Research Square

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Characteristics of spicy food consumption and its association with depressive symptoms in Sichuan and Qingdao populations: evidence from China Kadoorie Biobank (CKB)

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Article

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Abstract

Background

Depression is a leading cause of global disability, projected to become the foremost contributor to disease burden by 2030. In China, its prevalence has risen steadily, posing a major public health challenge. Evidence on the association between spicy food consumption and depressive symptoms remains inconsistent, with few studies considering regional dietary cultural differences.

Methods

This cross-sectional study analyzed baseline data from 86,542 participants in Sichuan and Qingdao from the China Kadoorie Biobank (CKB). Spicy food consumption was assessed across frequency, intensity, and cumulative burden. Depressive symptoms were evaluated using a four-item screening measure; participants reporting any item were classified as having depressive symptoms. Multivariable logistic regression was used to assess cross-sectional associations, and K-means clustering was used to identify consumption patterns.

Results

Marked regional differences were observed. In Sichuan, daily consumption (68.74% vs. 5.65% in Qingdao) and higher cumulative burden were prevalent. After full adjustment, higher frequency, intensity, and burden were cross-sectionally associated with lower odds of depressive symptoms overall and in Sichuan (e.g., daily: aOR = 0.733, 95% *CI*: 0.586–0.917). In Qingdao, only moderate-frequency consumption (3–5 days/week) showed an inverse association (aOR = 0.324, 95% *CI*: 0.132–0.797). Cluster analysis identified three patterns: Occasional Moderate, Intermediate Mild, and Frequent Intense Consumers. Only Frequent Intense Consumers (predominantly in Sichuan) showed a significant inverse association with depressive symptoms (aOR = 0.803, 95% *CI*: 0.672–0.959).

Conclusion

This cross-sectional study suggests the association between spicy food consumption and depressive symptoms may be context-dependent, shaped by regional dietary culture. In Sichuan, habitual intense consumption was associated with lower odds of depressive symptoms; in Qingdao, only moderate-frequency intake showed an inverse association. These findings suggest that culturally tailored dietary approaches warrant further investigation for mental health promotion.

1. Introduction

Depression is a heterogeneous condition characterized by a spectrum of affective, cognitive, and somatic symptoms, including depressed mood, anhedonia, changes in appetite or weight, sleep disturbances, psychomotor agitation or retardation, fatigue, feelings of worthlessness or guilt, difficulty concentrating, and suicidal ideation[1]. According to the 2023 Global Burden of Disease (GBD) data, depression ranks among three leading causes of disability worldwide[2], and it is projected to become the foremost contributor to the global disease burden by 2030[3]. In China, the prevalence of depression has risen steadily, representing a major public health challenge[4]. The onset and progression of depression are thought to involve a complex interplay of genetic[5], neurobiological[6], psychological[7], and socio-environmental factors[8]. Among these, diet has attracted increasing attention as a modifiable lifestyle factor linked to mental health[9, 10].

In particular, spicy foods—primarily those containing chili peppers—hold a prominent place in Chinese dietary culture. However, evidence regarding their association with mental health, especially depression, remains inconsistent and debated. Capsaicin, the active component in chili peppers, can influence neurotransmitter release (e.g., serotonin and dopamine) and the endorphin system by acting on receptors such as the transient receptor potential vanilloid 1 (TRPV1), thereby exerting dual-directional effects on mood regulation[11, 12]. While moderate consumption has been suggested to temporarily enhance well-being and pleasure [13, 14] and capsaicin has been shown in animal studies to exert antidepressant-like effects[15], other research reports contradictory findings. For example, among Chinese university students, spicy food intake has been positively correlated with symptoms of depression and anxiety[16], and among adults, high chili intake has been associated with cognitive decline[17]. These inconsistencies may stem from variations in study populations, assessment methods for chili intake, and inadequate control for confounding variables. To date, evidence remains inconclusive, and causal relationships have not been established.

China's vast territory and diverse dietary culture lead to substantial regional differences in food choices, seasoning preferences, and eating patterns[18], which may in turn influence how chili intake affects metabolism and systemic regulation[19]. Therefore, when examining the diet–mental health relationship, it is essential to account for regional dietary habits and their cultural underpinnings.

Although several studies have explored the association between spicy food consumption and depression, notable limitations persist. Existing research has largely focused on specific subgroups—such as university students[16], community-dwelling older adults[20], middle school students[21], and adolescent females[22] —lacking more representative, large-scale population data. Moreover, most studies have not sufficiently considered regional variations in Chinese dietary culture, and many have adopted an oversimplified assessment of chili exposure, often relying on a binary measure of consumption without capturing multidimensional aspects such as frequency, preferred spiciness intensity, or sources of chili intake.

To address these gaps, this study analyzed baseline data from the Qingdao and Sichuan populations within the China Kadoorie Biobank (CKB) resource. These two regions were selected for their contrasting dietary cultures, especially regarding spicy food habits. Sichuan Province, in southwestern China, is renowned for its deeply rooted and pervasive spicy food culture, characterized by long-term, frequent, and high-intensity chili consumption[23]. In contrast, Qingdao, a coastal city in eastern Shandong Province, follows a dietary pattern that emphasizes freshness and savory flavors, with spicy food consumption largely driven by modern dietary diffusion, migration, and individual preference[23]. This natural cultural contrast provides an ideal setting to explore the association between spicy food consumption and depressive symptoms, as well as its potential regional heterogeneity.

We examined the characteristics of spicy food consumption in both regions and employed multivariable logistic regression to assess cross-sectional associations between consumption frequency, intensity, cumulative duration, and depressive symptoms. Furthermore, K-means clustering was used to group participants with similar consumption patterns, allowing us to investigate how different profiles relate to depressive symptoms. The findings may help inform dietary strategies for the prevention and management of depression.

2. Method

2.1 Participants

The CKB project is a large prospective cohort comprising approximately 500,000 participants recruited from 10 provinces in China. A detailed description of the project can be found in the relevant literature[24–26]. For this study, baseline data were selected from the Pengzhou (rural) site in Sichuan Province and the Qingdao (urban) site in Shandong Province within the CKB project. We excluded participants who had peptic ulcer (3,297 cases), cancer (273 cases), mental disorders (138 cases), stroke/TIA (507 cases), or neurasthenia (437 cases) at baseline. Ultimately, 86,542 participants were included in the study analysis. All methods were performed in accordance with the relevant guidelines and regulations, including the Declaration of Helsinki. The CKB project obtained ethical approval from the relevant committees, and written informed consent was obtained from all participants.

2.2 Data collection

Well-trained interviewers conducted face-to-face interviews using laptop-based questionnaires. Information collected included sociodemographic characteristics (e.g., occupation, marital status, education level), lifestyle factors (e.g., smoking, alcohol consumption, physical activity), and personal medical history. Physical measurements—including height and weight—were obtained using calibrated instruments following standardized protocols.

2.3 Assessment of spicy food consumption

At baseline, all participants were asked, "In the past month, how often have you consumed spicy food?": never or almost never (1), only occasionally (2), 1–2 days/week (3), 3–5 days/week (4), or daily or almost daily (5). Participants who reported consuming spicy food at least one day per week were further asked about the age at which they started regular spicy food consumption, their preferred spice intensity, and the primary source of spicy food: "At what age did you begin eating spicy food at least once a week?", "What level of spiciness do you usually prefer (weak, moderate, and strong)?" and "What is the main source of your spicy food?" (multiple choices allowed fresh chilli pepper, dried chilli pepper, chilli sauce, chilli oil, and other or don't know) [27]. Additionally, the ratio of years of eating spicy food-to-current age was used as an indicator of a life-long burden of spicy food consumption[28]. The reproducibility of the spicy food consumption assessment has been tested in previous studies, with a Spearman correlation coefficient of 0.71 between the baseline and follow-up surveys[29]. This approach—using single questions to assess specific dietary behaviors—is a standard and widely accepted practice in large-scale epidemiological studies[29, 30].

2.4 Assessment of depressive symptoms

All participants were asked whether they had experienced any of the following symptoms lasting for ≥ 2 weeks within the past 12 months:Feeling more sad or depressed than usual; Losing interest in most activities or hobbies that typically bring you pleasure; Feeling disheartened, even losing appetite for your favorite foods; Feeling worthless and useless, believing all mistakes are your fault, and perceiving life as extremely difficult with no way out.

The present study focused on depressive symptoms rather than clinical diagnosis of major depression. These four screening questions are based on the well-established framework of the WHO Composite International Diagnostic Interview Short-Form (CIDI-SF). The CIDI-SF was developed by the World Health Organization (WHO), with its development and validation published by Kessler et al. (1998) in the International Journal of Methods in Psychiatric Research[31]. The study demonstrated that as few as 3–8 screening questions can accurately identify CIDI-diagnosed cases, with correct classification rates of 77%-100% for cases and 94%-99% for non-cases, and overall classification accuracy exceeding 93% (93% for major depressive episode). The full set of CIDI-SF scales can be administered in an average of 7 minutes, compared to over an hour for the full CIDI. The CIDI-SF employs a "skip-structure" design: only when the cardinal symptoms (sad mood or anhedonia) last for two weeks or more are the remaining seven symptoms assessed. This design allows the CIDI-SF to assess "worst-episode symptoms" in a clinically enriched population. Notably, the Chinese version of the CIDI has been applied and validated in Chinese populations[32–34].

Following the approach of Chen et al. (2017) in a study of 0.5 million Chinese adults[35], participants who answered "yes" to any of the above items were classified as having depressive symptoms (screen-positive), while those who answered "no" to all items were classified as asymptomatic (screen-negative).

