Original Article

Nutritional status and its influencing factors of urban Chinese adults aged 40-69 years

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Background and Objectives: To explore the nutritional challenges and its influencing factors of adults aged 40-69 living in Chinese cities. **Methods and Study Design:** This cross-sectional study involved 300 subjects from 29 cities in China. Questionnaires were used to collect demographic information, presence of chronic disease, and the use of nutritional supplements and fortified foods. 24-hour food intake was recorded using the Eat-Right Assistant, a validated digital service. **Results:** Fiber (56.7%), calcium (66.3%) and selenium (67.0%) were the nutrients with the highest insufficient intake. The foods with the highest inadequate consumption were dairy products (91%), fruits (84.3%), tubers (76.3%), soybeans and nuts (70%), and whole grains (65%). Even though 95.7% of the study population showed medium-high level of dietary diversity, dietary imbalance was present among 99% of the subjects. Higher socioeconomic status, passive health awareness, or the use of nutritional supplements or fortified foods showed positive influence on nutrient intake and dietary quality. **Conclusions:** This research provided insights into the dietary intake status and its influencing factors of 300 urban residents aged 40-69. The adult population still face a challenge of inadequate nutrient intake and imbalanced diet. In addition, this study supported the feasibility of using a digital service in research. Further studies with a larger sample size are needed to confirm current findings. This will help to clarify the unmet nutritional needs of adults in China and thus help to achieve healthy aging.

Key Words: Chinese middle-aged, healthy aging, dietary quality, health awareness, nutritional supplements and fortified foods

INTRODUCTION

During the past 50 years, the proportion of elderly population in China has risen sharply due to the decline in birth rates and extended life expectancy. This has resulted in an increased burden on individuals and healthcare systems.[1] Therefore, establishing a healthy lifestyle for individuals during the transition period from middle age to old age promotes health and longer life expectancy, enhances health status, and increases the likelihood for healthy aging. Dietary nutrition is a crucial modifiable factor influencing the health of the elderly. Research indicates that a balanced diet and appropriate food choices can significantly reduce the incidence of chronic non-communicable diseases (NCDs) and serve as a vital strategy for improving the quality of life among older adults.[2-5]

Around the age of 50, significant milestones in human aging and disease occurrence emerge, along with changes in nutritional requirements.[6-8] The recommended intakes for numerous nutrients alter at this age, including the recommendations for vitamin A, vitamin D, sodium, and energy.[8] In addition, numerous studies have demonstrated that people are falling ill at a younger age than in the past.[9-11] Therefore, the nutrient intake of this age group deserves attention. Most elderly people believe that nutritional supplements are an efficient way to replenish the daily dietary nutrition intake, and they are willing to use them.[12] Moreover, health awareness during the transition from middle age to old age may have a profound impact on health in older age, making this worth of attention.[13] There has been little research on the disease status, health awareness, nutritional supplements and fortified foods in the above mentioned population.

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This study aimed to examine the dietary intake and its influencing factors of 300 adults aged 40-69 years old in urban China. The ultimate objective of the study was to provide nutritional recommendations and intervention strategies for promoting a healthy diet in populations transitioning from middle age to elderly.

METHODS

Data collection

This was a cross-sectional study. The inclusion criteria for participants are as follows: (1) Age 40 or above; (2) Having a certain level of education, able to use mobile phones to record meals. Dietary intake data and additional data were collected from 300 subjects aged 40-69 years from 29 cities in China.

24-hour dietary intake was collected using a validated digital tool, the Eat-Right Assistant.[14] Artificial food molds, a booklet with food quality estimation pictures and a placemat marked with grids were used to facilitate the estimation of portion size.[15] Respondents were fully trained prior to the start of the study to ensure that they were able to complete the meal records independently. The survey team conducted quality control on the dietary data completed the previous day on a daily basis. For missing or duplicated dietary data, as well as any abnormal energy intake data, follow-up calls are made.

Trained professional investigators guided participants in completing the self-developed questionnaire through face-to-face instruction. This questionnaire was carried on to collect information on demographics (age, sex, educational level, household income, city classification, residence status), disease status, health awareness, the use of nutritional supplements and fortified foods.

Informed consent was obtained from all subjects involved in the study. The study adhered to the guidelines outlined in the Declaration of Helsinki and received approval from the Ethics Committee of Capital Medical University (Z2024SY053).

Dietary assessment

The daily nutrient intake for each subject was calculated using the Chinese Food Composition Table.[16-17] Standards for estimated average requirements (EAR), recommended nutrient intakes (RNI), adequate intakes (AI), the acceptable macronutrient distribution range (AMDR) and the proposed intake for reducing the risk of diet-related non-communicable diseases (PI-NCD) came from the Dietary Reference Intakes for Chinese (2023).[8] A dietary diversity score (DDS) was used to measure the variety of foods consumed among the participants. The specific calculation method has been described in previous research.[18-19] The diet balance index (DBI) is an index that considers both undernutrition and overnutrition in overall dietary intake. It can be used to assess the dietary nutritional status and the dietary balance of the population. Specific calculation and evaluation methods can be found in the indicated reference.[20]

Statistical analysis

Data analysis was conducted by SPSS27.0. Non-normally distributed continuous data were expressed as medians and interquartile ranges, while categorical data were expressed as counts (%). The rank sum test was used to analyze differences in nutrient intake across various characteristics. Generalized linear model was applied to further analyzed the influencing factors of the five nutrients with the highest intake inadequacies in the population, as well as the three major energy-providing nutrients. At the same time, the associations between disease status and dietary quality were analyzed, using the Kendall's tau-b level correlation, and relevant heat maps were drawn using GraphPad drawing software. $p<0.05$ indicated significant differences.

