



Influencing mechanisms of lifestyle and dietary factors on chronic diseases among community residents: updated evidence in Shanghai, China

Yan Yang¹, Hua Jin^{3,4}, Peipei Zhang⁵, Mingwang Cheng¹, Xiang Liu⁶, Zilong Cao², Xiang Gao², Liang Zhou², Yipeng Lv², Jiaoling Huang², Ning Chen², Zhaoxin Wang^{2,*}, Jianwei Shi^{2,3,*} and Wenya Yu^{2,*}

¹School of Economics and Management, Tongji University, Shanghai, People's Republic of China: ²School of Public Health, Shanghai Jiao Tong University School of Medicine, Shanghai 200025, People's Republic of China:

³Department of General Practice, Yangpu Hospital, Tongji University School of Medicine, Shanghai, People's Republic of China: ⁴Shanghai General Practice and Community Health Development Research Center, Shanghai, People's Republic of China: ⁵Anting Hospital, Jiading District, Shanghai, People's Republic of China: ⁶Department of Respiratory Disease, The 903rd Hospital of PLA, Hangzhou, Zhejiang, People's Republic of China

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Abstract

Objectives: This study aimed to determine the risk factors for chronic diseases and to identify the potential influencing mechanisms from the perspectives of lifestyle and dietary factors. The findings could provide updated and innovative evidence for the prevention and control of chronic diseases.

Design: A cross-sectional study.

Setting: Shanghai, China.

Participants: 1005 adults from Yangpu district of Shanghai participated in the study, and responded to questions on dietary habits, lifestyle and health status.

Results: Residents suffering from chronic diseases accounted for about 34.99% of the respondents. Logistic regression analysis showed that age, diet quality, amount of exercise and tea drinking were related to chronic diseases. Age > 60 and over-eating (Diet Balance Index total score > 0) had negative additive interaction on the occurrence of chronic disease, while overexercise (Physical Activity Index > 17.1) and tea drinking had negative multiplicative interaction and negative additive interaction on the occurrence of chronic disease. Diet quality, physical activity and tea drinking were incomplete mediators of the relationship between types of medical insurance residents participating in and chronic diseases.

Conclusions: The residents in Yangpu District of Shanghai have a high prevalence of chronic diseases. Strengthening access of residents to health education and interventions to prevent chronic diseases and cultivating healthy eating and exercise habits of residents are crucial. The nutritional environment of the elderly population should be considered, and the reimbursement level of different types of medical insurance should be designed reasonably to improve the accessibility of medical and health services and reduce the risk of chronic diseases.

Keywords
Chronic diseases
Lifestyle
Influencing
Community

As societies develop, the spectrum of diseases and number of deaths in urban residents undergo dramatic changes, and chronic diseases have become an important public health issue threatening residents' health⁽¹⁾.

Chronic non-communicable diseases (NCD), including heart disease, stroke, cancer, diabetes and chronic lung disease, are collectively responsible for almost 70% of all deaths worldwide⁽²⁾. Furthermore, NCD are more severe in low-and-middle-income countries, accounting for almost three quarters of all NCD' deaths and 82% of the 16 million people who die prematurely or before reaching age 70 years in low-and-middle-income

Yan Yang, Hua Jin and Peipei Zhang contributed equally to this work and were co-first authors.

*Corresponding author: Email supercell002@sina.com

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countries⁽³⁾. In China, due to the increased prevalence, the total number of deaths from NCD have increased, with 17% of people dying prematurely from any of cardiovascular diseases, cancers, diabetes or chronic respiratory diseases⁽⁴⁾. The high morbidity, disability and mortality from NCD bring about huge sufferings to the patients and their families, with very heavy medical cost. Therefore, the prevention and control of NCD have become an important public health issue⁽⁵⁾.

Previous studies in low-and-middle-income countries revealed the impact of demographical and sociological characteristics and lifestyle and environmental exposure on chronic diseases^(6–8). A study from rural India showed age, gender, socioeconomic status and geographical location of residence as predictors of chronic disease prevalence⁽⁹⁾. A study of six low-and-middle-income countries and upper-middle income countries, including South Africa, Mexico, India, Ghana, Russia and China, revealed that daily smoking, frequent alcohol abuse, low levels of physical activity, insufficient intake of vegetables and fruits, high risk waist-to-hip ratio, obesity and high blood pressure are the main risk factors for chronic diseases⁽¹⁰⁾. Consistent findings reported in Chinese studies revealed that in Ningxia, a remote province in northern China, gender, age, ethnicity, education, marital status, occupation and source of drinking water are the main influencing factors of chronic diseases among residents⁽¹¹⁾. In another northeastern city—Changchun—survey, age, occupation, physical activity and income are the top five risk factors for chronic diseases⁽¹²⁾. With increasing urbanisation and aging, changes in the socio-economic levels and lifestyles of residents have caused great changes in the spectrum, morbidity and mortality of chronic diseases^(13,14). However, few of these previous studies have examined the comprehensive impact mechanisms of medical insurance, modern lifestyle, diet quality and other factors on chronic diseases.

Therefore, this study was aimed to determine the prevalence of chronic diseases among the population in the surveyed area, explore their influencing factors and identify the underlying mechanisms among Shanghai, a highly urbanised city with well-developed social services. The results of this study are expected to provide updated and innovative evidence for the prevention and control of chronic diseases, especially in urban cities in developing countries.

Methods

Data sources

The data we used were from the survey of chronic diseases by Shanghai Center for Disease Control and Prevention in 2016. This survey included 1005 residents from 240 households in all 12 community streets in Yangpu District, Shanghai, and 20 households were randomly selected from

each street. The survey was conducted at the household level, and personal questionnaires were used to obtain data from family members. The respondents were community residents who had lived in the targeted district for at least 6 months preceding the survey. The questionnaire was completed by professional investigators, and the information obtained was recorded in the information system.

