

Type of Tea Consumption and Depressive Symptoms in Older Adults

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Abstract

Background

Existing research indicates that tea drinking may exert beneficiary effects on mental health. However, associations between different types of tea intake and mental health such as depression are not fully examined. The purpose of this study was to examine the associations of green tea, fermented tea, and flowering tea consumption with depressive symptoms.

Methods

We used data from the 2018 wave of Chinese Longitudinal Healthy Longevity Survey. The type (green, fermented [black, Oolong, white, yellow, dark, and compressed teas], and flower) and frequency of tea consumption and depressive symptoms for 13,115 participants were assessed. We examined the associations between type and frequency of tea intake and depression, controlling for a set of demographic, socioeconomic, psychosocial, behavioral, and health-related variables.

Results

Overall, intake of green tea, fermented tea, and flower tea were all significantly associated with a lower prevalence of depression, independent of other risk factors. Compared with the group for no tea intake, the adjusted ORs for daily green tea, fermented tea, and flower tea intake were 0.85 (0.76-0.95), 0.87 (0.76-0.99), and 0.70 (0.59-0.82), respectively. Linear associations were observed between frequency of all types of tea intake with depressive symptoms (P s for trend < 0.05). The associations of type and frequency of tea intake and depressive symptoms were robust in several sensitivity analyses.

Conclusions

Among Chinese old adults, regularly consumed any type of tea (green, fermented or flower) were less likely to show depressive symptoms, the associations seemed more pronounced among flower tea and green tea drinkers.

Highlights

1. Comprehensively investigate the type (green, fermented, or flower) and frequency of tea consumption and their associations with depressive symptoms in older adults.
2. A nationally representative dataset of Chinese older adults was used.
3. Consuming 1 + cup of tea daily was associated lower prevalence of depression.
4. Association was more pronounced for flower tea than other types of tea.

1. Introduction

Depression is a serious mental and public health problem among older adults ¹. The World Health Organization estimated that nearly 7% of older adults experience depression ². Depression is the leading cause of disability worldwide, accounting for 5.7% of years lived with disability among the older adults ³. Depression is underdiagnosed and undertreated ¹, especially for those who were undergoing adverse events such as COVID-19 pandemic ⁴. Given the increased risk of disability and mortality associated with depression ^{5,6}, it is vitally important to consider preventive interventions that improve the health and quality of life of older adults, and reduce the burden on families and societies. Potentially useful interventions that prevent depression include cognitive and behavioral interventions, such as mindfulness-based therapy and lifestyle interventions ^{7,8}. Recent research has also drawn attention to the potential anti-depressant effect of regular tea consumption ⁹.

Human trials, mouse models, and in vitro experiments have explored the underlying mechanisms for the neuroprotective effect and invigorating quality of tea. In mice models, green tea polyphenols exert antidepressant-like effects by inhibition of the hypothalamic–pituitary–adrenal axis ¹⁰. Green tea catechins, such as epigallocatechin gallate (EGCG), also exert anti-inflammatory and neuroprotective actions in laboratory experiments ¹¹. Anti-inflammatory properties of flavonoids from green tea is also found to associated with lower risk of depression ^{12,13}. Clinical trials show that L-theanine, a unique component in green tea, can ameliorate the stress-related symptoms and depressive disorders ¹⁴. Evidence from human electroencephalograph (EEG) studies show that L-theanine significantly increases activity in the alpha frequency band which indicating mental relaxation ¹⁵. In summary, these observations support the argument that tea consumption has benefits on relaxing mood and preventing depression.

However, to date, epidemiological evidence for the beneficial effect of tea consumption in reducing the risk and severity of depression in humans is inconclusive. Mixed findings are reported from less than a dozen cross-sectional and prospective cohort studies ^{16–19} and two meta-analyses ^{20,21} published in 2015 and 2016 have summarized the heterogeneous association between tea drinking and depression with divergent conclusions. Since then, there have been several more cross-sectional studies which support an inverse association of tea consumption with depression ^{22–27}. However, there remains a paucity of studies that examine dose-response effect for different types of tea. Bioactive components which vary in different types of tea through diverse processing methods in the markets may account for the heterogeneity of findings ^{28,29}. Green tea has a higher content of catechins than fermented teas (such as Oolong and black teas). The fermentation process during tea manufacturing reduces the levels of catechins but elevated levels of gallic acid, theaflavins and thearubigins ³⁰. There is a great heterogeneity of types of tea produced that are available and consumed around the world and particularly in China, where tea drinking originated.

In this study, we analyzed nationwide data of a large nationally representative sample of older adults which identified varied types of tea consumption (green tea, fermented tea, and flower tea) among the tea

drinkers widely distributed geographically across China. We examined the associations between the types, the frequencies of tea consumption and depressive symptoms, with stratified analyses by gender, age, and geographic regions to examine the heterogeneity of the associations.

2. Subjects And Methods

2.1. Study population

The present study used data from the 2018 wave of CLHLS, a longitudinal population study initiated in 1998 with follow-up surveys every 2 to 3 years. The CLHLS surveys were conducted in randomly selected counties and cities in China, which accounted for half of the counties and cities in 23 out of 31 provinces covering over 85% of China's population. Details of this survey have been published elsewhere^{31, 32}. The CLHLS is a specially designed sample with oversampled centenarians and very old adults aged in 90 s and 80 s.

In the 2018 wave of CLHLS, the self-reported types and frequencies of tea intake and depressive symptoms assessed by the Center for Epidemiologic Studies Depression Scale were collected. After excluding 2,469 participants with missing data on depressive symptoms, self-reported types of tea consumption, key covariables, the final analytical sample included 13,115 participants aged over 65 years old (5,121 were aged 65–79, 6,301 were aged 80–99, and 1,693 were aged over 100 years old) (Fig. 1).

The CLHLS study was approved by the Biomedical Ethics Committee of Peking University (IRB00001052-13074). All participants or their legal representatives signed written consent forms in the baseline and follow-up surveys.

2.2. Measurements

The questionnaire in the 2018 wave of the CLHLS included items about the frequency of habitual consumption of 8 types of tea (green, black, Oolong, white, yellow, dark, compressed, and flowering teas). The detailed types and classifications of tea consumption in this study are provided in supplements (Supplementary Table 1). In brief, we classified the type of tea into Green tea, Fermented tea (black, Oolong, white, yellow, dark, and compressed teas), and Flower tea³³. We grouped the frequency of tea consumption of each type of tea into 3 categories: daily (≥ 1 cup/day), occasionally (< 1 cup/day but ≥ 1 cup/month), and never or rarely (< 1 cup/month or never drink tea)³⁴.

We used the 10-item of the Center for Epidemiologic Studies Depression Scale (CES-D-10) to measure depressive symptoms in this study³⁵. The answers are indicated in a four-scale metric, from "rarely" to "some days" (1–2 days), "occasionally" (3–4 days), or "most of the time" (5–7 days). For the two positive questions—"I was happy" and "I felt hopeful about the future"—answers were reversely coded before summation. We then coded all answers from 0 to 3 as "rarely" and "most of the time", respectively. The total range of CES-D-10 scores in this study was 0–30, with higher scores indicating greater severity of

depressive symptoms. A person is considered to have depressive symptoms if he/she scored less than 10 in the CES-D-10. This threshold of 10 has been widely used in previous studies³⁶ and well validated in depression measurement in Chinese older populations, regardless of their age and dementia status^{37,38}.