RESULTS

Basic characteristics of the population

The participants' characteristics are summarized in Table 1. 300 respondents were included in the analysis, including 225 females and 75 males. The mean age of participants in this study was 48.77±7.24 years (range 40-69 years).

Nutrient and food intake

64% of individuals had protein intake within the acceptable range, 70% had excessive fat intake and 66.7% had inadequate carbohydrate intake when comparing the macronutrient intake with AMDR (Table 2). The micronutrient intakes were compared with EAR and RNI (Table 3). 90% of the respondents had insufficient dietary fiber intake, and more than 70% had insufficient calcium and selenium intake. Comparing the micronutrient intake with PI-NCD (Table 4), only a few participants met the recommended intake of vitamin C and potassium, 6% and 6.7% respectively. The insufficient intake in groups below 50 years and above 50 years were similar, and there was a significant difference in potassium intake between the two groups of people.

The intake of various food groups was compared with the recommendations indicated by the Chinese food pagoda (Table 5). Apart from animal foods and oil, most of the population did not meet the recommended intake of any food group. The largest insufficient intake of food groups were milk and dairy products (91%), fruits (84.3%), tubers (76.3%), soybeans and nuts (70%) and whole grains (65%). Most of the individuals (>70%) had moderate oil and added sugar intake, while approximately 50% of individuals had excessive salt intake.

Nutrient intake in populations with different characteristics

The analysis of dietary intake among populations with different characteristics revealed significant differences (Table 6 and Supplementary Table 1). Individuals using nutritional supplements and fortified foods tended to have higher intakes of energy, dietary fiber, phosphorus and magnesium ($p<0.05$). Furthermore, the use of senior milk powder was associated with higher dietary fiber intake ($p<0.05$). The study also indicated that individuals with higher education level had a higher intake of protein, potassium, iron, zinc and cholesterol ($p<0.05$).

Table 1. The study procedure

Characteristics	Total	Age 40-49	Age50-69	*p*
Total, n (%)	300 (100.0)	177 (59.0)	123 (41.0)	
Sex, n (%)				0.946
Male	75 (25.0)	44 (24.9)	31 (25.2)	
Female	225 (75.0)	113 (75.1)	92 (74.8)	
Educational level, n (%)				<0.001**
Junior high school and below	13 (4.3)	4 (2.3)	9 (7.3)	
High school/technical school/secondary school	90 (30.0)	25 (14.1)	65 (52.8)	
Bachelor/college	195 (65.0)	146 (82.5)	49 (39.8)	
Master or above	2 (0.7)	2 (1.1)	-	
Household income (CNY), n (%)				<0.001**
<10, 000	17 (5.7)	-	17 (13.8)	
10, 000-14, 999	93 (31.7)	45 (25.4)	50 (40.7)	
15, 000-19, 999	83 (27.7)	59 (33.3)	24 (19.5)	
20, 000-24, 999	60 (20.0)	38 (21.5)	22 (17.9)	
25, 000-29, 999	23 (7.7)	15 (8.5)	8 (6.5)	
≥30, 000	22 (7.3)	20 (11.3)	2 (1.6)	
City classification, n (%)				0.012*
First-tier cities	25 (8.3)	18 (10.2)	7 (5.7)	
New first-tier Cities	43 (14.3)	16 (9.0)	27 (22.0)	
Second-tier cities	120 (40.0)	73 (41.2)	47 (38.2)	
Third-tier cities and below	112 (37.3)	70 (39.5)	42 (34.1)	
Residence status, n(%)				<0.001**
Living alone	3 (1.0)	-	3 (2.4)	
Living with husband/wife	128 (42.7)	50 (28.2)	78 (63.4)	
Living with offspring	169 (56.3)	127 (71.8)	42 (34.1)	
Use of nutritional supplements and fortified foods, n (%)				0.012*
No	57 (19.0)	42 (23.7)	15 (12.2)	
Yes	243 (81.0)	135 (76.3)	108 (87.8)	
Use the senior milk powder †				<0.001**
No	57 (52.3)	42 (67.7)	15 (31.9)	
Yes	52 (47.7)	20 (32.3)	32 (68.1)	
Disease status n (%)				0.050
Sick	52 (17.3)	37 (20.9)	15 (12.2)	
Healthy	248 (82.7)	140 (79.1)	108 (87.8)	
Health awareness, n (%)				0.422
Proactive health awareness ‡	247 (82.3)	145 (81.9)	102 (82.9)	
Passive health awareness §	31 (10.3)	21 (11.9)	10 (8.1)	
No concern with diseases	22 (7.3)	11 (6.2)	11 (8.9)	
DDS, n (%)				0.254
Inadequate (1-3)	13 (4.3)	10 (5.6)	3 (2.4)	
Moderate (4-6)	122 (40.7)	67 (37.9)	55 (44.7)	
Adequate (7-9)	165 (55.5)	100 (56.5)	65 (52.8)	

