Original Article

Food consumption and mild cognitive impairment in Qingdao rural elderly: A cross-sectional study

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Background and Objectives: Diet plays a crucial role in cognition. Mild cognitive impairment has a high prevalence in rural elderly people. However, few studies have investigated the relationship between diet and mild cognitive impairment among rural elderly people in China. The study evaluated the association between diet and the risk of mild cognitive impairment among them. **Methods and Study Design:** In this cross-sectional study, we enrolled 1262 participants (≥65 years) living in rural Qingdao, China. Cognitive function was assessed using the Mini-Mental State Examination, and dietary consumption was measured using a food frequency questionnaire. Logistic regression models were used to assess the associations. **Results:** In all, 315 (25%) participants had mild cognitive impairment. The weekly frequency of food consumption was lower in the mild cognitive impairment group than in the no mild cognitive impairment group. After adjusting for covariates, compared with participants who consumed never/less than once a week, daily consumption of coarse cereals (OR: 0.64, 95% CI: 0.44-0.91), potatoes (OR: 0.54, 95% CI: 0.34-0.87), fruits (OR: 0.49, 95% CI: 0.35-0.69), livestock and poultry meat (OR: 0.66, 95% CI: 0.44-0.99), eggs (OR: 0.67, 95% CI: 0.47-0.97), and nuts (OR: 0.47, 95% CI: 0.28-0.80) was inversely associated with mild cognitive impairment (all $p<0.05$). **Conclusions:** Higher dietary diversity and more frequent consumption of coarse cereals, potatoes, fruits, livestock and poultry meat, eggs, and nuts were associated with a lower risk of mild cognitive impairment. Elderly people should develop healthy dietary habits to prevent or delay cognitive decline.

Key Words: diet, food habits, mild cognitive impairment, elderly, cross-sectional study

INTRODUCTION

Aging and age-related diseases, such as dementia, affect approximately over 50 million people in the world, and the number is expected to triple by 2050.[1] In China, the prevalence of dementia has reached 5.6%, which is higher in rural areas than in urban areas (6.6% vs 4.2%),[2] affecting 10-11 million people aged ≥60 years.[3] Because of stigma and lack of timely diagnosis and treatment, patients are often in relatively advanced stages of disease at the time of diagnosis, which imposes a heavy burden on society, economy, and caregivers.[1] Mild cognitive impairment (MCI) is a transitional or a gray area between normal aging and the onset of dementia in which memory, attention, and cognitive function are degraded, but functional independence remains intact.[4] Therefore, timely identification of MCI allows prevention or delay of the onset of dementia.[5] Although the prevalence of MCI among elderly people in China varies by region and population,[3] the prevalence tends to be higher in rural than in urban areas due to lower levels of education, lower income, and less diverse diet in rural areas.[6]

Epidemiological evidence indicates that various modifiable lifestyle factors such as diet[7] are correlated with cognition.[8] A diverse diet positively affects cognitive function,[9] and evaluating the effect of food consumption on cognition can provide an appropriate food selection strategy. Certain dietary habits, such as high intake of fruit and vegetables, nuts, and fish; moderate intake of alcohol; and low intake of red meat, can improve cognitive function.[8,10] However, due to the difference in diet and habits between China and other countries, results of studies in other countries may not be applicable to the Chinese population.

Considering the high prevalence of MCI in rural areas and their relatively simple diet, we conducted a cross-sectional study to evaluate the association between dietary consumption and the risk of MCI among elderly people living in rural Qingdao.

METHODS

Sample size calculation

To estimate the prevalence of MCI, we used the prevalence of 25.1%,[11] with a 95% confidence level, and the level of significance (α) was set at 5%; thus, the value of $Z^2_{0.05/2}$ equals 1.96 in the present study. The π in the formula was the expected present rate, δ was the desired

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level of precision, and set a 5% precision.[12] According to the formula, the required sample size was determined to be 288 individuals.

