Author/s:
Zheng, MR;Chen, P;Zhang, L;Feng, Y;Cheung, T;Xiang, NX;Ungvari, GS;Zhang, Q;Ng, CH;Xiang, YT

Title:
Prevalence and network structure of depression and its association with quality of life among older stroke survivors: findings from a national survey in China

Date:
2025-04-17

Citation:
Zheng, M. R., Chen, P., Zhang, L., Feng, Y., Cheung, T., Xiang, N. X., Ungvari, G. S., Zhang, Q., Ng, C. H. & Xiang, Y. T. (2025). Prevalence and network structure of depression and its association with quality of life among older stroke survivors: findings from a national survey in China. General Psychiatry, 38 (2), https://doi.org/10.1136/gpsych-2024-101838.

Persistent Link:
https://hdl.handle.net/11343/360587

General Psychiatry

Prevalence and network structure of depression and its association with quality of life among older stroke survivors: findings from a national survey in China

Mu-Rui Zheng ,[1] Pan Chen ,[1] Ling Zhang,[2] Yuan Feng,[2] Teris Cheung,[3] Nicole Xun Xiang,[4] Gabor S Ungvari,[5,6] Qinge Zhang,[2] Chee H Ng,[7] Yu-Tao Xiang[1]

To cite: Zheng M-R, Chen P, Zhang L, *et al*. Prevalence and network structure of depression and its association with quality of life among older stroke survivors: findings from a national survey in China. *General Psychiatry* 2025;**38**:e101838. doi:10.1136/gpsych-2024-101838

► Additional supplemental material is published online only. To view, please visit the journal online (https://doi.org/10.1136/gpsych-2024-101838).

M-RZ, PC, LZ and YF contributed equally.

M-RZ, PC, LZ and YF are joint first authors.

Received 20 August 2024
Accepted 16 March 2025

For numbered affiliations see end of article.

Correspondence to
Dr Yu-Tao Xiang;
xyutly@gmail.com

Dr Chee H Ng;
cng@unimelb.edu.au

Dr Qinge Zhang;
zqe81@126.com

ABSTRACT

Background Post-stroke depression (PSD) is a common neuropsychiatric problem associated with a high disease burden and reduced quality of life (QoL). To date, few studies have examined the network structure of depressive symptoms and their relationships with QoL in stroke survivors.

Aims This study aimed to explore the network structure of depressive symptoms in PSD and investigate the interrelationships between specific depressive symptoms and QoL among older stroke survivors.

Methods This study was based on the 2017–2018 collection of data from a large national survey in China. Depressive symptoms were assessed using the 10-item Centre for Epidemiological Studies Depression Scale (CESD), while QoL was measured with the World Health Organization Quality of Life-brief version. Network analysis was employed to explore the structure of PSD, using expected influence (EI) to identify the most central symptoms and the flow function to investigate the association between depressive symptoms and QoL.

Results A total of 1123 stroke survivors were included, with an overall prevalence of depression of 34.3% (n=385; 95% confidence interval 31.5% to 37.2%). In the network model of depression, the most central symptoms were CESD3 ('feeling blue/depressed', EI: 1.180), CESD6 ('feeling nervous/fearful', EI: 0.864) and CESD8 ('loneliness', EI: 0.843). In addition, CESD5 ('hopelessness', EI: −0.195), CESD10 ('sleep disturbances', EI: −0.169) and CESD4 ('everything was an effort', EI: −0.150) had strong negative associations with QoL.

Conclusion This study found that PSD was common among older Chinese stroke survivors. Given its negative impact on QoL, appropriate interventions targeting central symptoms and those associated with QoL should be developed and implemented for stroke survivors with PSD.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Post-stroke depression (PSD) is prevalent and has a negative impact on the quality of life (QoL) in stroke survivors.

WHAT THIS STUDY ADDS

⇒ The prevalence of PSD was 34.3% among older stroke survivors. Using network analysis, 'feeling blue/depressed', 'feeling nervous/fearful' and 'loneliness' were the most central depressive symptoms, while 'hopelessness', 'sleep disturbances' and 'everything was an effort' were most negatively associated with QoL.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ The findings highlight the importance of focusing interventions on central PSD symptoms to improve depressive symptoms and overall QoL among older stroke survivors.

