Association between dietary patterns and depressive symptoms in Chinese adults

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Shaopeng Guo MS[1], Xiaohui Sun MD[2], Kejia Huang MS[3], Chi Pan MS[4], Xiao Liu MS[1], Weijing Wang PhD[1], Feng Ning PhD[1,2], Jie Xu MS[5], Ao Li MS[1], Dongfeng Zhang MS[1] , Hairong Nan PhD[6,7]

[1]Department of Epidemiology and Health Statistics, Public Health College, Qingdao University, Qingdao, China
[2]Department of Chronic Diseases Prevention and Control, Qingdao Centers for Disease Control and Prevention, Qingdao, China
[3]Department of Chronic Diseases Prevention and Control, Laoshan District Centers for Disease Control and Prevention, Qingdao, China
[4]Department of Health Education and Promotion, Huangdao District Centers for Disease Control and Prevention, Qingdao, China
[5]Department of Rehabilitation Medicine, Qingdao Municipal Hospital, Qingdao, China
[6]Department of General Outpatient, Office of Shenzhen Municipal Health Committee, Shenzhen, China
[7]Department of Endocrinology, Shenzhen Longhua District Maternal and Child Health Center, Shenzhen, China

Authors' email addresses and contributions:
SG: 19663803509@163.com
Contribution: Conceptualization, Data curation,Methodology, Writing—original draft.

XS: 190982048@qq.com
Contribution: Conceptualization, Writing—review&editing.

KH: chenyu76128@163.com
Contribution: Conceptualization.

CP: p1085133@163.com
Contribution: Conceptualization, Data curation.

XL: 17606385658@163.com
Contribution: Data curation, Validation.

WW: wangwj793@126.com
Contribution: Conceptualization, Software, Validation.

FN: ningf1010@126.com
Contribution: Methodology, Conceptualization, Supervision, Writing—review & editing, Funding acquisition.

JX: adele7909@163.com
Contribution: Conceptualization, Supervision, Writing—review&editing.

AL: 1056302316@qq.com
Contribution: Data curation, Software.

DZ: zhangdf1961@126.com
Contribution: Writing—review & editing, Supervision.

Hairong Nan: hrn30@163.com
Contribution: Writing—review & editing, Supervision.

Corresponding author: Prof Feng Ning, Department of Epidemiology and Health Statistics, Public Health College, Qingdao University, NO. 308 Ningxia Road, Qingdao 266071, China. Tel: +86 0532-85661020. Fax: +86 0532-85646110. Email: ningf1010@126.com; MS Jie Xu, Department of Rehabilitation Medicine, Qingdao Municipal Hospital, No. 1 Jiaozhou Road, Rehabilitation Medicine, Qingdao 266011, China. Tel: +86 0532-82716767. Email: adele7909@163.com

ABSTRACT

Background and Objectives: This cross-sectional study explored the association between dietary patterns and depressive symptoms in middle-aged and older individuals in China. **Methods and Study Design:** A total of 2,956 individuals aged 45-74 years were included in the current data analysis, based on a community-based cross-sectional study from Qingdao, China. Data for this study were derived from field surveys conducted from August 2009 to November 2010. Their mean age was 57.21 ± 8.46 years, and 62.35% were women. Dietary intake was assessed using a validated semi-quantitative food frequency questionnaire (SQFFQ). Dietary patterns were derived using principal component analysis. Depressive symptoms were assessed using the validated Zung Self-Rating Depression Scale. Logistic regression and restricted cubic spline analyses were conducted to examine the association between dietary patterns and depressive symptoms. **Results:** Of the participants, 12.40% had depressive symptoms. These participants were younger, were more likely to be smokers, had a higher body mass index, and had lower income and education levels compared with individuals without depressive symptoms. Four dietary patterns were identified: Balanced, Animal-Pickled vegetables, High sugar-Alcohol, and Animal-Seafood-Egg dietary patterns. The Balanced (odds ratio = 0.53, $p < 0.01$) and Animal-Seafood-Egg (odds ratio = 0.74, $p < 0.01$) dietary patterns were negatively associated with depressive symptoms, whereas the Animal-Pickled vegetables dietary pattern was positively associated with depressive symptoms. No significant association was observed for the High sugar-Alcohol dietary pattern. Subgroup analysis revealed stronger inverse effects of Balanced and Animal-Seafood-Egg dietary patterns in women younger than 60 years, nonsmokers, and urban residents compared with in their counterparts. Sensitivity analysis confirmed stability across the continuous and quartile-based variables. **Conclusions:** The Balanced and Animal-Seafood-Egg dietary patterns were associated with lower odds of depressive symptoms, whereas the Animal-Pickled vegetables dietary pattern was associated with higher odds of depressive symptoms.

Key Words: dietary pattern, depressive symptoms, adult, cross-sectional study, restricted cubic spline analysis

INTRODUCTION

Depression is a leading cause of disability that affects more than 280 million individuals worldwide every year, and it has profound effects on families and societies.[1] Its complex etiology involves genetic, environmental, and lifestyle-related factors, including diet, which has emerged in research as a modifiable risk factor that can influence mental health outcomes.[2-4] Diet has been increasingly recognized as a key factor influencing mental health, with certain dietary patterns linked to depression. Diet monitoring is particularly crucial for middle-aged and older populations, who often have unhealthy dietary habits and are at an increased risk of depression. Understanding the association between dietary patterns and depressive symptoms is crucial to developing effective strategies aimed at depression prevention and intervention, particularly for these populations.[5]

Emerging evidence from Western populations suggests a significant association between dietary patterns and mental health.[6] Healthy dietary patterns involving, for example, the adoption of the Mediterranean diet, were reported to be linked to a reduced risk of depression.[7] By contrast, unhealthy dietary patterns involving a high intake of processed and sugary foods were reported to be associated with increased depressive symptoms.[8] Notably, these findings were obtained for Western populations; some non-Western regions, such as China, have distinct dietary cultures that may yield different results.[9] For example, in China, traditional diets are rich in rice, vegetables, and fish, and the effects of such diets on mental health may differ from those of Western diets. Generally, research has indicated that diets rich in vegetables, fish, and legumes are associated with a lower risk of depression among older adults, whereas diets rich in refined sugars and fats are associated with a higher risk of depression.[10-12] A systematic review and meta-analysis reported that plant-based diets were negatively associated with depression, whereas diets rich in processed foods and refined carbohydrates were positively associated with depression.[13] These findings indicate that although the general trend of dietary patterns influencing depression holds across cultures, the specific foods involved may differ between Western and non-Western populations.