The survey included four sections: (1) basic family information, including the number of family members, financial status, family diet and fuel usage; (2) basic personal information, including age, sex, education level, marital status, occupation, medical insurance participation and registered permanent residence; (3) personal dietary habits and lifestyles, including food intake, smoking, second-hand smoking, alcohol drinking, salt intake (self-assessment), tea drinking and amount of exercise and (4) personal health status, including weight status (self-assessment), height (actual measurement), weight (actual measurement), blood pressure and presence of chronic diseases. The questionnaire also included related information such as family history of chronic diseases. A total of 1005 completed questionnaires were collected, including 22 questionnaires with inconsistent or illogical responses. Ultimately, 983 valid questionnaires were retained, and the effective rate was 97.81%.

Measurement

Dietary quality

Most of the existing researches mainly included single nutrients or food composition indicators to measure the dietary structure or quality of residents; these can only reflect a certain aspect of the diet and hardly explain the complexity of the diet⁽¹⁵⁾. To evaluate the overall dietary quality and diet structure, this study comprehensively considered the problem of insufficient and excessive dietary intake and quantified the degree based on Chinese Diet Balance index⁽¹⁶⁾, which can better evaluate the dietary quality of Chinese adults.

Diet Balance Index₁₆ (DBI₁₆) is composed of eight food group level indicators, including cereal, fruits and vegetables, dairy, soybean, animal food (red meat and products, poultry and game, aquatic products, eggs), pure heat food (cooking oil and alcoholic beverage), condiments (added sugar and salt), diet variety and water. If the water quantity data is missing, such was excluded from the analysis⁽¹⁶⁾. The individual indicator in each group were set according to eleven energy levels, and the specific values were based on the revised standards of China's Dietary index⁽¹⁷⁾. The DBI score is used to calculate the high bound score, low bound score, total score (TS) and diet quality distance from the eight indicators. High bound score was calculated by adding the positive scores of all indicators to indicate the degree of dietary overconsumption; low bound score, the absolute value of the sum of the negative points of all indicators, reflects the degree of insufficient



dietary intake; TS, the sum of the scores of all indicators, reflects the average level of the overall dietary quality; while diet quality distance, the sum of the absolute values of each indicator, comprehensively reflects the problems with a particular diet.

Using the DBI_16 evaluation method, the average daily food intake of each group was first calculated, and the energy intake was calculated according to the food composition table 17. The DBI_16 index score of each person was then calculated according to the DBI_16 scoring method to derive the DBI_TS, Diet Balance Index high bound score and Diet Balance Index low bound score. To better reflect the average level of the dietary quality, DBI_TS was selected as the proxy variable of dietary quality in this study. Negative DBI_TS implied undereating by the people on the average; positive DBI_TS implied overeating on the average; while zero DBI_TS does not necessarily imply a balanced diet, but may mean that the degree of overeating and undereating of different kinds of food is equal; hence, they cancel out. DBI_TS ranges from -72 to 44. According to the quartile, the Dietary quality was classified into four categories: dietary under intake ($DBI_TS \leq -14$), mild dietary under intake ($-14 < DBI_TS \leq 0$), mild overeating ($0 < DBI_TS \leq 8$) and overeating ($DBI_TS > 8$).

Amount of exercise

Individual physiological load of exercise was measured according to the international general Physical Activity Index (PAI)⁽¹⁸⁾. Housework, working activities (reading, writing, reporting, etc.), outdoor activities (running, swimming, ball games, etc.) and other different types of exercise were assigned 0.85–9 points per hour and multiplied by the corresponding time to calculate the PAI. According to the quartile, the PAI was classified into four categories: appropriate amount of physical activity ($PAI < 12.8$), mild overexercise ($12.8 < PAI \leq 17.1$), moderate overexercise ($17.1 < PAI \leq 22.5$) and severe overexercise ($PAI > 22.5$).

Assessment of chronic disease status

Participants were asked to report only NCD that were once diagnosed by medical staff. Hypertension, diabetes, dyslipidemia or hyperlipidemia, chronic kidney disease, cardiovascular and cerebrovascular events were provided as examples. No chronic disease was recorded as '0' and having one or more chronic diseases were recorded as '1'.

Statistical analysis

The data collected were recorded in Information Collection Management Platform by investigators, analysed using IBM SPSS version 23.0; Stata version 13.0 and R version 2.8.1, and reported in frequency distribution tables. Chi-square test, logistic regression analysis and mediating effect test were performed. Chi-square tests and non-conditional logistic regression analysis were used to identify factors associated with chronic disease. Addition and multiplication interaction models were used to analyse the interaction

of different risk factors on chronic disease. The synergy index (S), relative excess risk due to interaction and attributable proportion due to interaction were calculated with reference to the interaction calculation table compiled by Andersson *et al.*, and determined whether there is additive interaction^(19,20). All tests were bilateral, and $P < 0.05$ was considered statistically significant.

The mediating effect model was used to further test whether medical insurance influenced chronic diseases through dietary quality, exercise and tea drinking variables. Taking dietary quality (DBI_TS) as an example to explore the influence mechanism of residents' participation in medical insurance on chronic disease. DBI_TS was the mediation variable (reported as a continuous variable), the independent variable was types of health insurance that residents participate in (reported as a categorical variable), while the dependent variable, having or not having chronic disease, was a dichotomous variable. The specific models are as follows:

$$TS_i = \alpha + \beta_1 \text{Medical insurance}_i + \beta_2 \text{Control}_i + \zeta_i \quad (1)$$

$$\text{Chronic disease}_i = \alpha + \gamma_1 \text{Medical insurance}_i + \gamma_2 \text{Control}_i + \zeta_i \quad (2)$$

$$\text{Chronic disease}_i = \alpha + \varphi_1 \text{Medical insurance}_i + \varphi_2 TS_i + \varphi_3 \text{Control}_i + \zeta_i \quad (3)$$

In the mediation analysis, where the mediating variable or dependent variable was a categorical variable, the usual linear regression analysis was replaced by the logistic regression analysis^(21–23). Since the dependent variable was a categorical variable, equations (2) and (3) for logistic regression analysis were adopted. Since the mediating variable was a continuous variable, the linear regression analysis in equation (1) was used^(24–26). The same was true for the analysis that medical insurance affected the risk of chronic disease by influencing the amount of exercise or tea consumption of residents.