DDS, dietary diversity score.
†The total number of people in this group was 109, excluding those who used nutritional supplements and fortified foods other than senior milk powder;
‡Proactive health awareness: pay attention to diseases when healthy.
§Passive health awareness: pay attention to the disease after getting sick.
*p<0.05 **p<0.01

Dietary quality

Dietary Balance Index (DBI) was used to assess the dietary balance of the population (Table 7). More than 99% of the population had a dietary imbalance, with 55% at a low level and 43.3% at a medium level. More than 52% of the population had an excessive intake of animal-based products. More than 60% had an inadequate intake of food that should be eaten more, such as fruits, vegetables and soybeans. Dietary Diversity Score (DDS) was used to evaluate the variety in foods consumed by the subjects (Table 8). The population exhibited a relatively high score for dietary diversity, with 55.5% of individuals being on a high level and 40.7% of individuals being on a medium level.

Factors influencing dietary quality

An analysis of the factors influencing dietary quality in the population (Table 9) showed a significant association between health awareness and Diet Quality Distance (DQD, indicating overall dietary imbalance, p<0.05). Models adjusted for age and sex. Individuals with passive health awareness showed a lower level of dietary imbalance. At the same time, household income, city classification, and health awareness may have an impact on the High Bound Score (HBS, indicating excessive intake). Individuals with higher household income exhibited a greater HBS than those with incomes below 1000 (p<0.001). Both residing in new first-tier cities (B=0.049, p=0.002) and possessing proactive health awareness

Table 2. Comparison of participants' macronutrients intake with AMDR

	Total			Age40-49			Age50-69			*p*
	Meet AMDR (%)	Below AMDR (%)	Exceed AMDR (%)	Meet AMDR (%)	Below AMDR (%)	Exceed AMDR (%)	Meet AMDR (%)	Below AMDR (%)	Exceed AMDR (%)	
Fat	17.0	7.0	76.0	17.5	7.3	75.2	16.2	6.5	77.3	0.425
Carbohydrate	26.3	66.7	7.0	27.1	66.1	6.8	25.2	67.5	7.3	0.805
Protein	64.0	1.7	34.3	60.5	1.7	37.8	69.1	1.6	29.3	0.435

AMDR, acceptable macronutrients distribution ranges
% indicates the population proportion.

Table 3. Comparison of participants' energy and nutrients intake with RNI and EAR

	Total population			Age 40-49			Age 50-69			*p*
	Overall intake, median (IQR)	<EAR (%)	≥RNI (%)	Overall intake, median (IQR)	<EAR (%)	≥RNI (%)	Overall intake, median (IQR)	<EAR (%)	≥RNI (%)	
Energy (kcal/d)	1632 (1174, 2069)	58.6	-	1647 (1193, 2057)	59.9	-	1541 (1141, 2110)	56.9	-	0.537
Protein (g/d)	70.1 (51.7, 96.1)	24.6	67.6	71.3 (53.9, 96.0)	20.3	71.7	68.5 (45.5, 96.1)	30.9	61.8	0.315
Carbohydrate (g/d)	169 (121, 227)	24.0	-	170 (119, 234)	25.5	-	168 (122, 216)	21.9	-	0.889
Dietary fiber (g/d)	7.1 (3.9, 11.4)	-	2.3	6.3 (3.5, 11.3)	-	3.4	8.0 (4.4, 12.2)	-	0.8	0.566
Vitamin A (μgRAE/d)	344 (204, 594)	56.7	18.7	304 (204, 492)	59.3	13.6	465 (209, 681)	52.9	26.1	0.142
Niacin (mg/d)	12.9 (8.8, 18.6)	46.0	50.3	13.2 (9.2, 19.4)	46.9	54.8	11.4 (6.7, 17.4)	44.7	43.9	0.422
Vitamin C (mg/d)	55.6 (23.7, 102)	69.0	26.3	54.9 (23.6, 99.8)	71.7	24.9	56.6 (23.7, 106.0)	65.0	28.5	0.209
Vitamin E (mg/d)	15.2 (9.9, 26.1)	-	55.7	14.7 (9.9, 25.5)	-	53.1	15.4 (9.9, 27.6)	-	59.4	0.394
Calcium (mg/d)	497 (303, 755)	66.3	20.4	481 (288, 755)	67.8	20.4	531 (374, 756)	64.2	20.3	0.146
Phosphorus (mg/d)	945 (667, 1202)	17.0	70.0	923 (668, 1160)	15.8	70.6	959 (658, 1282)	18.7	69.1	0.134
Potassium (mg/d)	1744 (1197, 2354)	-	38.0	1685 (162, 2220)	-	33.3	1803 (1247, 2801)	-	44.7	0.041*
Magnesium (mg/d)	227 (167, 328)	63.0	26.7	223 (173, 309)	66.1	23.2	237 (161, 349)	58.5	31.7	0.332
Sodium (mg/d)	2986 (1974, 4799)	-	85.1	3110 (1987, 5225)	-	84.3	2818 (1969, 4452)	-	86.2	0.630
Iron* (mg/d)	15.6 (10.9, 23.0)	20.3	57.7	15.5 (11.0, 22.1)	26.0	44.1	15.6 (10.3, 24.5)	12.2	77.3	0.834
Zinc (mg/d)	8.2 (5.8, 11.7)	41.7	41.0	8.3 (5.9, 11.6)	39.0	41.3	8.1 (5.2, 11.9)	45.5	40.7	0.976
Selenium (μg/d)	38.4 (27.1, 57.2)	67.0	22.4	37.3 (26.8, 55.6)	69.5	21.5	38.8 (27.2, 19.6)	63.4	23.6	0.644
Copper (mg/d)	1.1 (0.7, 1.7)	14.3	72.0	1.1 (0.7, 1.6)	13.6	71.2	1.1 (0.7, 1.7)	15.4	73.2	0.712
Manganese (mg/d)	2.6 (1.6, 3.9)	-	21.0	2.6 (1.6, 3.7)	-	17.5	2.6 (1.6, 4.2)	-	26.0	0.601

