The unhealthy lifestyle factors associated with an increased risk of poor nutrition among the elderly population in China

Wei-Quan Lin[1,2], Harry HX Wang[3,4], Le-Xin Yuan[5], Bo Li[6], Meng-Juan Jing[6], Jia-Li Luo[1], Jie Tang[1], Bao-Kui Ye[7], Pei-Xi Wang[1,6*]

Affiliations:

1. Department of Preventive Medicine, School of Public Health, Guangzhou Medical University, Guangzhou, 510180, China
2. Guangzhou Center for Disease Control and Prevention, Guangzhou 510080, China
3. School of Public Health, Sun Yat-Sen University, Guangzhou, 510080, China
4. JC School of Public Health and Primary Care, Faculty of Medicine, The Chinese University of Hong Kong, Hong Kong
5. Department of Nursing, School of Nursing, Guangzhou Medical University, Guangzhou, 510180, China
6. Institute of Public Health, School of Nursing, Henan University, Kaifeng, 475004, China
7. The Third Affiliated Hospital of Guangzhou Medical University, Guangzhou Medical University, Guangzhou, 510180, China

Corresponding author: peixi001@163.com

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List of abbreviations: MNA: Mini nutritional assessment; RM: Risk of malnutrition; BMI: Body mass index; BP: Blood pressure; SBP: Systolic blood pressure; DBP: Diastolic blood pressure.

Abstract

Objectives: The associations between nutritional status and lifestyle factors have not been well established. This study aimed to investigate the prevalence of poor nutrition and to examine the relationships between nutritional status and unhealthy lifestyle and other related factors among the elderly. Methods: This cross-sectional study was conducted in Liaobu Town, Dongguan city, China. A total of 708 community dwelling older adults aged ≥60 years were recruited by stratified random sampling. Data on sociodemographic characteristics, health and lifestyle factors, and the Mini Nutritional Assessment (MNA) scores were collected using structured questionnaires via face-to-face interviews. A multivariate logistic regression model was constructed to identify the risk factors of poor nutrition. Results: The prevalence of malnutrition among the elderly adults in this study was 1.3%, and 24.4% were at risk of malnutrition (RM). Poor nutrition was significantly associated with female gender, older age, lower education, a high number of self-reported chronic diseases, and hospitalization in the last year. Unhealthy lifestyle factors associated with poor nutrition included current smoking status, higher alcohol consumption, lack of physical activity, longer duration of sitting, negative attitude towards life, and a poor family relationship. Conclusions: While the prevalence of malnutrition was low, RM was high in the elderly population in China. The determinants of malnutrition were explored and the relationships between nutritional status and unhealthy lifestyle factors were examined. The results of this study provide information for future longitudinal studies with multi-factorial interventional design in order to determine the effects of the causal relationships.

Introduction

The population of elderly adults aged ≥60 years is increasing worldwide and is projected to reach 2 billion by 2050 (1). A similar situation was noted in China, the China Research Center on Ageing reported that the population elderly adults in China in 2013 was 202 million (approximately 15% of the total population) (2). Aging not only results in changes in an individual's physiology and psychology but it may also be changes in an individual's physiology and psychology but may also be a risk factor for malnutrition (3).

Previous research has shown that malnutrition can have serious consequences. It can exacerbate disease progress, reduce immune function, increase the risk of infection and complications, delay recovery, and prolong hospitalization. Moreover, malnutrition may lead to increased disease morbidity and mortality as well as increased healthcare expenditures and result in poor quality of life (3-8). Although malnutrition is costly and harmful for the elderly, it is frequently unrecognized and neglected (9). This may be due to a lack of awareness as well as poor knowledge among elderly adults (10). According to the 2016 Global Nutrition Report, malnutrition affects one in 3 people worldwide and is increasing in nearly every country, making it a growing public health challenge (11, 12); therefore, more attention is needed to develop prevention, detection, and treatment strategies.

During the past decades, a number of methods for nutritional risk assessment have been developed. Meanwhile, mixed findings have been reported regarding the prevalence of malnutrition and the risk of malnutrition (RM). Based on the Mini Nutritional Assessment (MNA) scale, the incidence of malnutrition in community-dwelling elderly adults varies between 0.2% and 13.7%, as well as 8% to 50.3% of elderly individuals have RM (10, 13-18). Differences in sample size, age distribution, diversified social environment, and geographical differences may all contribute to the variations between studies (14). Nonetheless, these findings indicate the urgency to explore malnutrition, especially RM, and the potential risk factors that

have contributed to this phenomenon.

Several factors have been associated with nutritional status in elderly adults (19). Sociodemographic factors such as female gender, older age, widowed status, and lower education and income levels may contribute to a poor nutritional status (10). Several health-related factors such as chronic diseases, physical and social barriers, risk of depression, and a lack of health-related knowledge are also related to malnutrition (16, 20). However, the associations between malnutrition and other factors, such as hospitalization in the last year and various unhealthy lifestyle factors, remain unclear. The present study assessed unhealthy lifestyle factors in 3 dimensions: behavioral factors such as smoking, alcohol consumption, exercise, duration of sitting, and sleep quality; attitudinal factors (e.g., towards life); and social factors such as family relationship. The effect of unhealthy lifestyle factors on malnutrition among community-dwelling elderly adults has not been well established in China (20).