The RMediation software package in R was used to calculate the CI for the mediation variable statistics. The significance level was set at $P < 0.05$ for all the tests. Since the family history of chronic diseases was a perfect predictor of chronic diseases, it was automatically omitted from the multiple logistic regression model. Considering that members from the same family are more similar in diet and other living habits, individuals with a family history of chronic diseases are more likely to experience chronic diseases. Therefore, family history of chronic diseases was not discussed in the follow-up analysis.

Data quality

Myer's blended index is a method used to estimate the quality of survey data based on the age distribution of the participants. The index score ranges from 0 to 99 and cannot be greater than 60, otherwise, that indicates a serious quality problem with the survey demographic data. In general,

Table 1 Socio-demographic characteristics of the respondents (*n* 983)

Variable	Group	Total (<i>n</i> 983)	
		<i>n</i>	%
Socio-demographic characteristics			
Age (years)	18–30	27	2.75
	31–45	87	8.85
	46–60	294	29.91
	61–75	459	46.69
	> 75	116	11.80
Sex	Male	408	41.51
	Female	575	58.49
Education	Primary school or below	85	8.65
	Junior high school	334	33.98
	Senior high school	406	41.30
	Bachelor's degree or above	158	16.07
Marital status	Unmarried	28	2.85
	Married	906	92.17
	Widowed or divorced	49	4.98
Occupation	Operators of production and transport equipment	21	2.14
	Personnel of business and services	24	2.44
	Personnel of government, political party, enterprise	7	0.71
	Clerk and related personnel	38	3.87
	Professional technical personnel	61	6.21
	Other workers	44	4.48
	Student or unemployed	13	1.32
	Household	7	0.71
	Retirees	768	78.13
	Monthly family income (CNY*)	< 5000	162
	5001–8000	217	22.08
	8001–11 000	523	53.20
	11 001–14 000	27	2.75
	> 14 000	54	5.49
Medical insurance†	Nonparticipant	23	2.34
	Urban and Rural Residents' Medical Insurance (URRMI)	227	23.09
	Urban Employees Basic Medical Insurance (UEBMI) (not retired)	192	19.53
	UEBMI (retired)	541	55.04
Registered residence in Shanghai	Yes	965	98.17
	No	18	1.83
Health status and family history			
Weight status (self-assessment)	Thin	65	6.61
	Normal	735	74.77
	Overweight	167	16.99
	Fat	16	1.63
	BMI‡	Thin (< 18.5)	19
	Normal (18.5–23.9)	453	46.41
	Overweight (24–27.9)	386	39.55
	Obesity (≥ 28)	118	12.09
Family history of chronic diseases	Yes	831	84.54
	No	152	15.46
Individual chronic diseases	Yes	344	34.99
	No	639	65.01
Dietary and living behavior (last 12 months)			
Smoking	Never smoke	859	87.39
	Used to smoke	45	4.58
	Smoke (not everyday)	12	1.22
	Smoking everyday	67	6.82
Second-hand smoking	Never	640	65.11
	1–2 d/week	134	13.63
	3–4 d/week	38	3.87
	5–6 d/week	30	3.05
	Everyday	141	14.34
Alcohol drinking	Never	800	81.38
	Less than 1 d/month	66	6.71
	1–3 d/month	43	4.37
	1–2 d/week	32	3.26
	3–4 d/week	9	0.92
	5–6 d/week	2	0.20
	Everyday	31	3.15

Table 1 *Continued*

Variable	Group	Total (n 983)	
		n	%
Salt intake (self-assessment)	Less	224	22.79
	Moderate	679	69.07
	More	80	8.14
Tea drinking	Never or hardly	658	66.94
	Only on special occasion	53	5.39
	Only for certain months	11	1.12
	Every month (less than once a week)	17	1.73
	Every week	244	24.82
Diet quality (DBI_TS)§	Dietary under intake (<- 14)	228	23.70
	Mild dietary under intake (-14-0)	261	27.13
	Mild overeating (0-8)	242	25.16
	Overeating (> 8)	231	24.01
Physical activity index§	Appropriate amount of physical activity (< 12.8)	255	25.94
	Mild overexercise (12.9-17.1)	240	24.42
	Moderate overexercise (17.2-22.5)	252	25.64
	Severe overexercise (> 22.5)	236	24.01

*CNY: Chinese Yuan (currency unit). The average exchange rate between USD and the CNY in 2016 was 6.6423.

†Since 2016, China has started the merger of New Rural Cooperative Medical Insurance System and Urban Residents Basic Medical Insurance, collectively referred to as URRMI. Due to the availability of data and the convenience of interpretation, the two were combined in this study. In addition, since the reimbursement ratio of urban employees after retirement is significantly higher than that before retirement, the UEBMI can be divided into two groups (not retire v. retired) according to China's statutory retirement age (males retire at the age of 60 and females retire at the age of 50).

‡BMI was calculated by the actually measured height and actually measured weight, and was divided into six categories according to guidelines for the prevention and control of overweight and obesity in adults in China.

§Classified by quartile.

errors while completing the question on age may occur due to 'number preference' and 'age heaping', and several participants tend to report the last digit of their ages as 0 or 5⁽²⁷⁾. In this study, the Myer's blended index of the survey data was 4.49, indicating that there was no data heaping; thus, confirming the overall validity of the data collected.

