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Association Between Different Types of Tea Consumption and Depressive Symptoms Among Chinese Older Adults

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Abstract

Background/Objectives: Existing research indicates that tea consumption may have beneficial effects on mental health, with growing evidence suggesting a protective effect against depression. However, the association between different types of tea consumption and depression in older populations has not been fully examined. This study, based on a national sample of older adults, explored the association between different types (green tea, fermented tea, and floral tea) and frequency of tea consumption with depressive symptoms. **Methods**: This study used data from the 2018 and 2021 waves of the Chinese Longitudinal Healthy Longevity Survey, a nationwide survey on older adults in mainland China. In total, 11,973 and 7421 participants with valid responses in 2018 and 2021, of whom 5973 participated in both waves, respectively (mean age 83.4 years, 53.6% female), were included in our study. The types of tea (green tea, fermented tea [black, Oolong, white, yellow, dark, and compressed tea], and floral tea) and frequency of tea consumption were recorded. Depressive symptoms were assessed using the 10-item Center for Epidemiologic Studies Depression Scale (CES-D-10). We examined the associations between the types and frequency of tea and depressive symptoms, controlling for a range of demographic, socioeconomic, psychosocial, behavioral, and health-related variables. **Results**: Consumption of different types of tea, including green tea and floral tea, was significantly associated with lower prevalence of depressive symptoms. With a series of controlled confounders and compared with the non-tea drinker group, the adjusted odds ratios (ORs) for depressive symptoms were 0.87 (95% CI: 0.79–0.96) for green tea drinkers and 0.79 (95% CI: 0.66–0.93) for floral tea drinkers, respectively. A linear association was found between the consumption frequency of green tea (OR = 0.67) and floral tea (OR = 0.46, $p < 0.05$) and depressive symptoms. Subgroup analysis showed that floral tea had a consistent protective effect among younger-old group (65–79 years) and in females. In males, green tea consumption was significantly associated with a lower prevalence of depressive symptoms in the younger-old group. **Conclusions**: Consistent consumption of green tea or floral tea was associated with a lower likelihood of experiencing depressive symptoms, the associations seemed more evident among floral tea and green tea drinkers. Promoting the traditional lifestyle of tea consumption could be a viable option for preventing or managing depressive symptoms.

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1. Introduction

The rising prevalence of depression among the elderly has become a major mental health and public health issue in aging societies [1]. Statistical data indicate that over 350 million people worldwide suffer from depressive symptoms of varying degrees [2]. A meta-analysis showed that approximately 20% of older adults in mainland China are troubled by depressive symptoms [3]. Implementing effective depression prevention measures can improve the health and quality of life of the elderly and is crucial for reducing family and societal burdens. Interventional measures include cognitive, behavioral, and lifestyle interventions [4,5].

The correlation between tea consumption and depression is receiving increasing attention. Tea, one of the world's three major non-alcoholic beverages with a long consumption history, possesses antioxidant activity, anti-inflammatory effects, immune system regulation, neuroprotective effects, and other health benefits [6]. It contains various bioactive compounds, including tea polyphenols, theanine, caffeine, catechins, aromatic compounds and saponins [7]. These compounds may reduce the risk of depressive symptoms by decreasing oxidative stress and inflammatory processes, modulating intracellular signaling pathways, regulating the hypothalamic–pituitary–adrenal (HPA) axis, and influencing monoamine neurotransmitter levels [8,9]. Catechins, such as epigallocatechin gallate (EGCG), have anti-inflammatory and neuroprotective effects, preventing the decrease in dopamine concentration in the brain. L-theanine, an important functional component in tea, can alleviate HPA axis abnormalities, improve stress-related symptoms by regulating the BDNF signaling pathway, and reduce post-stress cortisol levels, may exerting antidepressant effects [10–14]. Caffeine in tea can improve depressive symptoms in animal models and humans, having mood-enhancing and regulating effects [15–17]. Although flavonoids only account for 3–4% of tea's dry weight, they may exert antidepressant effects by scavenging free radicals, activating antioxidant enzymes in the body, and regulating gut microbiota [18,19]. Theaflavins alleviate depressive symptoms by reducing the production of pro-inflammatory cytokines, inhibiting IκB kinase, activating the NF-κB pathway, and modulating the monoaminergic system [20,21]. Tea saponins, natural inhibitors of the NF-κB signaling pathway, may reduce the incidence of depression through effects on the gut–brain axis [22]. Tea types differ mainly in how the leaves are processed. Green tea is minimally processed and retains most of its original catechins, whereas fermented tea undergo oxidation that changes their composition, and floral tea is tea scented with flowers. These compositional differences may underlie the different associations observed across tea types.

Epidemiological evidence for the beneficial effects of tea consumption in reducing depression risk in populations is still insufficient. Cross-sectional and prospective cohort studies summarizing the association between tea consumption and depression have drawn different conclusions [23–26]. Firstly, most studies only examined the type and frequency of tea consumption either at the time of survey or recently, lacking long-term follow-up patterns. The effects of tea may be long-term, necessitating the use of detailed data to elucidate the correlation between tea drinking and depressive symptoms. Secondly, different types of tea vary in bioactive components due to differences in tea plant varieties and processing methods, which may contribute to inconsistent research findings. Some studies suggest that frequent tea drinkers have significantly lower depression levels and that tea can effectively improve sleep quality in the elderly. However, research on the dose–response effects of different types of tea is lacking. This study, based on data from

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CLHLS, investigates the association between types and frequency of tea consumption and depressive symptoms in the elderly, conducting stratified analyses by gender, age, and geographical regions to examine the heterogeneity of the associations.

2. Materials and Methods

2.1. Study Population

Data from the Chinese Longitudinal Healthy Longevity Survey (CLHLS) in the 2018/2019 (briefly as 2018) and 2021 surveys were used. CLHLS was conducted in more than 630 counties/cities in 22 provinces of 31 provinces in mainland China. The survey collected self-reported tea consumption types and frequency, and depressive symptoms were assessed using the Center for Epidemiologic Studies Depression Scale. After excluding participants with missing data on depressive symptoms, self-reported types and frequency of tea consumption, and key covariates, 11,973 and 7421 valid participants remained in the 2018 and 2021 waves of CLHLS for empirical analyses in our study (mean age 83.4 years, 53.6% female), respectively. (Figure 1).

