374(60.0%)	95(65.5%)	0.222
Hyperlipidemia (%)	140(12.5%)	17(8.4%)	0.100	56(11.2%)	7(12.3%)	0.811	84(13.5%)	10(6.9%)	0.029
Stroke(%)	114(10.2%)	29(14.4%)	0.076	51(10.2%)	5(8.8%)	0.734	63(10.1%)	24(16.6%)	0.028
Gout (%)	66(5.9%)	10(5.0%)	0.613	43(8.6%)	5(8.9%)	0.934	23(3.7%)	5(3.4%)	0.888
Anemia (%)	51(4.5%)	13(6.4%)	0.248	18(3.6%)	3(5.3%)	0.532	33(5.3%)	10(6.9%)	0.450
Pulmonary disease (%)	96(8.5%)	15(7.4%)	0.596	58(11.6%)	6(10.5%)	0.810	38(6.1%)	9(6.2%)	0.961
Biliary tract disease (%)	166(14.8%)	32(15.8%)	0.697	49(9.8%)	7(12.3%)	0.555	117(18.8%)	25(17.2%)	0.667
Kidney disease (%)	117(10.4%)	12(5.9%)	0.048	70(14.0%)	5(8.8%)	0.273	47(7.5%)	7(4.8%)	0.249
Heart disease (%)	359(32.0%)	73(36.1%)	0.244	142(28.4%)	19(33.3%)	0.436	217(34.8%)	54(37.2%)	0.584
Thyroid disease (%)	44(3.9%)	10(5.0%)	0.494	11(2.2%)	0(0.0%)	0.258	33(5.3%)	10(6.9%)	0.450
Osteoarthritis(%)	179(15.9%)	39(19.3%)	0.235	68(13.6%)	11(19.3%)	0.243	111(17.8%)	28(19.3%)	0.674
Cancer(%)	44(3.9%)	6(3.0%)	0.515	26(86.7%)	4(7.0%)	0.565	18(2.9%)	2(1.4%)	0.304

BMI, Body Mass Index; MNA, Mini Nutritional Assessment; TUGT, Time Up and Go Test; GDS, Geriatric Depression Scale; IADL, Instrumental Activity of Daily Living; IPAQ, International Physical Activity Questionnaires.



TABLE 2 Unadjusted and Adjusted Model for Factors Related to MCI in the male.

Variable	Univariate Odds Ratio (95% CI)	P-value	Adjusted Model Odds Ratio (95% CI)	P-value
All sample (n = 557)				
Age (year)				
60-69 (n = 221)	1.0 (referent)		1.0 (referent)	
70-79 (n = 279)	1.14(0.62–2.11)	0.678	1.08(0.54–2.15)	0.823
≥ 80 (n = 57)	2.54(1.13–5.71)	0.024	1.44(0.49–4.27)	0.507
IADL	0.63(0.40–0.99)	0.044	0.83(0.47–1.44)	0.501
GDS	1.09(1.03–1.15)	0.004	1.07(1.01–1.14)	0.033
Illiteracy (n = 26)	2.19(0.79–6.06)	0.130	1.74(0.53–5.69)	0.358
Widowed (n = 52)	2.68(1.29–5.56)	0.008	1.15(0.33–4.01)	0.825
Living alone (n = 64)	2.93(1.50–5.73)	0.002	1.86(0.64–5.36)	0.252
Farming (n = 221)	1.03(0.59–1.80)	0.913	0.70(0.36–1.35)	0.283
<b>Monthly income</b>				
< 1,000 (n = 29)	1.0 (referent)		1.0 (referent)	
1,000–2,999 (n = 322)	0.48(0.18–1.26)	0.138	0.44(0.14–1.36)	0.152
3,000–5,000 (n = 87)	0.34(0.10–1.10)	0.071	0.29(0.07–1.16)	0.080
>5,000 (n = 119)	0.28(0.09–0.87)	0.028	0.28(0.07–1.12)	0.071
<b>Smoking</b>				
Current smokers (n = 202)	1.0 (referent)			
Never smokers (n = 150)	0.44(0.21–0.95)	0.035	0.22(0.09–0.54)	0.001
Ever smokers (n = 205)	0.64(0.34–1.18)	0.150	0.47(0.24–0.95)	0.036
Grip strength	0.95(0.92–0.99)	0.005	0.97(0.93–1.01)	0.105
4-meter walking test	0.16(0.05–0.46)	0.001	0.23(0.04–1.23)	0.085
TUGT	1.10(1.03–1.17)	0.005	0.98(0.88–1.09)	0.670
Hypertension (n = 353)	2.09(1.10–3.99)	0.025	2.33(1.15–4.73)	0.020
Hyperlipidemia (n = 63)	1.11(0.48–2.56)	0.811	1.08(0.42–2.79)	0.879
Stroke (n = 56)	0.85(0.32–2.22)	0.734	0.72(0.25–2.12)	0.554