Although academic interest in the association between diet and depression has grown, several gaps in the research on this topic remain. First, studies on non-Western dietary patterns and their effects on depression are limited. Second, many studies have focused on isolated nutrients or foods rather than on holistic dietary patterns, which better capture real-world dietary habits. Third, few studies have used robust statistical approaches, such as factor analysis and restricted cubic spline (RCS) analysis, to explore the linear and nonlinear associations between dietary patterns and depressive symptoms. To address these gaps, the present study examined the association between dietary patterns and depressive symptoms in a community-based random sample of middle-aged and older individuals from Qingdao, China.

MATERIALS AND METHODS

Study design and participants

The survey protocol and participant characteristics for the Qingdao Diabetes Prevention Program have been previously reported.[14, 15] Briefly, 5,110 individuals aged 35–74 years were randomly selected in 2009 from Qingdao, China. Considering the study purpose and data completion, 2,956 individuals aged 45–74 years were included in the final analysis.[16] Figure 1 depicts a flowchart of the participant selection process. A standard study protocol was applied at all survey sites by trained investigators. The present analysis was based on baseline, pre-intervention data collected at enrollment. At the time of data collection, no dietary, behavioral, or pharmacological intervention had been implemented; therefore, the observed associations reflect cross-sectional relationships rather than intervention effects.

Dietary assessment

Dietary intake was assessed using the Semi-Quantitative Food Frequency Questionnaire, a validated instrument with adequate reliability and accuracy in quantifying the frequency of food consumption and the portion sizes of food.[17] This questionnaire includes 41 food items specifically selected for middle-aged and older populations in Qingdao. These food items are classified into 16 distinct food groups according to the Chinese Food Composition Table (Supplementary Table 1).

The participants reported their food intake frequency on a daily, weekly, or monthly basis, with portion sizes recorded in grams. To mitigate the potential influence of extreme values, participants whose energy intake was within the lowest 1st and highest 99th percentiles were excluded from the analysis.

Dietary patterns were extracted using principal component analysis. The number of dietary patterns was determined using a combination of criteria, including eigenvalues greater than 1, inspection of scree plots, and the interpretability of the derived factors. Varimax rotation was applied to enhance the interpretability of factor loadings. Factor scores were derived using regression and treated as continuous variables in subsequent logistic regression and RCS analyses.

Depression assessment

Depressive symptoms were assessed using the validated Chinese version of the Zung Self-Rating Depression Scale (SDS), a widely used instrument for evaluating depressive symptoms across diverse populations.[18-20] The SDS comprises 20 items, with each scored on a 4-point Likert scale on which respondents report the frequency of symptoms experienced during the preceding week. The total score ranges from 20 to 80, with higher scores indicating greater severity of depressive symptoms. In this study, a cutoff score of 50 was applied to classify the participants into depressive and nondepressive groups, consistent with established SDS scoring guidelines adopted in related research.[19]

Covariates

Data were collected through a structured questionnaire designed to capture demographic characteristics, socioeconomic status, lifestyle patterns, and health-related factors. To ensure data completeness and accuracy, trained investigators conducted face-to-face interviews to help the participants complete the questionnaire. Age, sex, body mass index (BMI), residential area, marital status, employment status, education level, income level, smoking status, alcohol consumption, diabetes, hypertension, and hyperlipidemia were included in the analysis as covariates. Each participant's height and weight were measured with light clothing and without shoes. BMI was calculated as weight (kg) divided by height squared (m^2). BMI categories were defined in accordance with Chinese standards: underweight ($<$18.5 kg/m^2), normal weight (18.5–23.9 kg/m^2), and overweight or obesity ($\geq$24.0 kg/m^2).[21] Residential area was classified as either urban or rural. Monthly income was divided into three levels:

<US$137, US$137–US$410, and ≥US$410. Participants were categorized according to smoking status as either current smokers or nonsmokers and according to alcohol consumption as either current drinkers or nondrinkers. Education level was divided into four levels: primary school or below, junior high school, high school, and university. Marital status was categorized as either married or cohabitating, single, or divorced or widowed. Employment status was categorized as either employed, unemployed, retired, self-employed, or never employed. Hypertension was defined as having a history of physician-diagnosed hypertension, systolic blood pressure of ≥140 mmHg, or diastolic blood pressure of ≥90 mmHg.[22] Dyslipidemia was defined as receiving lipid-lowering therapy or having any of the following fasting plasma measurements: total cholesterol ≥5.2 mmol/L, low-density lipoprotein cholesterol ≥3.4 mmol/L, triglycerides ≥2.3 mmol/L, or high-density lipoprotein cholesterol <1.0 mmol/L.[23] Type 2 diabetes mellitus was defined as receiving a diagnosis of type 2 diabetes mellitus by a physician or having a fasting plasma glucose level of ≥7.0 mmol/L or a 2-hour plasma glucose level of ≥11.1 mmol/L.[24] Physical activity was assessed using a standardized questionnaire recommended by the National Health Commission of China and categorized into low, moderate, and high levels.

Statistical analysis

The participant characteristics were summarized as percentages for categorical variables and as means (standard deviations) for continuous variables. Group differences were examined using *t* tests for continuous variables and chi-square tests for categorical variables. A total of 41 food items were consolidated into 16 groups on the basis of the similarities in their food and nutrient composition. Dietary patterns were extracted using a principal component analysis of these 16 food groups, which was conducted in IBM SPSS Statistics, version 27 (IBM, Armonk, NY, USA). Orthogonal rotation was applied to enhance interpretability, and the number of factors was determined based on eigenvalues (>1), scree plot inspection, and factor interpretability. The Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy was 0.80, and Bartlett's test of sphericity was statistically significant ($\chi^2 = 6514.59$, $p < 0.001$), indicating that the data were suitable for principal component analysis. In the present analysis, four factors had eigenvalues greater than 1 and were therefore retained. The first factor explained 21.4% of the total variance, followed by the second (9.9%), third (7.9%), and fourth (6.6%) factors, with a cumulative variance explanation of 45.7%. These four factors demonstrated clear inflection points on the scree plot as well as coherent and interpretable loading structures. Food groups with absolute factor loadings≥0.30 were considered to contribute meaningfully to a given dietary pattern and were used for dietary pattern labeling. Factor scores were calculated by summing the weighted intake of each food group, and each participant was assigned a score that reflected their alignment with each dietary pattern. To ensure the robustness of the subsequent correlation analysis, outliers in factor scores—defined as values beyond the 1st and 99th percentiles—were truncated to the nearest valid value. The primary goal was to examine the associations between dietary pattern scores, which were treated as continuous variables, and depressive symptoms through logistic regression. This approach enabled a more nuanced understanding of the relationships, leveraging the full variability in dietary pattern scores. Odds ratios (ORs) with 95% confidence intervals (CIs) were calculated for three models: Model 1 was unadjusted; Model 2 was adjusted for age, sex, and BMI; and Model 3 was further adjusted for type 2 diabetes mellitus, hypertension, hyperlipidemia, smoking status, alcohol consumption, marital status, employment status, income level, education level, and residential area. To ensure the robustness of the findings, dietary patterns were categorized into quartiles for sensitivity analysis, which is consistent with the methods commonly used in the field. In addition, sensitivity analyses were performed among 2,897 participants by further adjusting for physical activity to evaluate the robustness of the observed associations.