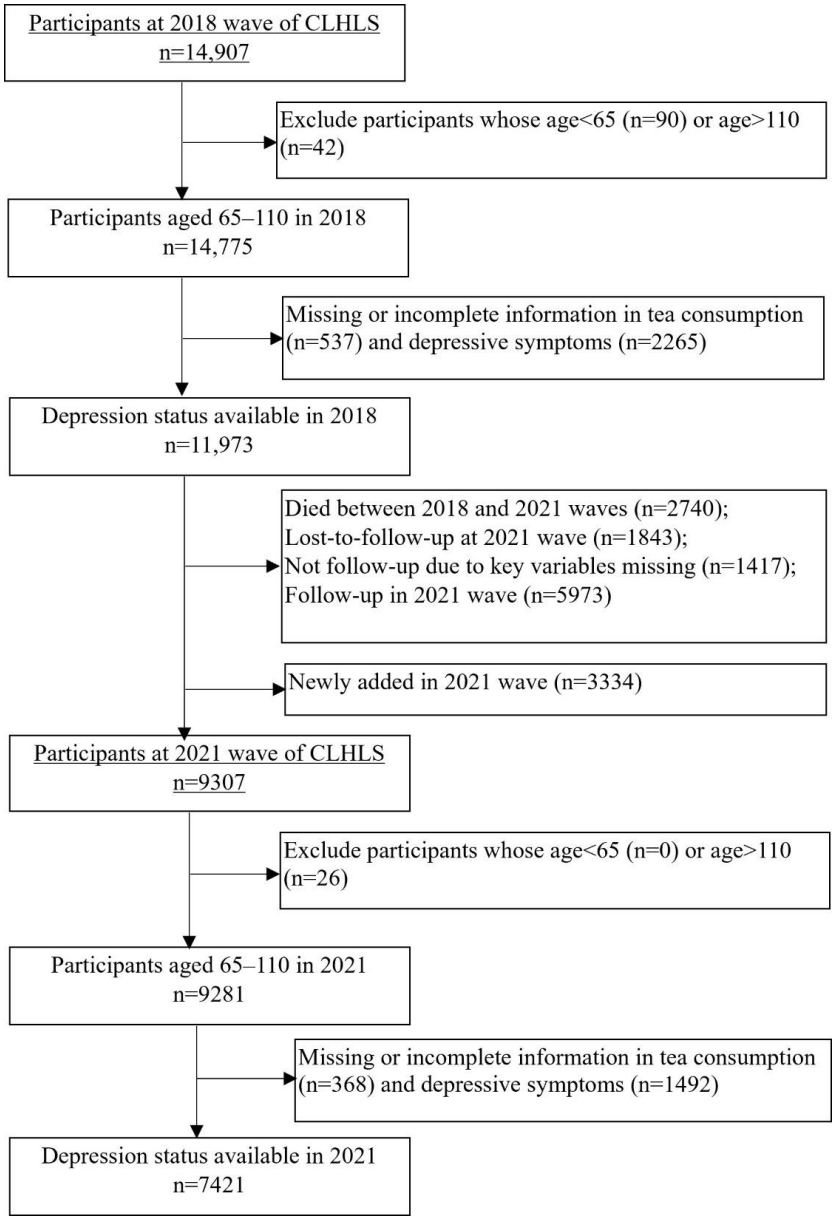


Figure 1. Derivation of the study population from participants of the 2018 and 2021 waves of CLHLS.

2.2. Measurements

The questionnaire included items on the type and frequency of tea consumption. Tea was categorized into green tea, fermented tea (black tea, oolong tea, white tea, yellow tea, dark tea, and compressed tea), and floral tea. The consumption frequency for each type of tea was classified into three dummy variable categories: daily (≥1 cup/day), occasionally (<1 cup/day but ≥1 cup/month), and never or rarely (<1 cup/month or never drinks tea). Participants were assigned to the type with the highest consumption frequency, making groups mutually exclusive.

In this study, we used the 10-item Center for Epidemiologic Studies Depression Scale (CES-D-10) to measure depressive symptoms [27]. Each item is coded from 0 to 4, from "rarely" to "seldom", "sometimes", "often" or "always". For the two positive questions—"I felt happy" and "I felt hopeful about the future"—responses were reversely coded before summing. We then coded all answers from 0 to 4 for "rarely" to "always", respectively. The CES-D-10 score is the sum of the scores of 10 items, ranging from 0 to 40, with higher scores indicating more severe depressive symptoms. Questions related to the depressive symptoms were answered by the participants themselves. A person was considered to have depressive symptoms if their CES-D-10 score was 12 or higher. This threshold of 12 has been applied based on a previous study; it was more specific (cut-off value = 12) to discriminate depressive symptoms, and well-validated for measuring depression in Chinese older adult populations, regardless of age and dementia status [28,29]. The Cronbach's alpha for internal consistency of the CES-D-10 is 0.933, indicating excellent internal consistency.

2.3. Covariates

To obtain more robust results, we controlled for a series of potential confounding factors, such as demographic characteristics, geographical region, socioeconomic status, psychosocial and behavioral variables, and health status. Demographic characteristics included age, sex, rural residence, marriage status, number of adult children alive, living arrangement. Socioeconomic status included education level, main occupation, family economic condition, and self-sufficient source of daily living. Psychosocial and behavioral variables included housework, outdoor activity, and regular dietary intake (vegetables/fruit/fish/nuts). Health status was measured by self-rated health, cognitive impairment, chronic diseases, disability in activities of daily living (ADL) and body mass index (BMI). All data were collected by the research team through face-to-face household interviews. Questions related to the Mini-Mental State Examination were answered by the participants themselves; If a participant was unable to answer other questions, the next-of-kin, the primary caregiver or other informants would provide the answer as a proxy respondent (usually a spouse or other close relative).