It is necessary to identify the nutritional status of community-dwelling older adults, especially those at RM, as well as risk factors that could be determined by a comprehensive geriatric evaluation. Indeed, effective nutritional interventions may reverse the course of malnutrition, thus preventing and controlling the serious consequences associated with its progression. However, data on the nutritional status and associated risk factors for malnutrition among community dwelling elderly adults are limited in China.

Thus, we investigated elderly adults aged ≥60 years living in different communities with the following aims: 1) to assess the prevalence of malnutrition and RM; 2) to identify the relationships between nutritional status and unhealthy lifestyle factors; and 3) to determine the factors associated with poor nutrition among elderly adults.

Methods

Study design and subjects

In April 2013, a cross-sectional study on the nutritional and health status of elderly adults was carried out in Liaobu Town, Dongguan City, Southern China. Since the reform and opening-up, Liaobu Town is a well-known and representative town in Dongguan city, with a fast-growing manufacturing industry. Liaobu Town consists of 30 villages, corresponding to a population of approximately 71,000 residents and an area of 71.38 square kilometers (21). These villages are managed by 21 community health service centers; therefore, we call the elderly living in Liaobu Town as community-dwelling elderly adults in this paper.

This study used stratified random sampling to generate the study samples. According to local economic levels (21), we divided the 30 villages into 3 levels, with 10 villages per level. Three villages were selected randomly in each level (3/10) and a total of 9 villages were generated (9/30). All of the elderly adults (aged ≥60 years) in the 9 villages were investigated. The sample distribution is presented in Additional file 1: Figure S1.

A total of 792 community-dwelling elderly adults lived in the 9 villages, according to the city's household registration system. The following selection criteria were used to select the final sample of 708 study subjects (Table 1): 1) long-term residents of Liaobu Town; 2) aged ≥60 years; 3) with measurable weight and height; 4) without acute disease or immediate emergency care requirements; 5) no serious cognitive impairments and with an ability to communicate normally. A flowchart illustrating the selection of the study subjects is demonstrated in Figure 1.

Ethics Statement

This study was approved by the ethics board of community health service center of Liaobu Town. Written informed consent was obtained from each study participant before the investigation.

Procedures

All interview groups included a local healthcare staff member (community health service center) and a medical student who were trained prior to the commencement of investigation in order to standardize data collection and recording. In addition, each group contained a supervisor to ensure that the interviews were conducted properly and that missing data were identified in a timely manner. The interviews took place in the participants' homes and data were collected from each participant through a structured study questionnaire that was administered verbally by the staff member and medical student. The entire interview process lasted approximately 30 minutes for each elderly adult who participated in the study.

Measurements and instruments

Sociodemographic characteristics

Data on sociodemographic characteristics including gender, age, marital status, educational level, retirement employment, health insurance, and living arrangements were collected for each participant.

Health and lifestyle factors

The health and lifestyle section of the questionnaire included 2 parts: unhealthy lifestyle factors and health-related factors. The unhealthy lifestyle factors included questions pertaining to current smoking status, alcohol consumption, physical activity, time of sitting, sleep status, attitude towards life, and family relationships. Current smoking status was defined as participants who had smoked ≥1 cigarette(s) per day for at least 6 months. Alcohol consumption was defined as drinking alcohol for participants who reported consuming alcohol an average of more than once a week within the last year. Participants who performed moderate exercise lasting no less than 30 minutes ≥3 times per week, including activities such as walking, jogging, square dancing, tai chi, and ba duan jin, were considered to be physically active. Time of sitting was defined by the response to the question: how long do you sit on an average day? Sleep status was defined based on the self-reported response to the question: How do you feel about your sleep status in the past month? a) good, b) fair, c) poor.

Attitude towards life was defined by the response to the following question: What is your attitude toward your life in the past month? a) positive, b) neutral, c) negative. Finally, family relationships were defined by responses to the question: How have you gotten along with your family members in the past month? a) good, b) fair, c) poor.

The health-related factors included questions on the number of self-reported chronic diseases (e.g., hypertension and diabetes), whether they had undergone a physical examination at least once per year, whether they had been hospitalized in the last year, and body mass index (BMI), blood pressure (BP), and blood glucose levels. The Chinese reference was used to categorize BMI, as follows: underweight (<18.5 kg/m2), normal weight (18.5–23.9 kg/m2), overweight (24.0–27.9 kg/m2), and obese (≥28.0 kg/m2) (22). BP was measured on the right arm using a mercury sphygmomanometer using the average of 3 readings for analysis.