RNI, recommended nutrient intake; EAR, estimated average requirement
% indicates the population proportion.

Table 4. Comparison of participants' micronutrient intake with PI-NCD

Micronutrients	Meet PI-NCD (%)			*p*
	Total	Age 40-49	Age 50-69	
Vitamin C	6.0	3.9	8.9	0.120
Potassium	6.7	5.1	8.9	0.395
Sodium	25.3	24.9	26.0	0.963

PI-NCD, proposed intakes for preventing non-communicable chronic diseases
% indicates the population proportion.

Table 5. Comparison of participants' food groups intake with the food pagoda (g/d)

Food groups	Overall intake (g/d)	Meet recommended intake (%)	Below recommended intake (%)	Exceed recommended intake (%)
Cereals	175 (100, 270)	30.0	53.0	17.0
Potatoes	0 (0, 33.3)	10.0	76.3	13.7
Coarse grains*	0 (0, 91.9)	22.0	65.0	13.0
Vegetables	237 (129, 400)	23.0	62.0	15.0
Fruits	0 (0, 139)	12.0	84.3	3.7
Animal-based products	210 (112, 321)	22.0	26.0	52.0
Milk and dairy products	138 (0, 250)	8.0	91.0	1.0
Soybeans and nuts	0 (0, 40.0)	4.0	70.0	26.0
Oil	15.0 (6.0, 24.1)	11.0	75.7	13.3
Salt	4.1 (2.5, 8.0)	55.0	-	45.0
Added sugar	0 (0, 6.3)	98.0	-	2.0

% indicates the population proportion.
*Recommended intake of coarse grains with reference to whole grains and mixed legumes.

(p<0.05) were associated with higher levels of food overconsumption. Additionally, education level was correlated with Low Bound Score (LBS, indicating insufficient food intake). There was a negative correlation, indicating that individuals with higher education levels experienced a lower incidence of insufficient intake compared to those with a high school education or below.

Correlation of dietary quality with disease status and health awareness

Correlation analysis was conducted among the groups (Figure 1), and there was no correlation among the groups in general (p>0.05). Models adjusted for age and sex. However, we can identify trends in some of the results that are worth exploring further. DDS was negatively correlated with disease status(r=-0.090), while it was positively correlated with health awareness (r=0.032). HBS was negatively correlated with disease status (r=-0.024) and health awareness (r=-0.083). LBS was positively correlated with disease status (r=0.016). DQD was positively correlated with disease status (r=0.004) and health awareness (r=0.012).

DISCUSSION

40-69 years is an age of transition from middle to old age. Although there have been many studies on the dietary intake of the elderly in China, only few studies have focused on the age group of 40-69 years. Creating a healthy lifestyle for this population early is conducive to improving the health of middle and old age adults in China. This will support achieving the national strategies for Healthy Aging. In this study, we used a variety of methods to comprehensively assess the dietary nutrient status of this population and conducted an in-depth analysis of their disease status, health awareness, intake of nutritional supplements and fortified foods. Compared with the results of CHNS data, the nutrient intake of this population has improved, but gaps remain.[11]

Our study observed that excessive fat intake and insufficient carbohydrate intake were common in the study population. This may be attributed to the significant changes in dietary consumption patterns among Chinese adults over the past two decades. This change is characterized by an increase in fat and animal product intake, alongside with a decrease in grain consumption, especially whole grains.[21] The shift has largely resulted in the inadequate intake of carbohydrates and dietary fiber. In addition, adequate protein intake is important for our survey population. Protein intake was sufficient and higher than the national intake,[22] which may be due to the study subjects living in an urban setting.[23]

Results of our study indicated that dietary fiber, calcium and selenium intakes were most insufficient in this population, which is consistent with the data from the Sixth National Nutrition Survey in China.[24] The intake of the important food sources of these nutrients such as dairy products, fruits, tubers, soy products and whole grains was inadequate contributing to the deficiency.[16-17] This was consistent with the data from the CHNS.[25] Low calcium intake is a key risk factor for osteoporosis in the elderly, increasing their risk of fractures.26-[27] Adequate selenium intake not only lowers fasting insulin levels and enhances insulin sensitivity but also plays a vital role in bone health.[28-29] Dietary fiber can reduce the risk of stroke, Type 2 diabetes, obesity and chronic kidney disease by affecting intestinal health and immunity.[30-34] It is worth noting that individuals who used nutritional supplements or nutritional fortified foods such as senior milk