Age was calculated according to self-reported date of birth with validations from various sources such as household registration record (hukou), personal identification card, genealogical records, ages of family members, and so forth. Dates were converted into Georgian calendar dates if they were based on Chinese lunar calendar dates. We considered geographical region on the basis of residential address to account for types of tea production areas as well as differences in regional economic developments and social cultures in China [30]. This is divided into the following categories: Northern China (Beijing, Tianjin, Hebei, Shanxi, Shaanxi, Shandong, Liaoning, Jilin, Heilongjiang, Gansu, and Ningxia provinces), Eastern China (Shanghai, Jiangsu, Zhejiang, and Fujian provinces), Central China (Henan, Hubei, Jiangxi, Anhui, and Hunan provinces) and Southwestern China (Guangdong, Guangxi, Chongqing, Sichuan, Hainan, Guizhou, and Yunnan provinces). Levels of educational attainment were grouped into three categories according to years of schooling (0, 1–6, and ≥7 years). Current residence was dichotomized as "urban

residence" or "rural residence". Marital status was divided into "currently married and living with spouse" or others (widowed, separated, divorced, or never married). Living arrangement was grouped into 3 categories: living with family members, living alone, and living in an institution. Family economic condition was classified into 3 dummy variables: rich, so so (as reference), poor. Dietary intake, including vegetables, fruit, fish, and nuts, was dichotomized as "almost every day intake" or "not every day intake". Cognitive function was tested by using the 30-point Mini-Mental State Examination (MMSE), and cognitive impairment was defined as an MMSE total score < 24 [31–33]. The index of activity of daily living (ADL) was assessed by the Katz index. We defined ADL disability as needing personal assistance in performing one or more of the six essential activities (bathing, transferring, dressing, eating, and toileting, or being incontinent). Fourteen self-reported chronic diseases were identified, including hypertension, diabetes, dyslipidemia, heart disease, stroke, Chronic Airway Inflammatory Diseases (asthma/COPD), cataracts or glaucoma, cancer, gastritis, arthritis, cholecystitis, rheumatism, nephritis, and hepatitis. Participants were categorized into two groups: "Suffering from at least one of the 14 self-reported chronic diseases" and "not suffering from any of the 14 chronic diseases". Self-rated health was defined as "bad/ very bad" or "so so/good/very good". BMI was calculated as weight in kilograms divided by height in meters squared.

2.4. Statistical Analysis

Participant characteristics were compared according to categories of type of tea consumption using ANOVA or chi-square tests. We used multivariable logistic regression analysis to calculate odds ratios (OR) of depressive symptoms for consumers of different types of tea (green tea, fermented tea, floral tea). Non-habitual tea drinkers act as the reference group. The base model (Model 1) included only types of tea consumption plus dummy of wave; Model 2 further controlled for demographic variables (age, sex, urban-rural residence, marriage status, number of adult children alive, living arrangement) and geographical regions; Model 3 additionally controlled for socioeconomic variables (education, occupation before age 60, family economic condition, primary source of daily living) and psychosocial and behavioral variables (housework, outdoor activities, regular dietary (fruit/fish/nut) intake); Model 4 added health variables in Model 3 including ADL disability, cognitive impairment, chronic illness, self-reported health status, and BMI. In the detailed analysis of the relationship between green, fermented, or floral tea frequency of consumption and depressive symptoms, the consumption frequency for each type of tea was classified into three categories: daily, occasionally, and never or rarely. Multiple logistic regressions analysis was repeated while controlling for all covariates as described above. We conducted subgroup analyses to examine whether the associations between types and frequencies of tea intake and depressive symptoms differed by sex, age (<80 years old vs. ≥80 years old), residence (urban residence vs. rural residence), and geographical regions (Northern China, Eastern China, Central China, and Southwestern China). Panel models were employed to examine the associations between tea consumption and continuous depressive symptom scores, with the CES-D-10 total score as the dependent variable. The CES-D-10 total score was the dependent variable; tea type (green, fermented, floral) and, separately, tea consumption frequency (daily, occasional, never or rarely) were the primary independent variables, adjusted for the same covariate sets as the logistic analyses. All analyses were performed using STATA version 18.0 (Stata Corp, College Station, TX, USA).

3. Results

3.1. General Characteristics

We summarized the characteristics of Chinese older adult respondents, categorized by types of tea (Table 1). The mean age of study participants was 83.4 years. Among the 19,394 older adult participants, 68.6% were non-tea drinkers, 18.0% consumed green tea, 8.1% consumed fermented tea, and 5.3% consumed floral tea. The mean CES-D-10 score was 11.9 (standard deviation: 6.1); 50.6% of study participants had a CES-D-10 score ≥ 12, indicating depression. The distribution of CES-D-10 scores in 2018 and 2021 is shown in Figure 2. Compared to non-tea drinkers, tea drinkers had significantly lower depressive symptom scores ($p < 0.001$) and a lower proportion with scores ≥ 12 ($p < 0.001$). Compared to non-tea drinkers, tea drinkers were generally younger, more often male, more likely to be married, less likely to live alone, urban residents rather than rural dwellers, more active in social and leisure activities, had more years of education, and had a better socioeconomic status. They were also more likely to report regular intake of fruits and nuts. Their self-rated health status and cognitive function were better. Green tea and fermented tea consumption were relatively more concentrated in the Central region, while floral tea consumption in the northern region was significantly higher than in several other regions.