TUGT, time up and go; OR, Odds Ratio; CI, confidence interval; IPAQ, international physical activity questionnaires; Adjusted model: Adjusted for age, BMI, IADL, GDS, IPAQ, Illiteracy, Widowed, Living alone, Farming, Monthly income, Smoking, Grip strength, 4-meter walking test, TUGT, Hypertension, Hyperlipidemia, Stroke, diabetes.

MCI. Male subjects who never smoked were less likely to have MCI than older male subjects who currently smoked (OR = 0.22, 95% CI = 0.09–0.54). Female subjects who were illiterate (OR = 2.95, 95% CI = 1.82–4.78), had a background in farming (OR = 1.69, 95% CI = 1.05–2.72), and had high grip strength (OR = 0.96, 95% CI = 0.92–0.99) were associated with MCI, but this was not true for males. The OR and 95% CI in the adjusted model for the factors statistically significantly associated with MCI were 0.45 (0.22–0.96) and 1.96 (1.07–3.59) for hyperlipidemia and stroke, respectively, in females.

## Discussion

This study estimates the prevalence of MCI and the factors associated with MCI in a suburb-dwelling population of elderly persons aged 60 and older in China. The overall prevalence of MCI was 15.2%, with 10.2% in men and 18.9% in women. After adjustment for potential confounders, the GDS scores, smoking, and hypertension were directly associated with the prevalence of MCI in men. Moreover,

grip strength, being illiterate, having a background in farming, hyperlipidemia, and stroke were associated with the prevalence of MCI in women.

## Prevalence of mild cognitive impairment in suburb-dwelling residents

A recent meta-analysis showed that the prevalence of MCI in the Chinese elderly was 15.2% (Deng et al., 2021), which was consistent with the results of the present study. A recent cross-sectional survey on the prevalence of MCI in women showed that the prevalence of MCI was 21.5% (Song et al., 2021), while another study found that the prevalence of cognitive impairment was 26.1% in men and 30.5% in women (Lyu and Kim, 2016). Additionally, a cross-sectional study found that the prevalence of MCI was 19.8% for men and 26.1% for women (Zhang et al., 2019). In the study by Fu et al. (2020), the MCI prevalence was 8.2% in males and 13.1% in females. These large differences in prevalence are likely due to diversity in population structure, screening tools, and diagnostic criteria.

TABLE 3 Unadjusted and adjusted model for factors related to MCI in the female.