The 8th survey of CLHLS in 2018 collected a range of self-reported data on demographic, socioeconomic, psychosocial, behavioral, health-related factors, including age, gender, education, socioeconomic level, rural residence, geographical regions, marital status, living condition, social and leisure activity index, smoking, alcohol drinking, BMI, regular dietary (vegetable/fruit/fish/nut) intake, self-rated health, cognitive impairment, medical illness, comorbidity, and ADL disability. All information was collected through face-to-face home interview by trained research staff members. Interviewees were encouraged to answer as many questions as possible. If they were unable to answer questions, a close family member or another proxy, such as a primary caregiver, provided the answers³⁹.

Age was calculated according to self-reported dates of birth. If dates were converted into Georgian calendar dates if they were based on Chinese lunar calendar dates. Levels of educational attainment were as grouped into three categories according to years of schooling (0, 1–6, and ≥ 7 years). Marital status was divided as “currently married and living with spouse” or others (widowed, separated, divorced, or never married). Living condition was grouped into 3 categories: living with family members or others, living alone, and living in an institution. Current residence was dichotomized as “urban residence” or “rural residence”. Smoking status was dichotomized as “non-current smoker or never-smoker” vs. “current smoker”, a similar approach was taken to define the alcohol consumption and physical activity. Dietary intake, included vegetables, fruit, fish, and nut, were dichotomized as “regular intake” or “occasional or seldom intake”. The body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared. Given that no direct indicator for individual socioeconomic status is provided in the CLHLS, we obtained individually socioeconomic status by using a principal component analysis (PCA) based on four questions (primary occupation before retirement [white collar vs. others], living conditions [living with family members or others, living alone, and living in an institution], retirement earnings, and living expenditure). A compositional score based on the first component generated from PCA has been suggested to be a qualified measure of socioeconomic status and has been widely employed in previous studies^{36,40}. Social and leisure activity score was calculated by eight kinds of activities (whether a respondent did gardening, practiced Tai Chi, participated in square dance, raised poultry or pets, reading, playing Mahjong or cards, listening to the radio or watching TV, and participating in community social activities) and we scored each activity 1 for ‘never’, 2 for ‘sometimes’ 3 for ‘almost every day’; The score ranged from 8 to 24 with higher score indicating more leisure activities, and low social and leisure activity level was defined by the score less than 14. Cognitive function was tested by using the Chinese version of the 30-point Mini-Mental State Examination (MMSE) and cognitive impairment was defined by an MMSE total score of < 24 ³². Activity of daily living (ADL) was assessed by the Katz index⁴¹, we defined ADL disability as needing personal assistance in performing one or more of the five essential activities (bathing, transferring, dressing, eating, and toileting) or being incontinent⁴². We ascertained 14 self-reported medical illnesses, including hypertension, diabetes, dyslipidemia, heart disease, stroke,

pneumonia (asthma/COPD), cataract or glaucoma, cancer, gastritis, arthritis, cholecystitis, rheumatism, nephritis, and hepatitis; we grouped the medical illness into 3 categories: “chronic inflammatory disorders (heart disease, stroke, diabetes, pneumonia, gastritis, arthritis, cholecystitis, rheumatism, nephritis, and hepatitis)”, “other disorders”, and “none”. Comorbidity was defined as having 5 or more medical illnesses. Self-rated health was defined as “excellent or good” or “average or poor”. We considered geographical region on the basis of residential address to account for types of tea production areas⁴³ as well as differences in regional economic developments and social cultures in China: Northern China (Beijing, Tianjin, Hebei, Shanxi, Shaanxi, Shandong, Liaoning, Jilin, and Heilongjiang provinces), Eastern China (Shanghai, Jiangsu, Zhejiang, and Fujian provinces), Central China (Henan, Hubei, Jiangxi, Anhui, and Hunan provinces), Southwestern China (Guangdong, Guangxi, Chongqing, Sichuan, and Hainan provinces) (Supplementary Fig. 1).

2.3. Statistical Analyses

The subjects’ characteristics according to categories of type of tea consumption were compared by using analysis of variance or chi-squared test, as appropriate. We used multivariate logistic regression analysis to calculate odds ratios (ORs) for depressive symptoms relative to the type of tea consumption including green tea, fermented tea, and flower tea, with no habitual tea intake treated as the reference group. The base model (Model 1) included types of tea consumption plus demographic variables; Model 2 further controlled for socioeconomic variables: education, socioeconomic status, rural residence and geographical regions; Model 3 additionally controlling for psychosocial and behavioral variables: marital status, living condition, social and leisure activity index, smoking, alcohol drinking, BMI, regular dietary (vegetable/fruit/fish/nut) intake; Model 4 added health variables in Model 3: self-rated health, cognitive impairment, medical illness, comorbidity, and ADL disability. In detailed analyses examining the dose-effect relation between the intake of green tea or fermented tea or flower tea with depressive symptoms, we classified the frequency of each type of tea consumption into 3 categories: daily (≥ 1 cup/day), occasionally (< 1 cup/day but ≥ 1 cup/month), and never or rarely (< 1 cup/month or never drink tea), and repeated multiple logistic regressions controlling for all covariates as above.

We conducted subgroup analyses to examine whether the associations between types and frequencies of tea intake and depressive symptoms differed by gender, 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). We performed several steps of sensitivity analyses for the full model (Model 4) to assess the possible outcomes of the different thresholds used for the CES-D-10. First, we considered varied cut-off thresholds for the CES-D-10, such as 8 and 12, which are more sensitive (cut-off value = 8) or specific (cut-off value = 12) to discriminate the depressive symptoms, and used the Model 4 to examine the associations. Second, we excluded the participants with severe cognitive impairment with scores of MMSE < 19 ⁴⁴, of whom substantial recall bias might have occurred in reporting types and frequencies of tea consumption. Moreover, we removed the participants who were long bedridden or terminally ill, restricting the sample to non-bedridden to see whether there is a change in the significance level of the observed associations. We also test our results by using full sample after multiple imputation

and by adjusting sampling weight based on age-sex-residence-specific distribution of 2015 mini-census of China.

A two-tailed *P*-value of less than 0.05 was considered statistically significant. All analyses were performed using STATA version 14.0 (Stata Corp, College Station, TX, USA). ArcGIS version 12.0 was used to perform map visualization of the geographical distribution of tea drinkers.

3. Results

3.1. General Characteristics

The 13,115 study participants with mean age of 83.7 years (13% aged 100 and above), were evenly distributed across the whole of China in four geographical regions, and diversified by socioeconomic, lifestyle and health-related characteristics (Table 1). Among them, the mean CES-D-10 score was 10.1 (SD: 4.7); 56.6% of the study participants showed CES-D-10 score of ≥ 10 indicating depression. Overall, 70.3% never or rarely consumed tea, 15.0% consumed green tea, 8.8% consumed fermented tea, and 5.9% consumed flower tea. They were widely distributed geographically, with fermented tea consumption relatively more concentrated in the Eastern tea production Region, and green tea in the Central Region (Fig. 2). Compared to non-drinkers, tea drinkers as a whole in the 2018 CLHLS sample were significantly younger, predominantly men, more likely to be married and living with a spouse, urban rather than rural dwellers, higher socioeconomic index, more active in social and leisure activity. However, tea drinkers were more likely to be smokers and alcohol drinkers as well. On the other hand, more of them were likely to report regular intake of vegetables, fruits, nuts, and fish. Their prevalence of reported chronic diseases, including chronic inflammatory diseases, and comorbidity were higher.

