British Journal of Nutrition (2024), 132, 162–168 doi:10.1017/S0007114524000850

Dietary inflammatory index is associated with severe depression in older adults with stroke: a cross-sectional study

Panpan Zhang[1], Yubin Wang[1], Xia Xie[1], Yuan Gao[2]* and Yurong Zhang[1]*

[1]*Department of Neurology, The First Affiliated Hospital of Xi'an Jiaotong University, Xi'an, People's Republic of China*
[2]*Department of Cardiology, The First Affiliated Hospital of Xi'an Jiaotong University, Xi'an, People's Republic of China*

(Submitted 3 October 2023 – Final revision received 9 March 2024 – Accepted 15 March 2024 – First published online 29 April 2024)

Abstract

Inflammation is involved in the pathogenesis of stroke and depression. We aimed to investigate the association between the dietary inflammatory index (DII) and depression in American adults with stroke. Adults with stroke were enrolled in the National Health and Nutrition Examination Survey between 2005 and 2018 in the USA. The DII was obtained from a 24-h dietary recall interview for each individual. Multivariate regression and restricted cubic spline analyses were conducted to evaluate the association between DII and depression in adults with stroke. The mean age of the 1239 participants was 63·85 years (50·20 % women), and the prevalence of depression was 18·26 %. DII showed a linear and positive association with severe depression in adults with stroke (OR 1·359; 95 % CI 1·021, 1·810; *P* for non-linearity = 0·493). Compared with those in the lowest tertile of the DII, adults with stroke in the third tertile of the DII had a 3·222-fold higher risk of severe depression (OR 3·222; 95 % CI 1·150, 9·026). In the stratified analyses, the association between DII score and severe depression was more significant in older adults (*P* for interaction = 0·010) but NS with respect to sex (*P* for interaction = 0·184) or smoking status (*P* for interaction = 0·396). No significant association was found between DII and moderate-to-moderately severe depression in adults with stroke. In conclusion, an increase in DII score was associated with a higher likelihood of severe depression in older adults with stroke.

Keywords: **Dietary inflammatory index: Depression: Stroke: Older adults**

Stroke is a major cause of mortality and disability worldwide[1]. Stroke survivors face great life challenges because of severe sequelae (such as paralysis, aphasia, cognitive impairment and psychological disorders)[2], and depression is one of the most common mental diseases after stroke[3]. Post-stroke depression further leads to poor quality of life and higher mortality[4,5].

The mechanisms of post-stroke depression are multifactorial and not fully understood[6,7]. The possible mechanisms of post-stroke depression included hypothalamic-pituitary-adrenal axis dysregulation, reduced monoamine levels, abnormal neurotrophic responses[6,7], neuronal ischaemic change and neuroinflammation[7,8]. In addition, the concentrations of the pro-inflammatory cytokines TNF-α and IL-6 in peripheral blood were significantly elevated in patients with depression[9]. Cytokines alter the production, metabolism and transport of neurotransmitters that synergistically affect mood and also affect neuronal growth and survival to promote depressive episodes[10]. Increasing evidence indicates that foods and nutrients may play a role in depressive episodes because of their anti-inflammatory and pro-inflammatory properties. A meta-analysis showed that an increased intake of total dietary fibre is associated with lower odds of depression[11]. Adhere to healthy dietary patterns[12], such as Mediterranean diet[13] and traditional Brazilian diet[14] rich in vegetables, fruits, fish, and olive oil are thought to be associated with reduced risk of depression, whereas Western-type dietary patterns are characterised by high consumption of red or processed meat, refined grains, sweets and high-fat dairy products and low intake of fruits and vegetables that aggravate depressive episodes[15], and a recent meta-analysis also suggested that ultra-processed food was associated with an increased risk of anxiety and depression[16]. The association between diet and depression may be partially mediated by inflammatory markers[17].

Studies have investigated the relationship between the inflammatory potential of diet and post-stroke depression[18,19]. A US population study showed that increasing dietary antioxidant intake may prevent depressive symptoms in adults with stroke[19]. However, the relationship between certain food antioxidants and depression remains controversial, which may be related to different food questionnaires and methods used to assess dietary intake in previous studies[17,20]. The dietary inflammatory index (DII) is a dietary index that provides a quantitative means to study the relationship between pro- and anti-inflammatory diets and disease[21]. A study of postmenopausal women suggested that DII can be used to predict the incidence of menopausal complications[22]. Ghazizadeh *et al.*

* **Corresponding authors:** Dr Yurong Zhang, email zhangyurong72@mail.xjtu.edu.cn; Dr Yuan Gao, email ginogao@sohu.com

found that DII is significantly associated with major depression in women[23]. However, the relationship between the DII and depression in adults with stroke remains unclear.