RCS regression was applied to assess potential linear and nonlinear associations between continuous dietary pattern scores and depressive symptoms, modeled as a binary outcome. Three knots were placed at the 25th, 50th, and 75th percentiles of the dietary pattern score distribution, with the median value serving as the reference. Tests for non-linearity were conducted by comparing the model containing only the linear term with the model containing both linear and spline terms. All RCS models were adjusted for the same covariates as Model 3 in the logistic regression analyses. Global and non-linear p-values were obtained to assess the overall association and deviation from linearity, respectively. Additionally, subgroup analyses were conducted to examine potential effect modifiers and determine whether the associations between dietary patterns and depressive symptoms varied across different subgroups with distinct demographic characteristics and health conditions.

Ethical approval

This study was approved by the Ethics Committee of the Qingdao Center for Disease Control and Prevention. All participants provided written informed consent before their enrollment. This trial was registered at ClinicalTrials.gov (registration number: NCT01053195).

RESULTS

Participant characteristics

Table 1 presents a summary of the sociodemographic characteristics of all participants, including those with and without depressive symptoms. Of the participants (n = 2,956), 62.35% were women, and they had a mean age of 57.21 ± 8.46 years. The overall prevalence of depressive symptoms was 12.40%. The participants with depression were younger, were more likely to be smokers, had a higher BMI, and had lower income and education levels compared with those without.

Dietary pattern classification

Factor analysis identified four major dietary patterns, which were labeled according to the food groups with the highest factor loadings (Supplementary Table 2). Positive factor loadings indicate a positive association with a dietary pattern, whereas negative loadings indicate an inverse association. The Balanced dietary pattern was characterized by higher consumption of refined grains, whole grains, legumes and soy products, nuts, and fresh fruits and vegetables. The Animal-Pickled vegetables dietary pattern was characterized by higher intake of poultry, organ meats, freshwater fish, and dried or pickled vegetables. The High sugar-Alcohol dietary pattern reflected higher consumption of dairy products, sugar-sweetened beverages, snacks, and alcoholic drinks. The Animal-Seafood-Egg dietary pattern was characterized by higher intake of eggs, seafood, poultry, and meat. Pattern names were intended to be descriptive summaries of dominant food group loadings rather than strict classifications. In this study, processed vegetables primarily referred to traditional dried or pickled vegetables rather than industrially processed vegetable products. The dietary pattern labels were intended to be descriptive summaries of food group loadings rather than strict classifications, and some overlap across patterns is inevitable.

Depressive symptoms and dietary patterns

Table 2 presents the logistic regression analysis results revealing the associations between dietary patterns and the risk of depressive symptoms. Multivariable model analysis revealed that a higher score for the Balanced dietary pattern was associated with a 47% lower odds of depressive symptoms (OR = 0.53, 95% CI = 0.33–0.86, $p < 0.01$). Additionally, a higher score for the Animal-Seafood-Egg dietary pattern was associated with approximately 26% lower odds of depressive symptoms (OR = 0.74, 95% CI = 0.64–0.84, $p < 0.01$). By contrast, an increase of one standard deviation in the score for the Animal-Pickled vegetables dietary pattern was associated with an 11.3% increase in the odds of depressive symptoms (OR = 1.13, 95% CI = 1.00–1.24, $p = 0.049$). No significant association was observed for the High sugar-Alcohol dietary pattern.

Sensitivity analysis

Sensitivity analysis was conducted using quartile-based logistic regression. Quartile analysis revealed significant differences between the quartiles that were not evident in the continuous analysis (Table 2). Specifically, the highest (Q4) and third (Q3) quartiles of the Balanced dietary pattern were associated with a 45.2% (OR = 0.55, 95% CI = 0.40–0.76) and 39.5% (OR = 0.61, 95% CI = 0.44–0.83) lower odds of depressive symptoms, respectively, compared with the lowest quartile (Q1). For the Animal-Seafood-Egg dietary pattern, the highest quartile (Q4) was associated with a 54.9% reduction in the odds of depressive symptoms (OR = 0.45, 95% CI = 0.32–0.64). These results support the robustness of the primary findings and reveal the potential differential effects of certain dietary patterns across specific quartiles, offering additional details that aided in the continuous variable analysis. In sensitivity analyses, physical activity was additionally included as a covariate in the fully adjusted logistic regression model. After further adjustment for physical activity, the associations between dietary pattern scores and depressive symptoms remained largely unchanged (Supplementary Table 3). Specifically, the Balanced dietary pattern remained inversely associated with depressive symptoms (OR = 0.54, p = 0.01), and the Animal-Seafood-Egg dietary pattern also showed a significant inverse association (OR = 0.74, p < 0.001). No significant association was observed for the High sugar and alcohol dietary pattern (OR = 1.00, p = 0.99). The association for the Animal-Pickled vegetables dietary pattern was attenuated and became non-significant (OR = 1.10, p = 0.08). The sample size for this sensitivity analysis was 2,897 participants.

RCS analysis

RCS analysis revealed a linear correlation between the balanced and Animal-Seafood-Egg dietary patterns and depressive symptoms (Figures 2). By contrast, it did not reveal a significant association between the Animal-Pickled vegetables or High sugar -Alcohol dietary pattern and depressive symptoms.

Subgroup analysis

Subgroup analyses based on factors such as age and sex were conducted. The results are presented as forest plots (Figures 3 and 4). The balanced dietary pattern had a inverse effect against depressive symptoms in women aged 45–60 years who did not smoke, did not consume alcohol, and lived in urban areas. Additionally, the Animal-Seafood-Egg dietary pattern had a inverse effect against depressive symptoms in middle-aged and older individuals who were employed, did not consume alcohol, and lived in urban areas.