Assessment of nutritional status

The MNA was specifically designed to assess the nutritional status of elderly adults based on responses to 18 items (23-25). The tool is divided into 4 parts. The first is anthropometric assessment (items 1 to 4; e.g., BMI and mid-arm and calf circumferences), with the circumference measurements performed twice using a portable tape with the smallest division of 0.1 cm. In the present study, the mid-arm circumference was measured as follows: first, the elderly adult was instructed to bend the arm at the elbow at a right angle with the palm facing up. Next, the health staff marked the midpoint between the acromial surface of the scapula and the olecranon process of the elbow on the back of the non-dominant arm. Finally, each participant was instructed to allow the arm hang loosely, and the mid-arm circumference was measured. Calf circumference was measured with the tape wrapped around the widest part of the calf when subject was sitting with the leg hanging loosely. In order to ensure that the widest point was measured, the circumference was also measured at point above and below the widest point (26). The second part of the MNA is a general assessment (items 5 to 10; e.g., medication use mobility, and the presence of a skin

ulcer); the third is dietary assessment (items 11 to 16; e.g., meals, food, and fluid intake); and the fourth is self-assessment (items 17 and 18; e.g., health and nutritional status). Given that lower scores predict a higher risk of malnutrition (27), the total score (of 30 points) can be used to classify elderly adults as malnourished individuals (<17 points), individuals at RM (17-23.5 points), or well-nourished individuals (≥ 24 points) (28). In this paper, MNA scores ≤23.5 points represented poor nutrition. Additionally, the MNA had been reported to be one of the most valid and frequently used nutritional screening tools in the elderly age group, and it is reported to have good reliability and validity (13, 15, 29).

Statistical analysis

Data were presented as means and standard deviations (SD) for continuous variables, while categorical variables were presented as frequency and percentages. All statistical analyses were performed using the Statistical Package for Social Sciences (SPSS), version 13.0 (SPSS Inc., Chicago, IL). First, 9 elderly participants with malnutrition were classified as individuals at RM. We then categorized nutritional status into 2 categories: well-nourished and poor nutrition. Second, the chi-square and t-tests were used to assess the differences in sociodemographic, health, and lifestyle factors among the elderly adults. In addition, we calculated Spearman correlation coefficients to assess the relationship between unhealthy lifestyle factors and MNA scores. Finally, all statistically significant variables identified in univariate analysis were included in a multivariate logistic regression analysis, except for BMI, which is an important part of the MNA scale. The logistic regression models used a forward stepwise selection strategy. The odds ratios (ORs) with 95% confidence intervals (95% CI) and Nagelkerke R^2 values were also calculated. Two tailed P values < 0.05 were considered statistically significant.

Results

Participant characteristics

A total of 708 elderly adults from 9 villages in Liaobu Town were included; the sample distribution is shown in Table 1 and Figure S1 (Additional File 1). Of the 708 total subjects, 337 (47.6%) were male and 371 (52.4%) were female. All participants were between 60 and 100 years of age, with an average age of 70.19 ± 8.25 years. Their sociodemographic and descriptive characteristics are shown in Table 2.

Overall prevalence

Only 9 of the elderly participants (1.3%) were classified as malnourished, while 173 (24.4%) were classified as those with RM. Hence, a total of 182 participants were categorized as having poor nutrition, corresponding to a prevalence of 25.7%. The mean MNA score was 25.45 ± 2.52. The epidemiological characteristics of the individuals within the poor nutrition category are reported in Table 2.

Univariate analysis

The results of the univariate analysis for poor nutrition are shown in Table 1, 2, and 3. Increasing age was accompanied by a decreasing MNA score, as shown in Figure 2.

Spearman correlation analysis

Table 4 shows the Spearman correlation coefficients between unhealthy lifestyle factors and the MNA score. Current smoking status, alcohol consumption, lack of physical activity, long stretches of time spent sitting, poor sleep quality, a negative attitude towards life, and a poor family relationship were significantly negatively correlated with the MNA score ($p < 0.05$).

Multivariate logistic regression analysis

Table 5 shows the results of the regression, after adjustment for gender, age, educational level, current smoking status, alcohol consumption, physical activity, and number of self-reported chronic diseases. Elderly adults who were female (OR = 2.06),

were aged ≥85 years, (OR = 4.45), had a lower education (OR = 1.94), had more self-reported chronic diseases (OR = 2.65), and had been hospitalized in the last year (OR = 2.10) were more likely to suffer from poor nutrition. The risk of poor nutrition increased significantly with the presence of the following unhealthy lifestyle factors: current smoking status (OR = 2.84), alcohol consumption (OR = 3.50), lack of physical activity (OR = 1.67), long stretches of time spent sitting (OR = 1.08), a negative attitude towards life (OR = 5.00), and a poor family relationship (OR = 1.97).

Discussion

Main findings

In the present study, 25.7% of the elderly adults suffered from poor nutrition. The following factors were identified as possible predictors for poor nutrition in this population: female gender, increasing age, lower education level, more self-reported chronic diseases, and hospitalization in the previous year. The relationships between poor nutrition and the majority of unhealthy lifestyle factors (e.g., current smoking status, alcohol consumption, and time of sitting) were also identified in the current study of elderly participants.

Comparison with previous studies

A longitudinal study conducted over 11 years demonstrated that malnutrition or RM were both significantly associated with shorter survival among community-dwelling elderly adults; the multi-adjusted HRs of mortality for malnutrition and RM were 2.40 and 1.49, respectively (8). These findings underscore the need to develop a better understanding of the prevalence of malnutrition, RM, and the associated risk factors for malnutrition in elderly adults.