Results

Socio-economic and demographic characteristics

As shown in Table 1, most respondents were aged 61-75 years (46.69%), women (58.49%), graduated from senior high school (41.30%), married (92.17%), retired (78.13%), enjoyed Urban Employees Basic Medical Insurance and retired (55.04%), and were registered Shanghai residents (98.17%). In terms of the health status, 77.74% of the respondents evaluated themselves as having normal weight, while the BMI showed that 46.41% of the respondents actually had normal BMI level, and 51.64% of the respondents were above normal BMI level. Of the 983 respondents, 34.99% had chronic diseases and 84.54% had a family history of chronic diseases.

Univariate analysis of chronic disease risk factors

The univariate analysis results showed that age, marital status, occupation, monthly family income, medical insurance, weight status (self-assessment), family history of chronic diseases, smoking, second-hand smoking, alcohol drinking, salt intake (self-assessment), tea drinking, diet

quality (DBI_TS) and PAI were associated individually with chronic diseases (all $P < 0.05$; Table 2).

Logistic regression analysis of chronic disease risk factors

The results of the logistic regression analysis, including significant variables in the chi-square test are shown in Table 3. Age, tea drinking, diet quality (DBI_TS) and PAI were significant influencing factors of chronic diseases. Among these factors, a higher prevalence of chronic disease was related to older age, drinking tea more often, more unbalanced diet and more excessive exercise.

Specifically, logistic regression analysis showed that, in the case of adjusting relevant variables, the risk of chronic disease of residents aged 46-60, 61-75 and > 75 were 6.88 times (95% CI: 1.47, 32.21), 8.54 times (95% CI: 1.80, 40.56) and 10.21 times (95% CI: 2.02, 51.52), compared with residents aged 18-30. Compared with those never or hardly drank tea, the risk of chronic disease was 1.84 times (95% CI: 1.30, 2.61) for those who drank tea weekly. Compared with the Dietary under intake (DBI_TS ≤ -14), the risk of chronic disease in the population with mild overeating (0 < DBI_TS ≤ 8) or overeating (DBI_TS > 8) were 2.04 times (95% CI: 1.32, 3.16) and 1.76 times (95% CI: 1.13, 2.74). Relative to residents with appropriate amount of physical activity (PAI < 12.8), the risk of chronic disease in mild overexercise (12.8 < PAI ≤ 17.1), moderate overexercise (17.1 < PAI ≤ 22.5) and severe overexercise (PAI > 22.5) group were 2.34 times (95% CI: 1.47, 3.74), 4.13 times (95% CI: 2.61, 6.53) and 4.42 times (95% CI: 2.75, 7.11), respectively (Table 3).

Table 2 Socio-demographic characteristics, health status, lifestyle and chronic diseases (*n* 983)

Variable	χ^2/T value	<i>P</i> value	Number	Without chronic disease		Having chronic disease	
				<i>n</i>	%	<i>n</i>	%
Socio-demographic characteristics							
Age (years)	29.623	< 0.001					
18–30			27	25	2.54 %	2	0.20 %
31–45			87	72	7.32 %	15	1.53 %
46–60			294	191	19.43 %	103	10.48 %
61–75			459	290	19.50 %	169	17.19 %
> 75			116	61	6.21 %	55	5.60 %
	–4.96	< 0.001	983	59.37	13.45	63.61	10.76
Sex	0.19	0.66					
Male			408	262	26.65 %	146	14.85 %
Female			575	377	38.35 %	198	20.14 %
Education	5.764	0.12					
Primary school or below			85	63	6.41 %	22	2.24 %
Junior high school			334	209	21.26 %	125	12.72 %
Senior high school			406	271	27.57 %	135	13.73 %
Bachelor's degree or above			158	96	9.77 %	62	6.31 %
Marital status	12.79	0.002					
Unmarried			28	25	2.54 %	3	0.31 %
Married			906	590	60.02 %	316	32.15 %
Widowed or divorced			49	24	2.44 %	25	2.54 %
Occupation	33.37	< 0.001					
Operators of production and transport equipment			21	10	1.02 %	11	1.12 %
Personnel of business and services			24	20	2.03 %	4	0.41 %
Personnel of government, political party, enterprise			7	4	0.41 %	3	0.31 %
Clerk and related personnel			38	33	3.36 %	5	0.51 %
Professional technical personnel			61	48	4.88 %	13	1.32 %
Other workers			44	27	2.75 %	17	1.73 %
Student or unemployed			13	13	1.32 %	0	0.00 %
Household			7	7	0.71 %	0	0.00 %
Retirees			768	477	48.52 %	291	29.60 %
Monthly family income (CNY*)	22.54	< 0.001					
< 5000			162	98	9.97 %	64	6.51 %
5001–8000			217	116	11.80 %	101	10.27 %
8001–11 000			523	367	37.33 %	156	15.87 %
11 001–14 000			27	21	2.14 %	6	0.61 %
> 14 000			54	37	3.76 %	17	1.73 %
Ln (Monthly family income)	3.26	0.001		9.04	0.42	8.94	0.48
Medical insurance†	30.723	< 0.001					
Nonparticipant			23	14	1.42 %	9	0.92 %
Urban and Rural Residents' Medical Insurance (URRMI)			227	114	11.60 %	113	11.50 %
Urban Employees Basic Medical Insurance (UEBMI) (not retired)			192	145	14.75 %	47	4.78 %
UEBMI (retired)			541	366	37.23 %	175	17.80 %
Registered residence in Shanghai	0.42	0.52					
Yes			965	626	63.68 %	339	34.49 %
No			18	13	1.32 %	5	0.51 %
Health status and family history							
Weight status (self-assessment)	67.808	< 0.001					
Thin			65	30	3.05 %	35	3.56 %
Normal			735	531	54.02 %	204	20.75 %
Overweight			167	70	7.12 %	97	9.87 %
Fat			16	8	0.81 %	8	0.81 %
BMI‡	1.07	0.79					
Thin (< 18.5)			19	13	1.32 %	6	0.61 %
Normal (18.5–23.9)			453	300	30.52 %	153	15.56 %
Overweight (24–27.9)			386	247	25.13 %	139	14.14 %
Obesity (\geq 28)			118	73	7.43 %	45	4.58 %
	–1.09	0.28		24.21	3.32	24.45	3.31
Family history of chronic diseases	333.99	< 0.001					
Yes			152	0	0.00 %	152	15.46 %
No			831	639	65.01 %	192	19.53 %
Dietary and living behavior (last 12 months)							
Smoking	9.44	0.02					
Never smoke			859	573	58.29 %	286	29.09 %
Used to smoke			45	22	2.24 %	23	2.34 %
Smoke (not everyday)			12	6	0.61 %	6	0.61 %
Smoking every day			67	38	3.87 %	29	2.95 %