DISCUSSION

In this study, both the Balanced and the Animal-Seafood-Egg dietary patterns were associated with lower odds of depressive symptoms in middle-aged and older individuals. Using the Center for Epidemiologic Studies Depression Scale, the China Health and Retirement Longitudinal Study reported a prevalence of 23.61% for depressive symptoms among individuals aged 45 years and older.[25] In the present study, a lower prevalence was observed, which may be explained by differences in scoring thresholds, along with regional factors such as Qingdao’s high socioeconomic development and high health-care access.

A healthy balanced diet involves high consumption of whole grains, legumes, nuts, and fresh fruits and vegetables and limited intake of high-fat, processed foods and sugar. This pattern represents a typical Asian dietary model, and such models have been widely recognized in the literature for having mental health benefits. Studies have indicated that adopting a balanced diet rich in vegetables, fruits, whole grains, and high-quality proteins has been associated with lower levels of depressive symptoms and improves psychological well-being.[26, 27] In a systematic review and meta-analysis, Ding et al. reported that adopting a diet rich in vegetables, fruits, and whole grains was associated with a lower risk of depression, supporting the positive role of a healthy diet in mental health.[28] These food items are rich in antioxidants, such as vitamin C, carotenoids, and zinc, which may be involved in pathways related to depressive symptoms. In addition, whole grains and refined grains are major sources of carbohydrates. Moreover, whole grains are rich in dietary fibers, B vitamins, and minerals, which support gut health by promoting beneficial gut bacteria. A growing body of evidence has linked gut health to mental well-being through the gut–brain axis, which influences mood and cognitive function, thereby mitigating the risk of depression.[29] In addition to gut-related pathways, B vitamins, such as folate, vitamin B_6, and vitamin B_{12}, are involved in neurotransmitter synthesis, and their deficiency is closely associated with the onset of depression.[30-33] Adopting a diet rich in plant-based proteins can help stabilize blood sugar levels, reduce mood fluctuations caused by blood sugar instability, and alleviate depressive symptoms.[34] Plant-based proteins derived from legumes provide essential amino acids that support the synthesis of neurotransmitters, including serotonin and dopamine, which play key roles in mood regulation.[35] Furthermore, nuts are rich in omega-3 fatty acids, particularly α-linolenic acid, which are believed to have antidepressant effects. These effects primarily involve reduction of brain inflammation, improvement in neurotransmitter function, and enhancement of neuroplasticity. Insufficient intake of omega-3 fatty acids is associated with the development of depressive symptoms, particularly because of the role of eicosapentaenoic acid and docosahexaenoic acid in enhancing brain health and regulating mood.[36] These nutrients may exert their effects through anti-inflammatory, antioxidant, neurotransmitter synthesis, and blood sugar regulation pathways, and have been implicated in a lower likelihood of depressive symptoms. Although processed vegetables may have been suggested to be related to depression through inflammation or oxidative stress, the nutrients in animal-based foods may have inverse effects.[12, 37-40] Therefore, adopting a healthy balanced diet that incorporates these foods may play a key role in the prevention and alleviation of depressive symptoms.

This study observed an inverse association between the seafood egg dietary pattern and depressive symptoms, which is likely related to seafood being a rich source of omega-3 fatty acids.[41] These fatty acids have been suggested to alleviate depressive symptoms by reducing brain inflammation and promoting neurotransmitter synthesis, as reported by Freeman.[42] Additionally, Larrieu emphasized the clinical importance of omega-3 fatty acids, particularly those derived from fish, in enhancing brain function and stabilizing mood.[43] In addition to seafood, eggs provide key nutrients such as vitamin B_{12} and folate, which support mood regulation and alleviate depressive symptoms .[44] Qi reported a significant inverse association between the Animal-Seafood-Egg dietary pattern and the risk of depression, consistent with the results of the present study.[45] Furthermore, the linear relationships observed in the present RCS analysis offer additional support for the inverse effects of this dietary pattern.

In this study, Logistic regression analysis showed a borderline positive association between the Animal-Pickled vegetables dietary pattern and depressive symptoms (OR = 1.13, 95% CI: 1.00–1.24, p = 0.049). Given the multiple dietary patterns examined, as well as the use of several statistical models and subgroup analyses, this finding may be susceptible to chance and should be interpreted with caution. Therefore, this association should be regarded as exploratory rather than conclusive. Moreover, the restricted cubic spline analysis did not show significant linear or non-linear associations for this dietary pattern, suggesting the absence of a clear dose − response relationship and further supporting cautious interpretation. This finding is consistent with those of studies suggesting that high-fat, high-protein, and low-fiber diets promote depression by altering the composition of the gut microbiota and increasing inflammation.[46, 47] Research indicates that high concentrations of salt and preservatives in processed vegetables may adversely affect mental health, which may be related to depressive symptoms.[48] It should be noted that in the present study, the Animal-Pickled vegetables dietary pattern primarily reflects higher consumption of animal-based foods and traditional dried or pickled vegetables, rather than industrially processed foods. Therefore, the observed association should not be interpreted as direct evidence linking ultra-processed food consumption to depressive symptoms in this population. However, in the current study, RCS analysis did not reveal any significant linear or nonlinear associations, likely because of the weak or unstable effects or counterbalancing impacts of different dietary components. In future studies, larger sample sizes are required to address the sensitivity of RCS analysis to variable distribution.

The current study's subgroup analysis revealed that the inverse effects of the balanced and Animal-Seafood-Egg dietary patterns against depressive symptoms were more pronounced in specific populations. For example, the balanced dietary pattern demonstrated strong inverse associations among women aged 45–60 years who did not smoke, who did not consume alcohol, and who were living in urban areas. Additionally, the Animal-Seafood-Egg dietary pattern demonstrated strong inverse effects among middle-aged and older individuals who were employed, who did not consume alcohol, and who were living in urban areas. These findings are consistent with evidence suggesting that smoking and alcohol consumption are risk factors for depression.[49] Urban residents often receive greater social support and health-care resources than do rural residents, which may amplify the inverse effects of healthy dietary patterns in this population.[50] Furthermore, employment may offer an individual social and economic stability, reducing psychological stress and enhancing dietary benefits.[51]

The findings of the current study highlight the complex association between dietary components and depression, offering insights that can aid in exploring underlying mechanisms and developing dietary interventions. They also highlight the role of sociodemographic and lifestyle factors in modulating dietary impacts on mental health, highlighting a need for tailored dietary interventions.