Table 6. Comparison of nutrient intake by different population characteristics

Characteristics	Energy		Protein		Fat	
	Median (IQR)	*p*	Median (IQR)	*p*	Median (IQR)	*p*
Sex		0.005*		0.186		0.282
Male	1882 (1295, 2291)		77.5 (53.8, 97.4)		73.5 (41.8, 111)	
Female	1577 (1153, 1961)		66.9 (50.8, 95.9)		63.9 (46.4, 87.3)	
Age (years old)		0.481		0.322		0.696
<50	1647 (1193, 2057)		71.3 (53.9, 96.0)		66.4 (46.2, 95.6)	
≥50	1541 (1141, 2110)		68.5 (45.5, 96.1)		63.0 (44.8, 89.0)	
Educational level		0.135		0.026*		0.007**
Junior high school and below	1481 (626, 1635)		52.4 (22.4, 70.0)		43.5 (14.5, 247)	
High school/technical school/secondary school	1666 (1207, 2108)		71.1 (49.4, 98.8)		74.4 (42.9, 98.9)	
Bachelor/college	1630 (1188, 2074)		71.6 (52.5, 95.9)		66.2 (46.4, 93.1)	
Master or above	1513 (1105, -)		93.3 (51.5, -)		45.4 (36.7, -)	

Characteristics	Carbohydrate		Dietary fiber	
	Median (IQR)	*p*	Median (IQR)	*p*
Sex		0.002**		0.007**
Male	205 (129, 276)		8.8 (5.4, 14.9)	
Female	162 (120, 215)		6.7 (3.5, 11.2)	
Age (years old)		0.842		0.051
<50	170 (119, 234)		6.3 (3.54, 1.3)	
≥50	168 (122, 216)		8.0 (4.4, 12.2)	
Educational level		0.924		0.847
Junior high school and below	148 (69.4, 247)		6.8 (2.0, 11.7)	
High school/technical school/secondary school	179 (120, 225)		7.1 (3.9, 12.3)	
Bachelor/college	168 (122, 230)		7.3 (4.0, 11.3)	
Master or above	187 (149, -)		9.2 (5.5, -)	

†$p<0.05$ Significant difference between those who used senior milk powder compared to those who did not use nutritional supplements and fortified foods.

*Because of the more common use of senior milk powder in the population, those who used only senior milk powder were also compared with those who did not use nutritional supplements or fortified foods.

‡Proactive health awareness: pay attention to diseases when healthy.

§Passive health awareness: pay attention to the disease after getting sick.

*$p<0.05$ **$p<0.01$

Table 6. Comparison of nutrient intake by different population characteristics (cont.)

Characteristics	Energy		Protein		Fat	
	Median (IQR)	*p*	Median (IQR)	*p*	Median (IQR)	*p*
Household income (CNY)		0.213		0.167		0.047*
<10, 000	1584 (857, 1714)		56.2 (41.8, 80.3)		52.4 (29.2, 14.9)	
10, 000-14, 999	1520 (1124, 2088)		65.1 (46.2, 96.1)		61.9 (42.1, 80.9)	
15, 000-19, 999	1659 (1335, 2081)		72.0 (56.3, 97.1)		73.2 (46.7, 108)	
20, 000-24, 999	1741 (1209, 2142)		81.1 (55.9, 107)		78.5 (52.2, 96.1)	
25, 000-29, 999	1409 (1079, 2131)		68.5 (54.4, 95.2)		62.2 (43.5, 95.6)	
≥30, 000	1601 (1175, 1870)		64.9 (44.9, 99.3)		58.5 (45.4, 79.1)	
City classification		0.525		0.080		0.040*
First-tier cities	1640 (1183, 2054)		69.4 (56.1, 87.9)		63.9 (38.2, 92.0)	
New first-tier Cities	1584 (1105, 2061)		58.6 (43.8, 85.6)		51.7 (36.7, 76.8)	
Second-tier cities	1655 (1224, 2093)		77.0 (53.7, 103)		70.3 (49.8, 106)	
Third-tier cities and below	1535 (1122, 2012)		68.6 (47.1, 94.3)		65.2 (43.0, 88.4)	

Characteristics	Carbohydrate		Dietary fiber	
	Median (IQR)	*p*	Median (IQR)	*p*
Household income (CNY)		0.735		0.758
<10, 000	160 (91.5, 217)		5.9 (3.2, 11.7)	
10, 000-14, 999	175 (124, 233)		7.3 (3.6, 11.3)	
15, 000-19, 999	178 (124, 226)		7.5 (4.0, 12.9)	
20, 000-24, 999	158 (112, 217)		7.1 (4.1, 11.8)	
25, 000-29, 999	161 (119, 203)		6.0 (4.1, 7.7)	
≥30, 000	190 (137, 245)		7.3 (4.4, 10.2)	
City classification		0.117		0.044*
First-tier cities	178 (125, 233)		5.4 (2.6 ,9.5)	
New first-tier Cities	205 (142, 241)		9.4 (4.6, 12.9)	
Second-tier cities	168 (121, 216)		7.6 (4.1, 12.5)	
Third-tier cities and below	159 (111, 223)		6.4 (3.4, 10.5)	

†$p<0.05$ Significant difference between those who used senior milk powder compared to those who did not use nutritional supplements and fortified foods.