Calculation formulas: $n = [Z^2_{\alpha/2}\, \pi\, (1- \pi)] / \delta^2$

Study population

From January to July 2019, we conducted a population-based cross-sectional study of residents in the rural area of Qingdao, Shandong province, China. Elderly people were recruited through face-to-face interviews. The inclusion criteria were age ≥65 years and living in the indicated region for >1 year. The exclusion criteria were as follows: diagnosed dementia and Alzheimer's disease (AD), diseases affecting cognitive function, long-term use of antidepressants and central nervous system drugs, and inability to provide cognitive information and dietary information even with the help of caregivers (e.g., due to language impairment or severe deafness). Finally, 1262 individuals were enrolled in this study. Ethics approval was granted by the Committee for Medical Research Ethics of the Center for Disease Control and Prevention in Qingdao (no. spaq-2016-125; date: 03-20-2018), and informed consent was obtained from each participant.

Dietary consumption

The FFQ was used to evaluate dietary consumption that participants consumed over the past 3 months.[13] The FFQ contains information on quantity (weight or volume) and frequency (daily, weekly, monthly, yearly, or never) of foods consumed. Food items were categorized into 14 food groups based on the Dietary Guideline for Chinese Residents and adjusted for local diet habits:[14] rice/wheat products, coarse cereals, potatoes, vegetables, scallions, garlic, fruits, livestock and poultry meat, fish/shellfish, eggs, dairy products, soybeans products, nuts, and pickles. To facilitate the calculation, we converted food frequency into times per week. Energy intake was calculated from participants' food intake data using the China Food Composition Tables.[15] Dietary diversity was calculated across the following nine food groups based on previous studies[16]: cereal, vegetable, fruit, meat (livestock and poultry meat), fish, egg, soybean, dairy products, and fat/oil; if participants consumed at least once a week from any of these categories, one point was given to those food categories The dietary diversity score (DDS) ranged from 0 to 9, with higher DDS indicating better dietary diversity. Because fat/oil is a necessary food group in the Chinese daily diet, one point was assigned to this category by default for all participants.

Cognitive assessment

The Mini-Mental State Examination (MMSE), a common brief screening test for cognitive function,[17] can be used to screen for cognitive decline in the aging population. Cognitive function was measured using the Chinese version of the MMSE, which was initially developed by Katzman et al. It encompassed five fields that evaluate various dimensions of cognition (orientation, memory, attention and calculation, recall, language), with total scores ranging from 0 to 30.[18] Because education is a potent demographic factor influencing MMSE performance,[19] an appropriate cutoff point was determined based on education level. In our study, 45.7% of participants did not have formal education, and only 18.6% had secondary education (>6 years). Therefore, the optimal cutoff points of the MMSE for elderly people were 16/17 for no education, 19/20 for 1–6 years of education, and 23/24 for >6 years of education. Participants who scored below the threshold in their education level group were considered as having MCI.[20]

Assessment of covariates

Data on demographic characteristics, including age, sex, education, marital status, family status, smoking, alcohol drinking, and physical activity were assessed using a self-reporting questionnaire. Nutritional status was measured using the Mini Nutritional Assessment-Short Form (MNA-SF), which can identify nutritional status in elderly people, with total scores ranging from 0 to 14.[21] Functional performance was assessed with the Instrumental Activities of Daily Living (IADL) scale. IADL involves the ability to shop, use public transportation, prepare meals, do housework, do laundry, use a telephone, take medications, and handle finances, with scores of the IADL scale ranging from 0 to 8.[22] Anthropometric data, including height, weight and BMI [calculated as the weight (kg)/height (m^2)], were collected. Hypertension was defined as systolic blood pressure ≥140 mmHg, diastolic blood pressure ≥90 mmHg, or use of antihypertensive drugs. Diabetes mellitus was defined as fasting glucose ≥7 mmol/L or use of antidiabetic drugs.

Statistical analysis

Continuous variables are expressed as mean ± standard deviation, and categorical variables as number (percentage). For intergroup comparisons, based on the distribution, data were analyzed using t test or Mann-Whitney U test for continuous variables and chi-square test or Fisher's exact test for categorical variables. The association between frequency of food group consumption and cognitive function was investigated using binary logistic regression analysis, with the lowest category (never/less than once a week) as a reference. Three models were used. The crude model was unadjusted. In the second model (Model 1), the covariates were sex and age. The third model (Model 2) included the covariates in Model 1 plus education, marital status, smoking, alcohol drinking, energy intake, diabetes mellitus, hypertension, physical activity, MNA-SF and IADL scores. All statistical analyses were performed with the SPSS (version 22). The level of significance was set as $p<0.05$.