Table 1. Main characteristics of the whole study population and its subgroups by type of tea consumption, CLHLS 2018 and 2021 waves combined. [1]

Variable/Subgroups	Total Sample	No Tea	Green Tea	Fermented Tea	Floral Tea	*p*-Value [2]
Total sample, n	19,394	13,297	3491	1577	1029	
%	100	68.6	18.0	8.1	5.3	
CES-D-10						
Total score (0–40)	11.9 ± 6.1	12.3 ± 6.1	10.9 ± 5.9	11.1 ± 6.0	10.5 ± 5.9	<0.001
Score ≥ 12, %	9818 (50.6)	7150 (53.8)	1546 (44.3)	718 (45.5)	404 (39.3)	<0.001
Age, years	83.4 ± 10.7	84.2 ± 10.8	81.4 ± 10.3	81.9 ± 10.5	82.4 ± 10.7	<0.001
Age group, %						
65–79	7722 (39.8)	4919 (37.0)	1615 (46.3)	728 (46.2)	460 (44.7)	<0.001
80–89	5777 (29.8)	4024 (30.3)	1023 (29.3)	443 (28.1)	287 (27.9)	0.0327
90–99	3770 (19.4)	2711 (20.4)	607 (17.4)	271 (17.2)	181 (17.6)	<0.001
≥100	2125 (11.0)	1643 (12.4)	246 (7.0)	135 (8.6)	101 (9.8)	<0.001
Men, %	8990 (46.4)	5120 (38.5)	2355 (67.5)	898 (56.9)	617 (60.0)	<0.001
Urban residence, %	11,560 (59.6)	7638 (57.4)	2239 (64.1)	983 (62.3)	700 (68.0)	<0.001
Geographical region, %						
Northern China	4680 (24.1)	2855 (21.5)	843 (24.1)	427 (27.1)	555 (53.9)	<0.001
Eastern China	3317 (17.1)	2333 (17.5)	633 (18.1)	290 (18.4)	61 (5.9)	0.0158
Central China	4052 (20.9)	3036 (22.8)	713 (20.4)	237 (15.0)	66 (6.4)	<0.001
Southern China	7345 (37.9)	5073 (38.2)	1302 (37.3)	623 (39.5)	347 (33.7)	0.237
Married and living with a spouse, %	8962 (46.2)	5590 (42.0)	1974 (56.5)	853 (54.1)	545 (53.0)	<0.001
Number of Adult children alive	3.35 ± 1.77	3.45 ± 1.77	3.07 ± 1.76	3.35 ± 1.74	2.98 ± 1.72	<0.001
Living arrangement, %						
With household members	15,423 (80.3)	10,406 (79.0)	2903 (83.9)	1244 (79.6)	870 (85.3)	<0.001
Alone	3367 (17.5)	2456 (18.6)	516 (14.9)	269 (17.2)	126 (12.4)	<0.001
Institution	426 (2.2)	311 (2.4)	42 (1.2)	49 (3.1)	24 (2.4)	0.0453
Education level, %						
0 years	9272 (47.8)	7134 (53.7)	1206 (34.5)	593 (37.6)	339 (32.9)	<0.001
1–6 years	6589 (34.0)	4265 (32.1)	1368 (39.2)	560 (35.5)	396 (38.5)	<0.001
≥7 years	3533 (18.2)	1898 (14.3)	917 (26.3)	424 (26.9)	294 (28.6)	<0.001

Good job position before age 60, %	1739 (9.0)	904 (6.8)	469 (13.4)	210 (13.3)	156 (15.2)	<0.001
Family economic condition in the local, %						
Rich	3604 (18.6)	2252 (17.0)	784 (22.5)	330 (21.0)	238 (23.2)	<0.001
So so	13,781 (71.1)	9516 (71.6)	2435 (69.8)	1115 (70.8)	715 (69.6)	0.0214
Poor	1990 (10.3)	1516 (11.4)	271 (7.8)	129 (8.2)	74 (7.2)	<0.001
Self-sufficient source of daily living, %	8401 (43.3)	5185 (39.0)	1832 (52.5)	815 (51.7)	569 (55.3)	<0.001
Doing housework at least once per week, %	10,603 (54.8)	7155 (53.9)	2020 (58.0)	897 (57.0)	531 (51.9)	0.0003
At least one outdoor activity per week, %	10,931 (56.5)	7223 (54.4)	2136 (61.3)	973 (61.8)	599 (58.4)	<0.001
Regular fruit consumption, %	4534 (23.4)	2811 (21.2)	913 (26.2)	468 (29.7)	342 (33.2)	<0.001
Regular fish intake, %	1590 (8.2)	942 (7.1)	331 (9.5)	251 (15.9)	66 (6.4)	<0.001
Regular nut intake, %	1255 (6.5)	653 (4.9)	311 (8.9)	136 (8.6)	155 (15.1)	<0.001
ADL functional disability, %	3797 (19.6)	2844 (21.4)	499 (14.3)	240 (15.2)	214 (20.8)	<0.001
Cognitive impaired, %	2732 (14.1)	2105 (15.9)	339 (9.7)	170 (10.8)	118 (11.5)	<0.001
Bad self-rated health, %	2615 (13.5)	1962 (14.8)	391 (11.2)	169 (10.7)	93 (9.0)	<0.001
Suffering from at least one chronic disease, %	13,419 (70.5)	9089 (69.9)	2459 (71.2)	1096 (70.3)	775 (77.0)	0.0041
BMI (kg/m^2)	22.4 ± 4.0	22.3 ± 4.0	22.7 ± 3.9	22.7 ± 4.0	23.5 ± 4.0	<0.001

[1] The percentages in the parentheses are unweighted and refer to those within each type of tea. CES-D-10: 10-item of Center for Epidemiological Studies Depression Scale, BMI: body mass index, ADL: activity of daily living. [2] Based on chi-square test (n, %) or ANOVA (mean ± SD).