Variable	Univariate Odds Ratio (95% CI)	P-value	Adjusted Model Odds Ratio (95% CI)	P-value
All sample (n = 768)				
Age (year)				
60-69 (n = 332)	1.0 (referent)		1.0 (referent)	
70-79 (n = 347)	1.64(1.06–2.52)	0.026	1.02(0.62–1.67)	0.939
≥ 80 (n = 89)	7.35(4.31–12.52)	<0.001	1.81(0.90–3.63)	0.097
IADL	0.79(0.63–0.98)	0.028	1.26(0.93–1.72)	0.142
GDS	1.03(0.99–1.07)	0.054	0.99(0.95–1.03)	0.608
Sleep duration	1.22(1.08–1.38)	0.001	1.05(0.92–1.20)	0.456
IPAQ	0.96(0.92–0.99)	0.001	0.98(0.96–1.09)	0.131
Illiteracy (n = 140)	5.45(3.63–8.18)	<0.001	2.95(1.82–4.78)	<0.001
Widowed (n = 214)	2.49(1.71–3.63)	<0.001	1.50(0.78–2.88)	0.226
Living alone (n = 163)	2.10(1.40–3.13)	<0.001	0.85(0.41–1.72)	0.642
Farming (n = 479)	2.37(1.56–3.60)	<0.001	1.69(1.05–2.72)	0.031
<b>Monthly income</b>				
< 1,000 (n = 70)	1.0 (referent)		1.0 (referent)	
1,000-2,999 (n = 492)	0.49(0.28–0.85)	0.010	0.67(0.35–1.30)	0.235
3,000-5,000 (n = 91)	0.28(0.13–0.63)	0.002	0.53(0.21–1.34)	0.179
>5,000 (n = 115)	0.33(0.16–0.68)	0.003	0.65(0.28–1.55)	0.330
Grip strength	0.91(0.88–0.94)	<0.001	0.96(0.92–0.99)	0.036
4-meter walking test	0.06(0.03–0.13)	<0.001	0.40(0.11–1.42)	0.156
TUGT	1.16(1.11–1.22)	<0.001	1.05(0.98–1.12)	0.142
Hypertension (n = 469)	1.27(0.87–1.85)	0.223	1.15(0.74–1.81)	0.537
Hyperlipidemia (n = 94)	0.48(0.24–0.94)	0.033	0.45(0.22–0.96)	0.038
Stroke (n = 87)	1.76(1.06–2.94)	0.029	1.96(1.07–3.59)	0.030

TUGT, time up and go; OR, Odds Ratio; CI, confidence interval; IPAQ, international physical activity questionnaires; Adjusted model: Adjusted for age, BMI, IADL, GDS, Sleep duration, IPAQ, Illiteracy, Widowed, Living alone, Farming, Monthly income, Smoking, Grip strength, 4-meter walking test, TUGT, Hypertension, Hyperlipidemia, Stroke, diabetes.

These inconsistencies necessitate further study to yield a more accurate estimate.

## Modifiable lifestyle and physical performance factors related to mild cognitive impairment in suburb-dwelling residents

The present study found that GDS scores were correlated with the prevalence of MCI. This was consistent with the results of previous studies (Vega and Newhouse, 2014). There is increasing evidence that depression strongly and independently accelerates the progression from MCI to dementia. In individuals with MCI, depressive symptoms mean a 2–4 fold increase in the risk of progression to dementia (Van der Mussele et al., 2014). In men, an association was found between smoking and MCI. This result was consistent with previous work that reported smoking was associated with cognitive impairment (Jia et al., 2020). Regarding the relationship between smoking and MCI, further studies on biomarker assessments of smoking are needed to illustrate the true association between smoking and MCI in the Chinese

population. This result also showed that MCI was significantly associated with a background in farming and illiteracy in women. A systematic review showed that those who have a predominantly manual occupation throughout life have a greater risk of cognitive impairment and/or dementia than those in intellectually demanding occupations (Gracia et al., 2016). Illiterate women were more than twice as likely to have MCI than educated women. Previous studies have found that women with little formal education have a higher risk of dementia than men with similar educational backgrounds (Zhang et al., 1990; Launer et al., 1999; Ott et al., 1999). Differences in the quality of education may contribute to an increased risk of dementia in women compared with men. Low-educated women are more likely to have poorer career achievement, lower income, poorer health, less leisure opportunities, and poorer cognitive outcomes than low-educated men (Ott et al., 1999; Sharp and Gatz, 2011). Compared with men, women have less access to education, and when women have access to education, it differs in quality. Zhang et al. (2006) point out that before 1950, only women belonging to the highest social classes could receive education in China. Additionally, a relationship was found between MCI and grip strength in women, as was found in previous studies (Atkinson et al., 2010). This simple measure may be useful for



future research on the relationship between cognitive function and physical performance.