RESULTS

The mean participant age was 72.3±6.0 years, and 315 of 1262 (25%) participants had MCI.

The basic characteristics of the participants stratified by cognitive status are presented in Table 1. Women had a higher prevalence of MCI than men ($p=0.008$). Compared with the no mild cognitive impairment (non-MCI) group, participants with MCI were more likely to be older, to have a higher BMI, to have poor nutritional status, and to report less physical activity, lower IADL scores, and lower DDS (all $p<0.05$). No significant differences were found in family status, smoking, alcohol drinking, hy-

Table 1. The characteristics of the participants by cognitive status†

Variable	Total (n=1262)	Non-MCI (n=947)	MCI (n=315)	*p*
Age (years)	72.3±6.0	71.6±5.6	74.4±6.7	<0.001
Sex, n (%)				0.008
Men	562 (44.5)	442 (46.7)	120 (38.1)	
Women	700 (55.5)	505 (53.3)	195 (61.9)	
Education, n (%)				<0.001
0 years	577 (45.7)	387 (40.9)	190 (60.3)	
1-6 years	450 (35.7)	363 (38.3)	87 (27.6)	
>6 years	235 (18.6)	197 (20.8)	38 (12.1)	
Marital status, n (%)				0.001
Single	17 (1.3)	11 (1.2)	6 (1.9)	
Married	953 (75.5)	741 (78.2)	212 (67.3)	
Widowed	292 (23.2)	195 (20.6)	97 (30.8)	
Family status, n (%)				0.090
Living alone	208 (16.5)	144 (15.2)	64 (20.3)	
Living with a partner	894 (70.8)	684 (72.2)	210 (66.7)	
Living with children	160 (12.7)	119 (12.6)	41 (13.0)	
Smoking, n (%)	315 (25.0)	247 (26.1)	68 (21.6)	0.110
Alcohol drinking, n (%)	336 (26.6)	264 (27.9)	72 (22.9)	0.081
Energy intake, kcal/d	2008±812	2091±809	1760±769	<0.001
Hypertension, n (%)	476 (37.9)	355 (37.6)	121 (38.7)	0.749
Diabetes mellitus, n (%)	153 (12.1)	106 (11.2)	47 (14.9)	0.079
BMI (kg/m^2)	24.7±3.2	24.5±2.9	24.9±3.4	0.013
Physical activity, h/d	2.20±1.52	2.27±1.55	1.99±1.42	0.006
MNA-SF score	12.6±1.5	12.8±1.3	12.2±1.8	<0.001
IADL score	7.07±1.39	7.29±1.12	6.42±1.83	<0.001
DDS	6.67±1.48	6.82±1.49	6.22±1.38	<0.001
MMSE score	22.1±5.8	24.6±3.8	14.8±4.0	<0.001

BMI: body mass index; MNA-SF: Mini Nutritional Assessment Short-Form; IADL: Instrumental Activities of Daily Living Scale; DDS: dietary diversity score; MMSE: Mini-Mental State Examination.
†Data are presented as n (%), mean±standard deviation. Differences in continuous variables compared using Student's t-test or Mann-Whitney U test, and chi-square test for categorical variables.

pertension, or diabetesf mellitus.