Table 2 Continued

Variable	χ^2/T value	P value	Number	Without chronic disease		Having chronic disease	
				n	%	n	%
Second-hand smoke	22.97	< 0.001					
Never			640	437	44.46 %	203	20.65 %
1–2 d/week			134	68	6.92 %	66	6.71 %
3–4 d/week			38	31	3.15 %	7	0.71 %
5–6 d/week			30	15	1.53 %	15	1.53 %
Everyday			141	88	8.95 %	53	5.39 %
Alcohol drinking	49.62	< 0.001					
Never			800	557	56.66 %	243	24.72 %
Less than 1 d/month			66	25	2.54 %	41	4.17 %
1–3 d/month			43	19	1.93 %	24	2.44 %
1–2 d/week			32	14	1.42 %	18	1.83 %
3–4 d/week			9	8	0.81 %	1	0.10 %
5–6 d/week			2	1	0.10 %	1	0.10 %
Everyday			31	15	1.53 %	16	1.63 %
Salt intake (self-assessment)	22.04	< 0.001					
Less			224	140	14.24 %	84	8.55 %
Moderate			679	465	47.30 %	214	21.77 %
More			80	34	3.46 %	46	4.66 %
Tea drinking	43.89	< 0.001					
Never or hardly			658	474	48.22 %	184	18.72 %
Only on special occasion			53	27	2.75 %	26	2.64 %
Only for certain months			11	5	0.51 %	6	0.61 %
Every month (less than once a week)			17	10	1.02 %	7	0.71 %
Every week			244	123	12.51 %	121	12.31 %
Diet quality (DBI_TS)§	22.25	< 0.001					
Dietary under intake (<– 14)			228	177	18.40 %	51	5.30 %
Mild dietary under intake (–14–0)			261	173	17.98 %	88	9.15 %
Mild overeating (0–8)			242	139	14.45 %	103	10.71 %
Overeating (> 8)			231	143	14.86 %	88	9.15 %
	–5.22	< 0.001		–7.36	19.02	–1.12	14.53
Physical activity index§	73.38	< 0.001					
Appropriate amount of physical activity (< 12.8)			255	218	22.66 %	36	3.74 %
Mild overexercise (12.8–17.1)			240	155	16.11 %	76	7.90 %
Moderate overexercise (17.1–22.5)			252	135	14.03 %	113	11.75 %
Severe overexercise (> 22.5)			236	124	12.89 %	105	10.91 %
	–7.27	< 0.001		17.19	6.92	20.72	7.54

*CNY: Chinese Yuan (currency unit). The average exchange rate between USD and the CNY in 2016 was 6.6423.

†Since 2016, China has started the merger of New Rural Cooperative Medical Insurance System and Urban Residents Basic Medical Insurance, collectively referred to as URRMI. Due to the availability of data and the convenience of interpretation, the two were combined in this study. In addition, since the reimbursement ratio of urban employees after retirement is significantly higher than that before retirement, the UEBMI can be divided into two groups (not retired v. retired) according to China's statutory retirement age (males retire at the age of 60 and females retire at the age of 50).

‡BMI was calculated by the actually measured height and actually measured weight, and was divided into six categories according to Guidelines for the prevention and control of overweight and obesity in adults in China.

§Classified by quartile.

Interaction analysis of chronic disease risk factors

As shown in Table 4, there were both multiplicative interactions ($P=0.003$) and additive interactions between excessive exercise ($PAI > 17.1$) and tea drinking on the occurrence of chronic diseases. The risk factor variables were converted into dichotomous variables, and their product items were included in the logistic regression model. After adjusting the relevant variables, the results showed that residents with excessive exercise ($PAI > 17.1$) and tea drinking had a lower risk of chronic disease than residents with relatively low exercise ($PAI < 17.1$) and no tea drinking ($OR=0.40$, 95% CI: 0.22, 0.72), and the risk of chronic disease when the two exist together was lower than the sum of the risk caused by the two factors alone (relative excess risk due to interaction = -5.97 , attributable proportion due to interaction = -15.06 , $S=-0.11$), that is, there

was negative interaction. There was no multiplicative interaction between age > 60 and overeating ($DBI_TS > 0$) on the occurrence of chronic disease, but there was additive interaction (relative excess risk due to interaction = -2.47 , attributable proportion due to interaction = -4.00 , $S=-0.18$). The risk of chronic disease in people with age > 60 and overeating was lower than the sum of the risk caused by the two factors alone, that is, there was negative interaction. In addition, there was no additive or multiplicative interaction between the combination of other risk factors and the risk of chronic disease.