In the present study, the incidence of malnutrition and RM was 1.3% and 24.4%, respectively, among community dwelling elders. Not surprisingly, our values were

similar to the findings of several other studies (13, 20, 30) using the same assessment tool (MNA), cut-off score (≤23.5 points), and research subjects (community-dwelling elderly adults). Specifically, the incidence of malnutrition and RM in our study were similar to findings from Shanghai (1.7% and 19.1%, respectively), Guangzhou (1.0% and 29.2%, respectively), and Beijing (0.2% and 32.3%, respectively) in China, as well as in Japan (0.2% and 20.6%, respectively) and Singapore (2.8% and 50.3%, respectively) [6, 14, 16, 17, 31]. Conversely, a study by Han and colleagues in Wuhan, China reported a higher prevalence of malnutrition and RM (8% and 36.4%, respectively) (10). There are 4 possible explanations for these differences. First, the current study did not include elderly individuals who experienced serious or acute diseases, or cognitive impairment. Second, there are differences in age distributions and sample sizes between studies. In the Wuhan study, the average age was 74.14 (SD, 5.95) years and included 162 participants, but the current study recruited 708 participants with an average age of 70.19 (SD, 8.25) years. Third, the results may be influenced by geographical differences and climates. Wuhan city in China is known for its hot and humid summers; the survey was conducted during the hot summer months, which may have affected individual participant appetites and weights, resulting in a higher incidence of malnutrition (10). Lastly, different economic levels may contribute to poor nutrition (7, 32). More specifically, Shanghai, Beijing, and Guangzhou are prosperous cities in China, as is Dongguan, which was the focus of the current study. However, Wuhan city is less prosperous in comparison.

The characteristics assessed in this sample population were of interest. With its accelerated industrialization and urbanization, Liaobu Town is becoming an affluent town that has benefited from the policy of reform and opening-up. Despite these advancements, a high prevalence of poor nutrition was identified in this study; more importantly, it seems to be neglected. The majority of elderly people (long-term residents) have experienced a transition from poverty to affluence with the reform and opening-up. We speculated that elderly adults would maintain their frugal living habits that were developed during the period of poverty and that the unhealthy

lifestyle factors might also play an important role in poor nutrition. In the present study, the high prevalence of poor nutrition was predicted by 11 risk factors, which were divided into sociodemographic characteristics, health-related factors, and unhealthy lifestyle factors in order to make comparisons.

In regards to the sociodemographic characteristics assessed in the present study, female gender, older age, and lower education level were associated with poor nutrition. Previous studies also reported older age to be associated with a higher prevalence of poor nutrition (6, 17). Han and colleagues demonstrated that aging was negatively correlated with MNA scores in China (10) Furthermore, the results of other studies have revealed that aging is accompanied by changes in physical composition, declining gastrointestinal function, and reduced feeding drive, which may also affect digestion and absorption (33, 34). Poor nutrition was more commonly observed among those with a single marital status (unmarried, divorced, or widowed) (Table 2); however, our study failed to observe an association between marital status and nutritional status in the multivariate logistic analysis (20, 35). A recent systematic review of 28 observational studies provided strong evidence for the lack of association between the death of a spouse and malnutrition (19). While some studies have suggested that there is a relationship between marital and nutritional status (10), these results remain controversial.

With regard to health-related factors, correlations have been reported between poor nutrition and the number of self-reported chronic diseases and hospitalization in the previous year. Consistent with the finding for chronic diseases (30, 36, 37), Shi and colleagues reported that the presence of ≥2 comorbidities contributed to the prevalence of malnutrition or RM (20). Generally, poor physical health is positively associated with poor nutrition. Therefore, hospitalization within the previous year may have impacted individual nutritional status (19). Dorner and colleagues also reported that 76.7% of elderly patients who were acutely hospitalized were malnourished or had RM (38); it is likely that those individuals may require a longer

time to recover after their hospital discharge.

Surprisingly, we found that that the majority of unhealthy lifestyle factors were independently associated with poor nutrition. In addition, the results of the Spearman correlation analysis (Table 4) further supported this phenomenon. Unhealthy lifestyle factors may play a predictive role in malnutrition among the elderly. A smoker's taste and appetite might be influenced by tobacco or the pro-inflammatory effect of smoking, which may lead to malnutrition (37, 39). Interestingly, a study from the Netherlands reported that alcohol consumption decreased the risk of malnutrition. However, our results supported the opposite association: drinking increased the risk of poor nutrition. The high energy content of alcohol may prevent or slow weight loss (37); however, data supporting this phenomenon in elderly adults are lacking. Arif and colleagues reported that moderate alcohol consumption has a protective effect on obesity; in other words, drinking may lead to weight loss (40). Another explanation for our observations might be related to the limited number of current alcohol consumers in our study. Moreover, other studies in China have suggested that smoking and drinking do not influence nutritional status (20, 41). Thus, further research is necessary to confirm this relationship.