Table 1

Main characteristics of the whole study population and its subgroups by type of tea consumption.¹

Variable/subgroups	Total sample	No tea	Green tea	Fermented tea	Flower tea	P value ²
Total sample, n	13,115	9,220	1,970	1,156	769	
%	100.0	70.3	15.0	8.8	5.9	
CES-D-10						
Total score	10.1 ± 4.7	10.4 ± 4.6	9.6 ± 4.8	9.5 ± 4.8	9.1 ± 4.8	< 0.001
≥10	7419 (56.6)	5454 (59.2)	1010 (51.3)	590 (51.0)	365 (47.5)	< 0.001
Age, years	83.7 ± 11.2	84.5 ± 11.3	81.4 ± 10.7	81.9 ± 11.0	82.6 ± 11.1	< 0.001
Age group, years						< 0.001
65–79	5121 (39.1)	3319 (36.0)	924 (46.9)	537 (46.5)	341 (44.3)	
80–99	6301 (48.0)	4577 (49.6)	868 (44.1)	514 (44.5)	342 (44.5)	
≥100	1693 (12.9)	1324 (14.4)	178 (9.0)	105 (9.1)	86 (11.2)	
Female (%)	7102 (54.2)	5574 (60.5)	689 (35.0)	521 (45.1)	451 (41.4)	< 0.001
Education level, years						< 0.001
0	7003 (53.4)	5487 (59.5)	686 (34.8)	511 (44.2)	319 (41.5)	
1–6	2643 (20.2)	1798 (19.5)	421 (21.4)	238 (20.6)	186 (24.2)	
7+	3469 (26.5)	1935 (21.0)	863 (43.8)	407 (35.2)	364 (34.3)	
Married and living with a spouse, %	5676 (43.3)	3604 (39.1)	1092 (55.4)	597 (51.6)	386 (49.8)	< 0.001
Living condition, %						< 0.001
With household members	10504 (80.1)	7287 (79.0)	1647 (83.6)	926 (80.1)	644 (83.8)	

Variable/subgroups	Total sample	No tea	Green tea	Fermented tea	Flower tea	P value ²
Alone	2178 (16.6)	1620 (17.6)	268 (13.6)	191 (16.5)	99 (12.9)	
Institution	433 (3.3)	313 (3.4)	55 (2.8)	39 (3.4)	26 (3.4)	
Rural residence, %	5782 (44.1)	4335 (47.0)	726 (36.9)	446 (38.6)	275 (35.8)	< 0.001
Socioeconomic level	-0.17 ± 1.00	0.08 ± 0.87	-0.31 ± 1.35	-0.16 ± 1.01	-0.24 ± 1.10	< 0.001
Social and leisure activity index	3.90 ± 2.76	3.53 ± 2.63	4.91 ± 2.90	4.64 ± 2.82	4.55 ± 2.86	< 0.001
Self-rated health excellent or good, %	6317 (48.2)	4307 (46.7)	1019 (51.7)	596 (51.6)	395 (51.4)	< 0.001
Current or former Smoker, %	4045 (30.8)	2312 (25.1)	922 (46.8)	470 (40.7)	341 (44.3)	< 0.001
Current alcohol drinker, %	1985 (15.1)	1124 (12.2)	482 (24.5)	944 (18.3)	167 (21.7)	< 0.001
BMI	22.4 ± 4.2	22.2 ± 4.2	22.8 ± 3.9	22.8 ± 4.2	23.4 ± 4.3	0.108
Regular vegetable consumption, %	11827 (90.2)	8245 (89.4)	1819 (92.3)	1069 (92.5)	694 (90.2)	< 0.001
Regular fruit consumption, %	6104 (46.5)	4041 (43.8)	1038 (52.7)	620 (53.6)	405 (52.7)	< 0.001
Regular fish intake, %	6301 (48.6)	4064 (44.6)	1197 (61.5)	665 (57.8)	375 (49.4)	< 0.001
Regular nut intake, %	2539 (19.6)	1510 (16.6)	521 (26.8)	252 (21.9)	256 (33.8)	< 0.001
Regularly physical activity, %	9651 (73.6)	6945 (75.3)	1336 (67.8)	842 (72.8)	528 (68.7)	< 0.001
Cognitive impairment, %	3300 (25.2)	2556 (27.7)	338 (17.2)	269 (23.3)	137 (17.8)	< 0.001
ADL functional disability, %	2974 (22.7)	2214 (24.0)	346 (17.6)	210 (18.2)	204 (26.5)	
Medical illness, %						< 0.001
Chronic inflammatory disorders ³	5714 (43.6)	3900 (42.3)	915 (46.5)	528 (45.7)	371 (48.2)	

Variable/subgroups	Total sample	No tea	Green tea	Fermented tea	Flower tea	P value ²
Other disorders	4607 (35.1)	3295 (35.7)	650 (33.0)	408 (35.3)	254 (33.0)	
None	2794 (21.3)	2025 (22.0)	405 (20.6)	220 (19.0)	144 (18.7)	
Comorbidity ⁴ , %						< 0.001
Yes	606 (4.6)	376 (4.1)	124 (6.3)	49 (4.2)	57 (7.4)	
No	12509 (95.4)	8844 (95.9)	1846 (93.7)	1107 (95.8)	712 (92.6)	
Geographical region ⁵ , %						< 0.001
Northern China	3157	1969 (62.4)	506 (16.0)	301 (9.5)	381 (12.1)	
Eastern China	2842	1933 (68.0)	607 (21.4)	258 (9.1)	44 (1.5)	
Central China	2967	2307 (77.8)	435 (14.7)	173 (5.8)	52 (1.8)	
Southwestern China	4149	3011 (72.6)	422 (10.2)	424 (10.2)	292 (7.0)	
¹ The percentages in the parentheses 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).						
³ Chronic inflammatory disorder was determined as having at least one condition of cardiovascular diseases/stroke, diabetes, asthma/COPD, arthritis, cholecystitis, nephritis, hepatitis, and gastric or duodenal ulcer.						
⁴ Comorbidity was determined as comorbid 5 or more in 14 medical illnesses consisting of hypertension, diabetes, dyslipidemia, heart disease, stroke, pneumonia (asthma/COPD), cataract or glaucoma, rheumatism, cancer, arthritis, cholecystitis, nephritis, hepatitis, and gastric or duodenal ulcer.						
⁵ Geographical regions were considered on the basis of residential address to account for tea consumption habits and dietary differences in China: Northern China (Beijing, Tianjin, Hebei, Shanxi, Shaanxi, Shandong, Liaoning, Jilin, Heilongjiang), Eastern China (Shanghai, Jiangsu, Zhejiang, Fujian), Central China (Henan, Hubei, Jiangxi, Anhui, Hunan), and Southwestern China (Guangdong, Guangxi, Chongqing, Sichuan, Hainan).						