Medical insurance and chronic diseases: an analysis of the mediating effects of diet quality

Table 5 presents the results of the mediation effect analysis. Models 1, 3, 5 and 7 were the results of logistic regression,

Table 3 Logistic regression analysis of chronic disease risk factors (*n* 962)

Variable	β	Std.	χ^2 value	<i>P</i>	OR	95 % CI	Adjusted* OR	95 % CI
Age (years)								
18–30					1.0		1.0	
31–45	0.83	0.82	1.02	0.31	3.13	0.63, 15.49	2.28	0.46, 11.35
46–60	1.93	0.79	5.99	0.01	9.52	2.09, 43.49	6.88	1.47, 32.21
61–75	2.15	0.80	7.28	0.01	11.89	2.62, 54.03	8.54	1.80, 40.56
> 75	2.32	0.83	7.92	0.01	15.26	3.20, 72.85	10.21	2.02, 51.52
Tea drinking								
Never or hardly					1.0		1.0	
Only on special occasion	0.56	0.32	3.12	0.08	1.84	1.00, 3.39	1.76	0.94, 3.28
Only for certain months	1.10	0.69	2.55	0.11	3.20	0.87, 11.80	3.00	0.78, 11.53
Every month (less than once a week)	0.34	0.58	0.35	0.56	1.40	0.46, 4.27	1.41	0.45, 4.41
Every week	0.61	0.18	11.77	0.00	1.98	1.41, 2.76	1.84	1.30, 2.61
Diet quality (DBI_TS)								
Dietary under intake (<– 14)					1.0		1.0	
Mild dietary under intake (–14–0)	0.42	0.23	3.45	0.06	1.54	0.99, 2.38	1.52	0.98, 2.36
Mild overeating (0–8)	0.71	0.22	10.16	0.00	2.17	1.41, 3.35	2.04	1.32, 3.16
Overeating (> 8)	0.56	0.23	6.17	0.01	1.77	1.14, 2.76	1.76	1.13, 2.74
Physical activity index								
Appropriate amount of physical activity (< 12.8)					1.0			
Mild overexercise (12.8–17.1)	0.85	0.24	12.67	0.00	2.46	1.55, 3.91	2.34	1.47, 3.74
Moderate overexercise (17.1–22.5)	1.42	0.23	36.64	0.00	4.56	2.91, 7.14	4.13	2.61, 6.53
Severe overexercise (> 22.5)	1.49	0.24	37.53	0.00	4.79	3.01, 7.64	4.42	2.75, 7.11

*Adjustment variables include gender, education, marital status, occupation, medical insurance, ln (monthly family income) and registered residence in Shanghai or not.

and Models 2, 4 and 6 were the results of linear ordinary least squares (OLS) regression (although the frequency of tea drinking is actually a classification variable, for the sake of simplicity of analysis, when the number of classification levels of the classification variable is greater than or equal to 5, it can be regarded as a continuous variable and put into the OLS regression equation⁽²⁸⁾). Taking the mediating effect of DBI_TS on medical insurance and chronic disease as an example, Model 2 showed $\beta_1 = -2.36$, SE (β_1) = 0.66, and $Z_{\beta_1} = -3.58$. Model 3 showed $\phi_2 = 0.02$, SE (ϕ_2) = 0.01, and $Z_{\phi_2} = 2$. Finally, using the product distribution method of R mediation software package, 95 % CI, $Z_{\beta_1}Z_{\phi_2}$ was (–0.097, –0.007), excluding 0. Therefore, diet quality had a significant mediating effect on the relationship between medical insurance and chronic diseases. According to Baron and Kenny causal stepwise regression analysis⁽²⁹⁾, γ_1 , β_1 , ϕ_1 and ϕ_2 were significant (all $P < 0.05$; Table 5). Further confirming that diet quality was an incomplete mediator of the relationship between medical insurance and chronic disease while medical insurance also influenced chronic illnesses from other pathways. As shown in Table 5, the 95 % CI of PAI and tea drinking did not contain 0, and the corresponding γ_1 , β_1 , ϕ_1 and ϕ_2 were both significant. Therefore, PAI and tea drinking were also incomplete mediators of medical insurance for chronic diseases.

Discussion

In the 2011 World Economic Forum, it was again emphasised that the five chronic diseases (cardiovascular diseases, tumor, diabetes, respiratory diseases and mental diseases)

would have a profound impact on the national medical and economic systems in the next 20 years⁽³⁰⁾. Shanghai has been an aging city since 1999, and the disease spectrum of the residents has changed greatly; furthermore, the prevention and treatment of chronic diseases in the elderly is facing severe challenges⁽³¹⁾. In this study, the survey showed that 34.99 % of the investigated residents in Yangpu District of Shanghai suffered from chronic diseases. This higher prevalence, compared to that at the national level, could be explained by the relatively complete community-level health service system in Shanghai, which makes it possible to diagnose chronic diseases of community residents more timeously. In addition, Shanghai, being the financial center of China, regular overtime work by the residents and higher work pressure, may have contributed to the high prevalence of chronic diseases, to some extent^(32–34).

