



# Association between the healthy eating index and anxiety among Chinese elderly: A population-based cross-sectional study

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## ABSTRACT

**Introduction:** Given that few studies have examined the relationship between healthy eating and anxiety in older adults, this study aimed to assess the relationship between the healthy eating index and anxiety in an older adult population using the Chinese Longevity Health Survey (CLHLS).

**Methods:** A national cross-sectional study from the CLHLS in 2018. The healthy eating index was constructed based on the frequency of intake of 13 dietary variables. Anxiety was assessed by the Generalized Anxiety Disorder scale. We used multivariate binary logistic regression to explore the association between the healthy eating index and anxiety and reported as odds ratio (OR) and 95 % confidence interval (95 % CI).

**Results:** A total of 13,873 older adults were included in the analysis after excluding participants with missing key variables. After adjusting for potential confounders, compared with participants in the lowest quartile of a healthy eating index, those in the second to the fourth quartile group had 4.7 %, 20.7 %, and 28.4 % lower odds of anxiety compared with those in the first quartile, respectively. Restricted cubic spline curves showed that anxiety risk decreased with increasing healthy eating index, and for each unit increase in the healthy eating index, the risk of anxiety in older adults decreased by 2.3 % (OR = 0.977; 95 % CI 0.970–0.985).

**Discussion:** In Chinese older adults, a healthy diet was associated with lower anxiety. Although prospective studies are still needed to confirm these associations in older populations, this result emphasizes the need to focus on dietary diversity in older adults to promote healthy aging.

## 1. Introduction

China's aging population is deepening globally at the most prominent and fastest rate (WHO, 2015). Data from the 7th census in 2020 show that the proportion of people over 60 has increased by 5.44 percentage points compared to 10 years ago and may increase by 10 million yearly (Central People's Government of the People's Republic of China, 2021). Anxiety is among the most common mental health problems among older adults in China, with an estimated prevalence of 11.24 % (Liu et al., 2023). It is characterized by excessive anxiety and worry, including fear, dread, and uneasiness, experienced as uncontrollable and lasting for at least six months or more (Whitley, 1992). It is associated with substantial adverse outcomes, including poorer health-related quality of life (Dangerfield et al., 2023), increased disability (Kang et al., 2017), and higher healthcare utilization (Lamoureux-Lamarche et al., 2022), compared to older adults who are not anxious. Therefore,

appropriate actions must be taken to prevent this psychological problem in older adults.

Mounting evidence suggests that modifiable risk factors, including poor diet quality, are associated with common mental disorders such as anxiety and depression (Chegini et al., 2022; Meller et al., 2021; Molendijk et al., 2018; Saul et al., 2022). Unfortunately, previous research on the relationship between a priori dietary patterns and mental health has focused on the latter (Hockey et al., 2020; Zielinska et al., 2022). In recent years, several studies have shown that a single-nutrient supplemental intake, e.g., Omega-3 (Kelaiditis et al., 2023) and B vitamins (Mahdavifar et al., 2021), is associated with a lower risk of anxiety. However, the modern view is that the relationship between diet and illness has mostly been suggested to be studied through a dietary pattern approach rather than individual foods and nutrients (Xiang et al., 2022). Several cross-sectional studies have reported that adherence to the Mediterranean diet and Dietary Approaches to Stop

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Hypertension is associated with a reduced risk of anxiety (Barkhordari et al., 2022; Sadeghi et al., 2021; Torabynasab et al., 2023). This favorable link was attributed to the components of both healthy dietary patterns, including vegetables, fruits, and the ratio of monounsaturated and polyunsaturated fatty acids. In addition, it was reported that military personnel in Iranian military centers with a high-quality diet, as measured by the healthy eating index-2015, had a lower risk of anxiety (Parastouei et al., 2023). The systematic review results also showed a significant inverse relationship between a healthy dietary pattern based on vegetables, fruits, and nuts and the risk of anxiety (Aucoin et al., 2021). A prospective cohort study based on a Swiss population found that people with current anxiety disorders had 1.2 lower healthy eating index scores compared to participants without anxiety (Richard et al., 2022), illustrating the bidirectional nature of the association between the healthy eating index and anxiety.