The internal consistency reliability of the four screening questions was assessed using Cronbach's alpha, which yielded a value of 0.847, indicating good internal consistency. This simplified approach is appropriate for descriptive analyses of symptom burden in large population-based studies, where the objective is to characterize the distribution of depressive symptoms across populations rather than to establish clinical diagnoses.[35]. In this study, participants who answered “yes” to any of the above items were classified as having depressive symptoms, while those who answered “no” to all items were classified as having no depressive symptoms.

2.5 Assessment of covariates

The baseline questionnaire collected participants' sociodemographic characteristics (age, gender, region, educational level, occupation, marital status, annual household income, health insurance), lifestyle factors (smoking, alcohol consumption, physical activity), and personal health and medical history (including hypertension, diabetes, and heart disease). Stressful events were primarily assessed by asking participants whether they had experienced any events with a significant impact on their lives in the past two years (e.g., marital separation/divorce, severe family conflicts, death of a spouse, loss of financial resources/heavy debt burden, unemployment/layoff/retirement, bankruptcy of a self-owned business or family finances, experiencing violence/sexual assault, severe trauma or car accidents, and major natural disasters). Participants who answered "yes" to any of the above stressful events were considered to have experienced stressful events, whereas those who answered "no" were considered to have not experienced such events.

Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared (kg/m²). In our study, participants were categorized into four groups based on their BMI (< 18.5, 18.5–23.9, 24.0–27.9, ≥ 28.0), corresponding to underweight, normal weight, overweight, and obese, respectively.

2.6 Statistical analysis

Data cleaning and statistical analyses were performed using SPSS (version 26.0). Data visualization was conducted with R software (version 4.4.1). Categorical variables are presented as counts (percentages), and continuous variables are presented as medians (P_{25}, P_{75}). Since the Kolmogorov-Smirnov test indicated that neither age nor spicy food burden followed a normal distribution (both $P < 0.001$), comparisons of continuous variables between the two regions were performed using the Mann-Whitney U test. Categorical variables were compared using the chi-square test. First, binary logistic regression was used to estimate crude odds ratios (ORs) and 95% confidence intervals (CIs) for the association between spicy food consumption and depressive symptoms. Subsequently, multiple logistic regression models were constructed with sequential adjustment for prespecified potential confounders based on prior literature and clinical plausibility: **Model 1** was unadjusted; **Model 2** adjusted for age, gender, education level, marital status, occupation, annual household income, and health insurance; **Model 3** additionally adjusted for smoking, alcohol consumption, and physical activity; **Model 4** further adjusted for stressful events, chronic diseases, and BMI.

Finally, K-means cluster analysis was performed to identify consumption patterns among regular spicy food consumers (frequency ≥ 1–2 days/week). K-means is an iterative partitioning procedure that attempts to group the data into k clusters in such a way as to maximize the overall R^2 value, defined as $R^2 = 1\text{-}W/T$, where W is the sum of squared Euclidean distances between each data point and its within-cluster

mean (or center), and T is the sum of squared distances between each data point and the overall mean[36].The k-means methodology is recommended when working with large data sets, and has previously been used in a large number of diet-chronic disease studies[37]. The cluster analysis was performed based on three standardized dimensions (Z-scores): consumption frequency, intensity, and burden (calculated as the ratio of years of consumption to age). Clustering tendency was formally assessed using the Hopkins statistic, with values > 0.5 indicating non-random structure suitable for clustering. The optimal number of clusters was determined using the elbow method by comparing the within-cluster sum of squares (WCSS) for K = 2 through K = 5, selecting the K value corresponding to the elbow point. To mitigate the risk of suboptimal solutions due to random initial center selection, the algorithm was run 100 times with random initial seeds, and the solution with the smallest WCSS was retained. Cluster stability was assessed by calculating the Adjusted Rand Index (ARI) using bootstrap resampling. Stratified analyses were conducted to examine subgroup differences. A two-sided $P < 0.05$ was considered statistically significant.

To examine the possibility of reverse causality, we conducted supplementary analyses with spicy food consumption characteristics (high-frequency consumption: ≥3–5 days/week; moderate-to-strong strength preference: moderate or strong spiciness; original values of spicy food burden, continuous variable) as dependent variables and depressive symptoms as the independent variable, adjusting for the same set of covariates as in the main analysis. Binary logistic regression was used for frequency and strength, and linear regression was used for burden. Analyses were performed using unadjusted (Model 1) and fully adjusted (Model 2, adjusting for all covariates) models, with results presented as OR or β with 95% *CI*.

3. Results

3.1 Baseline characteristics of participants

A total of 86,542 participants aged 30–79 years (mean age 51.12 years) were included, comprising 52,056 (60.15%) from Sichuan and 34,486 (39.85%) from Qingdao. As shown in Table 1, significant differences ($P < 0.001$) were observed between the two regions across all demographic, socioeconomic, and lifestyle characteristics.

Striking regional disparities were evident in spicy food consumption patterns. Daily or almost daily consumption was reported by 68.74% of Sichuan participants but only 5.65% of those in Qingdao ($P < 0.001$). Conversely, 80.49% of Qingdao residents reported never or only occasional consumption, compared with 22.18% in Sichuan. Among regular consumers (≥ 1 day/week), Sichuan participants had a significantly higher lifelong spicy food burden (years-of-eating-spicy-food-to-age ratio: [0.84(0.79,0.88)]) than those in Qingdao ([0.52(0.33,0.64)], $P < 0.001$). Although intensity preferences differed less markedly, a higher proportion of Sichuan residents preferred strong spiciness (20.22% vs. 17.08%, $P < 0.001$). Notable differences also emerged in commonly used spice types: Sichuan consumers predominantly used chili sauce (99.13% vs. 73.74%) and chili oil (78.96% vs. 50.26%), whereas Qingdao residents more frequently used dried chili pepper (81.47% vs. 54.23%) and fresh chili pepper (88.17% vs. 72.53%).

To further identify which specific categories within each categorical variable differed significantly between the two regions, standardized residual analysis (adjusted residuals) was performed for chi-square tests with degrees of freedom > 1, with adjusted residuals > |3.29| considered statistically significant at $P < 0.001$, following Sharpe [38]. The results showed significant distributional differences across education level, occupation type, household income, number of chronic diseases, smoking and alcohol consumption status, physical activity level, BMI category, and spicy food consumption frequency and intensity (complete results presented in Table 1 footnote).

Table 1
Baseline characteristics and spicy food consumption of the participants

Baseline characteristic	Total (N = 86542)	Qingdao (Urban) (N = 34486)	Sichuan (Rural) (N = 52056)	*Z*/χ2	*P*
Age, M (P_{25}, P_{75}), years	50.64(42.30,58.41)	49.40(42.55,57.25)	51.56(42.10,59.05)	-11.500	< 0.001
Gender, n (%)				288.029	< 0.001
Male	34867(40.29)	15093(43.77)	19774(37.99)		
Female	51675(59.71)	19393(56.23)	32282(62.01)		
Education level, n (%)				15096.174	< 0.001
Primary school or below	41851(48.36)	7949(23.05)	33902(65.13)		
Middle school/ High school	40352(46.63)	23355(67.72)	16997(32.65)		
College / Associate degree or above	4339(5.01)	3182(9.23)	1157(2.22)		
Marital status				85.181	< 0.001
Married	79113(91.42)	31898(92.50)	47215(90.70)		
Widowed/Separated/Divorced/Single	7429(8.58)	2588(7.50)	4841(9.30)		
occupation				24531.881	< 0.001
Agriculture/Industry	60873(70.34)	14194(41.16)	46679(89.67)		
Administration/Professional/Technical/Sales	6156(7.11)	4110(11.92)	2046(3.93)		
Self-employed/Other unspecified	1117(1.29)	530(1.54)	587(1.13)		
Unemployed/Retired/Not in labor force	18396(21.26)	15652(45.39)	2744(5.27)		
Household income (RMB)				33927.632	< 0.001
< 10000	35221(40.70)	2691(7.80)	32530(62.49)		
10000–19999	25906(29.93)	11050(32.04)	14856(28.54)		
20000–34999	17923(20.71)	14975(43.42)	2948(5.66)		
≥ 35000	7492(8.66)	5770(16.73)	1722(3.31)		
Health insurance				4005.404	< 0.001
No	13466(15.56)	2062(5.98)	11404(21.91)		
Yes	73076(84.44)	32424(94.02)	40652(78.09)		
Stressful events				499.004	< 0.001
No	83522(96.51)	33873(98.22)	49649(95.38)		
Yes	3020(3.49)	613(1.78)	2407(4.62)		
Chronic diseases				2740.511	< 0.001

* Participants who consumed spicy food ≥1days/week

Note: Continuous variables were compared using the Mann-Whitney U test, and categorical variables were compared using the χ^2 test. Standardized residual analysis (adjusted residuals) was performed for chi-square tests with degrees of freedom > 1 to identify specific categories with significant differences between the two regions.