Another finding of the current study was that a lack of exercise and sedentary behavior were independent risk factors for poor nutrition. During the survey period, we found that some elders were not willing to exercise, but preferred sitting for long stretches every day, especially those who were older and frail and those with diseases such as CVD. A recently systematic review supported the hypothesis that an exercise program for elderly patients may help to improve function and healthcare (42). Therefore, exercise may ameliorate nutritional status. Fuzeki and colleagues found that sedentary behavior was associated with overweight or weight gain (43); however, this observation may also be applied to young and middle-aged individuals. With aging, muscle mass and muscle strength are progressively lost (44); as a result, elderly adults lose their ability to be active, gradually leading them to sit for extended periods

of time. Van Cauwenberg and Buman reported that individuals aged ≥75 years had longer sedentary duration thanthose aged 65-74 years (45, 46). A lack of exercise and long stretches of time spent sitting may lead to a decrease in energy consumption and loss of appetite, which establishes a vicious cycle that may eventually lead to malnutrition. This cycle may also occur in elderly individuals who are frail or who have various diseases. In this study, the MNA score decreased with increasing age (Figure 2). Therefore, for the reasons suggested above, a lack of exercise and long stretches of time spent sitting might contribute to a higher risk of poor nutrition in elderly adults.

We also explored the association between an individual's attitude towards life and nutritional status. Previous studies have demonstrated that depression is a contributory factor for the development of undernutrition (16, 47). However, even if an individual was not depressed, those who felt negatively about life were at an increased risk of developing poor nutrition in this study. These findings may be explained by decreased food cravings, reduced appetite, and finding an enjoyment in sitting for a long time in elderly adults with a negative outlook (47). This finding suggests that maintaining a positive attitude towards life may contribute to improved nutritional status, which may be a useful finding for health education provided to elderly individuals.

Additionally, our study assessed the effects of a good family relationship on nutritional status. Having a family relationship was found to be an indispensable part of an individual's social network. Having a poor relationship with family members, as an unhealthy lifestyle factor, may cause social isolation and lead to appetite loss, malnutrition, and increased mortality (7, 48, 49). However, Ferdous and Posner found that, among the number of social networks an individual has, belonging to a social club was not associated with malnutrition (50, 51). The current study assessed whether the individuals had a positive relationship with their family members rather than the number of social networks, a difference that resulted in the observed association. However, the findings regarding family relationships may be better

supported by additional studies on this topic.

Based on these findings, the results of our study suggest that promotion of healthy lifestyles may be a prevention and intervention strategy to reverse the progression from having a RM to malnutrition or from being well-nourished to having a RM among the elderly.

Limitations

This study has several limitations. First, the study was conducted in a single town, which likely does not represent the entire population of China. Second, we did not collect income data for each individual, which is a very sensitive problem in China and may affect an individual's nutritional status. However, given that these data are unreliable in China, it would be difficult to draw accurate conclusions regarding the effect on an individual's nutritional status. In order to begin understanding the relationship between individual income level and nutritional status, we divided the participants into several groups according to their economic status. Third, because of the cross-sectional nature of this study design, causal relationships could not be inferred. Additionally, although the data were collected through face-to-face interviews, recall bias may have been introduced by the elderly participants. Future research is needed, which should utilize a larger and prospective cohort design to infer the causal relationships.

Conclusion

Although the prevalence of malnutrition was low, a high prevalence of RM was observed in elderly adults in this study population in China. Poor nutrition was associated with female gender, older age, lower education, more self-reported chronic diseases, hospitalization in the last year, current smoking status, alcohol consumption, lack of physical activity, long times spent sitting, negative attitude towards life, and a poor family relationship. These findings may provide useful information for future

longitudinal studies to establish the effects and causal relationships regarding malnutrition prevalence, as well as multifactorial interventions to prevent malnutrition among elderly adults.

Authors' contributions

All authors contributed to the development of the study framework, interpretation of the results, and revision of successive drafts of the manuscript, and all have approved the version submitted for publication. JLL, MJJ, JT, and BKY were responsible for data collection. WQL and JT conducted the data analyses. WQL and LXY drafted the manuscript. HHXW, BL, and PXW finalized the manuscript with input from all authors.

Competing interests

The authors have no potential conflicts of interest.

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Table 1. The results of stratified random sampling method of Liaobu Town, Dongguan City, China

Economical level	Poor nutrition [a]	Well-nourished [b]	All participants	*p* [c]	*p* [d]
Level 1				0.237	
Village 1	9 (12.7)	62 (87.3)	71 (10.0)		
Village 2	19 (23.2)	63 (76.8)	82 (11.7)		
Village 3	20 (20.4)	78 (79.6)	98 (13.8)		
Total 1	48 (19.1)	203 (80.9)	251 (35.5)		
Level 2				0.872	
Village 4	16 (25.0)	48 (75.0)	64 (9.1)		
Village 5	14 (28.6)	35 (71.4)	49 (6.9)		
Village 6	36 (28.3)	91 (71.7)	127 (17.9)		
Total 2	66 (27.5)	174 (72.5)	240 (33.9)		
Level 3				0.147	
Village 7	24 (24.7)	73 (75.3)	97 (13.6)		
Village 8	27 (38.6)	43 (61.4)	70 (9.9)		
Village 9	17 (34.0)	33 (66.0)	50 (7.1)		
Total 3	68 (31.3)	149 (68.7)	217 (30.6)		
Total	182 (25.7)	526 (74.3)	708 (100.0)		0.008**