3.2. Association of type and frequency of tea intake with depressive symptoms

Tea drinkers showed lower odds of association with depressive symptoms in model controlling for demographic and socioeconomic variables: green tea, OR = 0.72 (95% CI: 0.65–0.80); fermented tea, OR = 0.79 (95% CI: 0.70–0.89); flower tea, OR = 0.62 (95% CI: 0.53–0.72) (Table 2). The strength of association was lowered after further controlling for psychological, lifestyle behavioral and health variables, but the final model controlling for all confounding risk factors showed that tea consumption remained associated with 15% (green tea) to 30% (flower tea) lower odds of prevalent depressive symptoms. Stratified analyses showed some heterogeneity of associations by tea type, gender, age group and geographical regions: green tea in males (OR = 0.79) versus females (OR = 0.93), flower tea in males (OR = 0.77) versus females (OR = 0.61), fermented tea in younger-old (OR = 0.81) versus old-old (OR = 0.96), green tea in Southwestern Region (OR = 0.60) versus other regions (OR from 0.83 to 0.90), fermented tea in Central and Southwestern Regions (OR = 0.70 and 0.76) versus Northern and Eastern Regions (OR = 1.09 and 1.11), and flower tea in Eastern China (OR = 0.48) versus other regions (OR from 0.70 to 0.88).

Table 2
Associations of types of tea consumption with depressive symptoms among whole sample and subpopulations

	Green tea vs. No tea	Fermented tea vs. No tea	Flower tea vs. No tea
Whole sample			
Model 1	0.53 (0.48–0.58) *	0.63 (0.56–0.70) *	0.49 (0.43–0.57) *
Model 2	0.72 (0.65–0.80) *	0.79 (0.70–0.89) *	0.62 (0.53–0.72) *
Model 3	0.80 (0.72–0.89) *	0.84 (0.74–0.95) *	0.69 (0.60–0.81) *
Model 4	0.85 (0.76–0.95) *	0.87 (0.76–0.99) *	0.70 (0.59–0.82) *
Subpopulations based on Model 4			
By Gender			
Male	0.79 (0.69–0.92) *	0.85 (0.71–1.03)	0.77 (0.62–0.95) *
Female	0.93 (0.79–1.10)	0.89 (0.74–1.08)	0.61 (0.48–0.78) *
By Age group			
Age < 80 years	0.87 (0.75–1.00)	0.81 (0.68–0.97) *	0.70 (0.56–0.87) *
Age ≥ 80 years	0.82 (0.69–0.97) *	0.96 (0.79–1.18)	0.69 (0.54–0.88) *
By urban-rural residence			
Urban residency	0.82 (0.73–0.94) *	0.90 (0.76–1.07)	0.71 (0.58–0.88) *
Rural residency	0.91 (0.76–1.08)	0.84 (0.68–1.04)	0.68 (0.52–0.89) *
By Geographic region			
Northern China	0.84 (0.66–1.06)	1.09 (0.83–1.44)	0.74 (0.57–0.96) *
Eastern China	0.90 (0.74–1.11)	1.11 (0.85–1.46)	0.48 (0.25–0.94) *
Central China	0.83 (0.67–1.04)	0.76 (0.55–1.05)	0.70 (0.39–1.28)
¹ Model 1 included types of tea consumption as the sole variable; Model 2 controlling for demographic and socioeconomic variables: age (continuous), gender, education, socioeconomic level, rural residence and geographical regions; Model 3 additionally controlling for psychosocial and behavioral variables: marital status, living condition, social and leisure activity index, smoking, alcohol drinking, BMI, regular dietary (vegetable/fruit/fish/nut) intake; Model 4 additionally for health variables: self-rated health, cognitive impairment, and medical illness, comorbidity, and ADL disability.			
* P < 0.05			

	Green tea vs. No tea	Fermented tea vs. No tea	Flower tea vs. No tea
Southwestern China	0.60 (0.47–0.76) *	0.70 (0.56–0.87) *	0.88 (0.68–1.03)
¹ Model 1 included types of tea consumption as the sole variable; Model 2 controlling for demographic and socioeconomic variables: age (continuous), gender, education, socioeconomic level, rural residence and geographical regions; Model 3 additionally controlling for psychosocial and behavioral variables: marital status, living condition, social and leisure activity index, smoking, alcohol drinking, BMI, regular dietary (vegetable/fruit/fish/nut) intake; Model 4 additionally for health variables: self-rated health, cognitive impairment, and medical illness, comorbidity, and ADL disability.			
* P < 0.05			

The frequency of tea consumption of all three types showed linear associations with depressive symptoms particularly for green tea (P for a linear trend = 0.001) and flower tea (P for a linear trend = 0.001), controlling for all confounding variables (Fig. 3). Daily drinking of one or more cups of tea of all three types were significantly associated with 16% (fermented tea), 27% (green tea) and 47% (flower tea) lower odds of prevalent depressive symptoms. Those associations were generally consistent in the subgroup analyses by gender and residence, while the associations of green tea and flower tea intake with depressive symptoms were more pronounced in oldest-old group (≥ 80 years) compared than younger old group (60–79 years). In the oldest-old subsample with never or rarely tea intake group as the reference, the ORs of depressive symptoms for daily green tea drinkers and daily flower tea drinkers were 0.72 (95% CI: 0.60, 0.86) and 0.47 (95% CI: 0.35, 0.64), respectively; yet the ORs were 0.82 (95% CI: 0.67, 1.01) and 0.60 (95% CI: 0.42, 0.86) for daily green tea drinkers and daily flower tea drinkers in younger old groups. We also observed a geographical variation in the associations in green tea and fermented tea consumers, while the association seems more homogeneous in flower tea drinkers (Supplemental Table 2).

3.3. Sensitivity analyses

In sensitivity analysis using varied cut-off values of the CES-D-10 such as 8 and 12, we repeated the analysis for the full model (Model 4). The dose-effect relationship of frequencies of each type of tea intake with prevalence of depressive symptoms was only mildly altered in analyses using both cutoffs (Supplementary Fig. 2). After excluding participants who were likely to have severe cognitive impairment that had a score of MMSE less than 19 ($n = 1,432$), the effect estimates or the significance levels of the observed associations were not altered in three types of tea drinkers. Moreover, we removed the participants who were long bedridden or terminally ill ($n = 261$), restricting the sample to non-bedridden and the results were identical to those we presented in the main text (Supplementary Fig. 3). We also test our result using full sample after multiple imputation and further adjusting sampling weight (Supplementary Fig. 4). Those sensitivity analyses were all reasonably consistent with the final model.

4. Discussion

In this large population-based study, Chinese older adults who regularly consumed all types of tea (green, fermented, and floral) were less likely to show depressive symptoms, measured by the CES-D-10. Daily consumption of one or more cups of green, fermented, or floral tea was associated with up to 50% lowered odds of prevalent depressive symptoms. These findings are in line with previous observations of an inverse association of tea consumption with the risk of depression.

There are several noteworthy aspects of the association observed in this study that are not present in previous studies. One is that several types of tea consumption were investigated simultaneously in the study. Most prior studies mainly investigated only one type of tea alone^{22,25}; or unspecified tea type^{19,23,24,27}. In two studies, green and black (fermented) tea were both investigated^{26,27}. One study in rural North China reported lower odds of depressive symptoms for green and black tea²⁷, similar to our findings, whereas another study in Eastern China reported an inverse association of black tea and depression, but not for green tea²⁶. Our study reveals additionally an inverse association of flower tea with depression, which was also observed with marginal significance in the study in North China²⁷.