Baseline characteristic	Total (N = 86542)	Qingdao (Urban) (N = 34486)	Sichuan (Rural) (N = 52056)	*Z*/χ2	*P*
0	76331(88.20)	28191(81.75)	48140(92.48)		
1	8421(9.73)	4802(13.92)	3619(6.95)		
2	1535(1.77)	1251(3.63)	284(0.55)		
3	255(0.29)	242(0.70)	13(0.02)		
Smoking status				285.907	< 0.001
Never/Occasionally	55327(63.93)	23101(66.99)	32226(61.91)		
Former smoker	5750(6.64)	2343(6.79)	3407(6.54)		
Smoker	25465(29.43)	9042(26.22)	16423(31.55)		
Alcohol consumption				56.113	< 0.001
Never	31991(36.97)	12564(36.43)	19427(37.32)		
Occasionally	34677(40.07)	14321(41.53)	20356(39.10)		
Regularly	19874(22.96)	7601(22.04)	12273(23.58)		
Physical activity				9778.618	< 0.001
Never or almost never	65320(75.48)	19907(57.72)	45413(87.24)		
≤ Twice a week	6218(7.18)	4402(12.76)	1816(3.49)		
≥Three times a week	15004(17.34)	10177(29.51)	4827(9.27)		
BMI				8121.594	< 0.001
Underweight	2482(2.87)	253(0.73)	2229(4.28)		
Normal weight	40617(46.93)	10950(31.75)	29667(56.99)		
Overweight	30864(35.66)	15099(43.78)	15765(30.28)		
Obese	12579(14.54)	8184(23.73)	4395(8.44)		
Depressive symptoms				582.327	< 0.001
No	84885(98.09)	34302(99.47)	50583(97.17)		
Yes	1657(1.91)	184(0.53)	1473(2.83)		
Frequency of spicy food consumption				34999.613	< 0.001
Never or almost never/Only occasionally	39302(45.41)	27757(80.49)	11545(22.18)		
1-2days/week	5204(6.01)	2859(8.29)	2345(4.50)		
3-5days/week	4303(4.97)	1920(5.57)	2383(4.58)		
Daily or almost daily	37733(43.60)	1950(5.65)	35783(68.74)		

* Participants who consumed spicy food ≥1days/week

Note: Continuous variables were compared using the Mann-Whitney U test, and categorical variables were compared using the χ^2 test. Standardized residual analysis (adjusted residuals) was performed for chi-square tests with degrees of freedom > 1 to identify specific categories with significant differences between the two regions.

Baseline characteristic	Total (N = 86542)	Qingdao (Urban) (N = 34486)	Sichuan (Rural) (N = 52056)	*Z*/χ2	*P*
Years of eating spicy food-to-age ratio* M (P_{25}, P_{75})	0.83(0.74,0.87)	0.52(0.33,0.64)	0.84(0.79,0.88)	-112.212	< 0.001
Strength of spicy food consumption*				230.410	< 0.001
Weak	15879(33.61)	2806(41.70)	13073(32.27)		
Moderate	22022(46.62)	2774(41.22)	19248(47.51)		
Strong	9339(19.77)	1149(17.08)	8190(20.22)		
Commonly used types of spices *				2802.406	< 0.001
Chilli sauce	45121(95.51)	4962(73.74)	40159(99.13)		
Chilli oil	35371(74.88)	3382(50.26)	31989(78.96)		
Dried chilli pepper	27450(58.11)	5482(81.47)	21968(54.23)		
Fresh chilli pepper	35316(74.76)	5933(88.17)	29383(72.53)		
Other or don't know	19824(41.96)	1383(22.20)	18441(45.52)		

* Participants who consumed spicy food ≥1days/week

Note: Continuous variables were compared using the Mann-Whitney U test, and categorical variables were compared using the χ^2 test. Standardized residual analysis (adjusted residuals) was performed for chi-square tests with degrees of freedom > 1 to identify specific categories with significant differences between the two regions.

Qingdao participants were significantly overrepresented in the categories of: middle/high school education (101.3), college/associate degree or above (46.2), administration/professional/technical/sales occupations (44.8), self-employed/other unspecified occupations (5.2), unemployed/retired/not in labor force (141.2), household income 10,000–19,999 RMB (11.0), 20,000–34,999 RMB (134.2), ≥ 35,000 RMB (68.8), 1 chronic disease (33.9), 2 chronic diseases (33.6), 3 chronic diseases (18.0), never/occasional smoker (15.2), occasional alcohol consumption (7.1), physical activity ≤ 2 times/week (51.7), ≥ 3 times/week (77.0), overweight (40.6), obese (62.5), never/occasional spicy food consumption (168.7), 1–2 days/week spicy food consumption (22.9), 3–5 days/week spicy food consumption (6.6) and Weak spiciness strength (15.2).

Sichuan participants were significantly overrepresented in the categories of: primary education or below (121.3), agricultural occupations (153.0), household income < 10,000 RMB (160.3), 0 chronic diseases (47.9), smoker (16.8), never or almost never physical activity (98.8), underweight (30.6), normal weight (72.8), daily or almost daily spicy food consumption (183.2), moderate spiciness strength (9.6) and strong spiciness strength (6.0).

For 2×2 tables (gender, marital status, health insurance, stressful events, depressive symptoms), residual analysis was not performed as the chi-square test itself can identify the source of differences.

3.2 Association of spicy food consumption and depression symptoms

After full adjustment for confounders (Table 2, Model 4), multivariable logistic regression showed cross-sectional inverse associations between all three dimensions of spicy food consumption—frequency, intensity, and cumulative burden—and depressive symptoms in the total population, with significant regional heterogeneity.

Among all consumers (participants who consumed spicy food ≥1days/week), compared to participants consuming spicy food 1–2 days/week, those consuming it 3–5 days/week (adjusted odds ratio [aOR] = 0.658, 95%*CI*: 0.486–0.892) or daily/almost daily (aOR = 0.731, 95% *CI*: 0.593-0.900) had significantly lower odds of depressive symptoms (Nagelkerke R^2 = 0.142). With regard to spicy food intensity, participants preferring moderate (aOR = 0.820, 95% *CI*: 0.719–0.934) and strong (aOR = 0.677, 95% CI: 0.568–0.807) intensities had significantly lower odds of depressive symptoms compared to those preferring weak intensity (Nagelkerke R^2 = 0.143). Moreover, each unit increase in the spicy food burden was cross-sectionally associated with a 54% lower odds of depressive symptoms (aOR = 0.463, 95% *CI*: 0.289–0.741). The Nagelkerke R^2 for the fully adjusted model (Model 4) was 0.142.

However, region-stratified analyses revealed significant heterogeneity. In the traditional spicy-food-consuming region of Sichuan (rural), robust inverse associations were observed for daily/almost daily consumption (aOR = 0.733, 95% *CI*: 0.586–0.917, Nagelkerke R^2 = 0.135), preference for moderate (aOR = 0.817, 95% *CI*: 0.715–0.934) and strong (aOR = 0.671, 95% *CI*: 0.561–0.803) spicy food intensity (Nagelkerke R^2 = 0.136), and higher spicy food burden (aOR = 0.373, 95% *CI*: 0.227–0.612, Nagelkerke R^2 = 0.136). In contrast, in the non-traditional spicy-food-consuming region of Qingdao (urban), only consumption of spicy food 3–5 days/week was associated with reduced odds of depressive symptoms (aOR = 0.324, 95% *CI*: 0.132–0.797, Nagelkerke R^2 = 0.131), while no significant associations were found for daily consumption, spicy food intensity preference, or spicy food burden (Table 2).

Table 2
Association of spicy food consumption and depression symptoms

	aOR (95%*CI*)				Nagelkerke R^2	*P* (Model 4)
	Model 1	**Model 2**	**Model 3**	**Model 4**	**(Model 4)**	
Frequency of spicy food consumption						
Total						
1–2 days/week	Ref	Ref	Ref	Ref	0.142	< 0.001
3–5 days/week	**0.697(0.520, 0.935)** *	**0.654(0.486, 0.881)** **	**0.658(0.489, 0.886)** **	**0.658(0.486, 0.892)** **		
Daily or almost daily	1.177(0.975, 1.421)	**0.732(0.597, 0.896)** **	**0.739(0.603, 0.905)** **	**0.731(0.593, 0.900)** **		
Sichuan[a]						
1–2 days/week	Ref	Ref	Ref	Ref	0.135	< 0.001
3–5 days/week	**0.660(0.480, 0.907)** *	**0.716(0.519, 0.987)** *	**0.720(0.522, 0.993)** *	0.735(0.528, 1.022)		
Daily or almost daily	**0.691(0.559, 0.855)** ***	**0.731(0.589, 0.908)** **	**0.738(0.594, 0.917)** **	**0.733(0.586, 0.917)** **		
Qingdao[a]						
1–2 days/week	Ref	Ref	Ref	Ref	0.131	< 0.001
3–5 days/week	**0.329(0.135, 0.798)** *	**0.345(0.141, 0.839)** *	**0.348(0.143, 0.848)** *	**0.324(0.132, 0.797)** *		
Daily or almost daily	0.977(0.537, 1.779)	0.885(0.482, 1.626)	0.881(0.479, 1.620)	0.901(0.483, 1.682)		
Strength of spicy food consumption						
Total						
Weak	Ref	Ref	Ref	Ref	0.143	< 0.001
Moderate	**0.854(0.754, 0.966)** *	**0.806(0.710, 0.914)** ***	**0.809(0.713, 0.919)** **	**0.820(0.719, 0.934)** **		
Strong	**0.737(0.625, 0.869)**	**0.659(0.556, 0.780)** ***	**0.660(0.556, 0.783)** ***	**0.677(0.568, 0.807)** ***		
Sichuan[a]						
Weak	Ref	Ref	Ref	Ref	0.136	< 0.001
Moderate	**0.819(0.721, 0.929)** **	**0.805(0.708, 0.916)** **	**0.808(0.709, 0.920)** **	**0.817(0.715, 0.934)** **		
Strong	**0.704(0.595, 0.833)** ***	**0.655(0.551, 0.778)** ***	**0.655(0.550, 0.780)** ***	**0.671(0.561, 0.803)** ***		
Qingdao[a]						
Weak	Ref	Ref	Ref	Ref	0.119	< 0.001
Moderate	0.762(0.422, 1.396)	0.732(0.399, 1.345)	0.731(0.398, 1.344)	0.768(0.414, 1.426)		
Strong	0.682(0.294, 1.581)	0.611(0.260, 1.432)	0.632(0.269, 1.483)	0.676(0.285, 1.605)		
Years of eating spicy food-to-age ratio						

	aOR (95%*CI*)				Nagelkerke R^2	*P* (Model 4)
	Model 1	**Model 2**	**Model 3**	**Model 4**	**(Model 4)**	
Total	**1.785(1.239, 2.571)** **	**0.500(0.315, 0.793)** **	**0.498(0.314, 0.791)** **	**0.463(0.289, 0.741)** **	0.142	< 0.001
Sichuan[a]	**0.217(0.140, 0.336)** ***	**0.419(0.258, 0.679)** ***	**0.417(0.257, 0.677)** ***	**0.373(0.227, 0.612)** ***	0.136	< 0.001
Qingdao[a]	1.663(0.457, 6.057)	1.357(0.385, 4.789)	1.418(0.400, 5.027)	1.523(0.426, 5.442)	0.118	< 0.001

Model 1: original model without any adjustments.