Although earlier studies reported a protective association between healthy dietary patterns and anxiety in Western countries, data in this area are limited in the Chinese region, and the nutritional habits of Chinese older adults differ markedly from those in Western nations: plant-based protein intake is predominant, with grains as the staple food, supplemented by vegetables and red meat (pork, beef); people in most regions also prefer pickled foods; and the more popular overseas milk and dairy products, have a lower intake among older Chinese (Ma, 2015). Considering the nature of the available data, further research seems needed. Therefore, we aimed to explore the association between the healthy eating index and anxiety in the Chinese elderly population using the existing Chinese Longitudinal Healthy Longevity Survey (CLHLS) cohort study.

## 2. Methods

### 2.1. Study population

CLHLS is a national prospective cohort study of community-dwelling older adults in China. The sampling design of CLHLS used a multi-stage disproportionate targeted random sampling method, allowing for representative and reliable sample data (Zeng et al., 2013). The CLHLS study was approved by the Biomedical Ethics Committee of Peking University (IRB00001052-13074). This study was based on the 2018 CLHLS, and people aged 65 years and older were selected as participants. We removed samples that answered “not able to answer,” “I refuse to answer,” “not applicable,” and missing values for key variables (healthy eating index and anxiety). Finally, 13,873 participants were included in the study for analysis (Figure S1). This study followed Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guidelines (Vandenbroucke et al., 2007) (Table S1).

### 2.2. Healthy eating index

In the CLHLS dataset, respondents were asked to report their current frequency of intake of 13 food groups: fruits, vegetables, meat, fish, eggs, food made from beans, salt-preserved vegetables, sugar, tea, garlic, nut, mushroom or algae, and milk products. Based on previous knowledge of the relationship between these food groups and health, each respondent was reverse-scored for salt-preserved vegetables and sugar in the survey. The values assigned to each food group are shown in Table S2. Thus, the scores of the 13 variables were summed to obtain a healthy eating index ranging from 0 to 50, with higher scores considered a healthier dietary pattern.

### 2.3. Anxiety

The CLHLS evaluates anxiety using the Generalized Anxiety Disorder (GAD-7) scale. The GAD-7 consists of 7 items using a 4-point Likert scale ranging from 0=“never” to 3=“almost every day.” GAD-7 scores range

from 0 to 21, with higher scores associated with more anxiety symptoms. The respondents with scores above 4 in GAD-7 were thought to have anxiety symptoms (Spitzer et al., 2006).

### 2.4. Covariates

Information on the following nine covariates was also extracted from the dataset: age (<75 or  $\geq$  75), gender, marital status (married or widowed/divorced/single), self-reported economic status (rich, average, or difficult), activity ability (not limited/limited/strongly limited), current smoking status (yes or no), current drinking status (yes or no), current exercise habit (yes or no), smoking status (yes or no), and physical status (healthy or frailty).

### 2.5. Statistical analysis

Sociodemographic information was expressed as frequencies and percentages (%) of categorical variables, and chi-square tests were used to compare differences in variables between healthy eating index quartile groups. Multivariate binary logistic regression was used to calculate the odds ratio (OR) and 95 % confidence intervals (95 % CI) for the association between the healthy eating index and anxiety. We fitted three separate models: Model 1 was unadjusted, Model 2 was adjusted for age and gender, and Model 3 was obtained after adjusting for gender, age, marriage, economic status, smoking, drinking, exercise habits, and physical status. Next, a multivariate restricted cubic spline (RCS) model was used to investigate whether a dose–response linear relationship existed between the healthy eating index and anxiety, with three knots at the 10th, 50th, and 90th centiles. Finally, we performed subgroup analyses of the binary logistic regression model to test the stability of the results.

Missing values of covariates were estimated using the “Hmisc” package, and the interpolated data set was re-analyzed and compared to the original data.  $P < 0.05$  was considered statistically significant. All statistical analyses were performed using SPSS 26.0 and R software (<https://www.r-project.org>; version 4.2.0, The R Foundation).