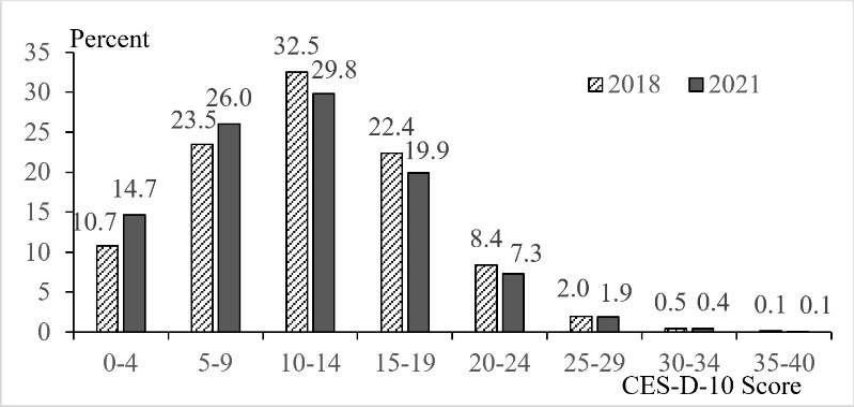


Figure 2. Distribution of CES-D-10 scores in 2018 and 2021.

3.2. Associations of Types and Frequencies of Tea Consumption with Depressive Symptoms

Results of regression analysis of tea consumption and depressive symptoms were shown in Table 2A. Compared with non-tea drinkers, green tea, fermented tea, and floral tea drinkers had lower odds of depressive symptoms: green tea OR = 0.62 (95% CI: 0.57–0.69); fermented tea OR = 0.69 (95% CI: 0.61–0.79); floral tea OR = 0.50 (95% CI: 0.43–0.59). This suggests a negative association between tea drinking and depressive symptoms in Chinese older adults. After adjusting for demographic and geographical region characteristics in Model 2, the inverse association between tea consumption and depressive symptom scores remained significant. After further controlling for socioeconomic, psychosocial and behavioral variables in Model 3, the associations between green tea and floral tea with depressive symptoms remained, though attenuated in strength. Introducing health variables in Model 4 further attenuated the associations. However, compared with non-tea

drinkers, tea consumption was associated with a 13% (green tea) and 21% (floral tea) reduction in the odds of depressive symptoms, suggesting tea drinking remains a significant protective factor against depressive symptoms. In contrast, the association for fermented tea was not statistically significant in the fully adjusted model (OR 0.94, 95% CI 0.82–1.08) or for daily consumption (OR 0.73, 95% CI 0.47–1.12). Analysis of depression severity showed that after controlling for all confounders, compared with non-tea drinkers, green tea (coefficient = −0.36, $p < 0.01$) and floral tea (coefficient = −0.36, $p < 0.10$) were associated with lower depressive symptom scores (Table 2B).

Table 2. (**A**) Odds ratios of depressive symptoms by type of tea consumption among the whole sample and subpopulations; (**B**) coefficients of depressive symptoms by type of tea consumption among the whole sample and subpopulations.

(**A**) Dependent variable: Depressive symptoms (1 = score no less than 12, 0 = score less than 12)			
	Types of Tea Consumption		
	Green Tea vs. No Tea	**Fermented Tea vs. No Tea**	**Flower Tea vs. No Tea**
Whole sample [a]			
Model 1	0.62 (0.57, 0.69) ***	0.69 (0.61, 0.79) ***	0.50 (0.43, 0.59) ***
Model 2	0.76 (0.69, 0.84) ***	0.81 (0.71, 0.92) ***	0.67 (0.57, 0.79) ***
Model 3	0.86 (0.78, 0.95) ***	0.90 (0.79, 1.02)	0.77 (0.66, 0.91) ***
Model 4	0.87 (0.79, 0.96) ***	0.94 (0.82, 1.08)	0.79 (0.66, 0.93) ***
Subpopulations based on model 4			
By Sex			
Men	0.79 (0.70, 0.90) ***	0.85 (0.70, 1.02) *	0.83 (0.66, 1.03) *
Women	1.05 (0.89, 1.23)	1.06 (0.87, 1.29)	0.74 (0.57, 0.96) **
By Age group			
Age < 80 years	0.82 (0.71, 0.95) ***	0.91 (0.75, 1.10)	0.75 (0.58, 0.96) **
Age ≥ 80 years	0.93 (0.81, 1.06)	0.97 (0.80, 1.16)	0.83 (0.66, 1.04) *
By urban-rural residence			
Urban residency	0.81 (0.71, 0.92) ***	1.00 (0.84, 1.19)	0.77 (0.63, 0.95) **
Rural residency	1.00 (0.85, 1.18)	0.86 (0.69, 1.07)	0.79 (0.59, 1.07)
By geographic region			
Northern China	1.02 (0.83, 1.26)	1.06 (0.81, 1.37)	0.82 (0.64, 1.04)
Eastern China	1.05 (0.84, 1.32)	1.41 (1.04, 1.92) **	0.57 (0.30, 1.08) *
Central China	0.86 (0.69, 1.07)	1.06 (0.76, 1.48)	0.49 (0.26, 0.91) **
Southern China	0.75 (0.64, 0.89) ***	0.71 (0.57, 0.89) ***	0.88 (0.66, 1.16)
(**B**) Dependent variable: Depressive index (0~40, higher index means worse depression)			
	Types of Tea Consumption		
	Green Tea vs. No Tea	**Fermented Tea vs. No Tea**	**Flower Tea vs. No Tea**
Whole sample [a]			
Model 1	−1.36 (−1.58, −1.13) ***	−1.05 (−1.37, −0.74) ***	−1.68 (−2.06, −1.29) ***
Model 2	−0.82 (−1.05, −0.59) ***	−0.63 (−0.95, −0.32) ***	−0.95 (−1.34, −0.57) ***
Model 3	−0.43 (−0.66, −0.21) ***	−0.29 (−0.59, 0.01) *	−0.56 (−0.93, −0.18) ***
Model 4	−0.36 (−0.58, −0.14) ***	−0.15 (−0.45, 0.15)	−0.36 (−0.72, 0.01) *
Subpopulations based on model 4			
By Sex			
Men	−0.58 (−0.85, −0.31) ***	−0.38 (−0.77, 0.01) *	−0.25 (−0.72, 0.21)
Women	0.07 (−0.30, 0.43)	0.12 (−0.33, 0.58)	−0.52 (−1.11, 0.07) *
By Age group			