To prevent and control chronic diseases effectively, nutrition, diet and exercise are the key factors. Imbalanced diet, including overeating, is a major contributor to chronic diseases. Compared with normal dietary intakes, people who eat excessively are at higher risks of chronic diseases, which is consistent with the findings of previous studies^(35–37). With changes in diet structure, the consumption of refined cereals increases, and long-term consumption causes insufficient intake of vitamins, minerals, dietary fibre, etc⁽³⁸⁾. Excessive intake of high-sodium food also increases the risk of chronic diseases⁽³⁹⁾. Consistent with the conclusion of previous studies, the older the person, the higher the risk of chronic diseases⁽⁴⁰⁾. However, in this study, it was found that there was negative additive interaction between age > 60 and overeating

**Table 4** Interaction analysis of chronic disease risk factors (*n* 962)

Variable 1	Variable 2	Having chronic disease (yes/no)	OR	95 % CI	Adjusted* OR (aOR)	95 % CI
Age (> 60)	Overexercise (Physical Activity Index, PAI > 17.1)					
No	No	36/144				
No	Yes	84/144	2.33	1.48, 3.67	2.31	1.46, 3.70
Yes	No	76/229	1.33	0.85, 2.08	1.29	0.80, 2.04
Yes	Yes	134/115	1.51	0.84, 2.69	1.37	0.76, 2.47
Additive interaction			Relative excess risk due to interaction (RERI) = -1.23	-2.91, 0.45		
			Attributable proportion due to interaction (AP) = -0.39	-1.99, 0.19		
			S = 0.23	0.03, 1.99		
Multiplicative interaction			aOR (95 % CI) = 1.37	0.76, 2.47	P = 0.30	
Age (> 60)	Overeating (DBI_TS > 0)					
No	No	45/162				
No	Yes	75/126	2.14	1.39, 3.32	2.20	1.41, 3.44
Yes	No	94/188	1.80	1.19, 2.72	1.88	1.22, 2.92
Yes	Yes	116/156	0.69	0.40, 1.21	0.62	0.35, 1.09
Additive interaction			RERI = -2.47	-4.85, -0.08		
			AP = -4.00	-6.58, -1.42		
			S = -0.18			
Multiplicative interaction			aOR (95 % CI) = 0.62	0.35, 1.09	P = 0.98	
Age (> 60)	Tea drinking					
No	No	61/205				
No	Yes	59/83		2.391-5.4, 3.71	2.35	1.49, 3.72
Yes	No	115/263	1.47	1.03, 2.11	1.41	0.95, 2.07
Yes	Yes	95/81	1.12	0.63, 1.99	1.04	0.57, 1.87
Additive interaction			RERI = -1.72	-3.68, 0.23		
			AP = -1.67	-3.14, -0.19		
			S = 0.02	0.00, 42919508.91		
Multiplicative interaction			aOR (95 % CI) = 1.04	0.57, 1.87	P = 0.91	
Overexercise (PAI > 17.1)	Overeating (DBI_TS > 0)					
No	No	48/218	1.0		1.0	
No	Yes	64/155	1.88	1.22, 2.88	1.78	1.15, 2.74
Yes	No	91/132	3.13	2.08, 4.72	3.03	1.98, 4.63
Yes	Yes	127/127	0.77	0.44, 1.36	0.82	0.46, 1.45
Additive interaction			RERI = -2.98	-6.01, 0.04		
			AP = -3.64	-6.30, -0.99		
			S = -0.07			
Multiplicative interaction			aOR (95 % CI) = 0.82	0.46, 1.45	P = 0.49	
Overexercise (PAI > 17.1)	Tea drinking					
No	No	62/308	1.0		1.0	
No	Yes	50/65	3.82	2.42, 6.05	3.78	2.35, 6.09
Yes	No	114/160	3.54	2.46, 5.09	3.59	2.46, 5.23
Yes	Yes	104/99	0.38	0.21, 0.69	0.40	0.22, 0.72
Additive interaction			RERI = -5.97	-11.15, -0.80		
			AP = -15.06	-23.26, -6.87		
			S = -0.11			
Multiplicative interaction			aOR (95 % CI) = 0.40	0.22, 0.72	P = 0.003	
Tea drinking	Overeating (DBI_TS > 0)					
No	No	77/269	1.0		1.0	
No	Yes	99/199	1.74	1.23, 2.47	1.68	1.17, 2.39
Yes	No	62/81	2.67	1.76, 4.06	2.59	1.68, 4.00
Yes	Yes	92/83	0.83	0.47, 1.47	0.84	0.47, 1.50

Table 4 *Continued*

Variable 1	Variable 2	Having chronic disease (yes/no)	OR	95 % CI	Adjusted* OR (aOR)	95 % CI
Additive interaction			RERI = -2.43 AP = -2.90 S = -0.07	-4.97, 0.11 -5.09, -0.72		
Multiplicative interaction			aOR (95 % CI) = 0.84	0.47, 1.50	P = 0.55	

*Adjustment variables include gender, education, marital status, occupation, medical insurance, monthly family income and registered residence in Shanghai or not.

(DBI_TS > 0) on chronic disease, which may be due to deviation in the measurement of diet quality by DBI_TS. DBI_16 is generally suitable for the dietary evaluation of adults. The elderly (age > 60) have very different nutritional requirements from normal adults due to their special physiological characteristics⁽¹⁶⁾. In addition, continuous variable DBI_TS may have a U-shaped relationship with the risk of chronic disease, which needs to be further explored in future studies. However, healthy food habits are always protective factors for chronic diseases. Eating reasonably is the basis of human health, and nutrient deficiency or excess may occur with long-term insufficient or excessive nutrient consumption^(41–44). Moreover, dietary nutrition has a long-term impact on health, and unreasonable dietary structure and pattern are facilitating factors for the occurrence of chronic diseases^(45–47).

Considering other aspects of diet habits, the high frequency of tea drinking increases the risks of chronic diseases. A prospective cohort study conducted in Zhejiang Province showed that moderate tea consumption could reduce the risk of stroke⁽⁴⁸⁾. However, an epidemiological investigation on the incidence of diabetes in Changsha City suggested that patients with gout or hyperuricaemia should not drink tea⁽⁴⁹⁾. Although the caffeine content of different teas varies depending on the production place, type and processing technic, Chinese consumers preferred more traditional tea varieties containing caffeine, such as green tea, black tea and oolong tea⁽⁵⁰⁾. Long-term excessive drinking of tea results in the over accumulation of caffeine in the body. This impairs the nervous and digestive system functions, increases the burden on the kidneys, and results in nervousness, fatigue and discomfort, headache and other symptoms in people⁽⁵¹⁾.