## 3. Results

Table 1 provides the sociodemographic characteristics of the study participants. The sample consisted of 13,873 participants, of which 6226 (44.9 %) were male and 7647 (55.1 %) were female. Of all participants, 77.4 % were 75 years and older; 56.6 % were married; 69.8 % were considered economically average; More than half (65.9 %) of older persons have no limitations on their living activities, 15.2 % and 14.5 % were current smokers and drinkers, respectively; 31.5 % were physically active; and 14.3 % were considered physically frail. The results of socio-demographic information before and after interpolation were similar (Table S3).

In this data set, the prevalence of anxiety in people aged 65 years and older was approximately 12.0 % (9.4 % in men and 14.2 % in women). Fig. 1 shows the prevalence of anxiety across quartiles of the healthy eating index. Participants with higher dietary indices had a lower prevalence of anxiety.

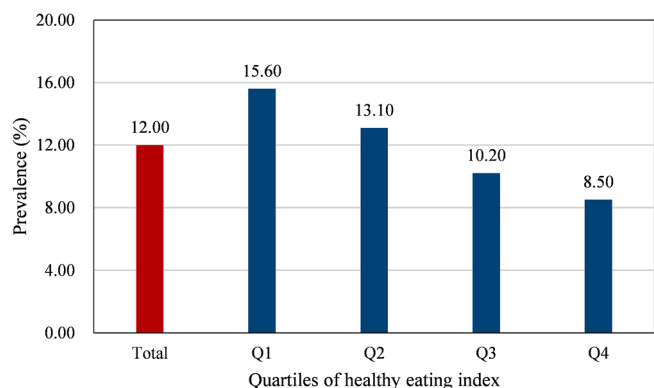
### 3.1. Relationship between the healthy eating index and anxiety

Results of multivariate logistic regression analyses showed that after adjusting for gender, age, marriage, economic status, smoking, drinking, habitual exercise, and physical status, each standard deviation (7.1) increase in the healthy eating index was associated with a 14.4 % reduction in the risk of anxiety (OR: 0.856; 95 % CI 0.806–0.909). Compared to those with a healthy eating index score below 21, those with a dietary index of 22–26, 27–30, and  $\geq$  31 had a lower risk of anxiety by 7.0 % (OR = 0.930; 95 % CI 0.809–1.069), 20.7 % (OR = 0.793; 95 % CI 0.672–0.936) and 28.0 % (OR = 0.720; 95 % CI

**Table 1**  
Descriptive statistics of Chinese elderly people (age ≥ 65 years) according to quartiles of health eating index in 2018 CLHLS.

Variables	Total (n = 13,873) Frequency (%)	Q1 (0–21) (n = 3734) Frequency (%)	Q2 (22–26) (n = 3835) Frequency (%)	Q3 (27–30) (n = 2667) Frequency (%)	Q4 (31–50) (n = 3637) Frequency (%)	P-value
Gender						
Male	6226 (44.9)	1339 (35.9)	1665 (43.4)	1239 (46.5)	1983 (54.5)	<0.001
Female	7647 (55.1)	2395 (61.1)	2170 (56.6)	1428 (53.5)	1654 (45.5)	
Age (year)						<0.001
<75	3137 (22.6)	618 (16.6)	803 (20.9)	633 (23.7)	1083 (29.8)	
≥75	10,736 (77.4)	3116 (83.4)	3032 (79.1)	2034 (76.3)	2554 (70.2)	
Marriage (n = 13,741)						<0.001
Married	7778 (56.6)	2408 (64.5)	2285 (59.6)	1449 (54.3)	1636 (45.0)	
Widowed/divorced/single	5963 (43.4)	1285 (34.4)	1509 (39.3)	1195 (44.8)	1974 (54.3)	
Self-reported economic status (n = 13,740)						<0.001
Rich	2729 (19.9)	385 (10.3)	647 (16.9)	602 (22.6)	1095 (30.1)	
Average	9592 (69.8)	2599 (69.6)	2760 (72.0)	1856 (69.6)	2377 (65.4)	
Difficult	1419 (10.3)	707 (18.9)	389 (10.1)	183 (6.9)	140 (3.8)	
Activity ability (n = 13,825)						0.166
Not limited	9137 (65.9)	2511 (67.2)	2502 (65.2)	1761 (66.0)	2363 (65.0)	
Limited	3245 (23.4)	856 (22.9)	934 (24.4)	604 (22.6)	851 (23.4)	
Strongly limited	1443 (10.4)	358 (9.6)	391 (10.2)	289 (10.8)	405 (11.1)	
Smoking (n = 13,743)						0.030
No	11,630 (83.8)	3189 (85.4)	3211 (83.7)	2208 (82.8)	3022 (83.1)	
Yes	2113 (15.2)	516 (13.8)	591 (15.4)	431 (16.2)	575 (15.8)	
Drinking (n = 13,668)						<0.001
No	11,650 (84.0)	3258 (87.3)	3279 (85.5)	2197 (82.4)	2916 (80.2)	
Yes	2018 (14.5)	423 (11.3)	507 (13.2)	429 (16.1)	659 (18.1)	
Habitual exercise (n = 13,687)						<0.001
No	9323 (67.2)	2975 (79.7)	2777 (72.4)	1773 (66.5)	1798 (49.4)	
Yes	4364 (31.5)	705 (18.9)	1006 (26.2)	865 (32.4)	1788 (49.4)	
Physical Status (n = 13,762)						<0.001
Healthy	11,772 (84.9)	2948 (79.0)	3205 (83.6)	2324 (87.1)	3295 (90.6)	
Frailty	1990 (14.3)	755 (20.2)	596 (15.5)	322 (12.1)	317 (8.7)	