Note: Data presented are n (%); MNA: Mini nutritional assessment;

[a] Poor nutrition: MNA scores ≤ 23.5, included 9 elders of malnutrition (MNA scores < 17.0);

[b] Well-nourished: MNA scores ≥ 24;

[c] *P* values in Chi square differences between the same group;

[d] *P* values in Chi square differences between the three groups;

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Table 2. The sociodemographic characteristics association with MNA score and its prevalence

Variable	Poor nutrition [a]	Well-nourished [b]	All participants	*p*
Gender				0.030*
Male	74 (22.0)	263 (78.0)	337 (47.6)	
Female	108 (29.1)	263 (70.9)	371 (52.4)	
Age, years	73.73 ± 9.39	68.97 ± 7.45	70.19 ± 8.25	< 0.001***
Age, years				< 0.001***
60~74	99 (19.6)	405 (80.4)	504 (71.2)	
75~84	54 (35.5)	98 (64.5)	152 (21.5)	
≥ 85	29 (55.8)	23 (44.2)	52 (7.3)	
Marital status				< 0.001**
Single [c]	58 (49.2)	96 (50.8)	154 (21.8)	
Married	124 (22.4)	430 (77.6)	554 (78.2)	
Education level				< 0.001***
No education	106 (35.2)	195 (64.8)	301 (42.5)	
Primary school	65 (21.9)	232 (78.1)	297 (42.0)	
Middle school or above	11 (10.0)	99 (90.0)	110 (15.5)	
Retirement employment				0.043*
Yes	32 (19.6)	131 (80.4)	163 (23.0)	
No	150 (27.5)	395 (72.5)	545 (77.0)	
Health insurance				
Yes	180 (25.8)	519 (74.2)	699 (98.7)	0.810
No	2 (22.2)	7 (77.8)	9 (1.3)	
Living arrangement				< 0.001***
Living alone	52 (40.9)	75 (59.1)	127 (17.9)	
Living with spouse only	86 (23.2)	284 (76.8)	370 (52.3)	
Living with children	44 (20.9)	167 (79.1)	211 (29.8)	
MNA scores	22.00 ± 2.03	26.65 ± 1.26	25.45 ± 2.52	< 0.001***
MNA status	182 (25.7)	526 (74.3)	708 (100.0)	

Note: Data presented are mean ± SD or n (%); MNA: Mini nutritional assessment;

[a] Poor nutrition: MNA scores ≤ 23.5, included 9 elders of malnutrition (MNA scores < 17.0);

[b] Well-nourished: MNA scores ≥ 24;

[c] Single: unmarried, divorced or widowed;

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Table 3. Health and lifestyle factors of participants related to MNA score

Variable	Poor nutrition [a]	Well-nourished [b]	All participants	*p*
unhealthy lifestyle factors				
Current smoking				0.006**
Yes	67 (32.8)	137 (67.2)	204 (28.8)	
No	115 (22.8)	389 (77.2)	504 (71.2)	
Alcohol consumption				< 0.001***
Yes	24 (47.1)	27 (52.9)	51 (7.2)	
No	158 (24.0)	499 (76.0)	619 (92.8)	
Physical activity				< 0.001***
Yes	95(21.3)	351 (78.7)	446 (63.0)	
No	87 (33.2)	175 (66.8)	262 (37.0)	
Time of sitting, hours				0.001**
< 6	96 (21.6)	349 (78.4)	445 (62.9)	
≥ 6	86 (32.7)	177 (67.3)	263 (37.1)	
Time of sitting, hours	6.05 ± 3.34	5.18 ± 2.59	5.40 ± 2.82	< 0.001***
Sleep status				0.001**
Good	96 (23.0)	321 (77.0)	417 (58.9)	
Fair	49 (24.1)	154 (75.9)	203 (28.7)	
Poor	37 (42.0)	51 (58.0)	88 (12.4)	
Attitude toward life				< 0.001***
Positive	117 (20.7)	448 (79.3)	565 (79.8)	
Neutral	48 (42.5)	65 (57.5)	113 (16.0)	
Negative	17 (56.7)	13 (43.3)	30 (4.2)	
Family relationship				< 0.001***
Good	61 (21.2)	227 (78.8)	288 (40.7)	
Fair	85 (24.4)	263 (75.6)	348 (49.1)	
Poor	36 (50.0)	36 (50.0)	72 (10.2)	
Health-related factors				
No. of self-reported chronic disease				< 0.001***
0	64 (18.8)	277 (81.2)	341 (48.1)	
1	72 (28.9)	177 (71.1)	249 (35.2)	
≥ 2	46 (39.0)	72 (61.0)	118 (16.7)	
Physical examination				0.875
Yes	137 (25.6)	399 (74.4)	536 (75.7)	
No	45 (26.2)	127 (73.8)	172 (24.3)	
Hospitalization in the last year				< 0.001***
Yes	52 (40.6)	76 (59.4)	128 (18.1)	
No	130 (22.4)	450 (77.6)	580 (81.9)	
BMI, kg/m^2				< 0.001***
Underweight	26 (89.7)	3 (10.3)	29 (4.1)	