Thus, the objective of this study was to investigate the association between DII and depression in American adults with stroke using data from the National Health and Nutrition Examination Survey (NHANES).

Materials and methods

Data source and study population

The present study was a cross-sectional analysis using data from NHANES 2005–2018. The NHANES is a nationally representative cross-sectional survey of the non-institutionalised US population with data collected in 2-year cycles. During each cycle, the NHANES was conducted based on a stratified multistage probability sampling design and included two components: a household interview and a health examination. This study included individuals older than 18 years who participated in the 2005–2018 NHANES survey cycles. From a total of 1658 participants with stroke, we excluded those with missing data, including the nine-item Patient Health Questionnaire (PHQ-9) score (n 304), DII score (n 59) and participants with missing data on covariates of interest (n 56). The final sample size for the analysis was 1239. All participants provided written informed consent before participating in the survey. The NHANES survey was approved by the Research Ethics Review Board of the National Centre for Health Statistics, and the procedures followed the principles of the Declaration of Helsinki. The NHANES data used in this study are publicly available (https://wwwn.cdc.gov/nchs/nhanes/) and do not require ethical or administrative approval.

Covariates selection

Sociodemographic and lifestyle information, including age, sex, race, marital status, smoking status, education level and sleep status, were obtained through standardised questionnaires. Race was classified as non-Hispanic White, non-Hispanic Black, Mexican American or other. Smoking status was defined as a non-smoker, former smoker or current smoker. Education was classified as less than high school and high school or above. Sleep status was obtained by participants answering the following questionnaire: over the last 2 weeks, how often have you been bothered by trouble falling or staying asleep or sleeping too much? And it was defined as not at all, several days, more than half the days and nearly every day. BMI was provided by the Mobile Examination Centre. A history of hypertension and diabetes was assessed using a combination of questionnaires and examination results. Hypertension was defined as follows: (1) average systolic blood pressure/average diastolic blood pressure ≥ 140/90 mmHg, (2) previous diagnosis by a doctor or health professional or (3) currently taking antihypertensive medications. Diabetes was defined as (1) self-reported diagnosis of diabetes, (2) fasting HbA1c level > 6·4 % or (3) current use of hypoglycaemic drugs. Stroke data were self-reported personal interview data obtained from the medical status section of the NHANES. In this questionnaire, stroke was identified as a stroke diagnosis by a physician or health professional.

Depressive symptom assessment

A validated PHQ-9 was used to assess depressive symptoms. PHQ-9 consists of a nine-item depression module to assess the frequency of depressive symptoms over the past 2 weeks. With each of the nine items ranging from '0' (not at all) to '3' (nearly every day), PHQ-9 has total scores ranging from 0 to 27. A higher PHQ-9 score was associated with more severe depressive symptoms. PHQ-9 scores of 5, 10, 15 and 20 represented mild, moderate, moderately severe and severe depression, respectively[24]. Depression was defined as PHQ-9 scores ≥ 10 in clinical practice[24]. In this study, we categorised depression into three grades based on the PHQ-9 scores: no clinical depression (PHQ-9: ≤ 9), moderate-to-moderately severe depression (PHQ-9: 10–19) and severe depression (PHQ-9: 20–27).

Dietary data and computation of DII scores

Dietary data were derived from self-reports, and DII was calculated by adding the scores of each dietary component consumed by each participant within a 24-h period. Higher DII scores were associated with a more pro-inflammatory diet, whereas lower DII scores indicated a more anti-inflammatory diet. The method for calculating DII was reported in detail by Shivappa *et al.*[21]. DII scores were based on eleven food consumption datasets worldwide[21], which provides reliable estimates of the mean and SD of forty-five food parameters. A participant's exposure relative to the standard global mean was calculated as a z-score, which was calculated by subtracting the mean of the energy-adjusted regionally representative database from each food parameter and dividing this value by the SD of the parameter. These z-scores were converted to central proportion scores by multiplying by 2 and subtracting 1 to reduce the effect of 'right-skewing'. The final values were multiplied by the overall food parameter-specific inflammatory effect score to obtain a food parameter-specific DII score. DII scores for specific food parameters were added to obtain an overall DII score for each individual. In this study, the NHANES 2008–2015 database provided 28 of the 45 food parameters to calculate DII. Previous studies revealed that the DII scores were still available even if the nutrients used to calculate DII were <30[21]. These food parameters and other basic information for calculating DII are shown in online Supplementary Table S1.