Tea is one of the most widely consumed beverages in the world, both in the traditional ways of drinking and also as a constituent of ready-to-drink beverages. In addition to green tea and black tea, some types of tea are becoming increasingly sold in the western world, such as white tea, yellow tea, dark tea, matcha, and floral tea²⁹. The main chemical compounds were varied between different types of teas due to varied processes of teas, which can be summarized as withering, fixation, rolling, fermentation, and drying steps. (-)-epigallocatechin gallate, trans-catechins, caffeine, and theanine are the main compounds of green, white, and oolong teas, which account for about 20–30% of the dry weight. In black tea, trans-catechins are scarcely detected, but gallic acid, caffeine, and theaflavin are the major compounds⁴⁵. In our study, we observed a lower prevalence of depressive symptoms in green tea drinkers than those who were fermented tea drinkers. The more pronounced antidepressant effect of green teas can be partly due to the antioxidant and anti-inflammatory components such as catechins or EGCG. In general, green tea has been found to be superior to fermented tea in terms of antioxidant activity owing to the higher content of (-)-epigallocatechin gallate³³. Notably, consuming at least 1 cup of flowering tea per day is significantly associated with lower odds of depressive symptoms, compared to those who were non-drinkers. Studies identified effective constituents of flower teas, such as Okanin, which can exert neuroprotective effect through inhibition of the TLR4/NF- κ B signaling pathways⁴⁶. Clinical trial data indicate that consuming chamomile tea, one of the most commonly consumed floral tea, can attenuate depression state in depressed patients with type 2 diabetes⁴⁷ and in postpartum women⁴⁸. Similar antidepressant and sedative effect of jasmine tea, especially for its odor such as (*R*)-(-)-linalool, was also reported^{49,50}.

The association of tea consumption with depression is observed to be highly heterogeneous among studies and populations across the world, and is true within China, as evidenced by the data in this study.

The heterogeneity may be partly explained by local popularity of different types of tea used for consumption and methods of infusion and preparation in production^{28,51}. In China, tea of different types is traditionally consumed on its own without or rarely with milk and remains so today, whereas tea, mostly of mixed blends of black fermented tea, is popularly consumed with milk in the West⁵². Some evidence suggest that the addition of milk may reduce the anti-oxidant activity of tea, due to the interaction between tea polyphenols and milk proteins, such as between catechins and caseins, among other factors^{53,54}. However, more research is clearly warranted to shed light on this.

Our study had several strengths. To our knowledge, this is the first study that has investigated the association of different types and frequencies of tea intake with depressive symptoms among a nationally representative sample of older adults in China. We also did subgroup investigations, especially among oldest-old participants and participants with varied geographical regions. In addition, we considered a wide range of covariates that allowed us to include and adjust for major potential confounders that were measured in the study population. Moreover, our study had a large sample size, which gave us the opportunity to test the associations between varied types and frequencies of tea consumption and various grades of depressive symptoms (using different cutoffs of CES-D-10 from 8, 10, and 12).

Several methodologic limitations should be considered in the interpretation of our results. First, our study had a cross-sectional design, which prevented us from firmly establishing a causal relationship between consumption of each type of tea and depressive symptoms. Second, the estimated inverse odds ratio of association between tea consumption and depressive symptoms were substantially attenuated by the additional inclusion of multiple covariates in the model, suggesting that the effect of tea consumption on depressive symptoms was explained in large parts by its association with socioeconomic, psychosocial, lifestyle behavioral and health factors. For example, healthier and socially active individuals with higher socioeconomic status tended to have more opportunities to consume varied types of teas⁵⁵. Among the Chinese, tea is often consumed as a social or leisure activity⁵⁶, and such a social or leisure activity itself as well as the process of preparing and drinking tea may contribute to maintaining better mental health^{57,58}. In addition, tea consumption has also been shown to be associated with lower cardio-metabolic risks and cardiovascular and total mortality^{59,60}, which in turn have also been demonstrated to be associated with depression⁶¹. Furthermore, inflammation may be a common underlying factor in this relationship, as it is associated with many chronic diseases and depression⁶². Although we were able to control for these and many other potential confounders, and the findings were generally robust to adjustments, we may not be able to fully exclude the possibility of residual confounding by unmeasured factors.

Finally, although CES-D-10 is well validated in assessing depression in Chinese older populations³⁷, there were no clinical assessment of depression in the community-based survey, hence we did not diagnose the presence of clinical depression or the subtype of depression. More interventional studies and clinical

trials among general health populations as well as clinically depressed patients are warranted to assess the generalizability of the present findings.

5. Conclusion

In conclusion, this large Chinese population-based study demonstrated that higher consumption of tea, including green, fermented, flower tea, was inversely associated to the prevalence of depressive symptoms, while the association was particularly pronounced among flower tea drinkers. These findings suggest that the consumption of various types of tea may be potentially beneficial for the prevention of depressive symptoms. Prospective studies or randomized trials are required to clarify the causality, taking into account the types of tea.

Abbreviations

CLHLS, Chinese Longitudinal Healthy Longevity Survey; CED-S-10, 10-item Center for Epidemiologic Studies Depression Scale; ECGG, epigallocatechin gallate; MMSE, Mini-Mental State Examination; ADL, Activity of daily living.

Declarations

Ethical Approval and Consent to participate

The CLHLS study was approved by the Biomedical Ethics Committee of Peking University (IRB00001052-13074). All participants or their legal representatives signed written consent forms in the baseline and follow-up surveys.

Consent for publication

Written informed consent for publication was obtained from all participants.

Availability of supporting data

The data that support the findings of this study are openly available in <https://opendata.pku.edu.cn/dataverse/CHADS>.

Competing interests

None reported.

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had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, and approval of the manuscript; or the decision to submit the manuscript for publication.

Authors' contributions

YY, CH, GD, and NT: conceived and designed the research; YY and CH: performed the statistical analyses and drafted the manuscript; CL, JS, YH and ZY: contributed to interpretation of the results, reviewed the manuscript. ZY, GD and NT: supervised the conduct of the research and had primary responsibility for the final content; and all authors: read and approved the final manuscript. The authors report no conflicts of interest.