*Because of the more common use of senior milk powder in the population, those who used only senior milk powder were also compared with those who did not use nutritional supplements or fortified foods.

‡Proactive health awareness: pay attention to diseases when healthy.

§Passive health awareness: pay attention to the disease after getting sick.

*$p<0.05$ **$p<0.01$

Table 6. Comparison of nutrient intake by different population characteristics (cont.)

Characteristics	Energy		Protein		Fat	
	Median (IQR)	*p*	Median (IQR)	*p*	Median (IQR)	*p*
Residence status		0.610		0.927		0.700
Living alone	1098 (720, -)		55.9 (43.0, -)		32.5 (27.3, -)	
Living with husband/wife	1533 (1158, 2102)		71.6 (49.8, 97.7)		63.0 (44.0, 93.7)	
Living with offspring	1647 (1201, 2057)		69.5 (53.1, 95.0)		67.9 (46.5, 89.2)	
Use of nutritional supplements and fortified foods						
No	1409 (1106, 1847)		69.3 (49.5, 86.6)		62.1 (43.8, 79.9)	
Yes	1647 (1207, 2094)	0.039*	71.1 (52.1, 99.5)	0.365	68.2 (46.1, 95.6)	0.300
Use the senior milk powder*	1590 (1097, 2055)	0.280	68.9 (51.1, 102)	0.619	74.5 (44.5, 93.7)	0.300
Health awareness		0.717		0.129		0.313
Proactive health awareness‡	1488 (1079, 2095)		59.4 (49.6, 57.1)		56.4 (34.6, 80.0)	
Passive health awareness§	1636 (1207, 2061)		72.0 (52.5, 97.4)		67.2 (46.3, 93.7)	
No concern with diseases	1654 (1093, 2122)		58.4 (41.7, 81.6)		62.0 (46.3, 27.5)	

Characteristics	Carbohydrate		Dietary fiber	
	Median (IQR)	*p*	Median (IQR)	*p*
Residence status		0.248		0.152
Living alone	128 (77.3, -)		7.1 (2.3, -)	
Living with husband/wife	165 (121, 219)		8.6 (4.1, 12.8)	
Living with offspring	173 (123, 235)		6.5 (3.8, 10.7)	
Use of nutritional supplements and fortified foods				
No	160 (104, 196)		5.4 (3.1, 8.8)	
Yes	173 (124, 234)	0.040*	7.5 (4.3, 12.1)	0.005**
Use the senior milk powder*	147 (120, 218)	0.474	7.5 (3.7, 11.3)	0.039†
Health awareness		0.632		0.312
Proactive health awareness‡	178 (121, 235)		5.9 (3.1, 13.2)	
Passive health awareness§	168 (121, 224)		7.2 (3.9, 11.3)	
No concern with diseases	166 (130, 269)		8.5 (6.0, 13.7)	

†$p<0.05$ Significant difference between those who used senior milk powder compared to those who did not use nutritional supplements and fortified foods.

*Because of the more common use of senior milk powder in the population, those who used only senior milk powder were also compared with those who did not use nutritional supplements or fortified foods.

‡Proactive health awareness: pay attention to diseases when healthy.

§Passive health awareness: pay attention to the disease after getting sick.

*$p<0.05$ **$p<0.01$

Table 7. DBI of the participants

Evaluation items	Indicators	DBI ($\bar{x}$±s)	Distribution of dietary quality n(%)				
			No problem	Almost no problem	Problems at the lowest levels	Problems at the medium levels	Problems at the high levels
Insufficient intake	LBS	25.47±6.92	5(1.7)	120 (40.0)	135 (45.0)	39 (13.0)	1 (0.3)
Excessive intake	HBS	11.36±6.31	0(0)	17 (5.7)	203 (67.7)	79 (26.3)	1 (0.3)
Overall imbalance	DQD	36.83±8.85	0(0)	3 (1.0)	165 (55.0)	130 (43.3)	2 (0.7)

DBI, Dietary Balance Index; LBS, Low Bound Score; HBS, High Bound Score; DQD, Diet Quality Distance.
% indicates the population proportion.

Table 8. DDS of the participants

DDS	Number (n)	Proportion (%)
Lowest dietary diversity (1-3)	13	4.3
Medium dietary diversity (4-6)	122	40.7
High dietary diversity (7-9)	165	55.0
Total	300	100

DDS, Dietary Diversity Score; % indicates the population proportion.