Statistical analysis

Descriptive data on participants' characteristics were expressed as means and SE or medians, interquartile ranges for continuous variables and numbers and weighted percentages for categorical variables. One-way ANOVA and χ^2 tests were used to compare continuous and categorical variables, respectively. The weight prevalence of different degrees of depression was evaluated in all participants. Multivariate logistic regression analyses were used to estimate the association between DII scores and different degrees of depression in adults with stroke.

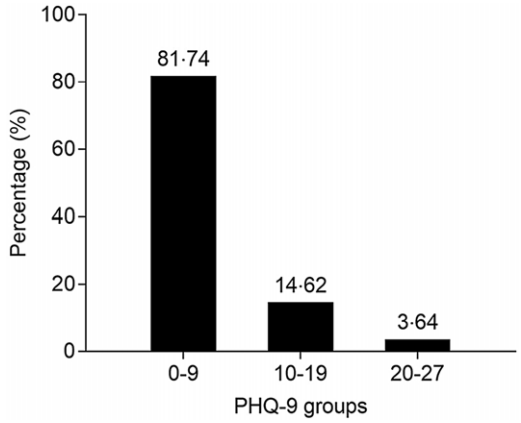

Fig. 1. Percentage (%) of depression status in adults with stroke, National Health and Nutrition Examination Survey 2005–2018.

Model 1 shows the age-adjusted results. Variables were entered in the multivariate logistic regression models if the *P* value was ≤ 0·10 in the univariable analysis. In the multivariate-adjusted model, we adjusted for baseline age, sex, race, educational status, marital status and smoking status. Restricted cubic spline was used to evaluate the potential non-linear relationship between DII and depression in adults with stroke. Stratification analysis was performed to estimate the relationship between DII and severe depression according to age, sex and smoking status. Data were weighted to ensure that they were representative of US adults using complex survey sampling analysis methods. All data analyses were performed using the R software (version R-4.1.0; Cary, NC, USA). Two-sided *P* values <0·05 were considered statistical significance.

Results

Characteristics of the study population

This study included 1239 adults with stroke. The mean age of the participants was 63·85 years, and 622 (50·20 %) were women. Among the 1239 participants, the weight prevalence of moderate-to-moderately severe and severe depression was 14·62 and 3·64 %, respectively (Fig. 1).

Table 1 presents the characteristics of the participants and DII score tertiles. Compared with participants in the lowest DII score tertile (tertile 1), those in the highest DII score tertile (tertile 3) were more likely to be female, highly educated and current smokers. There were no differences in the distribution of age, race, marital status, BMI, sleep status or history of diabetes or hypertension.

Table 1. Baseline characteristics of adults with stroke by the dietary inflammatory index (DII) tertiles (Q) from National Health and Nutrition Examination Survey 2005–2018

	DII score								
	Total (*N* 1239)		Q1 (*N* 413)		Q2 (*N* 413)		Q3 (*N* 413)		
Characteristic	*n*	%	*n*	%	*n*	%	*n*	%	*P*
Age, years*									0·06
Mean	63·85		65·38		62·56		63·67		
SE	0·58		0·82		0·93		0·95		
Female, *n* (%)	622	50·20	158	38·92	204	58·04	260	68·69	< 0·001
Race, *n* (%)									0·08
Non-Hispanic White	627	50·61	219	71·62	202	69·82	206	70·56	
Non-Hispanic Black	341	27·52	96	11·75	115	14·66	130	18·10	
Mexican American	115	9·28	43	5·72	40	4·19	32	3·94	
Other race	156	12·59	55	10·91	55	11·33	46	7·40	
Education Status, *n* (%)									0·01
Less than high school	404	32·61	121	20·12	123	22·65	160	30·94	
High school or above	835	67·39	292	79·88	289	77·35	254	69·06	
Smoking status, *n* (%)									0·05
Never	468	37·77	148	38·99	159	40·20	161	39·60	
Former	459	37·05	177	41·34	155	34·81	127	30·06	
Current	312	25·18	88	19·66	98	24·99	126	30·35	
Marital status, *n* (%)									0·08
Married/living with partner	653	52·7	224	61·47	230	62·02	199	52·04	
Never married	102	8·23	31	6·63	29	5·13	42	8·64	
Widowed/divorced/separated	484	39·06	158	31·91	153	32·85	173	39·32	
BMI (kg/m^2)*	30·33	0·27	29·62	0·41	30·84	0·53	30·54	0·41	0·13
Sleep disorders, *n* (%)									0·21
Not at all	643	51·9	211	53·00	224	51·38	208	45·16	
Several days	243	19·61	92	22·03	81	20·77	70	19·38	
More than half the days	131	10·57	47	9·31	40	10·73	44	11·57	
Nearly every day	222	17·92	63	15·66	67	17·12	92	23·89	
Medical history, *n* (%)									
Diabetes	442	35·67	131	28·32	155	33·23	156	34·21	0·29
Hypertension	1012	81·68	327	79·03	336	77·54	349	79·55	0·88

* Mean (SE).