INTRODUCTION

Stroke is the second most common cause of mortality globally and one of the highest contributors to disease burden in low- and middle-income countries.[1] The prevalence of stroke increases dramatically with age, and the number of people living with stroke is rising with the ageing population worldwide.[2] In the European Union, there were approximately 9.53 million stroke survivors in 2017, and the figure is expected to increase by 27% in the next 30 years.[3] Critically, in China there were 28.76 million cases of stroke in 2019, according to the Global Burden of Disease Study.[4] Additionally, stroke is the leading cause of chronic severe disabilities among adults, often resulting in substantial functional impairments and needing long-term rehabilitation across various phases of recovery.[1 5 6] Thus, despite current advances in prevention and treatment, stroke remains a significant concern for both survivors and families, posing exceptional challenges to healthcare systems worldwide.[7 8]

Post-stroke depression (PSD), which is the development of a depressive disorder after a stroke, is considered to be one of the most prevalent and important causes of illness burden among all neuropsychiatric disorders.[9 10] A meta-analysis of 61 studies covering 25 488 patients found that the pooled prevalence of PSD was 31% (95% confidence interval (CI) 28% to 35%) within a 5-year post-stroke period.[11] Depression is found to be significantly associated with stroke,[12 13] and the burden of both stroke and depression contributes to substantial loss of healthy life due to disability.[14] PSD typically occurs within 3–6 months following a stroke, and the prevalence of PSD can be high even up to 3 years after a stroke,[15] resulting in worse functional outcomes, poorer quality of life (QoL) and higher mortality among survivors.[16–19] For instance, a cross-sectional analysis from the Stroke Data Bank (USA) showed that stroke survivors with depression experienced greater impairment in activities of daily living (ADL) compared with those without PSD.[19] Additionally, a prospective survey found that QoL was significantly affected by PSD,[17] and a systematic review showed that lower QoL was associated with PSD.[18] Further, a meta-analysis including 119 075 individuals with stroke revealed a higher mortality in older adults with PSD compared with those without PSD (relative risk=1.50; 95% CI 1.28 to 1.75; p<0.001).[16] A recent review grouped the risk factors of PSD into three categories: (1) pre-stroke (eg, female gender and family history of mental illness), (2) stroke-related (eg, location of the lesion) and (3) post-stroke (eg, first year after stroke, higher level of disability and social isolation).[20] The most common risk factors found in PSD included stroke severity, cognitive dysfunction, physical impairment and functional dependency.[21] Identifying these risk factors could help guide early identification of comorbid depressive symptoms and facilitate timely preventive interventions.[20] In China, the average age of stroke survivors is around 65 years old, which is 10 years younger than that in developed countries.[22] Among older stroke survivors in China, PSD not only has an adverse long-term impact on their QoL but also contributes to caregiver burden.[23] Therefore, understanding the prevalence and correlates of depression among older Chinese stroke survivors is important to address the burden. However, to date, most previous studies have only examined PSD based on total or mean scores of standard scales such as the Hamilton Depression Rating Scale and Patient Health Questionnaire,[24 25] even though depression comprises different symptoms. Hence, the exploration of the relationships between individual depressive symptoms has not been adequately assessed.

Network analysis is a novel approach to understanding the psychopathological structure and conceptualising psychiatric disorders (eg, depression).[26] In contrast to traditional statistical methods (eg, regression analysis and factor analysis) which typically identify the effects of a latent disorder,[27] the network approach provides a consistent and transparent theoretical framework to conceptualise a psychiatric disorder or syndrome as a system of connected symptoms that can be visualised, analysed and studied.[26] Network theory suggests the potential for prioritising therapeutic targets by identifying central (influential) symptoms that are strongly connected to other symptoms within a network.[26 28] Few studies on PSD have used a network approach, for example, in a network analysis using the Centre for Epidemiological Studies Depression Scale-20 (CESD-20) among US stroke survivors aged 65 and above, 'sadness', 'blues' and 'depressed' emerged as the most central depressive symptoms.[27] In clinical practice, interventions for treating and/or decreasing a single central symptom might lead to the inhibition of symptom-to-symptom interactions and a reduction of overall network activation, which might eventually prevent the progression into a disorder.[29] Hence, it is critical to conduct a network analysis to depict the network structure of depressive symptoms and identify the central symptoms.