Model 2: adjusted for age, gender (male or female), region (Qingdao or Sichuan), education level (Primary school or below, Middle school/ High school, College / Associate degree or above), marital status (Married, Widowed/Separated/Divorced/Single), occupation (Agriculture/Industry, Administration/Professional/Technical/Sales, Self-employed/Other unspecified, Unemployed/Retired/Not in labor force), household income (< 10000, 10000–19999, 20000–34999, ≥ 35000), health insurance (No or Yes).

Model 3: adjusted for Model 2 plus smoking status (Never/Occasionally, Former, Smoker), alcohol consumption (Never, Occasionally, Regularly), physical activity (Never or almost never, ≤ Twice a week, ≥Three times a week).

Model 4: adjusted for Model 3 plus stressful events (No or Yes), chronic diseases (0, 1, 2, 3), BMI (Underweight, Normal weight, Overweight, Obese).

[a] without adjustment for region.

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$.

3.3 Cluster Analysis of Spicy Food Consumption Patterns

Clustering tendency was assessed using the Hopkins statistic, which yielded a value of 0.9871 (95% *CI*: 0.9864–0.9879), above the 0.5 threshold, indicating a moderately strong non-random structure reasonably suitable for clustering.

The elbow method was applied to determine the optimal number of clusters by comparing within-cluster sum of squares (WCSS) for K = 2 through K = 5. The WCSS values were 1.8274, 1.4348, 1.2726, and 0.7842 for K = 2, 3, 4, and 5, respectively. The reduction in WCSS slowed markedly beyond K = 3, with the relative decrease dropping from 21.5% (K = 2 to K = 3) to 11.3% (K = 3 to K = 4), supporting a three-cluster solution as the most parsimonious and interpretable model in the present data (Fig. 1).

To mitigate the risk of suboptimal solutions due to random initial center selection[39], the algorithm was run 100 times with random initial seeds, and the solution with the smallest within-cluster sum of squares was retained. Cluster stability was assessed using 100 bootstrap resamples, yielding a mean Adjusted Rand Index (ARI) of 0.9936 (95% *CI*: 0.9928–0.9945) between the original clustering and the resampled clusterings, indicating good cluster stability.

The final clusters were significantly differentiated across all three dimensions (all $P < 0.001$) and exhibited marked geographic distributions (Fig. 2). In Qingdao, Cluster 1 (Occasional Moderate Consumers) accounted for 35.99% (n = 2,442), Cluster 2 (Intermediate Mild Consumers) accounted for 45.73% (n = 3,077), and Cluster 3 (Frequent Intense Consumers) accounted for 18.28% (n = 1,230). In Sichuan, Cluster 1 accounted for 10.32% (n = 4,179), Cluster 2 for 2.25% (n = 913), and Cluster 3 for 87.43% (n = 35,419).

To visually illustrate the differences among the three clusters across the three clustering variables (spicy food consumption frequency, strength, and burden), a cluster profile plot was constructed (Fig. 3).

Cluster 1

Occasional Moderate Consumers (n = 6,601, 13.97%) showed the lowest consumption frequency, a preference for mild spiciness, and a near-average burden.

Cluster 2

Intermediate Mild Consumers (n = 3,990, 8.45%) were characterized by an extremely low consumption burden, below-average frequency, and low-to-moderate intensity.

Cluster3

Frequent Intense Consumers (n = 36,649,77.58%) displayed higher-than-average scores across all dimensions, most notably high frequency, moderate-to-high intensity, and an elevated burden.

The clustering solution explained 42.0% of the total variance in consumption patterns, and all pairwise between-cluster differences were statistically significant (Tukey's post-hoc test, $P < 0.001$ for each dimension).

3.4 Reverse causality analysis

The results of the reverse causality analysis are presented in eTable 3. In the fully adjusted models, individuals with depressive symptoms had lower odds of high-frequency spicy food consumption (aOR = 0.730, 95% *CI*: 0.598–0.892), lower odds of moderate-to-strong strength preference (aOR = 0.776, 95% *CI*: 0.689–0.874), and lower spicy food burden (β=-0.009, 95% *CI*: -0.017 to -0.003) compared to those without depressive symptoms. In region-stratified analyses, no significant associations were observed in Qingdao across any dimension (all $P > 0.05$); in Sichuan, the direction of the reverse analyses was consistent with the main analyses, and the effect estimates did not exceed those from the main analyses.

3.5 Association between Spicy Food Consumption Patterns and Depressive Symptoms

Following the identification of three distinct spicy food consumption clusters, we examined their associations with depressive symptoms using multivariable logistic regression (Table 3). In the fully adjusted model (Model 4, Nagelkerke $R^2 = 0.142$), compared to Occasional Moderate Consumers (Cluster 1), Frequent Intense Consumers (Cluster 3) showed a significant cross-sectional inverse association with depressive symptoms in the total population (aOR = 0.803, 95% *CI*: 0.672–0.959). No significant association was observed for Intermediate Mild Consumers (Cluster 2, aOR = 1.068, 95% *CI*: 0.777–1.467). The overall association across clusters was statistically significant ($P < 0.001$).

Regional stratified analyses revealed notable heterogeneity. In Qingdao, neither Intermediate Mild Consumers (aOR = 0.826, 95% *CI*: 0.438–1.558) nor Frequent Intense Consumers (aOR = 0.924, 95% *CI*: 0.420–2.030) showed a significant association with depressive symptoms compared to Occasional Moderate Consumers. In contrast, in Sichuan, Frequent Intense Consumers exhibited a consistent inverse association across all adjusted models, with an 18% reduction in odds of depressive symptoms in the fully adjusted model (aOR = 0.816, 95% *CI*: 0.678–0.982). Intermediate Mild Consumers in Sichuan did not show a significant association (aOR = 1.248, 95% *CI*: 0.870–1.789). The Nagelkerke R^2 for the fully adjusted model (Model 4) was 0.135.

The adjustment for covariates meaningfully influenced the observed associations, particularly for Frequent Intense Consumers (Cluster 3). In the unadjusted model (Model 1), this cluster showed no significant association in the total population (OR = 1.109, 95% *CI*: 0.939–1.309). After accounting for demographic and socioeconomic factors (Model 2), a significant inverse association emerged (aOR = 0.816, 95% *CI*: 0.687–0.970), suggesting potential confounding by these variables. Further adjustment for lifestyle and health-related factors (Models 3 and 4) did not substantially alter this association, suggesting the consistency of the observed inverse association observed for Frequent Intense Consumers, particularly in the Sichuan population.

Table 3
Association between Spicy Food Consumption Patterns and Depressive Symptoms

	aOR (95% *CI*)				Nagelkerke R^2	*P*
	Model 1	**Model 2**	**Model 3**	**Model 4**	**(Model 4)**	**(Model4)**
Patterns						
Total						
Occasional Moderate Consumers	Ref	Ref	Ref	Ref	0.142	< 0.001
Intermediate Mild Consumers	**0.642(0.939, 1.309)****	1.003(0.736, 1.366)	1.007(0.739, 1.372)	1.068(0.777, 1.467)		
Frequent Intense Consumers	1.109(0.939, 1.309)	**0.816(0.687, 0.970)***	**0.823(0.692, 0.978)***	**0.803(0.672, 0.959)***		
Sichuan[a]						
Occasional Moderate Consumers	Ref	Ref	Ref	Ref	0.135	< 0.001
Intermediate Mild Consumers	1.399(0.991, 1.975)	1.118(0.787, 1.588)	1.125(0.791, 1.598)	1.248(0.870, 1.789)		
Frequent Intense Consumers	**0.810(0.679, 0.966)***	**0.824(0.688, 0.986)***	**0.830(0.693, 0.994)***	**0.816(0.678, 0.982)***		
Qingdao[a]						
Occasional Moderate Consumers	Ref	Ref	Ref	Ref	0.118	< 0.001
Intermediate Mild Consumers	0.825(0.446, 1.526)	0.842(0.452, 1.569)	0.840(0.451, 1.567)	0.826(0.438, 1.558)		
Frequent Intense Consumers	0.984(0.459, 2.110)	0.893(0.413, 1.932)	0.903(0.417, 1.954)	0.924(0.420, 2.030)		

Model 1: original model without any adjustments.

Model 2: adjusted for age, gender (male or female), region (Qingdao or Sichuan), education level (Primary school or below, Middle school/ High school, College / Associate degree or above), marital status (Married, Widowed/Separated/Divorced/Single), occupation(Agriculture/Industry, Administration/Professional/Technical/Sales, Self-employed/Other unspecified, Unemployed/Retired/Not in labor force), household income (< 10000, 10000–19999, 20000–34999, ≥ 35000), health insurance (No or Yes).

Model 3: adjusted for Model 2 plus smoking status (Never/Occasionally, Former, Smoker), alcohol consumption (Never, Occasionally, Regularly), physical activity(Never or almost never, ≤ Twice a week, ≥Three times a week).

Model 4: adjusted for Model 3 plus stressful events(No or Yes), chronic diseases(0, 1, 2, 3), BMI (Underweight, Normal weight, Overweight, Obese).