Age < 80 years	−0.46 (−0.79, −0.14) ***	−0.35 (−0.77, 0.08)	−0.28 (−0.82, 0.26)
Age ≥ 80 years	−0.23 (−0.52, 0.07)	0.04 (−0.37, 0.45)	−0.40 (−0.90, 0.10)
By urban-rural residence			
Urban residency	−0.51 (−0.78, −0.23) ***	0.06 (−0.32, 0.44)	−0.42 (−0.87, 0.03) *
Rural residency	−0.06 (−0.42, 0.30)	−0.46 (−0.95, 0.02) *	−0.28 (−0.92, 0.36)
By geographic region			
Northern China	−0.08 (−0.55, 0.39)	−0.11 (−0.70, 0.48)	−0.39 (−0.94, 0.16)
Eastern China	0.08 (−0.43, 0.60)	1.28 (0.59, 1.98) ***	−0.40 (−1.76, 0.96)
Central China	−0.38 (−0.85, 0.09)	0.24 (−0.48, 0.96)	−1.27 (−2.61, 0.07) *
Southern China	−0.68 (−1.04, −0.33) ***	−0.95 (−1.43, −0.46) ***	−0.10 (−0.71, 0.51)

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$. [a] Model 1 included types of tea consumption as the sole variable; Model 2 controlled for demographic variables (age, sex, urban-rural residence, marriage status, number of adult children alive, living arrangement) and geographical regions; Model 3 additionally controlling for socioeconomic variables (education, occupation before age 60, family economic condition, primary source of daily living) and psychosocial and behavioral variables (housework, outdoor activities, regular dietary (fruit/fish/nut) intake); Model 4 additionally for health variables: ADL disability, cognitive impairment, chronic illness, self-reported health status, and BMI.

With controlling for major potential confounders, the consumption frequency of both green tea and floral tea showed linear associations with depressive symptoms (Table 3A). Daily consumption of one or more cups of green tea or floral tea was significantly associated with a 33% (green tea) and 54% (floral tea) reduction in the odds of depressive symptoms ($p < 0.05$). As shown in Table 3B, after adjusting for all confounders, daily consumption of one or more cups of green tea (coefficient = −1.03, $p < 0.05$) or floral tea (coefficient = −2.24, $p < 0.01$) was significantly negatively associated with depressive symptom scores, and even occasional floral tea consumption was associated with lower depressive symptom scores (coefficient = −1.62, $p < 0.05$). Although daily consumption of fermented tea did not reach statistical significance in reducing the odds of depressive symptoms (OR = 0.94, using score12 as the cut-off), it was associated with a reduction in depressive symptom scores to some extent (coefficient = −0.83, $p < 0.05$).

Table 3. (**A**) Odds ratios of depressive symptoms by types and frequencies of habitual tea consumption; (**B**) coefficients of depressive symptoms by types and frequencies of habitual tea consumption.

(**A**) Dependent variable: Depressive symptoms (1 = score no less than 12, 0 = score less than 12)

	Frequencies of Habitual Tea Consumption		
	Never or Rarely	**Occasionally**	**Daily**
Types of tea consumption			
Green tea drinkers	1.00	0.98 (0.65, 1.49)	0.67 (0.45, 0.99) **
Fermented tea drinkers	1.00	0.92 (0.57, 1.48)	0.73 (0.47, 1.12)
Flower tea drinkers	1.00	0.69 (0.36, 1.32)	0.46 (0.24, 0.89) **

(**B**) Dependent variable: Depressive index (0~40, higher index means worse depression)

	Frequencies of Habitual Tea Consumption		
	Never or Rarely	**Occasionally**	**Daily**
Types of tea consumption			
Green tea drinkers	0 (Reference)	−0.14 (−1.01, 0.73)	−1.03 (−1.86, −0.21) **
Fermented tea drinkers	0 (Reference)	−0.29 (−1.11, 0.53)	−0.83 (−1.57, −0.09) **
Flower tea drinkers	0 (Reference)	−1.62 (−3.05, −0.19) **	−2.24 (−3.59, −0.89) ***

*** $p < 0.01$, ** $p < 0.05$. The results were based on the full model (Model 4) in the above Table 2. Never or rarely means < 1 cup/month or never drinking tea.

Analysis of subpopulations based on Model 4 explored whether the benefits of tea consumption differed by sex, age, and geographical regions. Stratified analyses showed some heterogeneity in the associations across sex, age group, and geographical regions: green tea in males OR = 0.79 (0.70, 0.90) vs. females OR = 1.05 (0.89, 1.23); fermented tea in males OR = 0.85 (0.70, 1.02) vs. females OR = 1.06 (0.87, 1.29); floral tea in males OR = 0.83 (0.66, 1.03) vs. females OR = 0.74 (0.57, 0.96). Compared with non-tea drinkers, risk of depressive symptoms was significantly lower in males consuming any type of tea, most notably for green tea, while this trend in females was only found in the floral tea group. For green tea drinkers, the OR of depressive symptoms in the younger-old group (65–79 years) was 0.82, yet the OR in the oldest-old group (≥80 years) was 0.93, suggesting the association between green tea consumption and depressive symptoms was more pronounced in the younger-old group than in the oldest-old group. Floral tea consumption was negatively associated with depressive symptoms in the younger-old group OR = 0.75 (0.58, 0.96), $p < 0.05$. We observed residence and geographical variation in tea consumers: green tea in urban residents OR = 0.81 (0.71, 0.92) vs. rural residents OR = 1.0 (0.85, 1.18); floral tea in urban residents OR = 0.77 (0.63, 0.95)vs. rural residents OR = 0.79 (0.59, 1.07). Green tea in the Southwest region OR = 0.75 (0.64, 0.89) vs. other regions (OR from 0.86 to 1.05); fermented tea in the Southwest region OR = 0.71 (0.57, 0.89) vs. other regions (OR from 1.06 to 1.41); floral tea in the Central region OR = 0.49 (0.26, 0.91) and Eastern region OR = 0.57 (0.30, 1.08) vs. Northern region OR = 0.82 (0.64, 1.04) and Southern region OR = 0.88 (0.66, 1.16).