Normal weight	111 (32.4)	232 (67.6)	343 (48.4)	
Overweight	31 (13.1)	206 (86.9)	237 (33.5)	
Obese	14 (14.1)	85 (85.9)	99 (14.0)	
BMI, kg/m^2	22.06 ± 3.98	24.86 ± 3.32	24.14 ± 3.71	< 0.001***
SBP, mmHg	132.79 ± 17.11	132.30 ± 17.65	132.42 ± 17.50	0.746
DBP, mmHg	79.07 ± 9.60	80.12 ± 9.31	79.85 ± 9.39	0.194
Blood Glucose, mmol/L	6.22 ± 1.75	6.36 ± 2.04	6.32 ± 1.97	0.385

Note: Data presented are mean ± SD or n (%); MNA: Mini nutritional assessment; BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure;

[a] Poor nutrition: MNA scores ≤ 23.5, included 9 elders of malnutrition (MNA scores < 17.0);

[b] Well-nourished: MNA scores ≥ 24;

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Table 4. The spearman correlation coefficients between unhealthy lifestyle factors and MNA score

Variable	MNA score	***p***
Current smoking (No = 0, Yes = 1)	-0.080	0.033*
Alcohol consumption (No = 0, Yes = 1)	-0.094	0.013*
Lack of physical activity (No = 0, Yes = 1)	-0.182	< 0.001***
Long stretches of time sitting per day (< 6 hours = 0, ≥ 6 hours = 1)	-0.107	0.005**
The poor sleep quality (Good = 0, Medium = 1, Poor = 2)	-0.163	< 0.001***
Negative attitude toward life (Positive = 0, Medium = 1, Negative = 2)	-0.272	< 0.001***
The poor family relationship (Good = 0, Medium = 1, Poor = 2)	-0.180	< 0.001***

Note: MNA: Mini nutritional assessment;

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Table 5. Variables related to MNA score from multivariate logistic regression models [a]

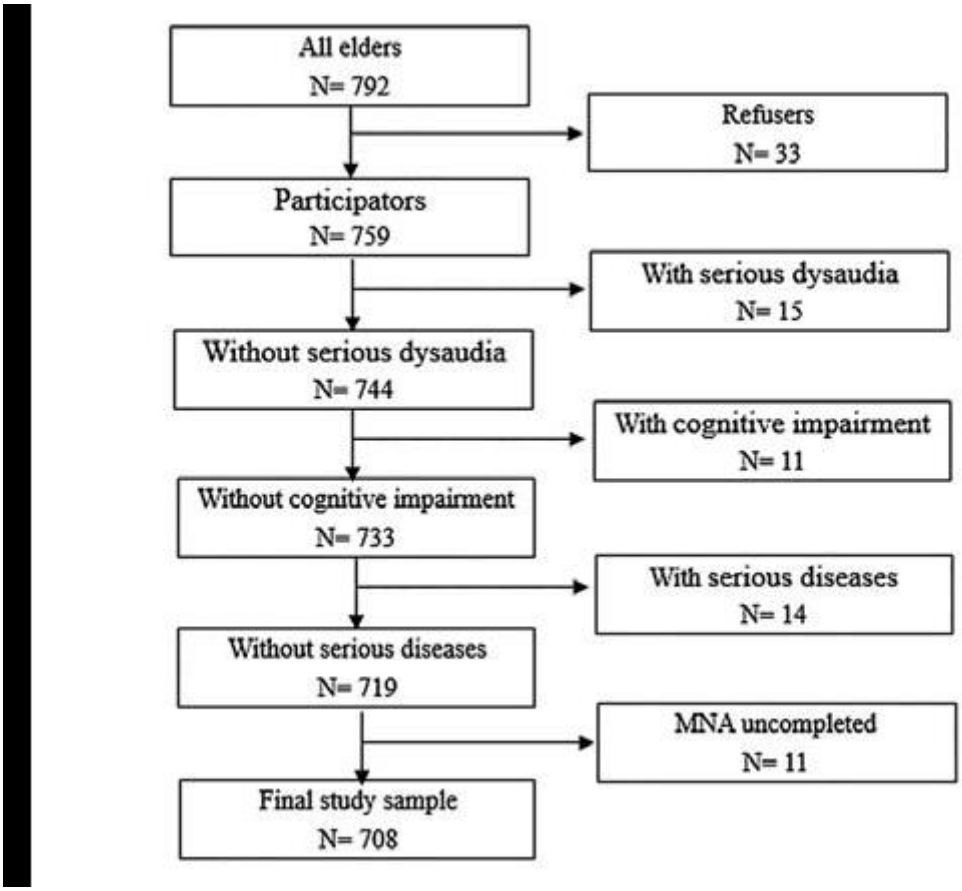
Variable	β	OR [b] (95% CI)	*P*	Nagelkerke R^2
Gender				0.078
Male		Reference		
Female	0.720	2.06 (1.22 - 3.48)	0.007**	
Age, years				0.150
60~74		Reference		
75~84	0.729	2.07 (1.30 - 3.30)	0.002**	
≥ 85	1.494	4.45 (2.24 - 8.87)	< 0.001***	
Education level				0.179
Middle school or above		Reference		
Primary school	0.825	2.28 (1.07 – 4.85)	0.032*	
No education	1.133	3.10 (1.42 – 6.77)	0.004**	
No. of self-reported chronic disease				0.211
0		Reference		
1	0.566	1.76 (1.12 – 2.77)	0.014*	
≥ 2	0.973	2.65 (1.52 – 4.61)	0.001**	
Hospitalization in the last year				0.236
No		Reference		
Yes	0.743	2.10 (1.29 - 3.41)	0.003**	
Current smoking				0.255
No		Reference		
Yes	1.045	2.84 (1.67 - 4.83)	< 0.001***	
Alcohol consumption				0.273
No		Reference		
Yes	1.253	3.50 (1.74 – 7.03)	< 0.001***	
Physical activity				0.285
Yes		Reference		
No	0.515	1.67 (1.10 – 2.54)	0.015*	
Time of sitting, hours	0.079	1.08 (1.01 – 1.16)	0.024*	0.297
Attitude toward life				0.310
Positive		Reference		
Neutral	0.947	2.58 (1.56 - 4.26)	< 0.001***	
Negative	1.610	5.00 (2.08 – 12.04)	< 0.001***	
Family relationship				0.318
Good		Reference		
Fair	-0.172	0.84 (0.55 – 1.30)	0.439	
poor	0.680	1.97 (1.04 – 3.75)	0.038*	