Further, few studies have investigated the prevalence of PSD and its associated factors, as well as employing network analysis to explore the structure of depressive symptoms among older stroke survivors. Therefore, based on a national survey in China, the Chinese Longitudinal Healthy Longevity Survey (CLHLS), our study aimed to investigate the prevalence and correlates of PSD among Chinese older stroke survivors, the depressive network structure and central symptoms, and examine the correlation of individual depressive symptoms with QoL. We hypothesised that PSD would be common among older Chinese stroke survivors, while certain depressive symptoms, such as 'feeling blue/depressed' would be the most central symptom and negatively associated with QoL.

METHODS

Study design and participants

The CLHLS is a nationwide community-based study initiated by Peking University in 1998, and was subsequently repeated in 2000, 2002, 2005, 2008–2009, 2011–2012, 2014 and 2017–2018.[30] Participants were recruited from counties and urban areas across China using an unequal probability multistage sampling method. The sociodemographic, behavioural and health-related data were collected through face-to-face interviews in each follow-up wave.[30] The detailed description of the methodology is reported in a study by Zeng *et al*.[31] Our study was a secondary analysis of the collection of data from the 2017–2018 data of the CLHLS project. Following the approach of a previous study by Han *et al*,[32] eligible participants were aged 65 years and older, and had previously experienced a stroke. The CLHLS research protocol was approved by the original Ethics Committee of Peking University (IRB00001052–13074). Written informed consent was obtained from all participants by the original institution.

The CLHLS collection of data from the 2017–2018 wave is publicly available. Information about the data can be found at: https://opendata.pku.edu.cn/file.xhtml?

fileId=10 356&version=2.1. The CLHLS had granted authorisation for the use of data prior to the commencement of this study. This study was a secondary analysis of the data previously collected.

Measures and assessments

Data on basic sociodemographic and health-related information were collected. Depressive symptoms were evaluated with the validated Chinese version of the CESD,[33–35] which consists of 10 items including (1) feeling bothered; (2) difficulty with concentrating; (3) feeling blue/depressed; (4) everything was an effort; (5) hopelessness; (6) feeling nervous/fearful; (7) lack of happiness; (8) loneliness; (9) inability to get going; and (10) sleep disturbances. The CESD-10 used in the CLHLS is a self-reported 5-point Likert scale that assesses the frequency of depressive symptoms with response options: 'never', 'rarely', 'sometimes', 'often' and 'most or all of the time'. In this study, 'never' and 'rarely' were scored as 0, 'sometimes' as 1, 'often' as 2 and 'most or all of the time' as 3, with total scores ranging from 0 to 30. Items 5, 7 and 10 were scored in reverse. A higher total CESD-10 score indicates more severe depressive symptoms, with a total score of ≥10 being considered as 'having depressive symptoms'.[36] The CESD has been widely used in research among stroke survivors.[37]

Anxiety symptoms were assessed using the validated Chinese version of the self-reported 7-item Generalised Anxiety Disorder Scale (GAD-7).[38 39] Each item was scored from 0 ('not at all') to 3 ('nearly every day'). The total scores range from 0 to 21, with a higher score indicating more severe anxiety symptoms.[40] Global QoL was measured with the total scores of the first two items in the Chinese version of the World Health Organization Quality of Life-brief version (WHOQOL-BREF) questionnaire.[41 42] The two items focus on the overall quality of life and health conditions and are answered on a 5-point Likert scale with options being scored from '1' (very poor) to '5' (very good). Both GAD-7 and WHOQOL-BREF scales have been widely used in studies conducted in Chinese populations.[40 43–45]