With physical activity, excessive exercise also increases the risk of chronic diseases, as it can lead to cardiovascular events, musculoskeletal injuries, upper respiratory infections, gastrointestinal symptoms or sudden death due to multi-organ system failure^(52,53). However, there were negative additive and multiplicative interactions between PAI greater than 17.1 and tea drinking on the occurrence of chronic diseases. May be associated with the increase of physical activity intensity, there will be internal organs, muscles and nervous fatigue, the tea polyphenols can

promote metabolism, accelerate liver detoxification and the caffeine, tea polysaccharide, amino acid and other nutrients can strengthen physique and eliminate fatigue^(54,55). Thus excessive physical activity combined with tea drinking reduced the risk of chronic diseases. It is likely that there is a U-shaped relationship between physical activity and chronic disease risk, which needs to be further analysed in future studies.

In addition, higher reimbursement level of medical insurance reduces the risk of chronic diseases, which is supported by a natural experiment, which showed that switching from Urban Residents Basic Medical Insurance to Urban Employees Basic Medical Insurance significantly improved health⁽⁵⁶⁾. In fact, in the current social basic medical insurance system in China, the urban employee compensation rate and maximum compensation amount are higher than those for urban and rural residents. Therefore, it is more likely for people with Urban Employees Basic Medical Insurance to utilise medical services due to the higher reimbursement value, which indirectly affects the residents' health⁽⁵⁷⁾. The mediating effect analysis on the impact of medical insurance on chronic disease showed that residents with higher reimbursement level of medical insurance had lower DBI_TS and PAI and less frequent drinking of tea. This is inconsistent with previous research conclusions, which believe that while medical insurance increases the accessibility of medical services, it may also lead the insured to reduce their investment in preventing disease risk before getting ill, thus leading to 'ex-ante moral hazard'⁽⁵⁸⁾. In this study, residents who participated in high-reimbursement health insurance were likely to be more risk averse and therefore focused more on eating a balanced diet and exercising reasonably, as well as limiting caffeine intake in tea, thereby reducing the probability of chronic disease, which further proved the robustness of the conclusion that participation in high-reimbursement health insurance can reduce the risk of chronic disease.

There are several limitations to this study. First, it was conducted in one district of Shanghai, due to the possible sampling bias, the respondents age showed a large proportion of aging. Therefore, the application of the findings to other areas needs to be done with caution. Second, we were unable to assess for the presence of undiagnosed

Table 5 The results of the mediation effect of variables on dietary quality (n 962)

Variable	Having or not having chronic disease Model 1	DBI_TS (Dietary quality index) Model 2	Having or not having chronic disease Model 3	Physical activity index Model 4	Having or not having chronic disease Model 5	Tea drinking Model 6	Having or not having chronic disease Model 7
Medical insurance	-0.35***	0.66	-0.32***	0.26	-0.27***	-0.34***	-0.29***
DBI_TS Dietary quality index			0.02***				
Physical activity index							
Tea drinking							
Gender	-0.06	1.44	-0.10	0.90	-0.13	-0.49***	0.21***
Age	0.03***	0.03	0.03***	-0.03	0.04***	0.01**	0.04
Education	0.31***	0.72	0.31***	1.27***	0.24**	0.27***	0.03***
Marital status	0.71*	1.38	0.70*	0.89	0.69*	0.16	0.74**
Ln (monthly family income)	-0.33*	-1.25	-0.32	0.60	0.29	-0.15	0.29
Occupation	0.03	-0.03	0.03	-0.82	-0.29	-0.15	-0.32
Registered residence in Shanghai	0.28	1.18	0.21	-0.19	0.04	-0.07*	0.04
_cons	-1.13	5.11	-1.19	2.17	0.17	-0.22	0.95
R-squared	0.10	14.88	0.13	25.43***	-3.02	4.83***	-2.11
Z _{β1}		-0.047		0.07	0.16	0.09	0.13
Z _{β2}		0.028		-0.093		-0.071	
Z _{β3}		-0.097, -0.007		0.023		0.019	
Z _{β4}				-0.132, -0.058		-0.104, -0.043	

*P < 0.05, **P < 0.01, ***P < 0.001.
DBI_TS, Diet Balanced Index total score.

chronic diseases in the population, and some answers were recalled and reported by participants, which could cause recall bias and response biases. Third, the study design was limited to some extent by the availability of data, and the cross-sectional data made it impossible to demonstrate causality between lifestyle factors and chronic disease. It is also a question need to be further explored. In addition, if data on alcohol consumption and severity of chronic diseases are available, further studies can be conducted in the future.

In conclusion, the proportion of residents suffering from chronic diseases in Yangpu District was relatively high. The age, diet habit, tea drinking habit and the amount of exercise were main risk factors of chronic diseases. Health insurance improved residents' access to medical services. But contrary to the conclusions of previous studies, this study proved that there was no ex-ante moral hazard of medical insurance among the surveyed residents. To facilitate the prevention and control of chronic diseases, the community residents should be encouraged to develop balanced eating habits and healthy exercise behaviours. In addition, the government should focus on improving the nutritional environment of old people, strengthening access to health education, coordinate different types of medical insurance to promote access to health services by the residents.

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W.Y., Z.W. and J.S. involved in analysis and interpretation of data, revising the manuscript and given final approval of the version to be published. *Ethics of human subject participation*: This study was approved by the ethics committees of Tongji University (ref: LL-2016-ZRKX-017). Official permission was obtained from selected hospitals and health centres. Confidentiality was kept and informed verbal consent was obtained from each study participants after explaining the purpose of the study. Verbal informed consent was approved by the Tongji University Research and Ethics Committee. This research was carried out in accordance with the principles of the Declaration of Helsinki.

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