This study has several strengths. For example, a factor analysis with continuous variables combined with traditional categorical methods was conducted to preserve the original data and enhance analytical precision. In addition, an RCS analysis was conducted, which enabled comprehensive exploration of the potential nonlinear associations between dietary patterns and depressive symptoms. Moreover, the integration of factor analysis, logistic regression, RCS analysis, and subgroup analysis enhanced the reliability and comprehensiveness of the findings. In this study, both the balanced and the Animal-Seafood-Egg dietary patterns were associated with lower odds of depressive symptoms in middle-aged and older individuals. Using the Center for Epidemiologic Studies Depression Scale, the China Health and Retirement Longitudinal Study reported a prevalence of 23.61% for depressive symptoms among individuals aged 45 years and older.[25] In the present study, a lower prevalence was observed, which may be explained by differences in scoring thresholds, along with regional factors such as Qingdao's high socioeconomic development and high health-care access.

Previous studies have extensively investigated the associations between individual dietary components or nutrients and depression, and several biological mechanisms have been proposed. A healthy balanced diet involves high consumption of whole grains, legumes, nuts, and fresh fruits and vegetables and limited intake of high-fat, processed foods and sugar. This pattern represents a typical Asian dietary model, and such models have been widely recognized in the literature for having mental health benefits. Studies have indicated that adopting a balanced diet rich in vegetables, fruits, whole grains, and high-quality proteins has been associated with lower levels of depressive symptoms and improves psychological well-being.[26, 27] In a systematic review and meta-analysis, Ding et al. reported that adopting a diet rich in vegetables, fruits, and whole grains was associated with a lower risk of depression, supporting the positive role of a healthy diet in mental health.[28] These food items are rich in antioxidants, such as vitamin C, carotenoids, and zinc, which may be involved in pathways related to depressive symptoms. In addition, whole grains and refined grains are major sources of carbohydrates. Moreover, whole grains are rich in dietary fibers, B vitamins, and minerals, which support gut health by promoting beneficial gut bacteria. A growing body of evidence has linked gut health to mental well-being through the gut–brain axis, which influences mood and cognitive function, thereby mitigating the risk of depression.[29] In addition to gut-related pathways, B vitamins, such as folate, vitamin B_6, and vitamin B_{12}, are involved in neurotransmitter synthesis, and their deficiency is closely associated with the onset of depression.[30-33] Adopting a diet rich in plant-based proteins can help stabilize blood sugar levels, reduce mood fluctuations caused by blood sugar instability, and alleviate depressive symptoms.[34] Plant-based proteins derived from legumes provide essential amino acids that support the synthesis of neurotransmitters, including serotonin and dopamine, which play key roles in mood regulation.[35] Furthermore, nuts are rich in omega-3 fatty acids, particularly α-linolenic acid, which are believed to have antidepressant effects. These effects primarily involve reduction of brain inflammation, improvement in neurotransmitter function, and enhancement of neuroplasticity. Insufficient intake of omega-3 fatty acids is associated with the development of depressive symptoms, particularly because of the role of eicosapentaenoic acid and docosahexaenoic acid in enhancing brain health and regulating mood.[36] Fresh fruits and vegetables contain high levels of vitamin E, vitamin C, and polyphenols, which help mitigate oxidative stress and inflammation—both of which are closely related to the onset of depression.[36]

These nutrients may exert their effects through anti-inflammatory, antioxidant, neurotransmitter synthesis, and blood sugar regulation pathways, and have been implicated in a lower likelihood of depressive symptoms. Although processed vegetables may have been suggested to be related to depression through inflammation or oxidative stress, the nutrients in animal-based foods may have inverse effects.[12, 37-40] Therefore, adopting a healthy balanced diet that incorporates these foods may play a key role in the prevention and alleviation of depressive symptoms.

This study observed an inverse association between the Animal-Seafood-Egg dietary pattern and depressive symptoms, which is likely related to seafood being a rich source of omega-3 fatty acids.[41] These fatty acids have been suggested to alleviate depressive symptoms by reducing brain inflammation and promoting neurotransmitter synthesis, as reported by Freeman.[42] Additionally, Larrieu emphasized the clinical importance of omega-3 fatty acids, particularly those derived from fish, in enhancing brain function and stabilizing mood.[43] In addition to seafood, eggs provide key nutrients such as vitamin B_{12} and folate, which support mood regulation and alleviate depressive symptoms .[44] Qi reported a significant inverse association between the seafood egg dietary pattern and the risk of depression, consistent with the results of the present study.[45] Furthermore, the linear relationships observed in the present RCS analysis offer additional support for the inverse effects of this dietary pattern.

In addition, although a High sugar-Alcohol dietary pattern was identified in the factor analysis, no significant association with depressive symptoms was observed. The inclusion of dairy products in the High sugar-Alcohol dietary pattern may reflect local dietary habits, such as the consumption of sweetened dairy beverages or dairy products consumed alongside alcoholic drinks, which could partly explain the null association observed in the present study. Notably, Qingdao, the hometown of Tsingtao Beer, has a culture where residents enjoy drinking fresh beer, a kind of low-alcohol beer, particularly in the summer. Incorporating fermented beverages like beer in moderation, as part of the High sugar-Alcohol dietary pattern, may be compatible with metabolic status, provided that energy balance is maintained and excessive alcohol consumption is avoided[52]. However, no association between High sugar-Alcohol dietary pattern and depression symptoms was observed in the current study.

The current study's subgroup analysis revealed that the inverse effects of the Balanced and Animal-Seafood-Egg dietary patterns against depressive symptoms were more pronounced in specific populations. For example, the balanced dietary pattern demonstrated strong inverse associations among women aged 45–60 years who did not smoke, who did not consume alcohol, and who were living in urban areas. Additionally, the Animal-Seafood-Egg dietary pattern demonstrated strong inverse effects among middle-aged and older individuals who were employed, who did not consume alcohol, and who were living in urban areas. These findings are consistent with evidence suggesting that smoking and alcohol consumption are risk factors for depression.[49] Urban residents often receive greater social support and health-care resources than do rural residents, which may amplify the inverse effects of healthy dietary patterns in this population.[50] Furthermore, employment may offer an individual social and economic stability, reducing psychological stress and enhancing dietary benefits.[51]

In sensitivity analyses that additionally adjusted for physical activity, the inverse associations for the Balanced and Animal-Seafood-Egg dietary patterns remained statistically significant, supporting the robustness of these findings. By contrast, the attenuation of the association for the Animal-Pickled vegetables dietary pattern suggests that this borderline finding may be partly explained by lifestyle-related confounding. The findings of this study underscore the complex associations between dietary patterns and depressive symptoms and suggest that these associations may vary across sociodemographic and lifestyle contexts. The potential mechanisms linking dietary patterns to depression were not directly examined and should be explored in future longitudinal and mechanistic studies.