Univariate and multivariate analyses

Data analyses were conducted using SPSS V.26.0 (SPSS, Chicago, Illinois, USA). Normal distributions for continuous variables were tested using Quantile-Quantile plots. As for univariate analysis, independent sample t-tests for normally distributed continuous variables, Mann-Whitney U tests for non-normally distributed continuous variables, and χ^2 tests for categorical variables were used when comparing demographic, socioeconomic, behavioural and health-related variables between stroke survivors with and those without depressive symptoms, as appropriate. For multivariate analyses, a binary logistic regression analysis using the 'Enter' method (ie, all independent variables were entered into the model simultaneously) was performed. Dependent variables were defined as having depressive symptoms, while independent variables were identified where there were significant group differences in univariate analyses. Analysis of covariance (ANCOVA) was performed to compare QoL between subgroups with and without depressive symptoms after adjusting for variables with significant differences in univariate analyses. The two-tailed significant level for all tests in this study was set at $p<0.05$.

Network structure

Network estimation and visualisation

Network analysis was performed using the R programme, V.4.3.2.[46] In the network model, nodes represented individual depressive symptoms, while edges represented the correlations between symptoms. Thicker edges indicated stronger correlations, with green edges showing positive correlations and red reflecting negative correlations.[47] We executed the network estimation and visualisation using R-packages, including 'qgraph' (V.1.9.8),[48] 'ggplot2' (V.3.4.4) and 'bootnet' (V.1.5.6).[49] To establish an undirected network model without edge interpretation relying on a causal interpretation, a Gaussian graphical model was conducted to enhance the accuracy of prediction, model simplicity and network interpretability.[50] A graphic least absolute shrinkage and selection operator (glasso) with a tuning parameter of 0.5 was performed to produce sparse models by setting coefficients of the weak or irrelevant correlations to zero and highlighting the strongest associations between variables.[51] In addition, an Extended Bayesian Information Criterion (EBIC) model was performed to select a simpler model that could balance model fit and model complexity.[52] Based on the EBICglasso procedure, the 'estimateNetwork' function in the 'bootnet' package was used to select an optimal model. Further, we performed the 'flow' function from the 'qgraph' package to assess the association between individual depressive symptoms and QoL.[48]

Node centrality and predictability

To identify central symptoms in the network, expected influence (EI) that accounts for the presence of negative edges was applied as a stable and reliable centrality index, with a higher EI indicating that the symptom is more strongly associated with other symptoms and is more central to the network.[29] The package 'qgraph' (V.1.9.8) was conducted to examine the most central symptoms.[48] In addition, node predictability, defined as the extent to which a given node's variance is explained by all other nodes in the network, was estimated with the R-package 'mgm' (V.1.2–14).[53]

Network stability and accuracy

The stability and accuracy of the network model of depressive symptoms were examined using the R-package 'bootnet'.[49] For network stability, we conducted a case-dropping bootstrap which dropped and repeatedly resampled the dataset, and subsequently assessed the stability of the network. A sufficiently stable network was identified if there were no significant changes in the centrality indices