[a] without adjustment for region. $^{*}P < 0.05$, $^{**}P < 0.01$, $^{***}P < 0.001$.

4. Discussion

To our knowledge, this is the first large-scale population-based study to examine the association between spicy food consumption characteristics and depressive symptoms across two distinct dietary cultural regions in China. Our findings reveal significant regional heterogeneity, providing cross-sectional evidence of regional differences in these associations.

Specifically, in the traditional high-spicy-food-consumption region (Sichuan), higher frequency, greater intensity, and higher cumulative burden of spicy food intake were consistently cross-sectionally associated with lower odds of depressive symptoms. In contrast, in the non-traditional spicy-food-consumption region (Qingdao), only moderate-frequency consumption (3–5 days/week) demonstrated a cross-sectional inverse association, while no significant associations were observed for spicy food intensity or cumulative burden. Furthermore,

cluster analysis identified three distinct spicy food consumption patterns—Occasional Moderate Consumers, Intermediate Mild Consumers, and Frequent Intense Consumers. Among these, only the Frequent Intense Consumers showed a cross-sectionally significant inverse association with depressive symptoms in Sichuan, whereas no such association was observed in Qingdao.

The present study selected Sichuan Province rather than Hunan Province as the representative traditional spicy-food-consuming region for comparison with Qingdao based on several considerations. First, although Hunan Province has an even higher prevalence of spicy food consumption (99.4% daily consumers)[28], the aim of this study was not merely to compare "high" versus "low" consumption, but to examine dose-response relationships across different frequency levels (never/occasional, 1-2 days/week, 3-5 days/week, daily). The Sichuan population exhibits a relatively dispersed distribution of consumption frequency, whereas Hunan's consumption prevalence approaches 100%, with limited internal variability, which would preclude meaningful examination of dose-response effects. Second, selecting Sichuan ensures comparability with previous CKB studies. Multiple CKB studies have used Sichuan as a representative high-consumption region [28, 29], facilitating direct comparison with prior literature. Third, Sichuan's distinct "numbing-spicy" (mala) flavor profile provides a highly recognizable cultural contrast with Qingdao's coastal cuisine (emphasizing fresh and savory flavors), helping to highlight the potential influence of dietary culture on health outcomes.

The findings of the present study are consistent with a subset of prior research. For instance, a cross-sectional study of Chinese community-dwelling adults aged ≥ 40 years reported that moderate capsaicin intake was associated with lower blood amyloid-β (Aβ) levels and better cognitive performance[40]. That study suggested that capsaicin may confer neuroprotective benefits through mechanisms such as anti-inflammatory and antioxidant effects, as well as by upregulating brain-derived neurotrophic factor expression. Although that study focused on cognitive function rather than depressive symptoms, its mechanistic insights align with those proposed in the current work. However, some findings appear inconsistent with ours. For example, Zhang et al. [16]reported a positive association between spicy food intake and symptoms of depression/anxiety among Chinese university students—a result that seems contradictory to the inverse association we observed in Sichuan. This discrepancy may stem from differences in study populations: university students face unique academic and social pressures, and their dietary choices may be more susceptible to emotional eating, wherein distress drives the seeking of high-intensity sensory stimulation. In contrast, our study was based on a broader, more stable community-based adult population and emphasized long-term dietary habits and cultural context. Thus, the underlying mechanisms linking spicy food intake to mental health outcomes may differ between these population groups.

The reversal of associations between unadjusted and adjusted models—where Intermediate Mild Consumers appeared protective in the unadjusted analysis, but Frequent Intense Consumers became protective only after adjustment for demographic and socioeconomic factors—suggests that these factors substantially confound the relationship between spicy food consumption patterns and depressive symptoms. In addition, the highly imbalanced cluster distribution in Sichuan (87.43% Frequent Intense Consumers vs. 2.25% Intermediate Mild Consumers) may limit statistical power to detect associations for the smaller group; the non-significant findings for Intermediate Mild Consumers in Sichuan likely reflect limited sample size (n = 913) rather than a genuine absence of association. By contrast, in Qingdao—where cluster distribution was more balanced—no significant differences were observed between clusters, suggesting that the association between spicy food consumption patterns and depressive symptoms may be less pronounced in non-traditional spicy food regions, possibly due to the lack of long-term adaptation to capsaicin and the absence of deeply embedded spicy food culture.

Notably, the present study reveals significant geographical variation in the association between spicy food consumption and depressive symptoms. In Sichuan, a region with a traditional spicy dietary culture, the humid climate and culinary practices have led to early-life initiation and long-term adaptation to capsaicin exposure among local residents. This chronic exposure may induce capsaicin desensitization[41], enhance metabolic efficiency, and reduce adverse physiological responses to capsaicin stimulation—such as oral burning sensation, gastrointestinal distress, or systemic stress reactions—potentially maximizing its mood-beneficial effects[11]. Furthermore, capsaicin consumption may directly activate central reward pathways, stimulating brain regions including the anterior insula and anterior cingulate cortex[42]. This promotes the release of dopamine and endogenous opioids (e.g., endorphins), generating a distinctive sensory experience often described as “pleasurable pain” or “benign masochism.” This neurochemical response can elicit a euphoric state analogous to that induced by physical exercise, thereby potentially contributing to observed mood-related associations [43].

An unexpected finding was that the inverse association for moderate-frequency consumption (3–5 days/week) in Qingdao (aOR = 0.324, 95% *CI*: 0.132–0.797) was substantially stronger in magnitude than the associations observed in Sichuan, where daily consumption conferred an approximately 27% reduction (aOR = 0.733, 95% *CI*: 0.586–0.917). This observation may be explained by considering threshold effects and capsaicin bioavailability. Lv et al. [29] reported a threshold effect in the association between spicy food consumption and mortality, suggesting that benefits plateau beyond a frequency of 1–2 days per week. Applied to our study, this threshold effect could imply that moderate consumption (3-5days/week) in a non-adapted population (Qingdao) may provide sufficient capsaicin stimulation to activate endogenous reward pathways without reaching levels that could induce adverse gastrointestinal effects or desensitization.

Furthermore, differences in capsaicin bioaccessibility and bioavailability between populations may contribute to the observed regional variation. Bioaccessibility refers to the proportion of capsaicin released from the food matrix during digestion, while bioavailability refers to the proportion absorbed and reaching systemic circulation. Long-term habitual consumers (e.g., Sichuan population) may develop physiological adaptations that alter capsaicin absorption and metabolism, potentially reducing its bioavailability or leading to receptor desensitization. Conversely, in non-adapted populations (Qingdao), even moderate capsaicin exposure may achieve higher relative bioavailability, producing a more pronounced physiological response. These mechanisms, while speculative, offer plausible explanations for the observed pattern and warrant investigation in future pharmacokinetic studies.

In contrast, Qingdao—a non-traditional spicy-food-consumption region—features distinct seasonal variations in climate. Its cuisine centers on seafood and emphasizes the natural flavors of ingredients; consequently, chili peppers have not been integrated into the mainstream culinary tradition. Our study found that among Qingdao participants, only moderate-frequency spicy food consumers exhibited a reduced risk of depressive symptoms. Moderate-frequency intake may provide a level of capsaicin stimulation sufficient to activate endogenous reward pathways (e.g., promoting endorphin release), while avoiding the adverse physiological reactions that could result from excessive frequency or intensity of exposure[44–46]. Given the lack of long-term adaptive exposure beginning in early life, individuals in Qingdao likely exhibit lower metabolic efficiency and physiological tolerance to capsaicin. Conversely, infrequent (occasional) consumption may deliver insufficient stimulus to effectively engage mood-regulatory pathways[47]. These observations collectively suggest that moderate-frequency intake may represent a level of consumption associated with lower odds of depressive symptoms in populations without a historical background of habitual spicy food consumption, whereas lower or higher frequencies were not significantly associated with depressive symptoms in this group.

The four screening questions used in this study are grounded in the well-established WHO CIDI-SF framework, which has demonstrated good classification accuracy and allows for the assessment of "worst-episode symptoms" in clinically enriched populations[31]. It is also important to recognize that depressive symptoms are not a unitary phenomenon. As highlighted by Fried (2015)[48], depression is not a consistent syndrome with clearly demarcated boundaries, and depression symptoms are not interchangeable indicators of an underlying disorder. Specific depressive symptoms—such as sad mood, insomnia, concentration problems, and suicidal ideation—are distinct phenomena that differ in important dimensions, including their underlying biology, impact on functional impairment, and associated risk factors. Symptoms have direct causal influence on each other: insomnia can cause fatigue which then triggers concentration and psychomotor problems. In the context of our study, the four screening questions assessed (sadness, anhedonia, hopelessness, worthlessness) represent a subset of the depressive symptom spectrum. Future studies with more comprehensive symptom assessments are needed to determine whether spicy food consumption is differentially associated with specific symptom clusters rather than with depressive symptomatology as a whole.

Furthermore, as discussed by Chen et al. (2017)[35], mood disorders such as major depressive episode should be viewed as a continuum rather than a dichotomous condition, and "depressive symptoms" may be considered as a pre-MDE status. Future studies should examine whether early intervention in people with depressive symptoms could prevent progression to MDE.