British Journal of Nutrition

Table 2. Associations of the dietary inflammatory index (DII) with depression in adults with stroke

Depressive symptom severity	Variables	Prevalence rate	Model 1 OR	95 % CI	*P*	Model 2 OR	95 % CI	*P*
Clinical depression	DII (Continuous)	232/1239	1·104	0·992, 1·228	0·07	1·065	0·949, 1·195	0·283
	Tertile1	64/413	Reference		Reference			
	Tertile2	68/413	1·044	0·702, 1·553	0·829	0·994	0·658, 1·503	0·978
	Tertile3	100/413	1·620	1·109, 2·367	0·013	1·411	0·926, 2·149	0·108
Moderate-to-moderately severe depression	DII (Continuous)	182/1239	1·049	0·932, 1·181	0·424	0·989	0·862, 1·134	0·871
	Tertile1	57/413	Reference			Reference		
	Tertile2	56/413	1·054	0·699, 1·589	0·800	1·011	0·655, 1·559	0·962
	Tertile3	69/413	1·292	0·824, 2·025	0·261	1·135	0·699, 1·841	0·606
Severe depression	DII (Continuous)	50/1239	1·437	1·066, 1·938	0·018	1·359	1·021, 1·810	0·036
	Tertile1	7/413	Reference			Reference		
	Tertile2	12/413	0·995	0·332, 2·976	0·992	0·942	0·327, 2·718	0·911
	Tertile3	31/413	3·853	1·417, 10·476	0·009	3·222	1·150, 9·026	0·026

Model 1: Adjusted for age. Model 2: Adjusted for age, sex, race, education status, marital status and smoking status.
Clinical depression: PHQ-9 ≥ 10; moderate-to-moderately severe depression: PHQ-9 scores:10–19; severe depression: PHQ-9 ≥ 20. PHQ-9, nine-item Patient Health Questionnaire.

Associations between DII and depression in adults with stroke

Table 2 shows that the DII score was positively associated with severe depression in adults with stroke. The age-adjusted OR (95 % CI) for severe depression across the DII score tertiles were 1·00 (reference), 0·995 (0·332, 2·976) and 3·853 (1·417, 10·476), respectively (Table 2). The OR for severe depression were similar following additional adjustments for sex, race, education, smoking and marital status (1·00 (reference), 0·942 (0·327, 2·718) and 3·222 (1·150, 9·026) across the DII tertiles). When modelling the DII score continuously, a similar positive association was observed in the fully adjusted models (model 2 in Table 2). A one-unit increase in the DII score was associated with 35·9 % higher odds ($P = 0·026$) of severe depression in adults with stroke. No significant association between the DII and depression was found for total depression ($P = 0·283$) or moderate-to-moderately severe depression ($P = 0·871$). In Fig. 2, the non-linear relationship between DII and severe depression was NS in the restricted cubic spline model (P for non-linearity > 0·05).

Stratification analysis

In the stratified analyses (Fig. 3), no interactions were observed between the DII and sex (P-interaction = 0·184) or smoking status (P-interaction = 0·396). However, the DII-severe depression association was stronger in older individuals (P-interaction = 0·010).

Discussion

In this cross-sectional study of a representative US sample, we found that older adults with stroke with higher DII scores were significantly associated with a higher risk of severe depression. No significant association was found in adults with stroke and moderate-to-moderately severe depression. These findings may provide clinical and public health implications for preventing depression in adults with stroke.