Table 9. Analysis of influencing factors for dietary quality

Characteristics	DDS		LBS		HBS	
	B	*p*	B	*p*	B	*p*
Educational level		0.138		0.009**		0.182
Junior high school and below						
High school/technical school/secondary school	0.802 (-0.048, 1.65)		-0.092 (-0.210, 0.025)		0.148 (-0.046, 0.341)	
Bachelor/college	0.898 (0.046, 1.75)		-0.168 (-0.286, -0.050)		0.157 (-0.036, 0.350)	
Master or above	-0.286 (-2.40, 1.83)		-0.096 (-0.395, 0.203)		0.429 (0.023, 0.835)	
Household income (CNY)		0.467		0.321		<0.001**
<10, 000						
10, 000-14, 999	-0.079 (-0.853, 0.694)		0.023 (-0.089, 0.135)		0.243 (0.064, 0.421)	
15, 000-19, 999	0.322 (-0.494, 1.14)		-0.031 (-0.149, 0.088)		0.291 (0.104, 0.477)	
20, 000-24, 999	0.178 (-0.664, 1.02)		0.035 (-0.087, 0.157)		0.211 (0.018, 0.403)	
25, 000-29, 999	0.026 (-0.959, 1.01)		0.053 (-0.089, 0.196)		0.427 (0.209, 0.644)	
≥30, 000	-0.166 (-1.19, 0.853)		0.040 (-0.107, 0.188)		0.075 (-0.164, 0.313)	

Characteristics	DQD	
	B	*p*
Educational level		0.099
Junior high school and below		
High school/technical school/secondary school	-0.024 (-0.124, 0.076)	
Bachelor/college	-0.073 (-0.174, 0.027)	
Master or above	0.068 (-0.171, 0.308)	
Household income (CNY)		0.064
<10, 000		
10, 000-14, 999	0.089 (-0.006, 0.183)	
15, 000-19, 999	0.068 (-0.032, 0.167)	
20, 000-24, 999	0.088 (-0.014, 0.191)	
25, 000-29, 999	0.167 (0.048, 0.286)	
≥30, 000	0.056 (-0.069, 0.182)	

DDS, Dietary Diversity Score; DBI, Dietary Balance Index; LBS, Low Bound Score; HBS, High Bound Score; DQD, Diet Quality Distance.
Generalized linear model was used to analyze the influencing factors.
Models adjusted for age and sex.
‡Proactive health awareness: pay attention to diseases when healthy.
§Passive health awareness: pay attention to the disease after getting sick.
*p<0.05 **p<0.01

Table 9. Analysis of influencing factors for dietary quality

Characteristics	DDS		LBS		HBS	
	B	*p*	B	*p*	B	*p*
City classification		0.873		0.978		0.002**
First-tier cities						
New first-tier cities	-0.228 (-0.944, 0.487)		0.018 (-0.085, 0.121)		0.049 (0.102, 0.201)	
Second-tier cities	-0.048 (-0.693, 0.597)		0.019 (-0.074, 0.112)		-0.018 (-0.155, 0.120)	
Third-tier cities and below	-0.141 (-0.833, 0.552)		0.012 (-0.088, 0.113)		-0.154 (-0.304, -0.005)	
Residence status		0.226		0.338		0.126
Living alone						
Living with husband/wife	-0.199 (-1.82, 1.42)		0.040 (-0.201, 0.281)		-0.272 (-0.604, 0.059)	
Living with offspring	0.111 (-1.52, 1.74)		0.002 (-0.240, 0.245)		-0.315 (-0.648, 0.019)	
Use of nutritional supplements and fortified foods		0.649		0.786		0.536
No						
Yes	-0.095 (-0.506, 0.315)		0.008 (-0.051, 0.068)		-0.028 (-0.117, 0.061)	
Health awareness		0.754		0.570		0.002**
Proactive health awareness ‡						
Passive health awareness §	0.177 (-0.351, 0.704)		0.005 (-0.072, 0.082)		-0.160 (-0.267, -0.053)	
No concern with diseases	0.046 (-0.728, 0.820)		0.051 (-0.060, 0.163)		-0.016 (-0.175, 0.142)	

Characteristics	DQD	
	B	*p*
City classification		0.157
First-tier cities		
New first-tier cities	0.029 (-0.057, 0.114)	
Second-tier cities	0.007 (-0.070, 0.084)	
Third-tier cities and below	-0.039 (-0.122, 0.044)	
Residence status		0.149
Living alone		
Living with husband/wife	-0.057 (-0.252, 0.138)	
Living with offspring	-0.096 (-0.292, 0.100)	
Use of nutritional supplements and fortified foods		0.890
No		
Yes	-0.004 (-0.053, 0.046)	
Health awareness		0.044**
Proactive health awareness ‡		
Passive health awareness §	-0.050 (-0.112, 0.013)	
No concern with diseases	0.027 (-0.064, 0.118)	

DDS, Dietary Diversity Score; DBI, Dietary Balance Index; LBS, Low Bound Score; HBS, High Bound Score; DQD, Diet Quality Distance.
Generalized linear model was used to analyze the influencing factors. Models adjusted for age and sex.
‡Proactive health awareness: pay attention to diseases when healthy.
§Passive health awareness: pay attention to the disease after getting sick.
*p<0.05 **p<0.01