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Figures

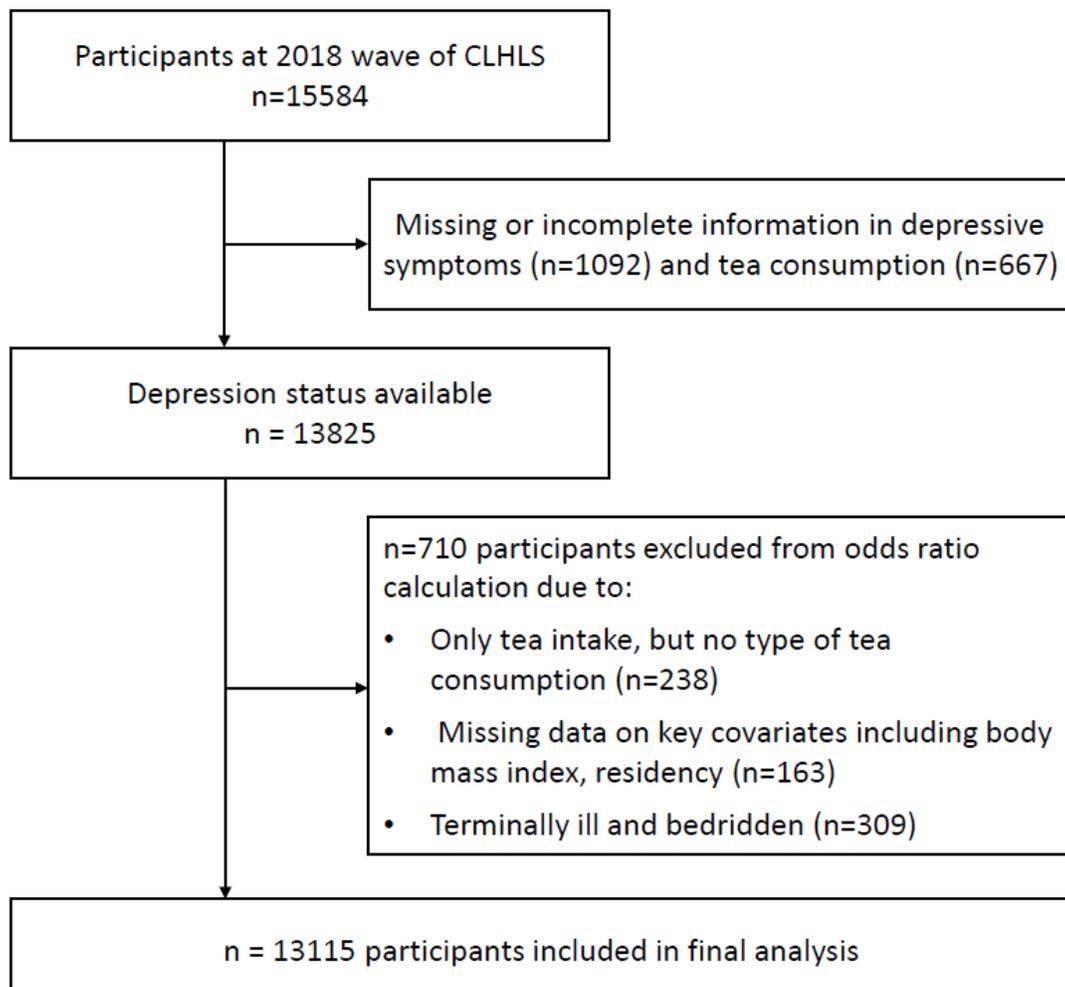


Figure 1

Derivation of the study population from participants of the Chinese Longitudinal Healthy Longevity Survey (CLHLS).