Despite these strengths, causal associations between dietary patterns and depressive symptoms could not be established. Given the cross-sectional design of this study, reverse causation cannot be excluded, as individuals with depressive symptoms may alter their dietary behaviors because of changes in appetite, motivation, or food preferences, which could influence the observed associations. Although a wide range of sociodemographic and lifestyle factors were adjusted for, residual confounding cannot be completely excluded. Specifically, information on lifestyle behaviors, prior psychiatric diagnoses, and antidepressant use was unavailable and thus unaccounted for, even though physical activity was included in sensitivity analyses. Therefore, residual confounding may have influenced the magnitude of some observed associations, particularly those with borderline significance in the primary analyses. Future prospective studies with more comprehensive adjustment for potential confounders are warranted to validate these tentative findings. It should also be noted that the subgroup analyses conducted in this study were exploratory in nature, and no formal statistical tests for interaction were performed. Therefore, the apparent differences observed across subgroups should be interpreted with caution and may reflect chance findings rather than true effect modification. In addition, the findings of this study are specific to an eastern coastal population, and therefore, caution should be exercised in extrapolating these findings to the general population of China. Moreover, although this study involved trained investigators and a standard protocol with quality control, recall bias in the food frequency questionnaires could not be avoided. Further longitudinal studies are required to confirm the associations reported in this study and explore their underlying mechanisms.

Conclusion

The Balanced and Animal-Seafood-Egg dietary patterns are associated with reduced depressive symptoms, whereas the Animal-Pickled vegetables dietary pattern was positively associated with depressive symptoms. Further research is required to explore the causal associations between dietary patterns and depressive symptoms.

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CONFLICT OF INTEREST AND FUNDING DISCLOSURE

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Table 1. Characteristics of the study participants with and without depressive symptoms

Variable	Overall	Participants without depressive symptoms	Participants with depressive symptoms	*P*-value
N	2,956	2,590	366	
Age (yrs)	57.21 ±8.46	57.00 ±8.43	58.67 ±8.61	<0.001
BMI (kg/m^2)	25.01 ±3.59	25.07 ±3.61	24.65 ±3.47	0.039
Gender				0.629
Male	1,113 (37.65)	971 (37.49)	142 (38.80)	
Female	1,843 (62.35)	1,619 (62.51)	224 (61.20)	
Marital status				0.172
Married or Cohabiting	2,734 (92.49)	2,403 (92.78)	331 (90.44)	
Unmarried	30 (1.01)	23 (0.89)	7 (1.91)	
Divorced	18 (0.61)	15 (0.58)	3 (0.82)	
Widowed	174 (5.89)	149 (5.75)	25 (6.83)	
Work status				<.001
Employed	1,142 (38.63)	1,000 (38.61)	142 (38.80)	
Unemployed	187 (6.33)	153 (5.91)	34 (9.29)	
Retired	998 (33.76)	859 (33.17)	139 (37.98)	
Self-employed	229 (7.75)	219 (8.46)	10 (2.73)	
Never Worked	400 (13.53)	359 (13.86)	41 (11.20)	
Residential status				0.076
Urban	985 (33.32)	878 (33.90)	107 (29.23)	
Rural	1971 (66.68)	1712 (66.10)	259 (70.77)	
Hypertension				0.387
No	1,335 (45.16)	1,162 (44.86)	173 (47.27)	
Yes	1,621 (54.84)	1,428 (55.14)	193 (52.73)	
Dyslipidemia				0.114
No	967 (32.71)	834 (32.20)	133 (36.34)	
Yes	1,989 (67.29)	1,756 (67.80)	233 (63.66)	
Diabetes				0.432
No	2387 (80.75)	2097 (80.97)	290 (79.23)	
Yes	569 (19.25)	493 (19.03)	76 (20.77)	
Income level				0.048
<1000	1,999 (67.63)	1,736 (67.03)	263 (71.86)	
1000-2999	886 (29.97)	795 (30.69)	91 (24.86)	
≥3000	71 (2.40)	59 (2.28)	12 (3.28)	
Education level				0.007
Elementary school and illiterate	1,404 (47.50)	1,202 (46.41)	202 (55.19)	
Secondary school	1,421 (48.07)	1,270 (49.03)	151 (41.26)	
College or high education	131 (4.43)	118 (4.56)	13 (3.55)	
Smoking status				0.004
No	2,132 (72.12)	1,891 (73.01)	241 (65.85)	
Yes	824 (27.88)	699 (26.99)	125 (34.15)	
Drinking status				0.342
No	2,466 (83.42)	2,167 (83.67)	299 (81.69)	
Yes	490 (16.58)	423 (16.33)	67 (18.31)	
Physical activity				0.445
Light	1,225(42.30)	1,080(42.60)	145(39.80)	
Moderate	239(8.20)	212(8.40)	27(7.40)	
high	1,433(49.50)	1,241(49.00)	192(52.70)	

Data were showed as mean and standard deviation or number(percent). BMI, Body Mass Index; SD, standard deviation

Due to missing data on physical activity, analyses for this variable were based on 2,897 participants.

Table 2. Association of dietary pattern with the risk of depression by multivariate-adjusted regression analysis

Dietary Pattern Quartiles/Continuous	Model 1	Model 2	Model 3
Balanced Dietary Pattern			
Q1 (Reference)	Reference	Reference	Reference
Q2	0.84 (0.63, 1.13)	0.79 (0.59, 1.06)	0.78 (0.58, 1.05)
Q3	0.58 (0.43, 0.80)	0.56 (0.41, 0.77)	0.55 (0.40, 0.76)
Q4	0.65 (0.48, 0.88)	0.63 (0.46, 0.86)	0.61 (0.44, 0.83)
Continuous Variable	0.58 (0.37, 0.90)	0.56 (0.35, 0.89)	0.53 (0.33, 0.86)
Animal-Pickled vegetables Dietary Pattern			
Q1 (Reference)	Reference	Reference	Reference
Q2	1.53 (1.10, 2.14)	1.60 (1.14, 2.24)	1.75 (1.24, 2.46)
Q3	1.26 (0.89, 1.80)	1.40 (0.98, 2.00)	1.52 (1.06, 2.20)
Q4	1.46 (1.04, 2.07)	1.71 (1.20, 2.45)	1.92 (1.33, 2.78)
Continuous Variable	1.05 (0.95, 1.17)	1.09 (0.98, 1.21)	1.11 (1.00, 1.24)
High sugar-Alcohol Dietary Pattern			
Q1 (Reference)	Reference	Reference	Reference
Q2	1.02 (0.77, 1.36)	0.96 (0.72, 1.28)	0.91 (0.68, 1.22)
Q3	0.48 (0.35, 0.67)	0.47 (0.34, 0.65)	0.45 (0.32, 0.63)
Q4	0.68 (0.50, 0.91)	0.70 (0.52, 0.95)	0.69 (0.51, 0.94)
Continuous Variable	0.98 (0.87, 1.10)	0.99 (0.89, 1.12)	0.99 (0.88, 1.11)
Animal-Seafood-Egg Dietary Pattern			
Q1 (Reference)	Reference	Reference	Reference
Q2	0.89 (0.66, 1.19)	0.88 (0.66, 1.18)	0.85 (0.63, 1.14)
Q3	0.81 (0.60, 1.08)	0.80 (0.59, 1.08)	0.75 (0.56, 1.02)
Q4	0.50 (0.36, 0.69)	0.49 (0.35, 0.68)	0.45 (0.32, 0.64)
Continuous Variable	0.76 (0.67, 0.87)	0.76 (0.66, 0.87)	0.74 (0.64, 0.84)