Nevertheless, the mechanisms underlying the association between spicy food consumption and psychological symptoms remain incompletely understood. The observed inverse associations may be partially attributed to the biological activity of capsaicin, the primary bioactive component in chili peppers[49]. Capsaicin acts on the transient receptor potential vanilloid 1 (TRPV1) receptor[50], which can promote the release of endorphins and other endogenous opioids, thereby potentially eliciting positive mood states and alleviating perceived stress[51]. Furthermore, capsaicin exhibits anti-inflammatory properties by suppressing the expression of pro-inflammatory genes or proteins[52, 53], which may buffer against the development of depression[54]. In addition, chronic capsaicin exposure may enhance neuroplasticity by upregulating brain-derived neurotrophic factor (BDNF) expression[55], particularly in brain regions critical for mood regulation and cognitive function, such as the hippocampus and prefrontal cortex. From a psychological perspective, the benign masochism theory posits that, within a safe context, individuals voluntarily seek controllable "painful" stimuli to activate the neural reward system, thereby converting physiological nociceptive signals into psychologically pleasurable experiences[43]. Spicy food consumption shares a similar neurobiological basis with activities such as riding roller coasters or watching horror movies, all of which simulate perceived danger to trigger the body’s stress-reward pathway, ultimately generating pleasure and a sense of achievement. These mechanisms may help explain why Frequent Intense Consumers, who likely sustain prolonged capsaicin exposure, exhibit a stronger inverse association with depressive symptoms than occasional consumers.

In addition, psychosocial and behavioral factors should not be overlooked. In Sichuan, spicy food consumption is often deeply embedded within social activities and family gatherings. This “commensality culture” may confer mental health benefits by enhancing perceived social support and fostering a sense of belonging[56], which aligns with the perspective proposed by Lee et al[13]. that spicy foods can provide sensory-mediated emotional comfort in stressful situations. By contrast, in Qingdao, spicy food consumption is more of an individual

dietary choice, lacking the same degree of social embeddedness. Consequently, the sociocultural context in which dietary behaviors occur, along with the attendant psychological experiences, constitutes another important dimension that may help explain the observed regional heterogeneity in the spicy food-depression association.

The substantial regional variation in cluster distribution further underscores the influence of local dietary culture on spicy food consumption patterns.

Our findings suggest that dietary recommendations concerning spicy food should account for regional dietary culture and individual adaptation. In traditional high-consumption regions such as Sichuan, maintaining regular spicy food intake may be considered a culturally congruent lifestyle component. In non-traditional regions such as Qingdao, public health guidance might encourage interested individuals to explore spice levels suited to their personal preference—starting low and progressing gradually—rather than advocating abrupt or excessive consumption. Individuals should also self-monitor their tolerance to avoid gastrointestinal discomfort, which could offset the hypothesized mood-related benefits of capsaicin intake.

The strengths of this study include the large, population-based sample from two distinct dietary cultural regions, the comprehensive assessment of spicy food consumption across multiple dimensions (frequency, intensity, cumulative burden), and the use of cluster analysis to identify meaningful consumption patterns. Moreover, extensive adjustment for demographic, socioeconomic, lifestyle, and health-related confounders enhances the robustness of our findings.

However, several limitations should be acknowledged when interpreting the findings of this study. First, the cross-sectional design precludes any inference of causality. While we observed significant associations, we cannot determine whether spicy food consumption precedes depressive symptoms, whether depressive symptoms influence dietary choices (reverse causality), or whether unmeasured confounding accounts for the observed relationships. Reverse causality analyses (eTable 3) showed that the direction of the reverse associations was consistent with the main analyses, and the effect estimates did not exceed those from the main analyses, which does not support reverse causality as a primary explanation for our findings. Nevertheless, the inherent temporal ambiguity of the cross-sectional design remains, and longitudinal follow-up of the CKB cohort will be necessary to establish temporal precedence in future analyses.

Second, depressive symptoms were assessed using a four-item measure rather than a validated clinical screening instrument. Following the well-established framework of previous large-scale studies[57] ,we classified participants who endorsed any of the four screening questions as having depressive symptoms (screen-positive). This measure captures selected depressive symptoms (sadness, anhedonia, hopelessness, worthlessness) but has not been formally validated against diagnostic criteria such as the DSM-5 or standardized scales such as the PHQ-9 or CES-D. Importantly, atypical depressive symptoms (e.g., increased appetite, hypersomnia, leaden paralysis, rejection sensitivity) may not be fully captured by these items. This limitation is particularly relevant for older adult populations, where atypical presentations may be more common. Future studies incorporating validated instruments are warranted to confirm our findings.

Third, spicy food consumption was assessed via self-report, which may be subject to recall bias. While the measure has demonstrated acceptable test-retest reliability (Spearman correlation coefficient = 0.71), we lacked objective biomarkers of capsaicin exposure (e.g., urinary capsaicin metabolites) to validate intake estimates.

Fourth, the samples from Sichuan and Qingdao differ significantly in demographic and socioeconomic characteristics, representing a fundamental challenge in observational studies comparing distinct populations. Although we adjusted for a wide range of potential confounders in the multivariable logistic regression models, the samples remain unmatched in key characteristics such as education, occupation, and income. This lack of matching may affect the observed associations, particularly in the cluster analyses—Sichuan was dominated by Frequent Intense Consumers, while Qingdao had a more balanced cluster distribution. The marked changes in association patterns between the unadjusted model and adjusted models underscore the importance of rigorous confounding control. However, residual confounding cannot be completely ruled out. Future studies using propensity score matching or other causal inference methods may help address this limitation more effectively.

Fifth, the generalizability of our findings may be limited. Although Sichuan and Qingdao were selected to represent contrasting dietary cultures, they may not fully capture the diversity of spicy food consumption patterns across other regions of China.

5. Conclusion

In conclusion, this study provides cross-sectional evidence suggesting that the association between spicy food consumption and depressive symptoms may be context-dependent and shaped by regional dietary culture and individual adaptation histories. In Sichuan, a traditional spicy food-consuming region, higher frequency, intensity, and cumulative burden of spicy food intake were cross-sectionally

associated with lower odds of depressive symptoms, particularly among habitual regular consumers. In Qingdao, only moderate-frequency consumption showed a cross-sectional inverse association. These findings suggest the importance of considering cultural and physiological adaptation when evaluating diet–mood relationships and suggest that culturally tailored dietary approaches may warrant further investigation as a potential strategy for mental health promotion in specific populations.

Declarations

Ethics approval and consent to participate

This research has been conducted using the China Kadoorie Biobank (CKB) resource (Request No. DAR-2025-00383, DAR-2025-00528). The study was approved by the Ethical Review Committee of the Chinese Centre for Disease Control and Prevention (Beijing, China) and the Oxford Tropical Research Ethics Committee at the University of Oxford (Oxford, UK). Written informed consent was obtained from all participants.

Consent for publication

Not applicable. This manuscript does not contain any individual person's data in any form.

Competing interests

The authors declare that they have no competing interests.

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Author Contribution

CL: Data curation, Formal analysis, Methodology, Writing - original draft. YH: Data curation, Formal analysis, Methodology, Writing - original draft. HC: Methodology; Supervision; Writing – review and editing. BL: Supervision; Resources; Writing – review and editing.All authors critically reviewed the manuscript and approved the final version for submission.

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Data Availability

This research has been conducted using the China Kadoorie Biobank (CKB) resource (https://www.ckbiobank.org). CKB data are available through formal application to the CKB Collaborative Group. The data supporting the conclusions of this study are available from the corresponding author upon reasonable request.

References

1. Kendler, K. S., Aggen, S. H. & Neale, M. C. Evidence for multiple genetic factors underlying DSM-IV criteria for major depression. *JAMA Psychiatry*. **70** (6), 599–607 (2013).
2. Burden of 375 diseases. and injuries, risk-attributable burden of 88 risk factors, and healthy life expectancy in 204 countries and territories, including 660 subnational locations, 1990–2023: a systematic analysis for the Global Burden of Disease Study 2023. *Lancet* **406** (10513), 1873–1922 (2025).
3. Hidaka, B. H. Depression as a disease of modernity: explanations for increasing prevalence. *J. Affect. Disord*. **140** (3), 205–214 (2012).
4. Global incidence. prevalence, years lived with disability (YLDs), disability-adjusted life-years (DALYs), and healthy life expectancy (HALE) for 371 diseases and injuries in 204 countries and territories and 811 subnational locations, 1990–2021: a systematic analysis for the Global Burden of Disease Study 2021. *Lancet* **403** (10440), 2133–2161 (2024).
5. Budala, D. G. et al. Salivary Biomarkers as a Predictive Factor in Anxiety, Depression, and Stress. *Curr. Issues Mol. Biol.* **47**(7). (2025).
6. Rodolpho, J. M. A. et al. Biomarkers and Mental Disorders: A Relevance Analysis Using a Random Forest Algorithm. Biomolecules : 15(6). (2025).
7. Lamontagne, S. J., Ballard, E. D. & Zarate, C. A. Jr. Effects of stress on endophenotypes of suicide across species: A role for ketamine in risk mitigation. *Neurobiol. Stress*. **18**, 100450 (2022).
8. Li, W. et al. Mediation and Interaction of Cognitive Reappraisal in the Relationship Between Depression and Social Pain Among College Students. *Psychol. Res. Behav. Manag*. **18**, 2387–2399 (2025).
9. Oddo, V. M. et al. Adherence to a Mediterranean Diet Is Associated with Lower Depressive Symptoms among U.S. *Adults Nutrients* **14**(2). (2022).
10. Yan, F. et al. Dose–response relationships of DASH, Mediterranean, and AHEI dietary patterns with heart failure incidence: a systematic review and meta-analysis of cohort studies. *Eur. J. Clin. Nutr.* (2025).
11. Peng, Z. et al. Recent advances in analysis of capsaicin and its effects on metabolic pathways by mass spectrometry. *Front. Nutr.* **10**, 1227517 (2023).
12. Guo, L. et al. Metabolic pathways, pharmacokinetic, and brain neurochemicals effects of capsaicin: Comprehensively insights from in vivo studies. *Phytomedicine* **135**, 156212 (2024).
13. Lee, S-H. & Hong, J-H. Exploring the roles of food with different sensory attributes in stress relief: Insights from sweet and spicy foods. *Food Qual. Prefer.* **126**, 105422 (2025).
14. Lu, J., Zhou, W., Dou, F., Wang, C. & Yu, Z. TRPV1 sustains microglial metabolic reprogramming in Alzheimer's disease. *EMBO Rep.* **22** (6), e52013 (2021).
15. Kasckow, J. W., Mulchahey, J. J. & Geracioti, T. D. Jr. Effects of the vanilloid agonist olvanil and antagonist capsazepine on rat behaviors. *Prog Neuropsychopharmacol. Biol. Psychiatry*. **28** (2), 291–295 (2004).
16. Zhang, C. et al. The Association between Spicy Food Consumption and Psychological Health in Chinese College Students: A Cross-Sectional Study. *Nutrients* **14**(21). (2022).
17. Shi, Z. et al. High Chili Intake and Cognitive Function among 4582 Adults: An Open Cohort Study over 15 Years. *Nutrients* **11**(5). (2019).
18. Zhou, W., Zhang, H., He, J. & Shen, J. Association Between Plant-Based Dietary Patterns and the Long-Term Trajectory of Depressive Symptoms: A 10-Year Longitudinal Study. *J. Am. Med. Dir. Assoc.* **26** (8), 105712 (2025).
19. Zhao, R. et al. Geographic Variations in Dietary Patterns and Their Associations with Overweight/Obesity and Hypertension in China: Findings from China Nutrition and Health Surveillance (2015–2017). Nutrients : 14(19). (2022).
20. Hwang, J. et al. Spicy food intake predicts Alzheimer-related cognitive decline in older adults with low physical activity. *Sci. Rep.* **13** (1), 7942 (2023).
21. Yu, X. et al. Heterogeneity of depressive mood and its influences on adolescents: A latent profile analysis. *J. Affect. Disord*. **387**, 119431 (2025).
22. Sangouni, A. A. et al. Association between dietary behaviors and depression in adolescent girls. *BMC Public. Health*. **22** (1), 1169 (2022).
23. Zhang, N. & Ma, G. Nutritional characteristics and health effects of regional cuisines in China. *J. Ethnic Foods*. **7** (1), 7 (2020).
24. Chen, Z. et al. Cohort profile: the Kadoorie Study of Chronic Disease in China (KSCDC). *Int. J. Epidemiol.* **34** (6), 1243–1249 (2005).
25. Chen, Z. et al. China Kadoorie Biobank of 0.5 million people: survey methods, baseline characteristics and long-term follow-up. *Int. J. Epidemiol.* **40** (6), 1652–1666 (2011).
26. Li, L. M. et al. The China Kadoorie Biobank: study methods and baseline characteristics of the participants. *Chin. J. Epidemiol.* **33** (3), 249–255 (2012). Chinese.