Note: Data are presented as frequency (%). Q, quartiles.



**Fig. 1.** Prevalence of anxiety in Chinese elderly people (age ≥ 65 years) across quartiles of healthy eating index in 2018 CLHLS.

0.610–0.848), respectively (Table 2). The analysis of the interpolated data shows similar results (Model 4).

**3.2. Analysis of the nonlinear correlation between the healthy eating index and anxiety in older adults**

Dose-response relationships based on restricted cubic spline curves showed a nonlinear negative association between a healthy eating index and the risk of anxiety in older adults. The risk of anxiety gradually decreased as the healthy dietary index increased (Fig. 2), e.g., for each unit increase in the healthy eating index, the risk of anxiety in older adults decreased by 2.3 % (OR = 0.977; 95 % CI 0.970–0.985) (Table 2).

**3.3. Subgroup analysis**

We performed subgroup analyses to stratify the association between

the healthy eating index and anxiety by age, gender, marriage, economic status, smoking, drinking, exercise habits, and physical status, as shown in Table S4. Stratified analyses by gender showed that among females, participants in the fourth quartile had a 33 % (OR = 0.670; 95 % CI 0.541–0.829) lower risk of anxiety than those in the first quartile after adjustment for different confounders; however, no significant association between the dietary index and anxiety was found among males. Similar results were found in the population with or without exercise habits and physical status. No interaction was found between subgroup variables and the association between the healthy eating index and the risk of anxiety, except for the physical status.

**4. Discussion**

The prevalence of anxiety in the Chinese elderly population is approximately 12.0 %. As a result of the 2018 CLHLS data analysis revealed a significant inverse association between the healthy eating index and the odds of anxiety in the Chinese elderly population. This association remained significant even after adjusting for potential confounders. In stratified analyses, we found this inverse relationship significant only among females, non-exercise habits, and frail older adults.

Anxiety is a growing psychological disorder globally, especially in the context of the COVID-19 outbreak in the last three years (Blasbalg et al., 2023; Dai et al., 2022; Janiri et al., 2022), and is associated with poor quality of life and disease prognosis in individuals. In addition, anxiety-based psychological disorders place a significant burden on the healthcare system. Although dietary intake, a modifiable lifestyle, is considered an effective strategy to prevent anxiety, data on the association between the healthy eating index and anxiety are scarce. An Australian cohort study showed that a “traditional” dietary pattern characterized by vegetables, fruits, meat, fish, and whole grains was associated with a lower prevalence of anxiety disorders (OR = 0.68; 95 % CI 0.47–0.99) after adjustment for age, socioeconomic status, education, and health behaviors, but the study was limited to female

**Table 2**

Association between the healthy eating index and anxiety by multivariate logistic regression models among elderly Chinese of age ≥ 65 years in 2018 CLHLS.