### Specific diseases associated with mild cognitive impairment in suburb-dwelling residents

As demonstrated in the present study, hypertension was associated with MCI in men, but not in women. This finding was in accordance with previous studies (Wu et al., 2016; Fu et al., 2020). The potential gender differences between hypertension and cognition are not fully understood (Iadecola et al., 2016). It may be that the women in the present study were all menopausal. Previous evidence suggests that older postmenopausal women have a lower risk of cardiometabolic disease because of their favorable hormonal and metabolic profile (Regensteiner et al., 2015), which may mitigate cognitive impairment caused by hypertension. However, the observational studies conducted for the present study could not provide insight into the underlying biological mechanisms. Accordingly, more research should be conducted to explore possible explanations for the underlying gender differences. In addition, similar to previous studies (Kim and Park, 2017; Fu et al., 2020), the present study found no significant correlation between hyperlipidemia and the prevalence of MCI in the elderly. Interestingly, when stratified by gender, the association between hyperlipidemia and MCI was only significant in women, and women with hyperlipidemia had higher cognitive function than women without hyperlipidemia. In the study conducted by Kim and Park (2017), hyperlipidemia was reported as a protective factor for MCI in women. The relationship between hyperlipidemia and MCI prevalence remains controversial. Studies have shown that a reduced risk of cognitive impairment was associated with higher serum cholesterol levels (Lv et al., 2016). In contrast, earlier research found significantly higher cholesterol levels in older adults with cognitive impairment and suggested that cholesterol-lowering treatments, such as lipid-lowering drugs, may have cardiovascular benefits while preventing cognitive impairment (Vance, 2012). However, the underlying mechanism of the interaction between gender and hyperlipidemia and cognitive impairment remains unclear. Further prospective studies are needed to explore the sex differences with the association of hyperlipidemia with MCI. A recent meta-analysis showed that stroke was a risk factor for dementia, which was consistent with the results of the present study (Deng et al., 2021). Similarly, a study examining gender differences in cognitive outcomes after stroke found that women had significantly worse cognitive outcomes than men (Dong et al., 2020). Since only a few previous works investigated the gender differences between stroke and MCI, further research is needed to explore the potential pathological associations.

### Strengths and limitations

This study presents several strengths. First, the study was conducted on a relatively large sample of well-characterized suburban elderly men and women who had lived in a particular geographic area for a long time. Second, the participants were from suburban areas, and their lifestyles were more active, which may have been different from subjects in other areas. However, this study has some limitations that must be addressed. First, because this is a cross-sectional study, a causal relationship of the identified associated factors could not be established. Second, all participants in this study were relatively healthy. We did not include those who were hospitalized, or those who were bedridden with severe illness and could not be tested on-site, and those who refused to participate in the program. This choice could constitute a selective survival and a healthy selection bias. Third, although there were no patients with depression in our population, we found that men with higher GDS scores had worse cognitive function, which we also adjusted as an adjustment variable in multivariate regression. In the future, we will continue to follow up to observe the impact of depression on cognitive function.

### Conclusion

In summary, in this study, 15.2% of adults aged 60 and older were found to have mild cognitive impairment. The prevalence of MCI is shown to be higher in females compared to males for the elderly population. Furthermore, GDS scores, smoking, farming, illiteracy, grip strength, hypertension, hyperlipidemia, and stroke may have different associations with MCI in different genders. Additional studies with longer follow-up periods are needed to confirm these associations and to further examine other lifestyle behaviors and diseases that may contribute to MCI. This study may be of great significance to the prevention of MCI and ensuring a healthy aging policy.

### Data availability statement

The original contributions presented in this study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

### Ethics statement

The studies involving human participants were reviewed and approved by the Ethics Committee of Shanghai University of Medicine and Health Sciences. The

patients/participants provided their written informed consent to participate in this study.

## Author contributions

YY, QG, and ML contributed to the conception and design of the study. YL wrote the first draft of the manuscript. PH organized the database. XY performed the statistical analysis. XC, FW, JuL, YZ, and ZZ wrote sections of the manuscript. XL, JiL, RL, BW, and CX participate in the survey. All authors contributed to the article and approved the submitted version.