27. Mei, C., Fang, Z., Yin, R., Yang, R. & Tang, K. Spicy food and self-reported fractures. *Clin. Nutr.* **38** (5), 2239–2245 (2019).
28. Sun, D. et al. Spicy food consumption is associated with adiposity measures among half a million Chinese people: the China Kadoorie Biobank study. *BMC Public. Health*. **14**, 1293 (2014).
29. Lv, J. et al. Consumption of spicy foods and total and cause specific mortality: population based cohort study. *Bmj* **351**, h3942 (2015).
30. You, D. et al. Spicy food consumption and risk of vascular disease: Evidence from a large-scale Chinese prospective cohort of 0.5 million people. *Chin. Med. J. (Engl)*. **138** (14), 1696–1704 (2025).
31. Kessler, R. C., Andrews, G., Mroczek, D., Ustun, B. & Wittchen, H-U. The World Health Organization Composite International Diagnostic Interview short-form (CIDI-SF). *Int. J. Methods Psychiatr. Res.* **7** (4), 171–185 (1998).
32. Yu, C. Q. et al. Regional and population distribution of major depressive episode in Chinese adults aged 30–79 years: findings from the China Kadoorie Biobank. *Chin. J. Epidemiol.* **36** (1), 52–56 (2015). Chinese.
33. Jin, L., Huang, Y. Q., Liu, Z. R. & Chen, X. L. Validity of Chinese version of the Composite International Diagnostic Interview-3.0 in psychiatric settings. *Chin. Med. J. (Engl)*. **128** (18), 2462–2466 (2015).
34. Huang, Y. Q. et al. Community-based evaluation of the reliability and validity of the Chinese version of Composite International Diagnostic Interview-3.0. *Chin. Ment Health J.* **24** (1), 21–24 (2010). Chinese.
35. Chen, Y. et al. Patterns and correlates of major depression in Chinese adults: a cross-sectional study of 0.5 million men and women. *Psychol. Med.* **47** (5), 958–970 (2017).
36. Wirfält, E. et al. Associations between food patterns defined by cluster analysis and colorectal cancer incidence in the NIH-AARP diet and health study. *Eur. J. Clin. Nutr.* **63** (6), 707–717 (2009).
37. Zhao, J. et al. A review of statistical methods for dietary pattern analysis. *Nutr. J.* **20** (1), 37 (2021).
38. Sharpe, D. Your Chi-Square Test is Statistically Significant: Now What? Practical Assessment. *Res. Evaluation*. **20** (8–12), 1–10 (2015).
39. du Toit, S. H. C., Steyn, A. G. W. & Stumpf, R. H. Cluster Analysis. In: Graphical Exploratory Data Analysis. edn. Edited by du Toit SHC, Steyn AGW, Stumpf RH. New York, NY: Springer New York; : 73–104. (1986).
40. Liu, C. H. et al. The Associations between a Capsaicin-Rich Diet and Blood Amyloid-β Levels and Cognitive Function. *J. Alzheimers Dis.* **52** (3), 1081–1088 (2016).
41. Hayes, J. E. Types of chemesthesis I. Pungency and burn. In: *Chemesthesis edn* ; : 92–105. (2016).
42. Li, H-B. et al. Antistress Effect of TRPV1 Channel on Synaptic Plasticity and Spatial Memory. *Biol. Psychiatry*. **64** (4), 286–292 (2008).
43. Wuyts, E. & Morrens, M. The Biology of BDSM: A Systematic Review. *J. Sex. Med.* **19** (1), 144–157 (2022).
44. Duan, G. et al. Effects of Spicy Stimulation and Spicy-Food Consumption on Human Pain Sensitivity: A Healthy Volunteer Study. *J. Pain*. **21** (7), 848–857 (2020).
45. Xiang, Q. et al. Capsaicin, the Spicy Ingredient of Chili Peppers: Effects on Gastrointestinal Tract and Composition of Gut Microbiota at Various Dosages. *Foods* **11** (5), 686 (2022).
46. Powell, K. et al. Trigeminal nerve stimulation: a current state-of-the-art review. *Bioelectronic Med.* **9** (1), 30 (2023).
47. Spence, C. Why is piquant/spicy food so popular? *Int. J. Gastronomy Food Sci.* **12**, 16–21 (2018).
48. Fried, E. I. Problematic assumptions have slowed down depression research: why symptoms, not syndromes are the way forward. *Front. Psychol.* **6**, 309 (2015).
49. Chahl, L. A. TRPV1 Channels in the Central Nervous System as Drug Targets. *Pharmaceuticals (Basel)* **17**(6). (2024).
50. Iftinca, M., Defaye, M. & Altier, C. TRPV1-Targeted Drugs in Development for Human Pain Conditions. *Drugs* **81** (1), 7–27 (2021).
51. Dunbar, R. I. M. Laughter and its role in the evolution of human social bonding. *Philos. Trans. R Soc. Lond. B Biol. Sci.* **377** (1863), 20210176 (2022).
52. Inyang, D., Saumtally, T., Nnadi, C. N., Devi, S. & So, P. W. A Systematic Review of the Effects of Capsaicin on Alzheimer's Disease. *Int. J. Mol. Sci.* **24**(12). (2023).
53. Woo, M., Kim, M. J. & Song, Y. O. Bioactive Compounds in Kimchi Improve the Cognitive and Memory Functions Impaired by Amyloid Beta. *Nutrients* **10** (10), 1554 (2018).
54. Miller, A. H. & Raison, C. L. The role of inflammation in depression: from evolutionary imperative to modern treatment target. *Nat. Rev. Immunol.* **16** (1), 22–34 (2016).
55. Castrén, E. & Monteggia, L. M. Brain-Derived Neurotrophic Factor Signaling in Depression and Antidepressant Action. *Biol. Psychiatry*. **90** (2), 128–136 (2021).
56. Armstrong, J. D. et al. Social well-being moderates behavioral therapy response for generalized anxiety disorder. *J. Mood Anxiety Disord*. **12**, 100160 (2025).

57. Chair, S. Y., Choi, K. C., Chong, M. S., Liu, T. & Chien, W. T. Household air pollution from solid fuel use and depression among adults in rural China: evidence from the China Kadoorie Biobank data. *BMC Public. Health*. **23** (1), 1081 (2023).