4. Discussion

Based on data from a large national sample, this study examined the relationship between tea consumption and depressive symptoms among Chinese older adults by analyzing types and frequency of tea. Chinese older adults who regularly consumed different types of tea (green tea and floral tea) had a lower probability of depressive symptoms as measured by the CES-D-10. Daily consumption of one or more cups of green or floral tea was associated with a 33–54% reduction in the odds of depressive symptoms. Our findings corroborate previous epidemiological studies reporting a negative association between tea consumption and depression in the elderly [24,25,34,35].

There are several noteworthy aspects of the association observed in this study that are not present in previous studies. Our study investigated different types of tea consumption. Different types of tea vary in cultivar and contents of bioactive compounds, which may account for the inconsistent conclusions observed. To better understand the association between tea consumption and depression, it is more important to study the specific antidepressant effects of different tea varieties. Although studies support a negative correlation between tea consumption and depression, most prior studies did not specify the type of tea or only investigated one or two types of tea. Cross-sectional studies and prospective cohort studies in China confirmed a negative association between depression and green tea intake. Studies in Japan [25], South Korea [36] and Singapore [37] showed similar results. Green tea contains higher levels of catechins compared with fermented tea like oolong tea and black tea. This study and our previous research [38] revealed a significant negative association between green tea and floral tea consumption and depressive symptoms in Chinese older adults. Tea exerts antidepressant effects on drinkers through synergistic mechanisms, affecting multiple physiological pathways. Tea consumption has been proposed to help regulate the immune system, inhibit the expression of pro-inflammatory factors, scavenge free radicals, and increase the abundance of gut microbiota, demonstrating antidepressant effects. The more pronounced antidepressant effect of green tea may be partially attributed to components like catechins or (−)-epigallocatechin

gallate. Green tea has higher levels of (−)-epigallocatechin gallate, exhibiting superior antioxidant activity compared with fermented tea [39]. In contrast, catechin content decreases to 3–30% during red tea production, possibly explaining differing study results. Research suggests that active ingredients in floral tea, such as Okanin and aroma components, may exert neuroprotective effects by inhibiting the TLR4/NF-κB signaling pathway [40,41]. A clinical trial indicated that consuming chamomile tea can alleviate depressive symptoms in postpartum women [42] and cancer patients [43]. These findings provide a possible biological rationale for the inverse association between floral tea consumption and depressive symptoms observed among older women in our study, although this association did not reach statistical significance ($p > 0.05$) in our study. Further studies are needed to clarify this potential relationship. As an important caffeine-free alternative to traditional tea, the habit of floral tea drinking warrants more research. Some types of floral tea, made by scenting green tea base with fresh flowers, exhibit a synergistic antidepressant effect. Variation in the bioactive components of different types of tea may contribute to the inconsistent findings regarding the association between tea consumption and depression. Further research is warranted to investigate the negative relationship between specific types of tea and depression.

Our study found that after controlling for all confounders, daily consumption of fermented tea was associated with a reduction in depression severity scores to some extent. Yet it did not reach statistical significance in reducing the odds of depressive symptoms in the elderly. Preparation methods for different types of tea vary considerably; the processing of fermented tea typically reduces the content of active ingredients such as catechins and theanine. Especially in fully fermented tea, catechin oxidation levels are much higher than in semi-fermented tea. Commonly, red tea is fully fermented, with higher oxidation levels than green, oolong, white, or yellow tea. Oolong tea is traditional semi-fermented tea; its oxidation level can range from 8% to 85% depending on the cultivar and manufacturing method, specifically the timing before fixation. Generally, oolong tea contains more caffeine than green tea [44]. The processing of dark tea and pu-erh tea affects the content of chemicals like caffeine, gallic acid, theanine, and catechins [45,46]. These characteristics are potential mechanisms for the lack of a strong association between fermented tea consumption and reduced risk of depressive symptoms in the elderly.

However, some studies suggest that green tea does not exert antidepressant effects [23,47]. Inconsistencies in previous findings on the association between tea consumption and depressive symptoms may be partly attributable to differences in tea consumption amounts. We not only studied respondents' habitual types of tea, but also categorized tea drinkers based on frequency, to explore the relationship between tea consumption frequency and depressive symptoms. Our study showed that compared with non-tea drinkers, daily consumption of at least one cup or more of green tea or floral tea was significantly associated with lower odds of depressive symptoms. Catechins, with their antioxidant, anti-inflammatory, and neuroprotective effects, are well documented to alleviate stress and improve mood. However, only with sufficient frequency and quantity of tea consumption can the effective components reach sufficient concentrations in the blood to exert meaningful effects. Niu et al. observed that participants consuming ≥ 4 cups of green tea daily had a significantly lower odds ratio for depressive symptoms compared to those consuming ≤ 1 cup daily [29]. Hozawa et al. found significantly lower psychological distress in individuals consuming ≥ 5 cups/day compared to < 1 cup/day, but not for 3–4 cups/day or 1–2 cups/day [48]. The Singapore Longitudinal Aging Study found that older adults consuming three or more cups of green tea or oolong tea daily had a significantly reduced risk of depressive symptoms [26]. However, excessive caffeine intake has been

noted to have some adverse effects, such as headache, increased blood pressure, palpitations, and anxiety [49]. More data are needed to determine the appropriate dosage of tea for preventing depressive symptoms.