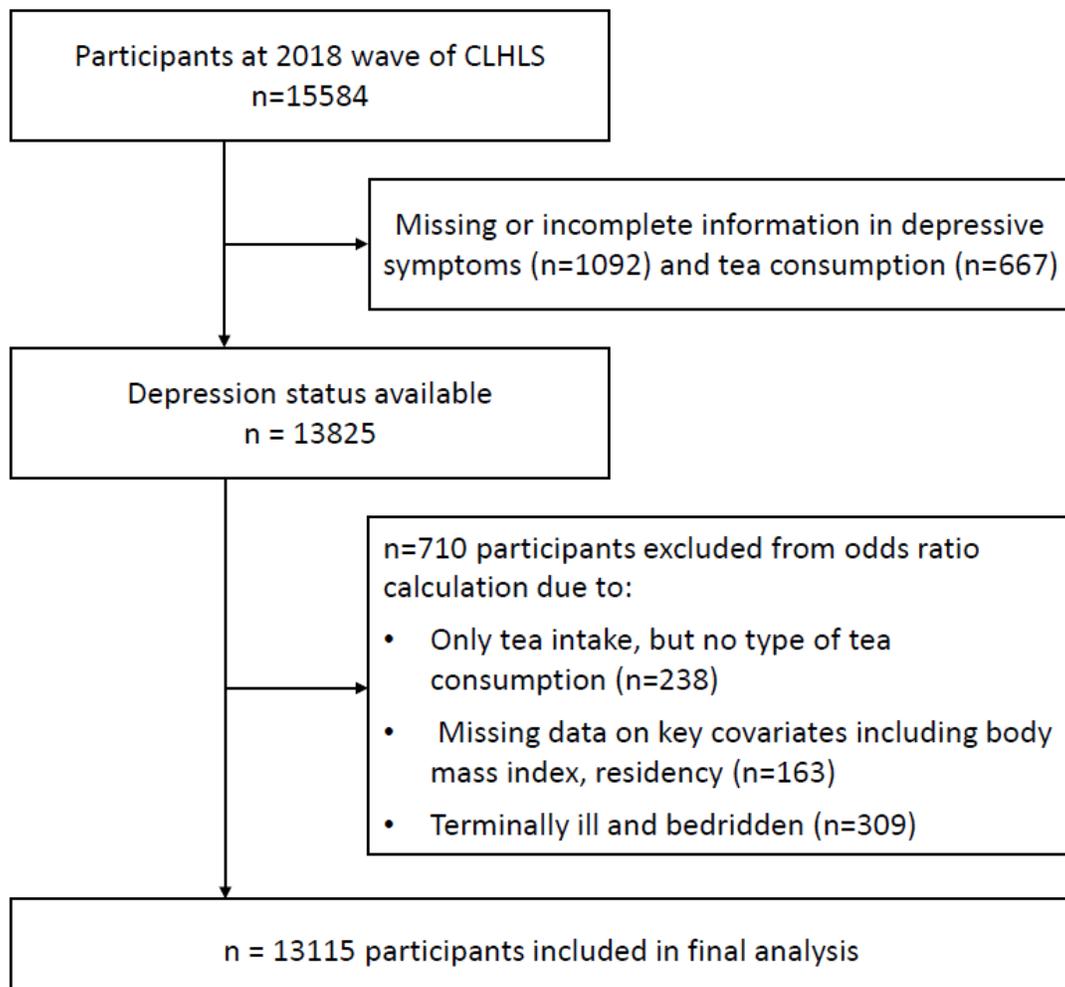


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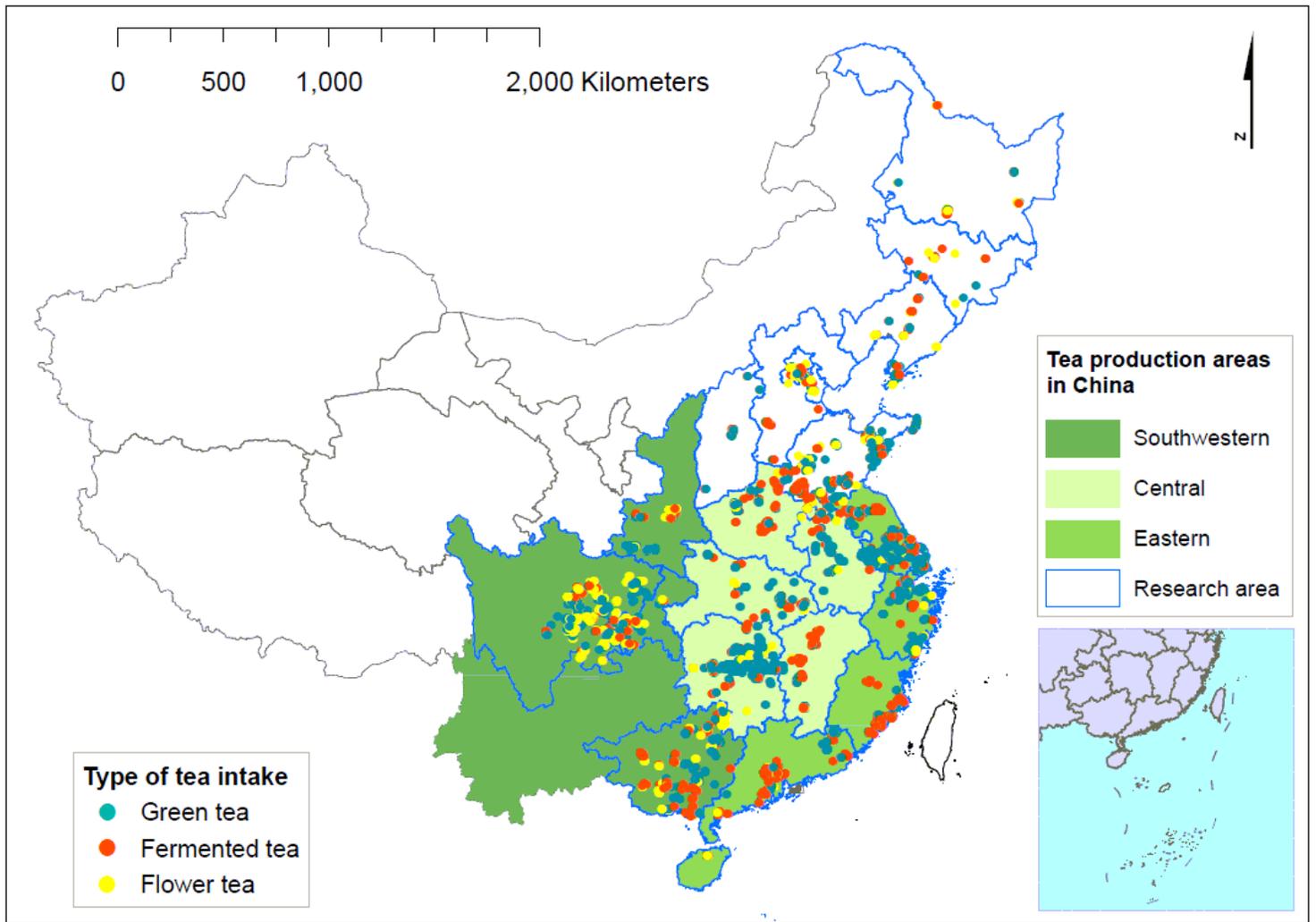


Figure 2

Map of tea production areas in China and distribution of participants of CLHLS who consumed main type of teas. Type of tea was determined as Green tea, Fermented tea, and Flower tea, the distribution of type of tea was depicted according to the participants' resident location. The participants are from 23 provinces of China and they are shown in area of the blue frame. According to the Economic Regionalization Scheme of the National Bureau of Statistics of China, tea production regions were classified into Southwestern, Central, and Eastern areas. Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.