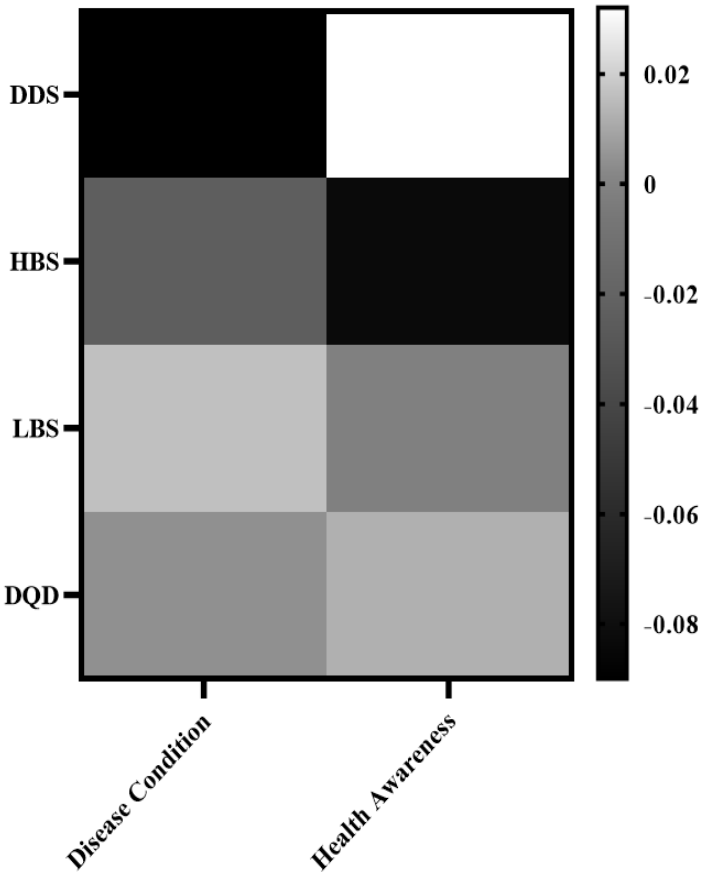

Figure 1. Heatmap correlating disease statue with dietary quality. The chart displayed the r value, where white indicated a positive correlation and dark grey indicated a negative correlation, medium gray indicated no correlation.The closer the color was to white or dark grey , the greater the r value, signifying a stronger degree of association.

powder had significantly higher intakes of several nutrients such as dietary fiber. Previous research has demonstrated that choosing appropriate nutritional supplements and fortified foods can compensate for nutrient deficiencies such as dietary fiber while aiding in the prevention of chronic diseases and slowing disease progression.[35-39] The dietary diversification score and the intake levels of nutrients such as protein, potassium, iron, zinc, and vitamin C are related to educational attainment, with the overall trend indicating that populations with higher education levels have higher dietary diversification scores and greater intake levels of the aforementioned nutrients; additionally, individuals residing in cities ranked as second-tier or above exhibit higher intake levels of vitamin E and manganese compared to those in other city rankings.

Nearly half of the population reported excessive salt intake, aligning with findings from the latest comprehensive dietary study in China.[21] This observation may be closely linked to the prevalent consumption of preserved foods and excessive salt and sodium addition during cooking.[40] The "Healthy China 2030" has recommended reducing salt, oil and added sugar intake, all of which may contribute to reducing the risks of cardiovascular diseases such as coronary heart disease and hypertension.[41-42]

Most of the population met the dietary diversity requirements, however there was an imbalanced intake of recommended foods. However, a study based on CHNS indicated that the dietary intake deficiencies and excesses among the middle-aged and elderly population were mostly at moderate or high levels.[25] This discrepancy may be due to our participants primarily being urban residents from economically developed regions of China, who had a higher health awareness and better economic conditions than the overall population in China.[43-45] The study population had certain advantages when selecting food, such as understanding the significance of food portion size and greater economic ability to purchase nutrient rich foods.[45-48] Our findings also indicated that those with passive health awareness have lower levels of inadequate and unbalanced dietary intake compared to individuals who have proactive health awareness. People with passive health awareness had stricter and more balanced dietary intake due to guidance of professional medical staff after developing an illness.[49-50]

Furthermore, we found that individuals aged between 40-49 had lower intake of fiber, calcium and vitamin A compared to those aged between 50-69. Additionally, the dietary diversity score and dietary balance index of individuals aged between 50-69 were superior to those aged between 40-49. This may be attributed to the gradual decline in physical condition associated with aging, leading older adults to become more health-conscious and place greater emphasis on nutritional balance in their daily diets. They consciously seek to improve their dietary intake to replenish essential micronutrients that may be lacking in the elderly population. Furthermore, social roles for those above 50 evolve over time, granting them more

discretionary time to prepare daily meals, thereby ensuring dietary diversity and nutritional balance.[51]

This study utilized a digital tool for the dietary survey, which allowed participants to record food intake timely and accurately, thus avoiding retrospective bias and ensuring the reliability of the dietary data.[52] Like other methodologies of collecting dietary data, our dietary data were recorded by participants, which may underestimate their dietary intake.

In this cross-sectional study, we were unable to fully capture long-term dietary trends and establish clear cause-and-effect associations. Furthermore, significant work remains necessary in the future to explore some of these phenomena more thoroughly. We aim to expand the scope of future studies to enhance the ability to generalize the findings.

Conclusion

Our study found that the dietary nutritional status of Chinese residents aged 40-69 has improved compared to the past, but there are still gaps compared to recommendations. In addition, this study serves as a valuable reference for the application of digital services in the research field. In the future, we aim to conduct further investigations into the underlying causes of our study findings, with the goal to provide more tailored health education and promote healthy aging.

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CONFLICT OF INTEREST AND FUNDING DISCLOSURE

The authors declare no conflict of interest.

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