Figures

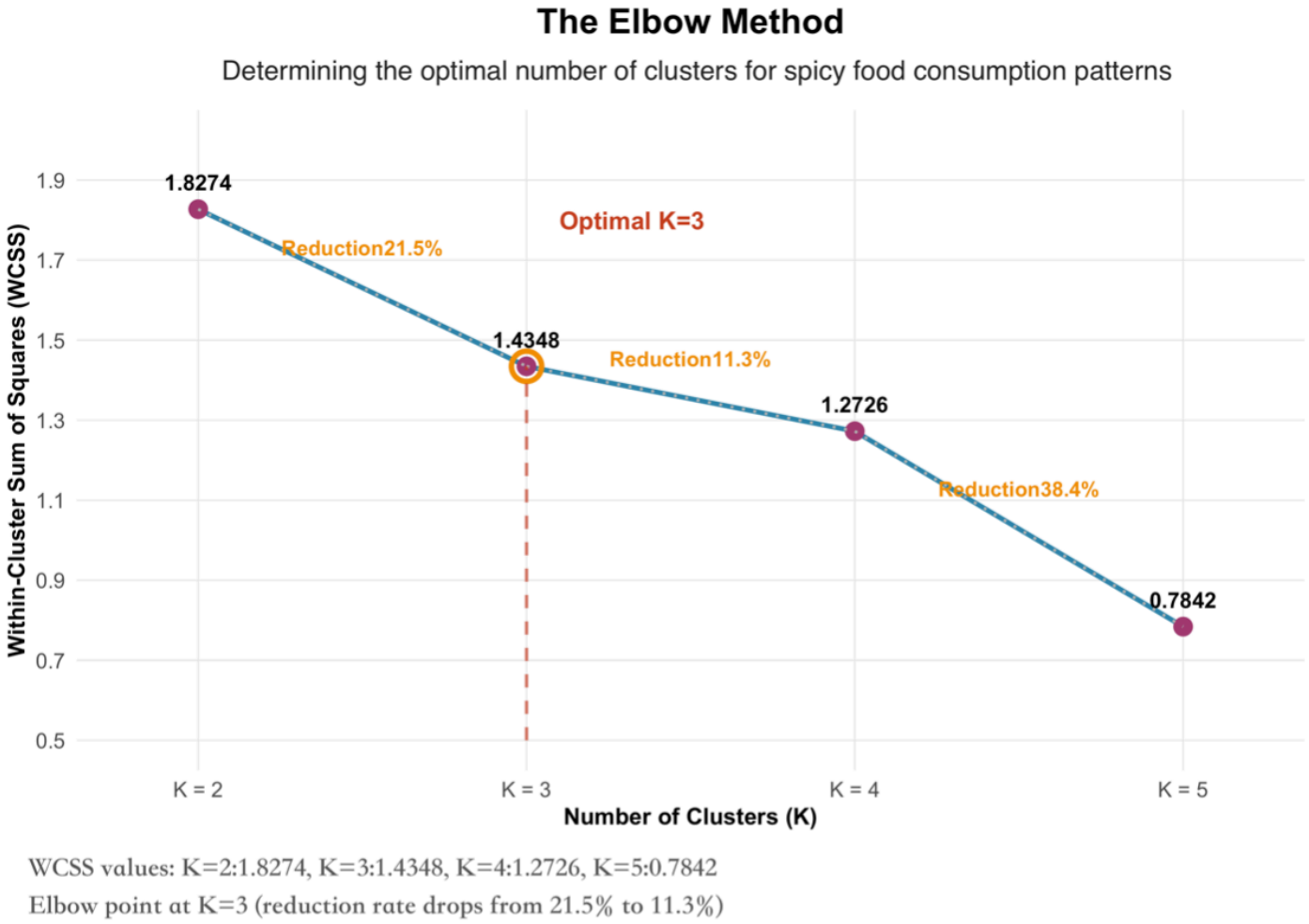


Figure 1

Elbow method plot for K-means clustering of spicy food consumption

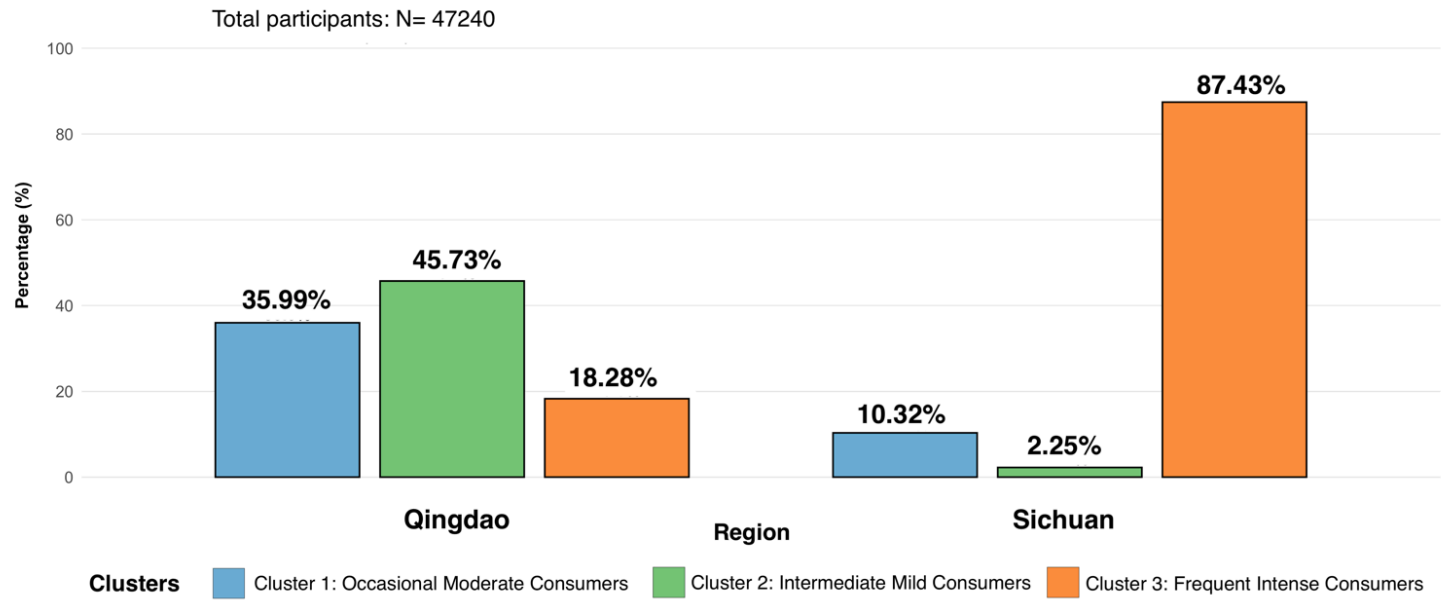


Figure 2

Distribution of spicy food consumers in Sichuan and Qingdao

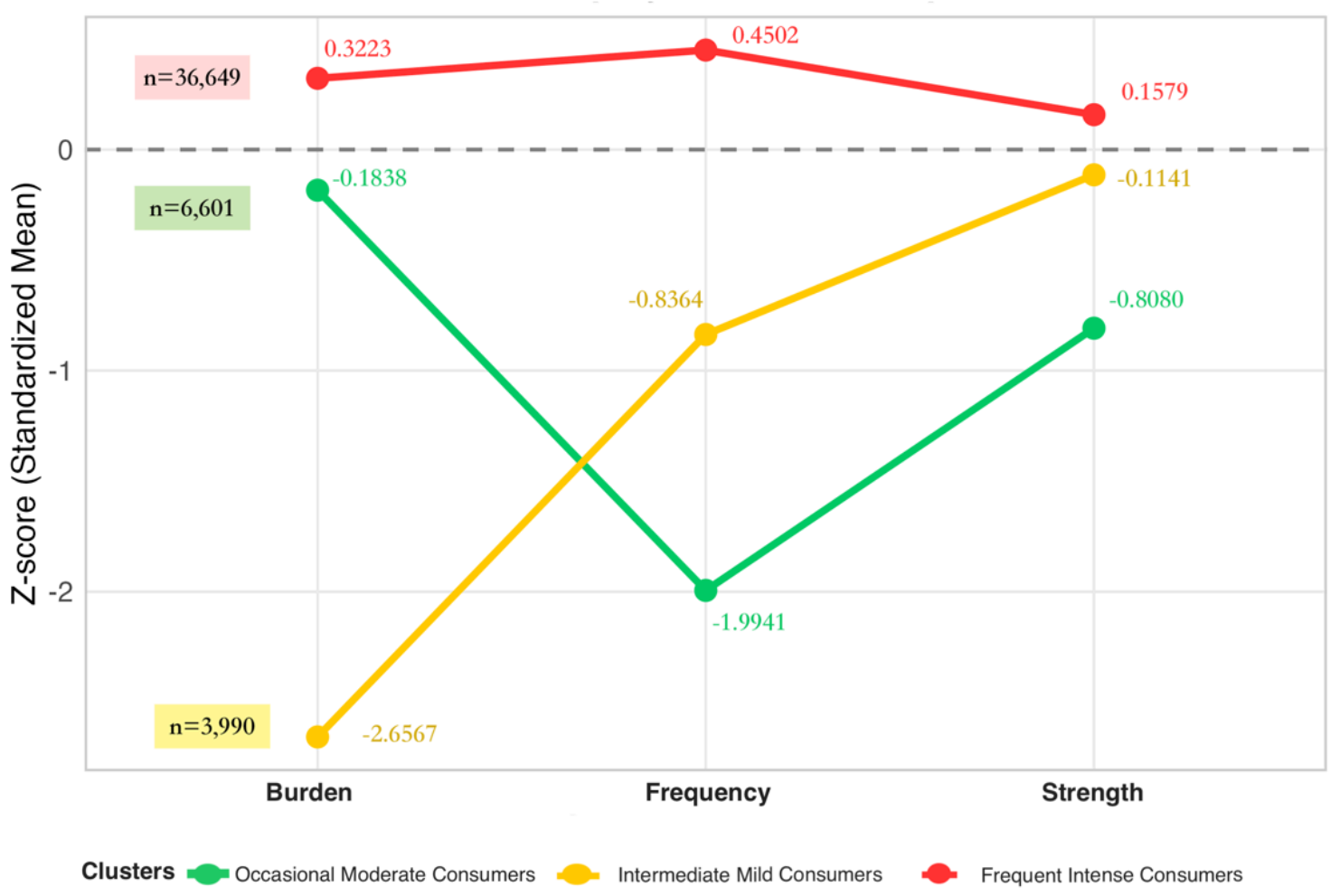


Figure 3

Profile plot of the three spicy food consumption clusters

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