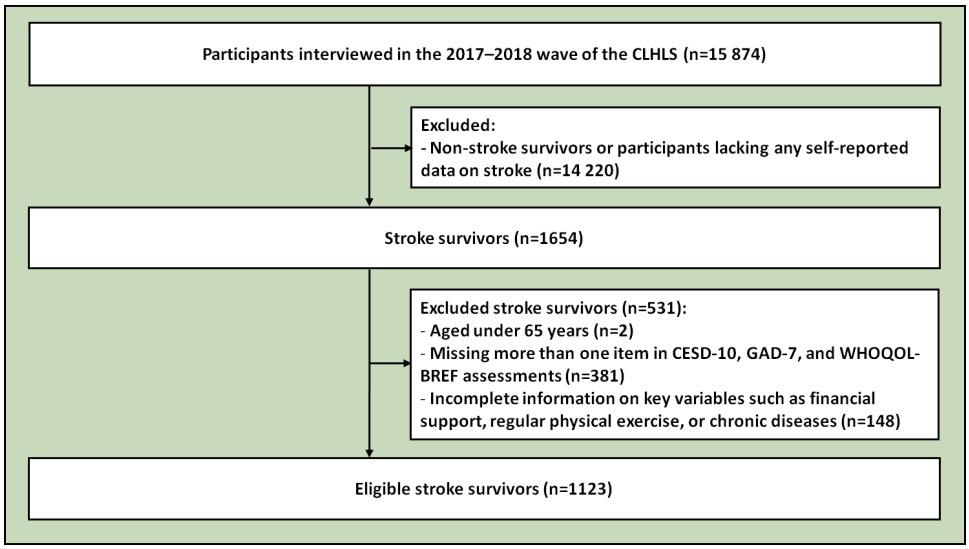

Figure 1 Flowchart of the study sample inclusion process. CESD, Centre for Epidemiological Studies Depression Scale; CLHLS, Chinese Longitudinal Healthy Longevity Survey; GAD-7, 7-item Generalised Anxiety Disorder Scale; WHOQOL-BREF, World Health Organization Quality of Life-brief version.

of the nodes across the different bootstrap samples. Moreover, the Correlation Stability Coefficient (CS-coefficient) was computed to assess centrality stability. A CS-coefficient value above 0.25 indicates that results from the observed network model are stable, although a value above 0.5 is preferable.[54] For the network accuracy, bootstrapped 95% CIs on the edge weights were conducted to evaluate edge accuracy, with a narrower range of CI representing a more reliable network. Differences between edges were assessed using a non-parametric bootstrapped difference test.[49]

RESULTS

Participant characteristics

Based on the 2017–2018 wave of the CLHLS, a total of 1123 older stroke survivors were included in this study (figure 1). Demographic and clinical characteristics of the participants are shown in table 1. The mean (standard deviation (SD)) age of the participants was 81.93 (9.53) years and 51.5% (n=578) were male. Most of the participants were married (n=566, 50.4%) and lived with family members (n=898, 80.0%), but only 38.6% had received education for 6 years or longer (n=433).

Prevalence and correlates of depression

The overall prevalence of depression (CESD-10 total score≥10) among older stroke survivors was 34.3% (n=385; 95% CI 31.5% to 37.2%). Table 1 indicates the significant differences found in terms of male gender (χ^2=8.856, p=0.003), sufficient financial support (χ^2=39.372, p<0.001), recent physical exercise (χ^2=46.596, p<0.001), limitations in ADL (χ^2=23.710, p<0.001), diabetes (χ^2=5.506, p=0.019) and heart diseases (χ^2=12.511, p<0.001) between stroke survivors with and without depression. Further, those with depression tended to have more severe anxiety (GAD-7) (Z=−8.211, p<0.001) and a lower QoL (Z=16.714, p<0.001).

A binary logistic regression analysis revealed that male gender (OR=0.695; p=0.014), sufficient financial support (OR=0.579; p=0.012) and recent physical exercise (OR=0.492; p<0.001) were significantly associated with a lower risk of depression, whereas limitations in ADL (OR=1.340; p=0.048), having heart diseases (OR=1.589; p=0.002) and more severe anxiety (OR=1.472; p<0.001) were significantly associated with a higher risk of depression. Additionally, after controlling for covariates using ANCOVA, stroke survivors with depressive symptoms still had lower QoL (F (1123)=127.431, p<0.001) compared with those without depressive symptoms.

Network structure of depressive symptoms

Figure 2 shows the network structure of depressive symptoms. The three nodes with the highest centrality were CESD3 (‘feeling blue/depressed’, EI: 1.180), CESD6 (‘feeling nervous/fearful’, EI: 0.864) and CESD8 (‘loneliness’, EI: 0.843). The mean predictability was 0.631, indicating an average of 63.10% of the variance in each node could be accounted for by its neighbouring nodes in the model. Online supplemental table S1 shows the descriptive statistics and network centrality indices for each item in CESD-10.

Figure 3 demonstrates that CESD5 (‘hopelessness’, average edge weight=−0.195) had the strongest negative association with QoL, followed by CESD10 (‘sleep disturbances’, average edge weight=−0.169) and CESD4 (‘everything was an effort’, average edge weight=−0.150).