Note: OR = Odds ratio; 95%CI = 95% confidence interval; MNA: Mini nutritional assessment;

[a] Well-nourished = 0, Poor nutrition = 1;

[b] Adjusted OR; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Figure 1 Flow chart in the selection of study subjects

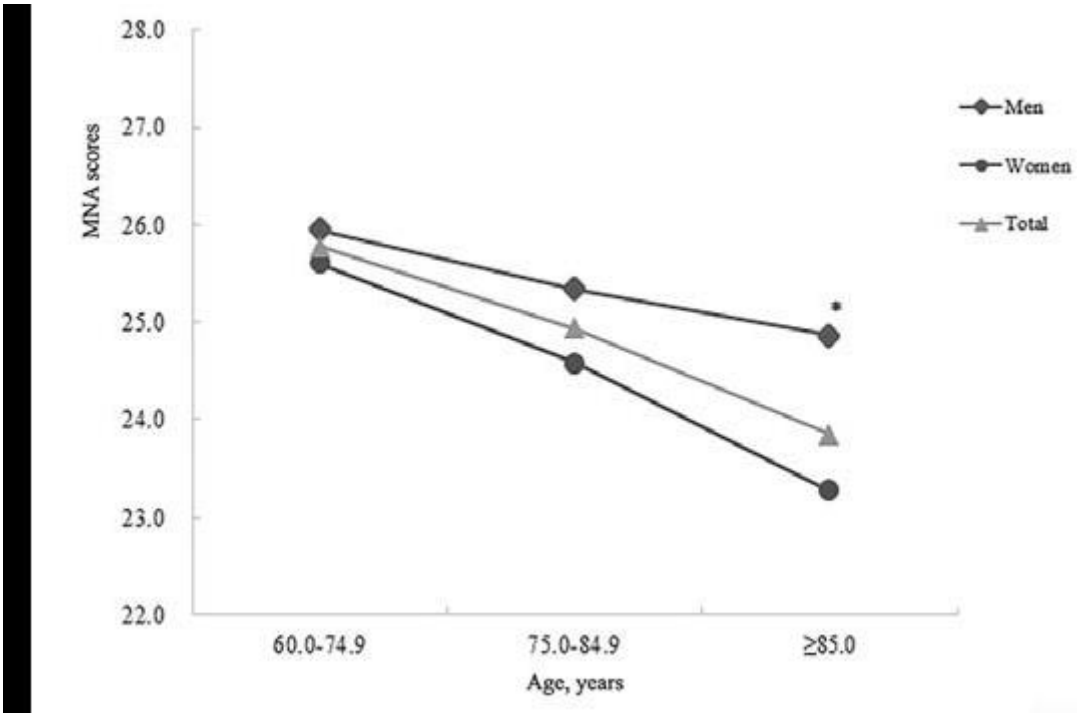


Note: MNA: Mini nutritional assessment.

Figure S1 Map of Liaobu Town, the figure of sample distribution

Note: 708 elders, 3 economical levels, 9 villages, $p < 0.05$; poor nutrition: Mini Nutritional Assessment scores ≤ 23.5.

Figure 2 Changes of Age with MNA score for men and women



Note: MNA: Mini nutritional assessment; Mean values in t test differences form men and women. * $p < 0.05$; ** $p < 0.01$.