The mean frequency of the food group per week among the 1262 participants is presented in Table 2. In both non-MCI and MCI groups, rice/wheat products and vegetables were consumed daily; coarse cereals, scallions, garlic, fruits, livestock and poultry meat, and eggs were consumed 4–6 times per week; and potatoes, fish/shellfish, dairy products, soybean products, and nuts were consumed about 1–2 times per week. In the MCI group, fish/shellfish consumption was less than once a week. The weekly frequency of food consumption in the MCI group was significantly lower than that in the non-MCI group for all food categories, except pickles. Hence, to further assess the relationship between food consumption and MCI, we divided food consumption into four categories based on a previous study:[23] never/less than once a

Table 2. Comparison of the frequency of food group consumption by cognitive status†

Food group (times/week)	Total (n=1262)	Non-MCI (n=947)	MCI (n=315)	*p*
Rice/wheat products	18.5±4.36	18.7±4.23	17.9±4.68	0.001
Coarse cereals	4.63±5.98	4.82±5.97	4.04±5.98	<0.001
Potatoes	2.49±3.64	2.74±3.71	1.73±3.28	<0.001
Vegetables	15.7±5.55	15.9±5.49	14.9±5.69	0.004
Scallions	5.58±6.92	5.87±6.92	4.71±6.85	0.001
Garlic	4.73±6.31	5.03±6.43	3.82±5.84	0.003
Fruits	4.64±4.30	5.04±4.37	3.43±3.82	<0.001
Livestock and poultry meat	7.13±6.70	7.74±6.77	5.30±6.14	<0.001
Fish/Shellfish	1.26±2.18	1.36±2.19	0.95±2.13	<0.001
Eggs	5.18±3.45	5.36±3.43	4.67±3.46	0.002
Dairy products	2.09±3.06	2.19±3.07	1.79±2.99	0.017
Soybean products	1.48±2.45	1.58±2.56	1.19±2.07	0.006
Nuts	1.73±2.82	1.93±3.00	1.15±2.08	<0.001
Pickles	3.04±5.44	3.12±5.52	2.80±5.20	0.532

†Data are presented as mean±standard deviation.
p values were calculated by using *t* test or Mann-Whitney U test based on data distribution.

week, 1-3 times per week, 4-6 times per week and daily.

The distribution of cognitive status by the frequency of food group consumption is presented in Table 3. The distribution of the non-MCI and MCI groups varied in the consumption frequency of coarse cereals, potatoes, scallions, garlic, fruits, livestock and poultry meat, fish/shellfish, eggs, soybean products, and nuts consumption (all $p<0.05$). With the increasing consumption frequency of these food groups, the prevalence of MCI decreased. We found that higher DDS was associated with a lower risk of MCI (Supplemental table 1). Therefore, we analyzed the association between the consumption of these food groups and MCI, and the results are presented in Table 4.

After adjustment for potential confounders, compared with participants who consumed never/less than once a week, daily consumption of coarse cereals (OR: 0.64, 95% CI: 0.44-0.91), potatoes (OR: 0.54, 95% CI: 0.34-0.87), fruits (OR: 0.49, 95% CI: 0.35-0.69), livestock and poultry meat (OR: 0.66, 95% CI: 0.44-0.99), eggs (OR: 0.67, 95% CI: 0.47-0.97) and nuts (OR: 0.47, 95% CI: 0.28-0.80) had a lower risk of MCI (all $p<0.05$). No significant association was observed between the frequency of fish/shellfish and soybeans products consumption and MCI.

Table 3. The distribution of cognitive status by frequency of food group consumption†