## Funding

This work was supported by the National Natural Science Foundation of China (grant no. 82172552), the Hygiene and Health Commission of Shanghai municipality (2019HP76), the Scientific Research Foundation of SUMHS (SSF-22-03-002), and the Scientific Research Foundation of SUMHS (SSF-21-03-005).

## References

- Atkinson, H. H., Rapp, S. R., Williamson, J. D., Lovato, J., Absher, J. R., Gass, M., et al. (2010). The relationship between cognitive function and physical performance in older women: Results from the Women's Health Initiative Memory study. *J. Gerontol. A Biol. Sci. Med. Sci.* 65, 300–306. doi: 10.1093/gerona/glp149
- Au, B., Dale-McGrath, S., and Tierney, M. C. (2017). Sex differences in the prevalence and incidence of mild cognitive impairment: A meta-analysis. *Ageing Res. Rev.* 35, 176–199. doi: 10.1016/j.arr.2016.09.005
- Chen, X., Han, P., Yu, X., Zhang, Y., Song, P., Liu, Y., et al. (2021). Relationships between sarcopenia, depressive symptoms, and mild cognitive impairment in Chinese community-dwelling older adults. *J. Affect. Disord.* 286, 71–77. doi: 10.1016/j.jad.2021.02.067
- Deng, Y., Zhao, S., Cheng, G., Yang, J., Li, B., Xu, K., et al. (2021). The prevalence of mild cognitive impairment among Chinese people: A meta-analysis. *Neuroepidemiology* 55, 79–91. doi: 10.1159/000512597
- Dong, L., Briceno, E., Morgenstern, L. B., and Lisabeth, L. D. (2020). Poststroke cognitive outcomes: Sex differences and contributing factors. *J. Am. Heart Assoc.* 9:e16683. doi: 10.1161/JAHA.120.016683
- Folstein, M. F., Folstein, S. E., and McHugh, P. R. (1975). "Mini-mental state". A practical method for grading the cognitive state of patients for the clinician. *J. Psychiatr. Res.* 12, 189–198. doi: 10.1016/0022-3956(75)90026-6
- Fu, J., Liu, Q., Du, Y., Zhu, Y., Sun, C., Lin, H., et al. (2020). Age- and sex-specific prevalence and modifiable risk factors of mild cognitive impairment among older adults in china: A population-based observational study. *Front. Aging Neurosci.* 12:578742. doi: 10.3389/fnagi.2020.578742
- Ganguli, M., Fu, B., Snitz, B. E., Hughes, T. F., and Chang, C. C. (2013). Mild cognitive impairment: Incidence and vascular risk factors in a population-based cohort. *Neurology* 80, 2112–2120. doi: 10.1212/WNL.0b013e318295d776
- Gracia, R. A., Santabarbara, S. J., Lopez, A. R., Tomas, A. C., and Marcos, A. G. (2016). [Occupation and risk of cognitive impairment and dementia in people in over 55 years: A systematic review, Spain]. *Rev. Esp. Salud Publica* 90, e1–e15.
- Iadecola, C., Yaffe, K., Biller, J., Bratzke, L. C., Faraci, F. M., Gorelick, P. B., et al. (2016). Impact of hypertension on cognitive function: A scientific statement from the American Heart Association. *Hypertension* 68, e67–e94. doi: 10.1161/HYP.0000000000000053
- Jia, L., Du, Y., Chu, L., Zhang, Z., Li, F., Lyu, D., et al. (2020). Prevalence, risk factors, and management of dementia and mild cognitive impairment in adults aged 60 years or older in China: A cross-sectional study. *Lancet Public Health* 5, e661–e671. doi: 10.1016/S2468-2667(20)30185-7
- Jiang, C. Q., Xu, L., Lam, T. H., Zhang, W. S., Liu, B., Lin, J. M., et al. (2009). [Effect of physical activity strength on the diabetes mellitus prevalence in the elderly under the influence of International Physical Activity Questionnaire]. *Zhonghua Liu Xing Bing Xue Za Zhi* 30, 462–465.
- Kaiser, M. J., Bauer, J. M., Ramsch, C., Uter, W., Guigoz, Y., Cederholm, T., et al. (2009). Validation of the mini nutritional assessment short-form (MNA-SF): A practical tool for identification of nutritional status. *J. Nutr. Health Aging* 13, 782–788. doi: 10.1007/s12603-009-0214-7
- Kim, M., and Park, J. M. (2017). Factors affecting cognitive function according to gender in community-dwelling elderly individuals. *Epidemiol. Health* 39:e2017054. doi: 10.4178/epih.e2017054
- Launer, L. J., Andersen, K., Dewey, M. E., Letenneur, L., Ott, A., Amaducci, L. A., et al. (1999). Rates and risk factors for dementia and Alzheimer's disease: Results from EURODEM pooled analyses. EURODEM Incidence Research Group and Work Groups. European Studies of Dementia. *Neurology* 52, 78–84. doi: 10.1212/WNL.52.1.78
- Lawton, M. P., and Brody, E. M. (1969). Assessment of older people: Self-maintaining and instrumental activities of daily living. *Gerontologist* 9, 179–186. doi: 10.1093/geront/9.3\_Part\_1.179
- Li, J., Wang, Y. J., Zhang, M., Xu, Z. Q., Gao, C. Y., Fang, C. Q., et al. (2011). Vascular risk factors promote conversion from mild cognitive impairment to Alzheimer disease. *Neurology* 76, 1485–1491. doi: 10.1212/WNL.0b013e318217e7a4
- Liu, Y., Ma, W., Li, M., Han, P., Cai, M., Wang, F., et al. (2021). Relationship between physical performance and mild cognitive impairment in Chinese community-dwelling older adults. *Clin. Interv. Aging* 16, 119–127. doi: 10.2147/CIA.S288164
- Livingston, G., Sommerlad, A., Orgeta, V., Costafreda, S. G., Huntley, J., Ames, D., et al. (2017). Dementia prevention, intervention, and care. *Lancet* 390, 2673–2734. doi: 10.1016/S0140-6736(17)31363-6
- Lv, Y. B., Yin, Z. X., Chei, C. L., Brasher, M. S., Zhang, J., Kraus, V. B., et al. (2016). Serum cholesterol levels within the high normal range are associated with