	N	Model 1 (OR, 95 % CI)	Model 2 (OR, 95 % CI)	Model 3 (OR, 95 % CI)	Model 4* (OR, 95 % CI)
Per SD (7.1) increase		0.738 (0.700 to 0.778) < 0.001	0.751 (0.712 to 0.793) < 0.001	0.856 (0.806 to 0.909) < 0.001	0.851 (0.804 to 0.901) < 0.001
Per 1-unit increase		0.958 (0.951 to 0.965) < 0.001	0.960 (0.953 to 0.968) < 0.001	0.978 (0.970 to 0.987) < 0.001	0.977 (0.970 to 0.985) < 0.001
Quartiles					
Q1 (≤21)	3,734	Ref.	Ref.	Ref.	Ref.
Q2 (22–26)	3,835	0.814 (0.716 to 0.926) 0.002	0.833 (0.732 to 0.948) 0.006	0.930 (0.809 to 1.069) 0.308	0.953 (0.834 to 1.089) 0.483
Q3 (27–30)	2,667	0.615 (0.528 to 0.717) < 0.001	0.634 (0.543 to 0.739) < 0.001	0.793 (0.672 to 0.936) 0.006	0.793 (0.676 to 0.930) 0.004
Q4 (≥31)	3,637	0.501 (0.433 to 0.580) < 0.001	0.528 (0.455 to 0.612) < 0.001	0.720 (0.610 to 0.848) < 0.001	0.716 (0.612 to 0.839) < 0.001
P for trend		<0.001	<0.001	<0.001	<0.001

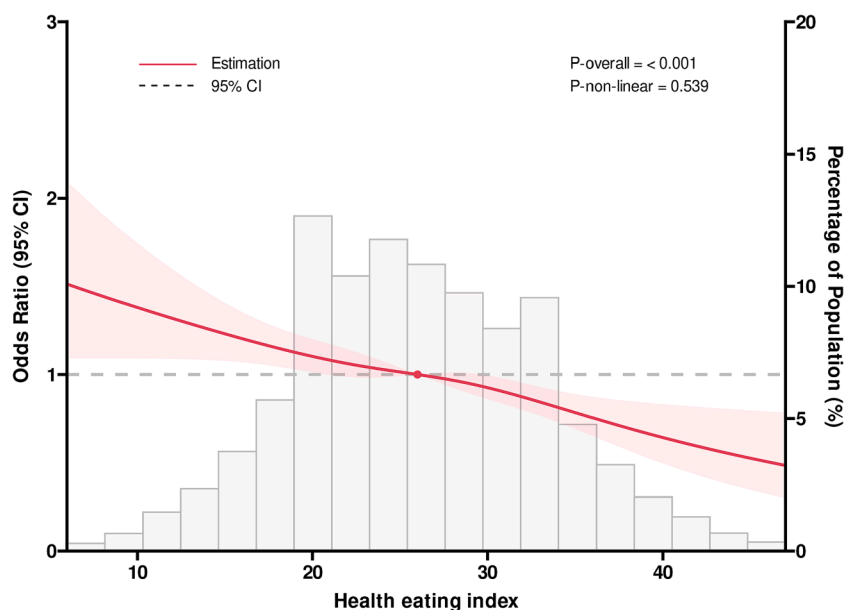
Note: Data are presented as odds ratio (95% confidence interval) and P-value. SD, standard deviation; Q, quartiles; Ref., reference.

Model 1 unadjusted.

Model 2 adjusted for age and gender.

Model 3 adjusted for gender, age, marriage, economic status, smoking, drinking, habitual exercise, and physical status.

\* Adjusted covariates as in Model 3, but using interpolated data.