The DII level is related to the pro- and anti-inflammatory ability of the diet[21], with a higher DII indicating a stronger pro-inflammatory ability. Inflammation is a defence mechanism that prevents harmful substances from entering the body; however, sustained and prolonged inflammation is detrimental to health[25]. Increasing evidence indicates that the inflammatory properties of diet are associated with a variety of diseases (such as CHD and various types of cancer)[26]. A pro-inflammatory diet can promote depression by affecting the hypothalamic-pituitary-adrenal axis, oxidative stress, gut-brain axis and other pathways to increase neuroinflammation and change the secretion of neurotransmitters[27–29]. In a previous meta-analysis, participants with the highest DII scores had a 23 % higher risk of depression than those with the lowest DII scores[30]. A significant association between DII and depression has been confirmed in the general population[31] and in individuals with co-morbid chronic diseases (such as diabetes and CHD)[32]. A cohort study from Iran showed that DII is significantly associated with major depression in women[23]. However, few studies have reported the association between DII scores and depression severity in adults with stroke. We found a significant association between the DII and severe depressive episodes in adults with stroke, whereas this relationship was not observed for

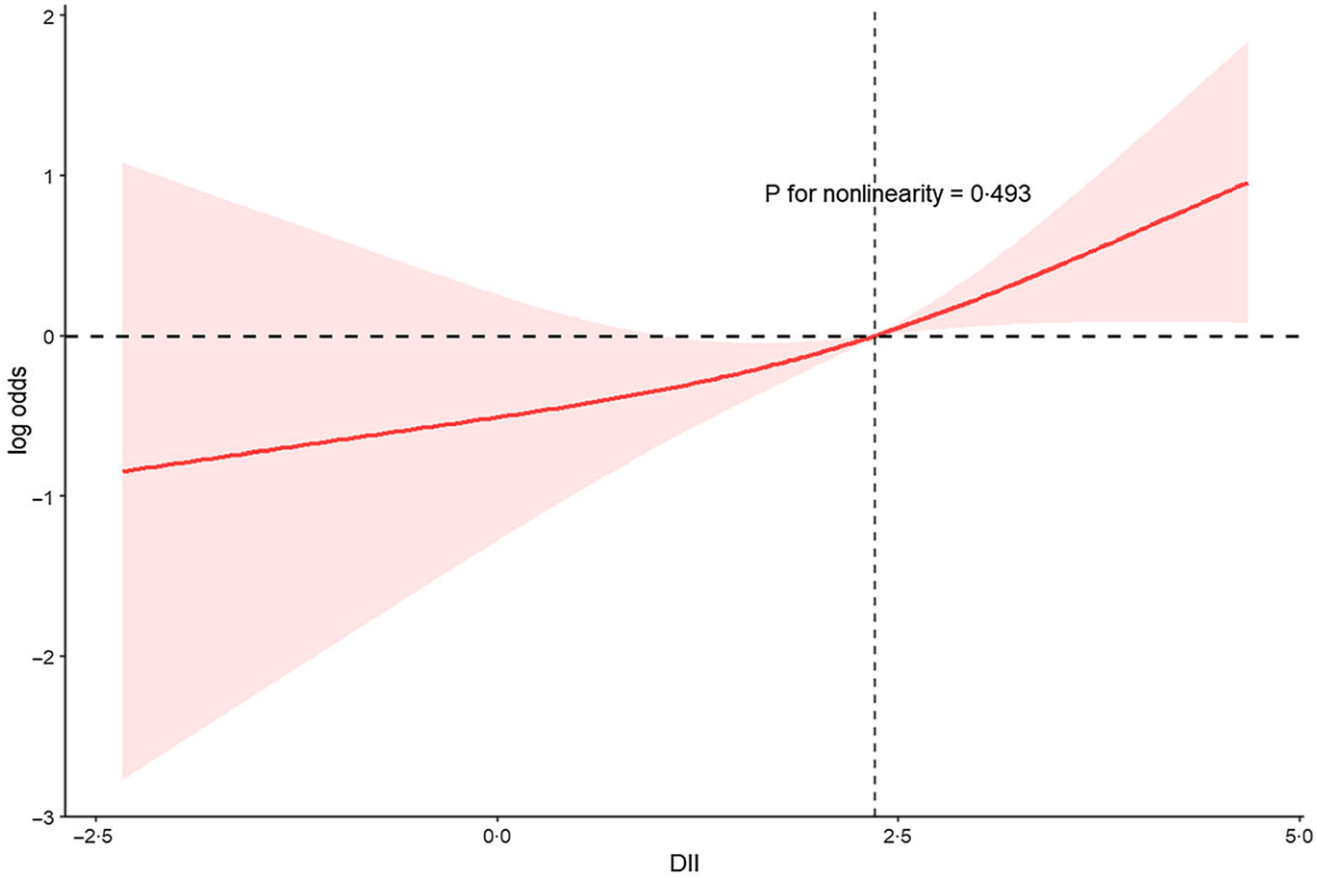

Fig. 2. Restricted cubic spline of dietary inflammatory index with severe depression.