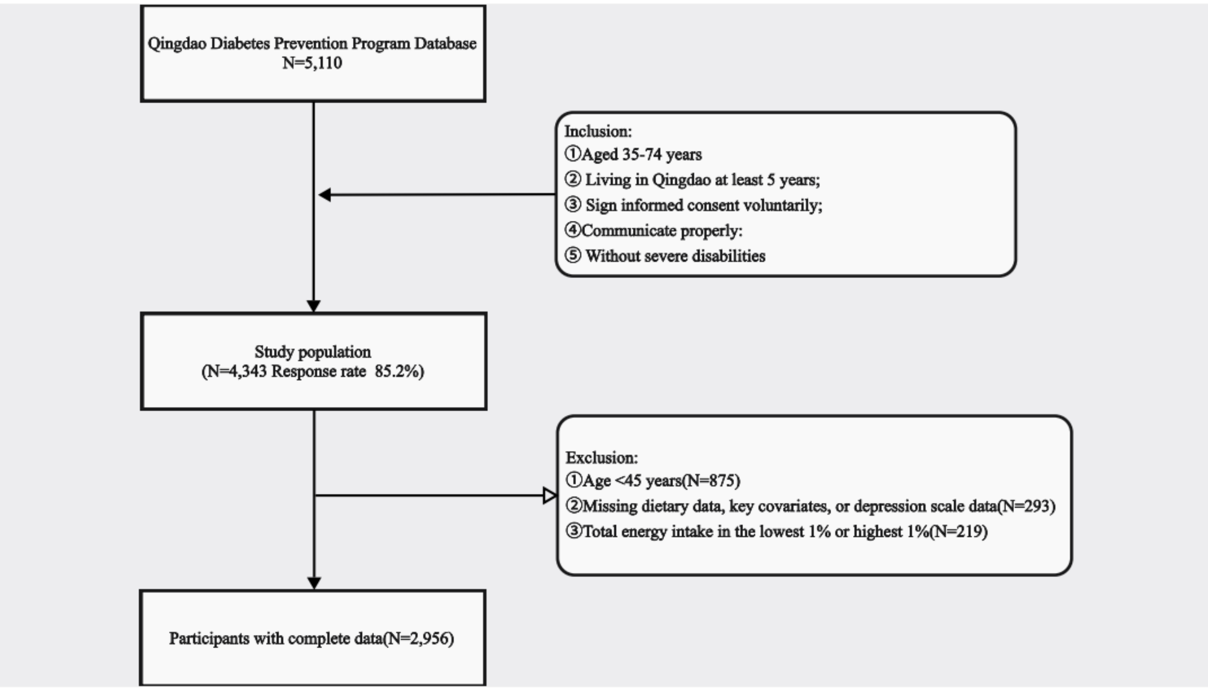

Figure 1. Flow chart for the study population selection of this cross-sectional study.

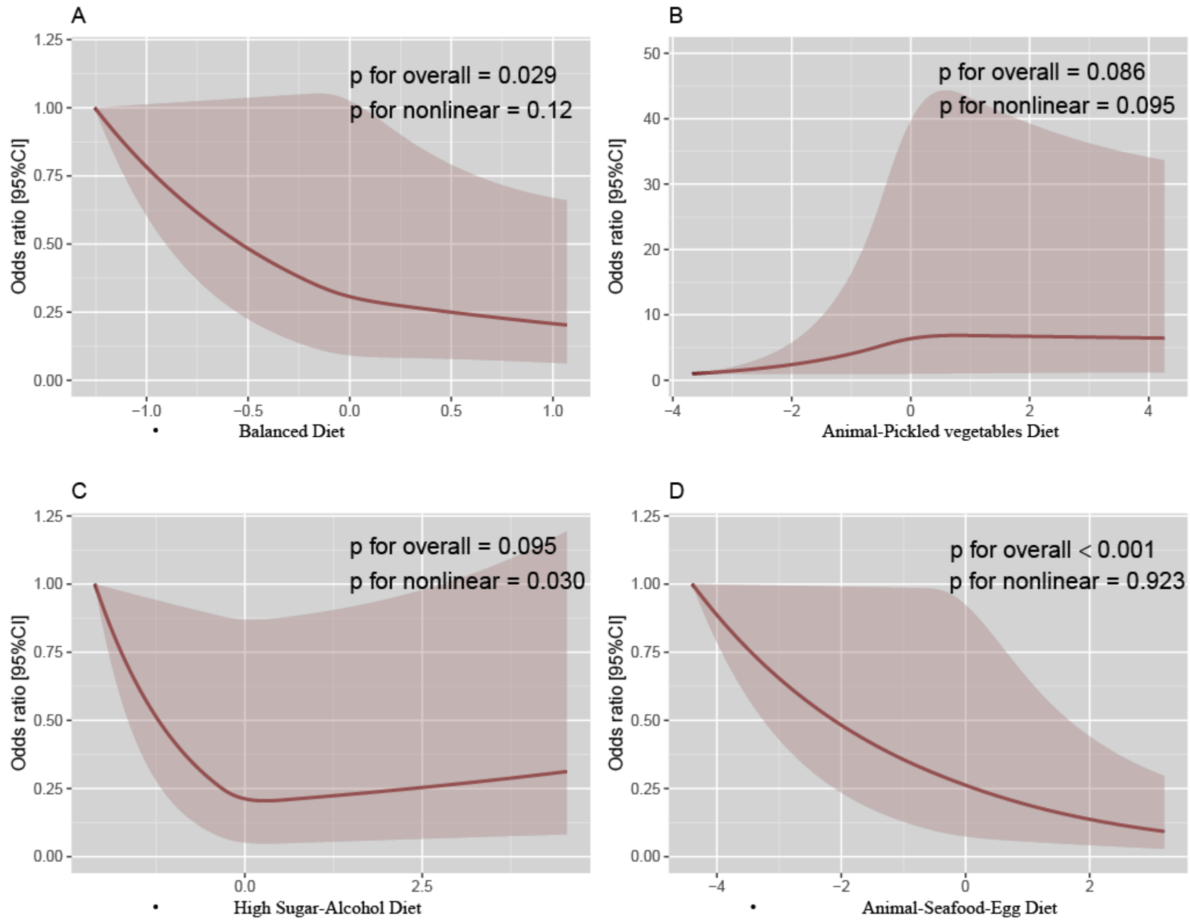

Figure 2. The dose-response relationship of four dietary patterns with depressive symptoms