Food group	Frequency of food group consumption				
	Never/less than once a week	1-3 times/week	4-6 times/week	Daily	p
Rice/Wheat products					0.433
Non-MCI	9 (60.0)	7 (87.5)	2 (100)	929 (75.1)	
MCI	6 (40.0)	1 (12.5)	0 (0.0)	308 (24.9)	
Coarse cereals					0.001
Non-MCI	266 (70.7)	266 (71.1)	55 (77.5)	359 (81.6)	
MCI	110 (29.3)	108 (28.9)	16 (22.5)	81 (18.4)	
Potatoes					<0.001
Non-MCI	355 (68.0)	351 (77.3)	69 (82.1)	172 (85.1)	
MCI	167 (32.0)	103 (22.7)	15 (17.9)	30 (14.9)	
Vegetables					0.506
Non-MCI	32 (68.1)	10 (66.7)	10 (71.4)	894 (75.4)	
MCI	15 (31.9)	5 (33.3)	4 (28.6)	291 (24.6)	
Scallions					0.001
Non-MCI	378 (71.1)	104 (69.3)	31 (72.1)	434 (80.8)	
MCI	154 (28.9)	46 (30.7)	12 (27.9)	103 (19.2)	
Garlic					0.010
Non-MCI	395 (72.7)	138 (69.3)	46 (75.4)	368 (80.2)	
MCI	148 (27.3)	61 (30.7)	15 (24.6)	91 (19.8)	
Fruits					<0.001
Non-MCI	220 (64.5)	158 (69.9)	62 (79.5)	507 (82.2)	
MCI	121 (35.5)	68 (30.1)	16 (20.5)	110 (17.8)	
Livestock and poultry meat					<0.001
Non-MCI	142 (68.3)	183 (64.0)	96 (71.1)	523 (83.0)	
MCI	66 (31.7)	103 (36.0)	39 (28.9)	107 (17.0)	
Fish/Shellfish					0.001
Non-MCI	466 (70.4)	380 (79.2)	36 (87.8)	64 (82.1)	
MCI	196 (29.6)	100 (20.8)	5 (12.2)	14 (17.9)	
Eggs					0.005
Non-MCI	142 (67.0)	146 (71.9)	78 (82.1)	578 (77.2)	
MCI	70 (33.0)	57 (28.1)	17 (17.9)	171 (22.8)	
Dairy products					0.102
Non-MCI	557 (72.6)	124 (78.0)	32 (82.1)	232 (78.6)	
MCI	210 (27.4)	35 (22.0)	7 (17.9)	63 (21.4)	
Soybean products					0.031
Non-MCI	499 (72.2)	310 (76.9)	50 (86.2)	87 (79.8)	
MCI	192 (27.8)	93 (23.1)	8 (13.8)	22 (20.2)	
Nuts					<0.001
Non-MCI	500 (71.0)	261 (76.3)	36 (78.3)	149 (88.2)	
MCI	204 (29.0)	81 (23.7)	10 (21.7)	20 (11.8)	
Pickles					0.484
Non-MCI	573 (74.6)	107 (71.8)	36 (81.8)	231 (76.7)	
MCI	195 (25.4)	42 (28.2)	8 (18.2)	70 (23.3)	

MCI: mild cognitive impairment.
†Data are presented as n (%).
p values were calculated by chi-square and Fisher's exact test.

Table 4. The association between frequency of food group consumption and mild cognitive impairment†