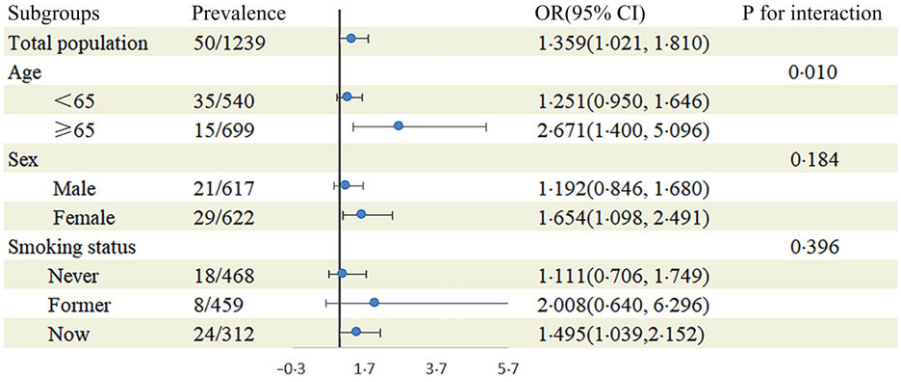

Fig. 3. Subgroup analysis of the association of the dietary inflammatory index with severe depression in adults with stroke. Results were adjusted for all covariates except the corresponding stratification variable.

moderate-to-moderately severe depression. It should be noted that the DII score was not significantly associated with depression in adults with stroke before the degree of depression was graded, contradicting to the positive results of previous studies in other populations[30–32]. Depression is a multifactorial disease[33]. Post-stroke depression is directly related to cerebrovascular injury[7]. Compared with the general population, the composition of risk factors for depression in the stroke population may be different[7,34], which may lead to different conclusions on the correlation between DII and depression in different populations. In addition, the crude diagnosis of depression may mask the actual relationship between the DII and different degrees of depression. The complex composition of risk factors for depression and the relationship between diet and different levels of depression in different populations need to be further explored.

We further performed a subgroup analysis of the association between the DII score and severe depression in adults with stroke. A higher DII score conferred a higher risk of major depressive episodes in older adults. In line with previous studies, older age was a risk factor for depression[33]. Ageing, increased levels of

accompanying diseases, lower activity and lower living standards predispose older adults to psychological problems[35], which may be attributed to immune dysregulation, most notably, high blood levels of pro-inflammatory immunogenic stimuli[36,37]. Additionally, DII promotes the onset of depression by increasing pro-inflammatory factors in the body[28,29]; therefore, there may be a synergistic effect between DII and ageing.

Depression plays an important role in the progression and prognosis of stroke[3]. Diet appears to be a modifiable risk factor for depression[14,38]. Our results extend the association between dietary inflammation potential and depression in the stroke population, with a more detailed classification of the degree of depression and a relative subgroup analysis to identify special populations.

Despite the significance of our findings, this study has a few limitations. First, the NHANES is a cross-sectional observational study; therefore, causality cannot be established, and residual confounding factors cannot be completely ruled out. Second, dietary data were obtained from only one 24-h dietary recall; this may not represent habitual diet, although 24-h dietary recalls have been widely used in previous studies[39,40]. Third, the history of antidepressant use and some other characteristic data were not available due to the limitations of the NHANES database. Finally, stroke, depression and dietary recalls were self-reported and may be limited by underlying cognitive difficulties in a stroke population, which may have introduced a bias. However, these questionnaires have been widely used to assess stroke, depression and DII[41–43]. Future longitudinal studies are needed to explore the relationship between DII and depression in different populations.

Conclusions

A high DII was associated with a higher likelihood of having severe depression in older adults with stroke. Future studies with prospective designs or clinical trials are needed to confirm the results of this study.

Supplementary material

For supplementary material/s referred to in this article, please visit https://doi.org/10.1017/S0007114524000850.

Acknowledgements

We would like to thank Editage (www.editage.cn) for English language editing.

Financial support

This study was funded by the Clinical Research Award of the First Affiliated Hospital of Xi'an Jiaotong University (grant no. XJTU1AF2018CRF-024) and by the horizontal subject of the First Affiliated Hospital of Xi'an Jiaotong University (grant no. HX201872). The study funders were not involved in the design of the study.

Authorship

Y. G. and Y. R. Z. designed the research; P. P. Z. conducted research and wrote the manuscript; P. P. Z. and Y. R. Z. analysed data; X. X. and Y. B. W. revised the tables and images; Y. G. and Y. R. Z. provided important revisions for the final content. All authors reviewed and approved the final version of the manuscript.