## Acknowledgments

We thank Bin Mao and Yue Gu from the Chongming public health center for providing place and organization.

## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

better cognitive performance among Chinese elderly. *J. Nutr. Health Aging* 20, 280–287. doi: 10.1007/s12603-016-0701-6

Lyu, J., and Kim, H. Y. (2016). Gender-specific incidence and predictors of cognitive impairment among older Koreans: Findings from a 6-year prospective cohort study. *Psychiatry Investig.* 13, 473–479. doi: 10.4306/pi.2016.13.5.473

Ma, W., Zhang, H., Wu, N., Liu, Y., Han, P., Wang, F., et al. (2021). Relationship between obesity-related anthropometric indicators and cognitive function in Chinese suburb-dwelling older adults. *PLoS One* 16:e258922. doi: 10.1371/journal.pone.0258922

Nagamatsu, L. S., Chan, A., Davis, J. C., Beattie, B. L., Graf, P., Voss, M. W., et al. (2013). Physical activity improves verbal and spatial memory in older adults with probable mild cognitive impairment: A 6-month randomized controlled trial. *J. Aging Res.* 2013:861893. doi: 10.1155/2013/861893

National Bureau of Statistics of China (2021). *China statistical yearbook 2019*. Available online at: <http://www.stats.gov.cn/tjsj/ndsj/>

Ott, A., van Rossum, C. T., van Harskamp, F., van de Mheen, H., Hofman, A., and Breteler, M. M. (1999). Education and the incidence of dementia in a large population-based study: The Rotterdam study. *Neurology* 52, 663–666. doi: 10.1212/WNL.52.3.663

Overton, M., Pihlgard, M., and Elmstahl, S. (2019). Prevalence and incidence of mild cognitive impairment across subtypes, age, and sex. *Dement. Geriatr. Cogn. Disord.* 47, 219–232. doi: 10.1159/000499763