Food group	Frequency of food group consumption								p
	Never/less than once a week		1-3 times/week		4-6 times/week		Daily		
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	
Coarse cereals									
Crude	1.00		1.15	(0.89-1.65)	1.04	(0.53-2.06)	0.84	(0.58-1.21)	0.350
Model 1	1.00		1.01	(0.73-1.40)	0.82	(0.44-1.51)	0.53	(0.38-0.74)	<0.001
Model 2	1.00		1.28	(0.91-1.82)	1.09	(0.58-2.06)	0.64	(0.44-0.91)	0.014
Potatoes									
Crude	1.00		0.81	(0.58-1.13)	0.69	(0.36-1.31)	0.59	(0.37-0.95)	0.031
Model 1	1.00		0.67	(0.50-0.90)	0.52	(0.29-0.95)	0.43	(0.28-0.67)	<0.001
Model 2	1.00		0.84	(0.61-1.16)	0.58	(0.30-1.11)	0.54	(0.34-0.87)	0.012
Scallions									
Crude	1.00		0.99	(0.58-1.71)	1.19	(0.49-2.89)	0.75	(0.52-1.08)	0.120
Model 1	1.00		1.12	(0.75-1.68)	1.12	(0.55-2.26)	0.64	(0.48-0.85)	0.002
Model 2	1.00		1.19	(0.77-1.83)	1.47	(0.71-3.06)	0.74	(0.54-1.01)	0.059
Garlic									
Crude	1.00		1.24	(0.76-2.03)	0.87	(0.39-1.93)	1.02	(0.70-1.48)	0.946
Model 1	1.00		1.36	(0.94-1.96)	1.05	(0.56-1.98)	0.73	(0.54-0.99)	0.045
Model 2	1.00		1.58	(1.06-2.34)	1.51	(0.78-2.92)	0.93	(0.67-1.29)	0.661
Fruits									
Crude	1.00		0.74	(0.50-1.11)	0.63	(0.32-1.21)	0.53	(0.38-0.75)	<0.001
Model 1	1.00		0.82	(0.56-1.18)	0.50	(0.27-0.92)	0.40	(0.30-0.55)	<0.001
Model 2	1.00		0.93	(0.63-1.38)	0.60	(0.32-1.14)	0.49	(0.35-0.69)	<0.001
Livestock and poultry meat									
Crude	1..00		1.21	(0.83-1.77)	0.87	(0.55-1.40)	0.44	(0.31-0.63)	<0.001
Model 1	1.00		1.30	(0.88-1.93)	0.98	(0.60-1.60)	0.50	(0.34-0.72)	<0.001
Model 2	1.00		1.47	(0.97-2.24)	1.40	(0.82-2.36)	0.66	(0.44-0.99)	0.044
Fish/shellfish									
Crude	1.00		0.91	(0.66-1.27)	0.50	(0.18-1.36)	0.94	(0.48-1.85)	0.850
Model 1	1.00		0.66	(0.50-0.88)	0.37	(0.14-0.97)	0.60	(0.33-1.11)	0.105
Model 2	1.00		0.77	(0.57-1.04)	0.48	(0.18-1.30)	0.90	(0.47-1.70)	0.741
Eggs									
Crude	1.00		0.95	(0.60-1.52)	0.66	(0.34-1.28)	0.83	(0.57-1.21)	0.320
Model 1	1.00		0.81	(0.52-1.24)	0.47	(0.25-0.87)	0.56	(0.40-0.80)	0.001
Model 2	1.00		0.86	(0.55-1.36)	0.55	(0.29-1.06)	0.67	(0.47-0.97)	0.034
Soybeans products									
Crude	1.00		1.04	(0.74-1.46)	0.73	(0.31-1.70)	0.96	(0.55-1.68)	0.890
Model 1	1.00		0.82	(0.61-1.10)	0.50	(0.23-1.09)	0.72	(0.44-1.20)	0.210
Model 2	1.00		0.98	(0.72-1.34)	0.62	(0.27-1.41)	0.86	(0.50-1.47)	0.581
Nuts									
Crude	1.00		0.91	(0.64-1.27)	1.21	(0.53-2.78)	0.46	(0.27-0.79)	0.005
Model 1	1.00		0.89	(0.65-1.21)	0.64	(0.31-1.33)	0.37	(0.22-0.60)	<0.001
Model 2	1.00		1.02	(0.74-1.41)	0.80	(0.37-1.73)	0.47	(0.28-0.80)	0.005

MNA-SF: Mini Nutritional Assessment Short-Form; IADL: Instrumental Activities of Daily Living Scale.
†All of the models were constructed using binary logistic regression method, results are presented as OR (95% CIs).
Crude model was unadjusted. Model 1 adjusted on sex, age (years). Model 2 same as Model 1 plus adjusted on education, marital status, smoking, alcohol drinking, energy intake, diabetes mellitus, hypertension, physical activity, MNA-SF and IADL score.

DISCUSSION

In this cross-sectional study involving 1262 elderly people, 25% had MCI. Daily consumption of coarse cereals, potatoes, fruits, livestock and poultry meat, eggs, and nuts was associated with a lower risk of MCI than consuming these food categories never/less than once a week.

The prevalence of MCI in our result was higher than those reported from other regions of China. MCI prevalence among the elderly people was 14.2% in Guangzhou and 20.3% in rural areas[24] and 21.3% in Hebei Province.[25] In a systematic review, the combined pooled prevalence of MCI in China was 14.7%.[26] In Italy and Greece, the prevalence of MCI was 21.6%[27] and 15.3%,[28] respectively. The discrepancies may be caused by differences in study population and MCI screening scales.