Conflict of interest

None.

References

1. Feigin VL, Brainin M, Norrving B, *et al.* (2022) World stroke organization (WSO): global stroke fact sheet 2022. *Int J Stroke* **17**, 18–29.
2. van Dongen L, Hafsteinsdóttir TB, Parker E, *et al.* (2021) Stroke survivors' experiences with rebuilding life in the community and exercising at home: a qualitative study. *Nursing open* **8**, 2567–2577.
3. Jørgensen TS, Wium-Andersen IK, Wium-Andersen MK, *et al.* (2016) Incidence of depression after stroke, and associated risk factors and mortality outcomes, in a large cohort of Danish patients. *JAMA Psychiatry* **73**, 1032–1040.
4. Bartoli F, Di Brita C, Crocamo C, *et al.* (2018) Early post-stroke depression and mortality: meta-analysis and meta-regression. *Front Psychiatry* **9**, 530.
5. Villa RF, Ferrari F & Moretti A (2018) Post-stroke depression: mechanisms and pharmacological treatment. *Pharmacol Ther* **184**, 131–144.
6. Loubinoux I, Kronenberg G, Endres M, *et al.* (2012) Post-stroke depression: mechanisms, translation and therapy. *J Cell Mol Med* **16**, 1961–1969.
7. Medeiros GC, Roy D, Kontos N, *et al.* (2020) Post-stroke depression: a 2020 updated review. *Gen Hosp Psychiatry* **66**, 70–80.
8. Fan Q, Liu Y, Sheng L, *et al.* (2023) Chaihu-Shugan-San inhibits neuroinflammation in the treatment of post-stroke depression through the JAK/STAT3-GSK3β/PTEN/Akt pathway. *Biomed Pharmacother* **160**, 114385.
9. Dowlati Y, Herrmann N, Swardfager W, *et al.* (2010) A meta-analysis of cytokines in major depression. *Biol Psychiatry* **67**, 446–457.
10. Kiecolt-Glaser JK, Derry HM & Fagundes CP (2015) Inflammation: depression fans the flames and feasts on the heat. *Am J Psychiatry* **172**, 1075–1091.
11. Fatahi S, Matin SS, Sohouli MH, *et al.* (2021) Association of dietary fiber and depression symptom: a systematic review and meta-analysis of observational studies. *Complement Ther Med* **56**, 102621.
12. Lassale C, Batty GD, Baghdadli A, *et al.* (2019) Healthy dietary indices and risk of depressive outcomes: a systematic review and meta-analysis of observational studies. *Mol Psychiatry* **24**, 965–986.
13. Psaltopoulou T, Sergentanis TN, Panagiotakos DB, *et al.* (2013) Mediterranean diet, stroke, cognitive impairment, and depression: a meta-analysis. *Ann Neurol* **74**, 580–591.
14. Canheta ABS, Santos A, Souza JD, *et al.* (2021) Traditional Brazilian diet and extra virgin olive oil reduce symptoms of anxiety and depression in individuals with severe obesity: randomized clinical trial. *Clin Nutr* **40**, 404–411.