Through modeling social participation factors, we found that the negative association between tea drinking and depressive symptoms was partially attenuated by socioeconomic, psychosocial, lifestyle behavioral, health-related factors, and social activity participation. However, Asian studies have geographical limitations, and cultural factors might affect the accuracy of survey data. Studies from the US [50] and Finland [51] found no association between tea consumption and depression. This reveals that tea drinking may not only have biological properties that prevent depression but might also ameliorate depressive symptoms by enhancing social interaction. Tea drinking is often accompanied by social interaction, where verbal communication and behavioral expressions trigger corresponding psychological responses. Previous studies have suggested that social participation helps prevent depression among older adults [52,53]. As tea drinking is a cultural tradition with social functions in China, the confounding effect of social context is particularly pronounced. These findings suggest that socioeconomic, psychosocial, lifestyle and health-related factors partly explain the observed association, consistent with the social functions of tea drinking in China. Nevertheless, the association between green and floral tea consumption and depressive symptoms remained statistically significant after adjustment, indicating that these beverage-specific associations are not wholly attributable to the social and behavioral context in which tea is consumed. Further research is needed to elucidate the influence of behavioral and socio-cultural factors associated with tea drinking.

This study further examined the heterogeneity of the association between tea drinking and depressive symptoms across sex, age groups, and regions. The association between tea drinking and depression exhibits high heterogeneity across studies and populations worldwide, including different regions in China, as demonstrated by our data. We found that the risk of depressive symptoms was significantly lower in males consuming any type of tea, most notably for green tea, while in females this trend was only found in the floral tea group. The positive associations between green tea intake and depressive symptoms were more pronounced in the younger-old group (65–79 years) than in the oldest-old group (≥80 years). Similarly, the protective effect of green tea and floral tea was better among urban residents than rural residents. Similar to previous findings [34,54], possible reasons are that younger-old adults and urban residents typically have relatively better health status and more social participation than oldest-old adults and rural residents. The varying results regarding the correlation between different types of tea and depressive symptoms in different regions may be partly attributable to local preferences for types of tea and differences in brewing and preparation methods.

Notably, the antidepressant effect of tea manifests over the long term. Studies have shown that long-term tea consumption helps reduce the risk of depression in middle-aged and older adult men by lowering inflammation and improving sleep quality [37,55,56]. Our study draws on data from a large, national sample of Chinese older adults. Data from two time points allowed for the use of mixed-effects models to examine the longitudinal association between different types of tea consumption and depressive symptoms. Regarding the beneficial impact of tea on mental health, it is likely that long-term data based on two time points may offer advantages in analyzing the effects of tea on mental health.

This study has several limitations that need attention. First, our study's two-wave pooled cross-sectional design prevents us from determining causality between the consumption of each type of tea and depressive symptoms. Due to the lack of high-level clinical research, definitive conclusions about tea's preventive and therapeutic effects on de-

pression cannot be drawn. Furthermore, the temporal direction of these associations cannot be established, and the possibility of reverse causality cannot be ruled out. Placebo-controlled trials are necessary to validate the antidepressant effects of compounds in tea, and future longitudinal studies are needed to clarify the temporal and potentially causal relationships between tea consumption and depressive symptoms. Second, we only had data on frequency of tea consumption, lacking more precise data on the amount and duration of tea consumption. The role of caffeine in tea means excessive consumption could potentially cause adverse effects like sleep disturbances, affecting the accurate assessment of mental health benefits of tea consumption. Moreover, the survey data relied mainly on self-reporting, which may introduce recall and reporting bias into the study results. Third, bioactive components may vary within the same type of tea due to differences in tea plant cultivars used, leaf freshness, growing region, and processing techniques, limiting the generalizability of the results. Furthermore, the biological mechanisms potentially underlying the observed associations were not directly investigated in this study and warrant further research. Fourth, in the fully adjusted model, we additionally adjusted for self-rated health, activities of daily living (ADL) disability, and cognitive impairment. Because these health-related variables may themselves be consequences of depressive symptoms or lie on the causal pathway between tea consumption and depression, adjusting for them may constitute overadjustment and could have attenuated the observed associations. The estimates from the fully adjusted model should therefore be interpreted with caution, as they may underestimate the true strength of the relationship. Nevertheless, the direction of the associations remained consistent across all models, and the analyses treating the CES-D-10 score as a continuous outcome yielded concordant results, suggesting that our overall conclusions are robust to this potential overadjustment. Fifth, this study focused on the associations between tea consumption and depressive symptoms without examining potential interactions between tea consumption and other dietary factors. Given the complex relationships between lifestyle behaviors and depressive symptoms among older adults, residual confounding arising from unmeasured or imperfectly measured factors may have influenced the observed associations. Sixth, we did not perform formal tests for interaction (tea type × sex, age, residence, and region); the subgroup analyses were therefore exploratory and provide only preliminary insights into potential variations in the associations across population subgroups. These findings warrant confirmation in future studies with adequate power for interaction testing. Finally, although the CES-D depression scale was used, the obtained depressive symptom scores cannot be equated with clinically diagnosed depression. In-depth interventional studies in patients with clinically diagnosed depression are needed to assess the generalizability of our findings.

5. Conclusions

This study provides a new perspective on enhancing mental health in an aging society from the standpoint of tea consumption. According to our research, consuming different types of tea was associated with significantly fewer depressive symptoms in Chinese older adults, even after adjusting for socioeconomic status, lifestyle, health-related factors, and social participation. Furthermore, daily tea consumption was associated with lower odds of depressive symptoms, especially for green and floral tea. These findings suggest that consuming various types of tea may have benefits for preventing depressive symptoms. Prospective studies or randomized trials are needed to further validate causality. From a public health perspective, in the context of population aging, the potential association between traditional lifestyle habits such as tea drinking and mental health among older adults represents a hypothesis that warrants further investigation in prospective and interventional studies.

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Abbreviations

The following abbreviations are used in this manuscript:

ADL	activities of daily living
BDNF	Brain-Derived Neurotrophic Factor
BMI	body mass index
CES-D-10	10-item Center for Epidemiologic Studies Depression Scale
CI	confidence interval
CLHLS	the Chinese Longitudinal Healthy Longevity Survey
COPD	Chronic Airway Inflammatory Diseases
HPA	hypothalamic–pituitary–adrenal
MMSE	Mini-Mental State Examination
ORs	odds ratios

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