Our result observed that the MCI group had lower consumption of all food groups than the non-MCI group. This may be because the MCI group had less physical activity time, which affects energy requirement, than the non-MCI group. In addition, the MCI group was more likely to be older. Aging is associated with changes in the digestive system, hormones, smell, taste, and reduced energy needs, which might be limit the desire to eat.[29] However, cognitive decline is accompanied by olfactory identification and taste deficits.[30,31] Changes in smell and taste may contribute to a decreased appetite, leading to a reduction in dietary intake.[32] Therefore, further research is required to determine the causality of the association between MCI and frequency of food consumption in elderly people.

Our result revealed that the non-MCI group had better dietary diversity than the MCI group and that higher DDS was inversely associated with MCI. Dietary diversity has been used to evaluate diet quality and is related to appropriate nutritional and health status, including cognition.[33] A study reported that elderly people with normal cognition had higher DDS than those with cognitive impairment, and further analyze found that higher DDS was significantly associated with better cognitive function.[34] Therefore, increasing the number of food groups and choosing foods beneficial for cognitive function to ensure dietary diversity may protect against MCI.

Coarse cereals and potatoes are indispensable in the traditional Chinese diet, which are potential sources of carbohydrate and dietary fiber. Some carbohydrates such as saccharides are critical structural and functional components of the brain, which may play a role by participating in energy supply, neurotransmitter synthesis, insulin and cortisol effects, and peripheral mechanisms.[35] Kaplan et al[36] found that cognitive performance was associated with glucose regulation in elderly people, common carbohydrate-containing foods (such as potato and barley) improve cognition in individuals with relatively poor memory or poor β cell function. Higher whole grain and potato consumption was found to be related to better average global cognition,[37] which is consistent with our data.

Higher intake of fruit is inversely associated with the risk of cognitive impairment and dementia,[38] but this finding has been inconsistent. Gehlich KH et al[39] reported that fruit consumption predicted better cognitive performance in older adults, whereas a cohort study observed that a higher consumption of vegetables, but not fruits, is associated with a decreased risk of dementia or cognitive decline.[40] Our result, however, indicated that a high frequency of fruits consumption positively affected MCI. Antioxidants in vegetables and fruits can reduce oxidative stress, which was one of the main therapeutic mechanisms of AD.[41] However, bioactive compounds differ in composition between different fruits and interact with each other.[42] A cross-sectional study involving a Puerto Rican population demonstrated that a greater variety, but not quantity, of fruit intake was significantly associated with better cognitive function in older adults.[43] Therefore, future studies should focus on the effects of the variety of fruits and vegetables consumed and consider their role in cognitive function among elderly people.

Daily consumption of livestock and poultry meat was associated with a reduced risk of MCI in our study, which is inconsistent with most study results.[44] However, the results require further review. In a randomized controlled trial, participants who consumed an average of 3 weekly servings of fresh pork had more positive cognitive outcomes than those consuming the control diet.[45] Low hemoglobin levels may contribute to cognitive impairment, and anemia was found to be positively correlated with global cognitive decline and dementia incidence.[46] In the UK Biobank, people who eat meat were found to be less likely to suffer from anemia than those who less or no meat.[47] In addition, high-quality protein from animal sources can promote nutritional status and benefit cognitive function in the elderly people.[48] As the age increases, digestion and absorption functions, teeth health, and chewing ability decline, resulting in decreased meat intake. Therefore, adequate meat intake must be ensured by increasing the frequency of consumption.

In addition to meat consumption, our finding revealed that individuals who consumed eggs daily were less likely to have MCI. Similarly, a cohort study with 21.9 years of follow-up indicated that egg intake can improve cognitive performance in certain areas.[49] However, the cognitive effects of eggs remain controversial. Bishop et al[50] suggested that egg consumption is neither beneficial nor harmful for the cognitive health of older adults. Egg is a vital source of high-quality protein and dietary cholesterol, and is rich in lutein, zeaxanthin, and choline, which promote healthy aging of the brain and improve the nutritional status of the elderly people. Choline exerts neuroprotective effects. Sufficient choline concentrations in the brain may protect neurons and brain volume, and are thought to prevent age-related cognitive decline and certain types of dementia.[51] In addition, lutein and zeaxanthin have a positive effect on cognition, may enhance neural efficiency[52] and cerebral perfusion,[53] and improve white matter integrity in regions[54] in older adults. Nonetheless, the effect of these nutrients on cognition is related to their concentrations in the brain, so when studying their effects, their intake and absorption of these nutrients must be considered.