15. Li Y, Lv MR, Wei YJ, *et al.* (2017) Dietary patterns and depression risk: a meta-analysis. *Psychiatry Res* **253**, 373–382.
16. Lane MM, Gamage E, Travica N, *et al.* (2022) Ultra-processed food consumption and mental health: a systematic review and meta-analysis of observational studies. *Nutrients* **14**, 2568.
17. Lai JS, Oldmeadow C, Hure AJ, *et al.* (2016) Inflammation mediates the association between fatty acid intake and depression in older men and women. *Nutr Res* **36**, 234–245.
18. Pereira GA, da Silva A, Hermsdorff HHM, *et al.* (2021) Association of dietary total antioxidant capacity with depression, anxiety, and sleep disorders: a systematic review of observational studies. *J Clin Transl Res* **7**, 631–640.
19. Xu Q, Qian X, Sun F, *et al.* (2023) Independent and joint associations of dietary antioxidant intake with risk of post-stroke depression and all-cause mortality. *J Affect Disord* **322**, 84–90.
20. Lin S & Shen Y (2021) Dietary carotenoids intake and depressive symptoms in US adults, NHANES 2015–2016. *J Affect Disord* **282**, 41–45.
21. Shivappa N, Steck SE, Hurley TG, *et al.* (2014) Designing and developing a literature-derived, population-based dietary inflammatory index. *Public Health Nutr* **17**, 1689–1696.
22. Haghshenas N, Baharanchi FH, Melekoglu E, *et al.* (2023) Comparison of predictive effect of the dietary inflammatory index and empirically derived food-based dietary inflammatory index on the menopause-specific quality of life and its complications. *BMC women's na* **23**, 349.
23. Ghazizadeh H, Yaghooti-Khorasani M, Asadi Z, *et al.* (2020) Association between dietary inflammatory index (DII®) and depression and anxiety in the Mashhad stroke and heart atherosclerotic disorder (MASHAD) study population. *BMC Psychiatry* **20**, 282.
24. Kroenke K, Spitzer RL & Williams JB (2001) The PHQ-9: validity of a brief depression severity measure. *J Gen Intern Med* **16**, 606–613.
25. Ferrucci L & Fabbri E (2018) Inflammageing: chronic inflammation in ageing, cardiovascular disease, and frailty. *Nat Rev Cardiol* **15**, 505–522.
26. Marx W, Veronese N, Kelly JT, *et al.* (2021) The dietary inflammatory index and human health: an umbrella review of meta-analyses of observational studies. *Adv Nutr* **12**, 1681–1690.
27. Marx W, Lane M, Hockey M, *et al.* (2021) Diet and depression: exploring the biological mechanisms of action. *Mol Psychiatry* **26**, 134–150.
28. Postal M & Appenzeller S (2015) The importance of cytokines and autoantibodies in depression. *Autoimmun Rev* **14**, 30–35.
29. Richards JL, Yap YA, McLeod KH, *et al.* (2016) Dietary metabolites and the gut microbiota: an alternative approach to control inflammatory and autoimmune diseases. *Clin Transl Immunol* **5**, e82.
30. Wang J, Zhou Y, Chen K, *et al.* (2018) Dietary inflammatory index and depression: a meta-analysis. *Public Health Nutr* **22**, 1–7.
31. Zhao L, Sun Y, Liu Y, *et al.* (2023) A J-shaped association between dietary inflammatory index (DII) and depression: a cross-sectional study from NHANES 2007–2018. *J Affect Disord* **323**, 257–263.
32. Jiang C, Yin H, Liu A, *et al.* (2022) Dietary inflammatory index and depression risk in patients with chronic diseases and comorbidity. *J Affect Disord* **301**, 307–314.
33. McCarron RM, Shapiro B, Rawles J, *et al.* (2021) Depression. *Ann Intern Med* **174**, ITC65–ITC80.
34. Disu TR, Anne NJ, Griffiths MD, *et al.* (2019) Risk factors of geriatric depression among elderly Bangladeshi people: a pilot interview study. *Asian J Psychiatr* **44**, 163–169.
35. Zhang S, Xiang K, Li S, *et al.* (2021) Physical activity and depression in older adults: the knowns and unknowns. *Psychiatry Res* **297**, 113738.
36. Ferrucci L, Semba RD, Guralnik JM, *et al.* (2010) Proinflammatory state, hepcidin, and anemia in older persons. *Blood* **115**, 3810–3816.
37. Fulop T, Larbi A, Dupuis G, *et al.* (2017) Immunosenescence and inflamm-aging as two sides of the same coin: friends or foes? *Front Immunol* **8**, 1960.
38. Akbaraly TN, Brunner EJ, Ferrie JE, *et al.* (2009) Dietary pattern and depressive symptoms in middle age. *Br J Psychiatry* **195**, 408–413.
39. Zhou N, Xie ZP, Liu Q, *et al.* (2022) The dietary inflammatory index and its association with the prevalence of hypertension: a cross-sectional study. *Front Immunol* **13**, 1097228.
40. Wu L, Shi Y, Kong C, *et al.* (2022) Dietary inflammatory index and its association with the prevalence of coronary heart disease among 45,306 US adults. *Nutrients* **14**, 4553.
41. Iranpour S & Sabour S (2019) Inverse association between caffeine intake and depressive symptoms in US adults: data from National Health and Nutrition Examination Survey (NHANES) 2005–2006. *Psychiatry Res* **271**, 732–739.
42. Song Y, Chang Z, Jia L, *et al.* (2023) Better adherence to the MIND diet is associated with lower risk of all-cause death and cardiovascular death in patients with atherosclerotic cardiovascular disease or stroke: a cohort study from NHANES analysis. *Food Funct* **14**, 1740–1749.
43. Chen X, Hou C, Yao L, *et al.* (2023) Dietary inflammation index is associated with dyslipidemia: evidence from national health and nutrition examination survey, 1999–2019. *Lipids Health Dis* **22**, 149.

British Journal of Nutrition