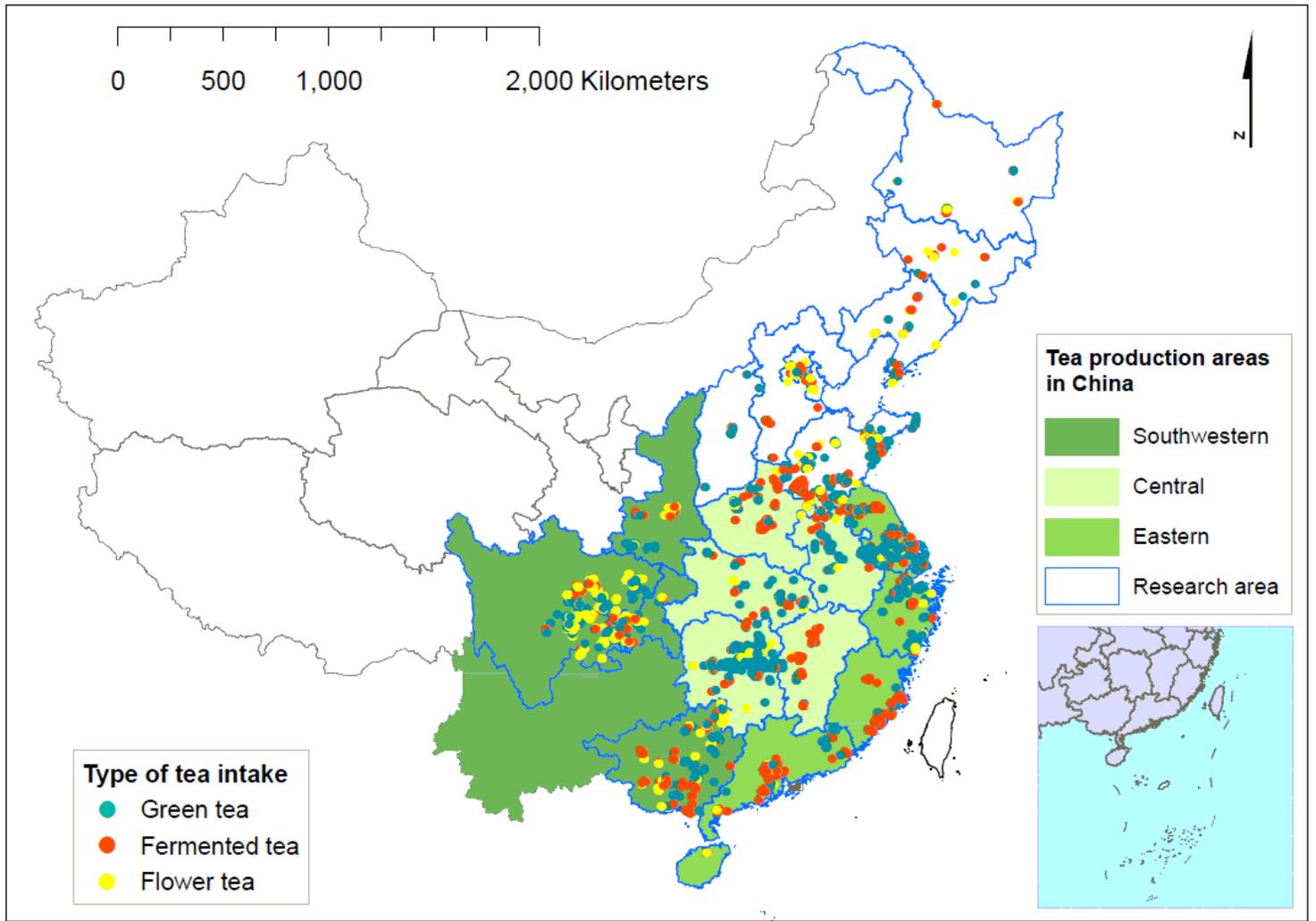


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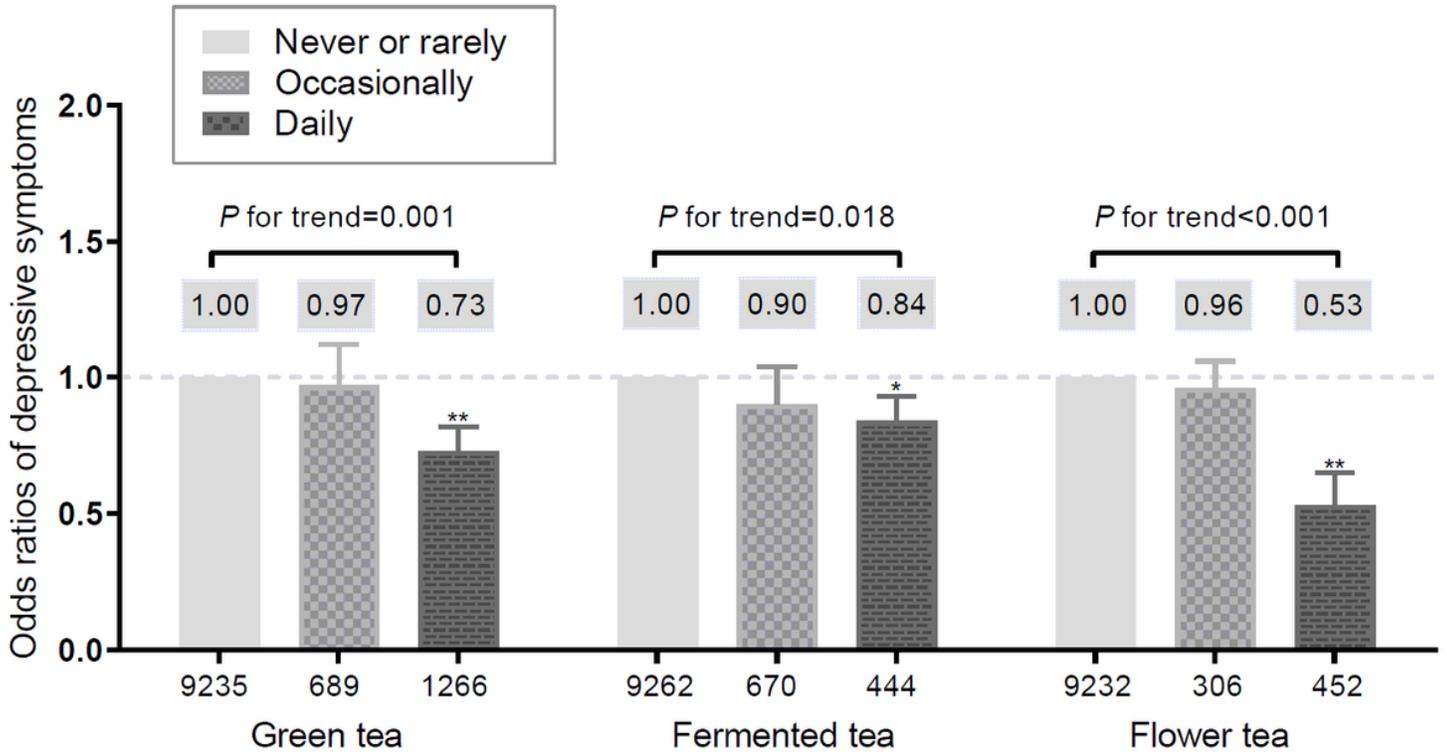


Figure 3

Type and frequency of tea consumption and depressive symptoms. Main model (Model 4) included types of tea consumption as the sole variable and controlling for demographic and socioeconomic variables (age, gender, education, socioeconomic level, rural residence and geographical regions), psychosocial and behavioral variables (marital status, living condition, social and leisure activity index, smoking, alcohol drinking, BMI, regular dietary [vegetable/fruit/fish/nut] intake), and health variables (self-rated health, cognitive impairment, and medical illness, comorbidity, and ADL disability). Frequency was grouped into 3 categories: daily (≥ 1 cup/day), occasionally (< 1 cup/day but ≥ 1 cup/month), and never or rarely (< 1 cup/month or never drink tea) * $P < 0.05$ ** $P < 0.01$

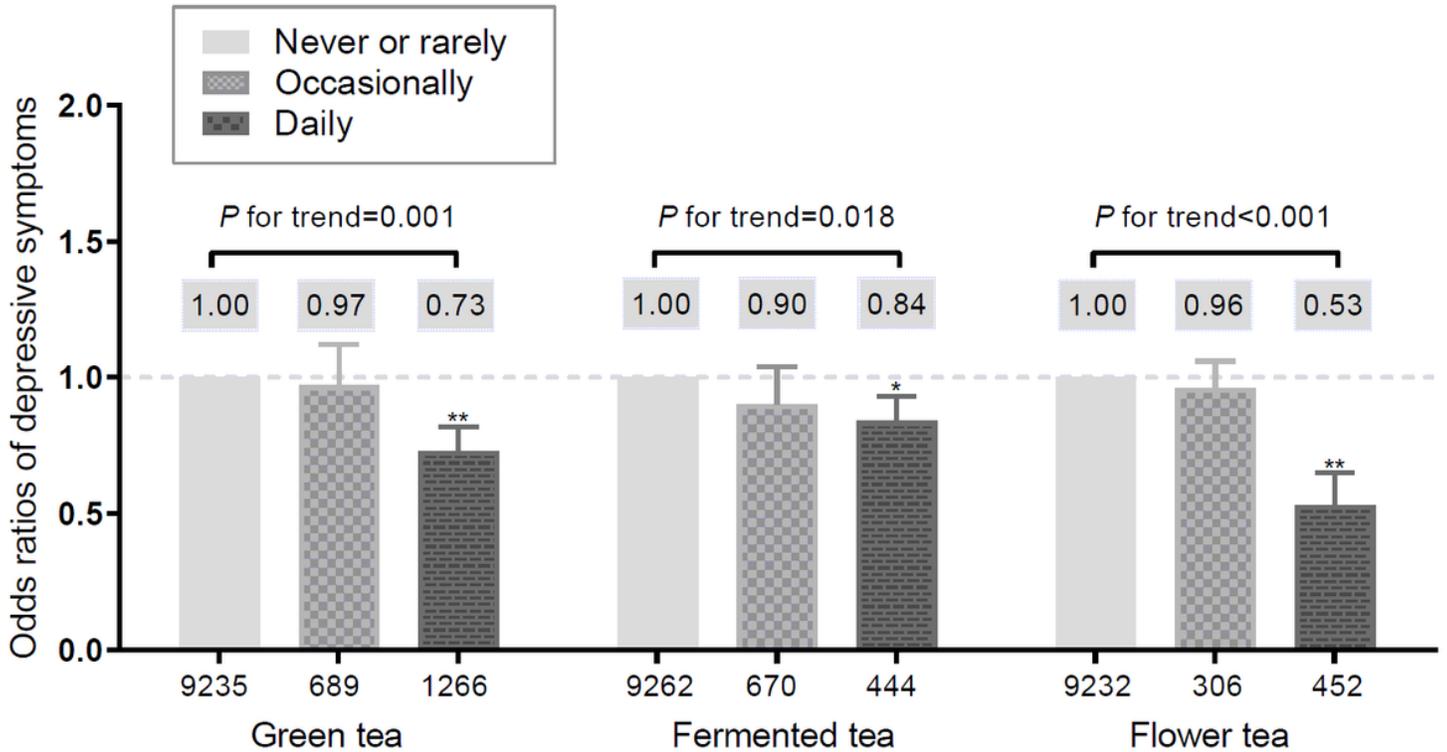


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