Petersen, R. C., Smith, G. E., Waring, S. C., Ivnik, R. J., Tangalos, E. G., and Kokmen, E. (1999). Mild cognitive impairment: Clinical characterization and outcome. *Arch. Neurol.* 56, 303–308. doi: 10.1001/archneur.56.3.303

Regensteiner, J. G., Golden, S., Huebschmann, A. G., Barrett-Connor, E., Chang, A. Y., Chyun, D., et al. (2015). Sex differences in the cardiovascular consequences of diabetes mellitus: A scientific statement from the American Heart Association. *Circulation* 132, 2424–2447. doi: 10.1161/CIR.0000000000000343

Sharp, E. S., and Gatz, M. (2011). Relationship between education and dementia: An updated systematic review. *Alzheimer Dis. Assoc. Disord.* 25, 289–304. doi: 10.1097/WAD.0b013e318211c83c

Song, M., Wang, Y. M., Wang, R., Xu, S. J., Yu, L. L., Wang, L., et al. (2021). Prevalence and risks of mild cognitive impairment of Chinese community-dwelling women aged above 60 years: A cross-sectional study. *Arch. Womens Ment. Health* 24, 903–911. doi: 10.1007/s00737-021-01137-0

Van der Musselle, S., Fransen, E., Struyfs, H., Luyckx, J., Marien, P., Saelens, J., et al. (2014). Depression in mild cognitive impairment is associated with progression to Alzheimer's disease: A longitudinal study. *J. Alzheimers Dis.* 42, 1239–1250. doi: 10.3233/JAD-140405

Vance, J. E. (2012). Dysregulation of cholesterol balance in the brain: Contribution to neurodegenerative diseases. *Dis. Model. Mech.* 5, 746–755. doi: 10.1242/dmm.010124

Vega, J. N., and Newhouse, P. A. (2014). Mild cognitive impairment: Diagnosis, longitudinal course, and emerging treatments. *Curr. Psychiatry Rep.* 16:490. doi: 10.1007/s11920-014-0490-8

Winblad, B., Palmer, K., Kivipelto, M., Jelic, V., Fratiglioni, L., Wahlund, L. O., et al. (2004). Mild cognitive impairment—beyond controversies, towards a consensus: Report of the International Working Group on mild cognitive impairment. *J. Intern. Med.* 256, 240–246. doi: 10.1111/j.1365-2796.2004.01380.x

Wu, L., He, Y., Jiang, B., Liu, M., Wang, J., Yang, S., et al. (2016). The association between the prevalence, treatment and control of hypertension and the risk of mild cognitive impairment in an elderly urban population in China. *Hypertens. Res.* 39, 367–375. doi: 10.1038/hr.2015.146

Yesavage, J. A., Brink, T. L., Rose, T. L., Lum, O., Huang, V., Adey, M., et al. (1982). Development and validation of a geriatric depression screening scale: A preliminary report. *J. Psychiatr. Res.* 17, 37–49. doi: 10.1016/0022-3956(82)90033-4

Zhang, M. Y., Katzman, R., Salmon, D., Jin, H., Cai, G. J., Wang, Z. Y., et al. (1990). The prevalence of dementia and Alzheimer's disease in Shanghai, China: Impact of age, gender, and education. *Ann. Neurol.* 27, 428–437. doi: 10.1002/ana.410270412

Zhang, Y., Guan, Y., Shi, Z., Yue, W., Liu, S., Liu, S., et al. (2019). Sex differences in the prevalence of and risk factors for cognitive impairment no dementia among the elderly in a rural area of northern China: A population-based cross-sectional study. *Neuroepidemiology* 52, 25–31. doi: 10.1159/000493141

Zhang, Z. X., Zahner, G. E., Roman, G. C., Liu, X. H., Wu, C. B., Hong, Z., et al. (2006). Socio-demographic variation of dementia subtypes in China: Methodology and results of a prevalence study in Beijing, Chengdu, Shanghai, and Xian. *Neuroepidemiology* 27, 177–187. doi: 10.1159/000096131