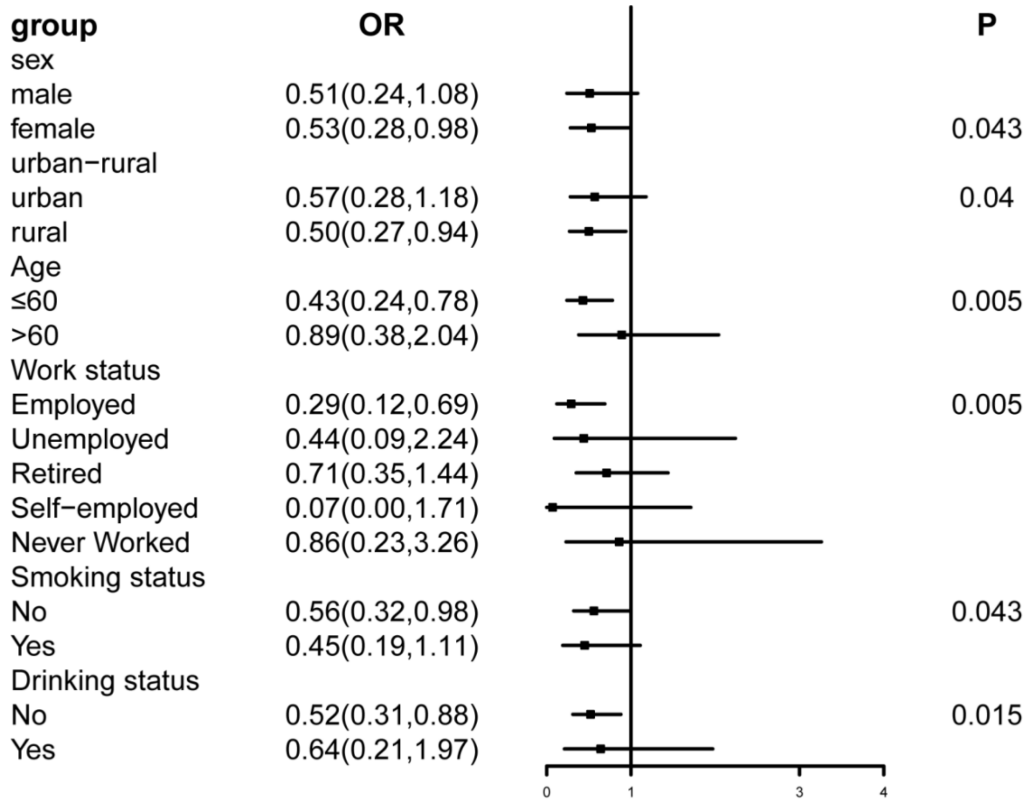

Figure 3. Subgroup analysis of Balanced dietary pattern and depressive symptoms

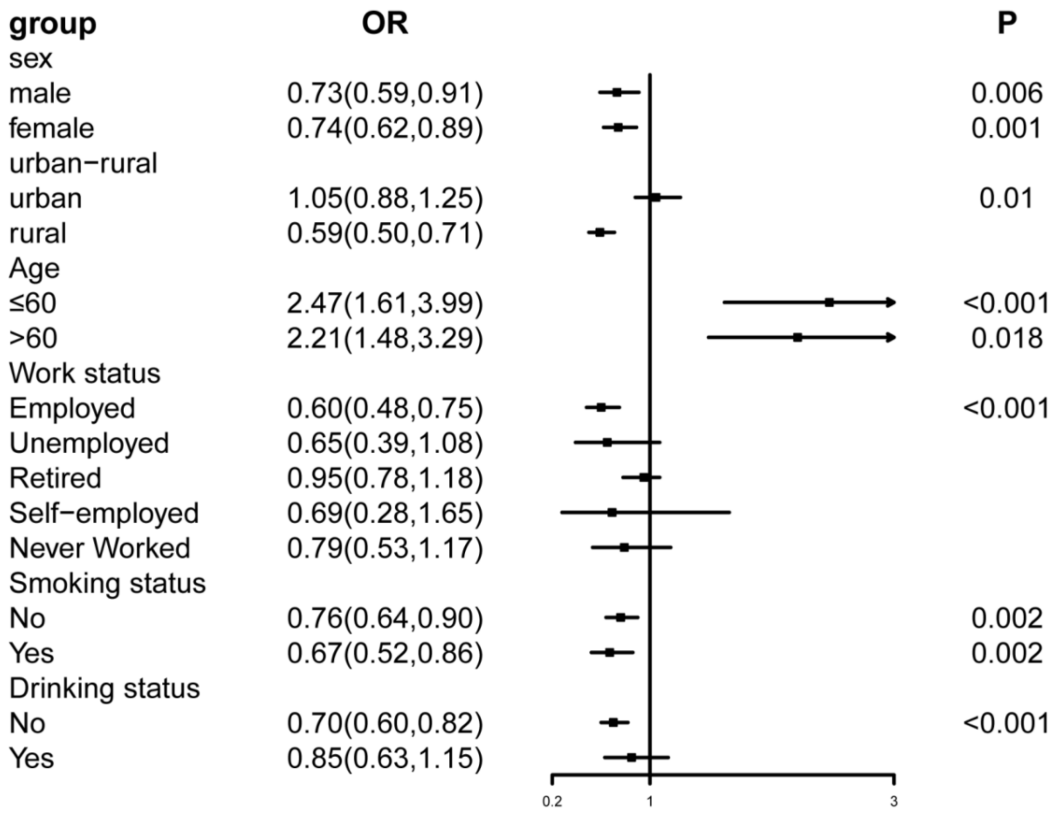

Figure 4. Subgroup analysis of Animal-Seafood-Egg dietary pattern and depressive symptoms