**Fig. 2.** Adjusted restricted cubic spline model of the association between healthy eating index and risk of anxiety among elderly Chinese of age ≥65 years in 2018 CLHLS. 95 % CI, 95 % confidence interval.

participants (Saneei et al., 2016). And a later study among Iranian adults showed that after adjusting for potential confounders, those in the top quartile of the healthy eating index had 49 % lower odds of anxiety compared to those in the bottom quartile (OR = 0.51; 95 % CI 0.35–0.72) (Jacka et al., 2010), a value of 28.4 % in the current study (OR = 0.716; 95 % CI 0.612–0.839), but both results were limited by the cross-sectional design. It is worth mentioning that using different foods to calculate the healthy eating index may explain these inconsistent but modestly different results.

Interestingly, in our subgroup analysis, a similar result to that of Saneei P et al. (Saneei et al., 2016) was found, i.e., a healthy eating index was associated with anxiety in female participants, but a nonsignificant association was observed in males. Saneei P et al. interpreted this because of a larger difference in the prevalence of anxiety by gender, a phenomenon similar to the present study (male: 9.4 %; female: 14.2 %). Also, an interesting result was found in our research, where a significant association between the healthy eating index and anxiety was observed only in the frail elderly population. A potential reason could be that frailty is a series of non-specific clinical syndromes resulting from decreased physiological reserve capacity and function, increased vulnerability, and reduced stress resistance associated with advanced aging in the elderly (Fried et al., 2001). Proper nutritional intake is one

of the most essential strategies to prevent frailty (Mehta et al., 2021). A higher dietary index indicates a higher overall nutritional diet quality (Shams-White et al., 2023), reflected in a high intake of fruits and vegetables, fish, and bean products, thus ensuring individual nutrition, improving physical condition, and reducing the risk of anxiety.

There are several plausible mechanisms to explain the inverse association of the Healthy eating index with anxiety. The link arises from the cumulative effect of all components of the dietary index rather than individual nutrients or food groups. High magnesium and B vitamin levels in a healthy dietary pattern may reduce neuronal damage from oxidative stress (MahdaviFar et al., 2021; Sartori et al., 2012). Considering the relationship between high levels of inflammatory factor expression and anxiety, a higher tea intake (tea polyphenols) and bean products in older Chinese adults could help suppress inflammatory responses and alleviate anxiety (Prokopidis et al., 2023; Williams et al., 2020). In addition, the high content of Omega-3 in fish has been suggested to have a possible anxiolytic effect (Su et al., 2018).

The strengths of this study are that a representative national population cohort was included and that the associations identified were independent of several factors. However, several limitations should be considered when interpreting our findings. First, our results are limited by the cross-sectional design, which does not allow for inference of

causality. Future analyses of prospective cohort studies are needed to provide evidence for a causal relationship between the healthy eating index and anxiety. Second, although the study population represents an elderly population in China, it is prudent to extrapolate the findings to other countries or regions because of inconsistent dietary habits among older adults in different geographic areas. Third, the CLHLS cohort was assessed for dietary intake by a food frequency questionnaire, and the findings may be subject to recall bias given the diminished memory of older adults. Fourth, although we controlled for some potential confounders, the effect of residual confounders cannot be excluded, for example, living situation and number of children may be associated with anxiety symptoms in older adults. Fifth, it is important to note that the covariate of physical status is an interviewer's assessment of the respondent and is not the result of an evaluation through a frailty-specific scale, which may introduce a bias to the results.

## 5. Conclusion

In summary, analysis based on the 2018 CLHLS showed that the healthy eating index, consisting of 13 foods, was associated with lower odds of anxiety. The dietary index was associated with a reduced risk of anxiety in females and individuals with physical frailty or non-exercise habit. These preliminary findings need to be confirmed by prospective cohort studies to clarify the causal association between the healthy eating index and anxiety.

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## CRediT authorship contribution statement

**Qiuzi Sun:** Methodology, Conceptualization. **Hui Wang:** Formal analysis, Data curation. **Huachun Zhang:** Writing – review & editing. **Fan Zhang:** Writing – original draft, Formal analysis, Data curation, Conceptualization.

## Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Fan Zhang reports financial support, administrative support, and article publishing charges were provided by Longhua Hospital Shanghai University of Traditional Chinese Medicine. None.

## Data availability

The dataset is publicly available at <https://opendata.pku.edu.cn/file.xhtml?fileId=10357>

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## Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.pmedr.2023.102576>.

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