Nuts, as a key component in the Mediterranean diet, are positively associated with cognitive function.[8] Nuts are rich in a range of nutrients that have protective effect on vascular health, which potentially improves cerebral vascular function and thus, cognitive performance.[55] In older adults with high cardiovascular risk, 30 g of walnut per day was related with better working memory.[56] In a 3-year Italian cohort study, older adults with higher nut intake had better cognitive function.[57] These findings are in line with our results.

This study focused on the rural older adults and explored their food consumption and the association with MCI (Figure 1). Several study limitations should be noted. First, the cross-sectional design was impossible to describe causal relationships. Long-term prospective and interventional studies are required to validate our findings and determine the causality. Second, most participants were willing and able to come to the physical examination center for healthy check-ups, leading to possible volunteer bias.

Conclusion

In our study of rural Chinese elderly people, higher dietary diversity was negatively associated with MCI and daily consumption of coarse cereals, potatoes, fruits, livestock and poultry meat, eggs, and nuts was associated with a lower risk of MCI. It is paramount to prevent or delay cognitive decline by sticking to a diverse diet, even in old age.

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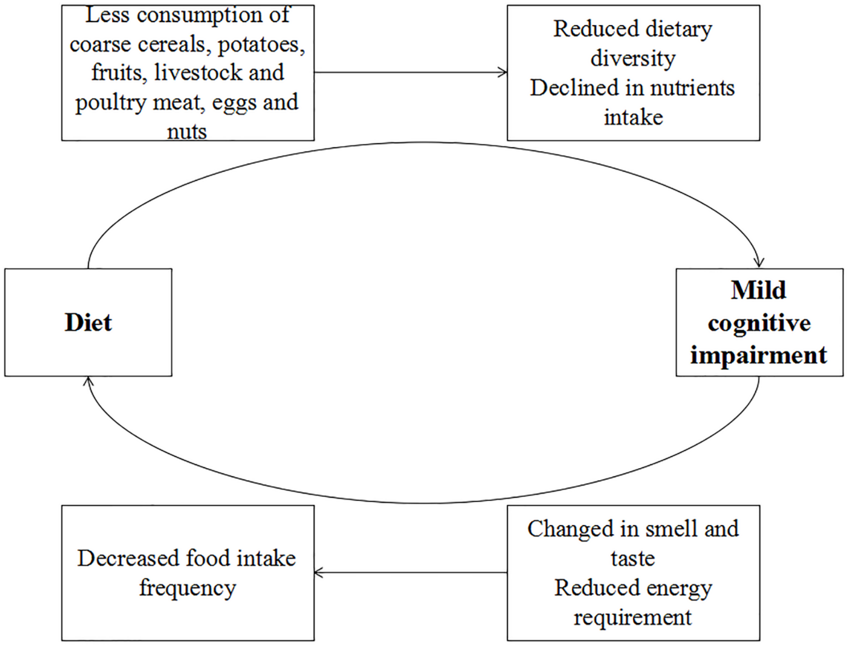

Figure 1. Association between diet and mild cognitive impairment

AUTHOR DISCLOSURES
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Supplementary table 1. The association between dietary diversity score and mild cognitive impairment†

	Dietary diversity score		*p*
	OR	95% CI	
Crude	0.76	(0.70-0.83)	<0.001
Model 1	0.78	(0.71-0.85)	<0.001
Model 2	0.85	(0.77-0.94)	0.002

BMI: body mass index; MNA-SF: Mini Nutritional Assessment Short-Form; IADL: Instrumental Activities of Daily Living Scale; DDS: dietary diversity score; MMSE: Mini-Mental State Examination.
†All of the models were constructed using binary logistic regression method, results are presented as OR (95% CIs).
Crude model was unadjusted. Model 1 adjusted on sex, age (years). Model 2 same as Model 1 plus adjusted on education, marital status, smoking, alcohol drinking, energy intake, diabetes mellitus, hypertension, physical activity, MNA-SF and IADL score.