Online supplemental figure S1 shows the results of the network stability. The CS-coefficient of EI was 0.75 after running a case-dropping bootstrap, which indicated that the network structure would remain stable even if 75% of the entire sample were dropped. As shown in online

Table 1 Demographic and clinical characteristics of older adults with a history of stroke

	Total (n=1123)		No DEP (n=738)		DEP (n=385)		Univariate analyses		
Variable	**n**	**%**	**n**	**%**	**n**	**%**	χ^2	**df**	**P value**
Male gender	578	51.5	404	54.7	174	45.2	8.856	1	**0.003**
Urban residence	515	45.9	334	45.3	181	47.0	0.247	1	0.619
Married status	566	50.4	338	45.8	228	59.2	3.820	1	0.051
Living with family members	898	80.0	597	80.9	301	78.2	0.728	1	0.394
Education years (≥6 years)	433	38.6	283	38.3	150	39.0	0.104	1	0.747
Sufficient financial support	975	86.8	675	91.5	300	77.9	39.372	1	**<0.001**
Recent physical exercise	417	37.1	327	44.3	90	23.4	46.596	1	**<0.001**
Limitations in ADL	516	45.9	300	40.7	216	56.1	23.710	1	**<0.001**
Hypertension	715	63.7	461	62.5	254	66.0	1.138	1	0.286
Diabetes	218	19.4	128	17.3	90	23.4	5.506	1	**0.019**
Dyslipidaemia	170	15.1	106	14.4	64	16.6	0.829	1	0.363
Heart disease	418	37.2	247	33.5	171	44.4	12.511	1	**<0.001**
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**t/Z**	**df**	**P value**
Age (years)	81.93	9.53	82.12	9.75	81.55	9.09	0.970	828.17	0.332
GAD-7 total	1.67	2.93	0.73	1.65	3.48	3.86	–8.211	---*	**<0.001**
Global QoL	4.93	1.51	5.42	1.37	4.01	1.32	16.714	805.58	**<0.001**

Bolded values: <0.05; limitations in activities of daily living: being limited in activities because of health problems for the last 6 months.
*Mann-Whitney U test.
ADL, activities of daily living; DEP, depressive symptoms; GAD-7, 7-item Generalized Anxiety Disorder Scale; QoL, quality of life; SD, standard deviation.

supplemental figure S2, the narrow bootstrapped 95% CIs of edge weights in the network showed that most of the edges within the depressive network were stable and accurate. Based on a bootstrapped difference test, a large proportion of edge weight differences and EI differences were significant, suggesting the network model was reliable (online supplemental figures S3–S4).

Table 2 Independent correlates of depressive symptoms among older adults with a history of stroke (n=1123)

	Depression		
Variables	**P value**	**OR**	**95% CI**
Male gender	**0.014**	0.695	0.521 to 0.927
Sufficient financial support	**0.012**	0.579	0.378 to 0.889
Recent physical exercise	**<0.001**	0.492	0.358 to 0.672
Limitations in activities of daily living	**0.048**	1.340	1.003 to 1.791
Diabetes	0.361	1.184	0.821 to 1.698
Heart disease	**0.002**	1.589	1.177 to 2.145
GAD-7 total	**<0.001**	1.472	1.381 to 1.574

Bolded value: <0.05.
GAD-7, 7-item Generalised Anxiety Disorder Scale.

DISCUSSION

Main findings

To the best of our knowledge, this was the first study to investigate the prevalence, correlates and network structure of PSD among older stroke survivors. We found that PSD was common (34.3%; 95% CI 31.5% to 37.2%) based on data from the 2017–2018 wave of the CLHLS in China, which is consistent with the overall PSD prevalence of 33.0% found by a previous systematic review (95% CI 29.0% to 36.0%)[11] but slightly higher than the range of PSD prevalence (19.6% to 22.2%) among stroke survivors.[55 56] In addition, the prevalence of depression in this study was higher than that reported among older adults receiving primary care (30.6%; 95% CI 27.3% to 34.0%) and the general older adult population in China (23.6%; 95% CI 20.3% to 27.2%).[57 58] The relatively high prevalence of PSD in this study could be attributed to a complex interaction of biological, psychological and social factors, including a previous history of depression,

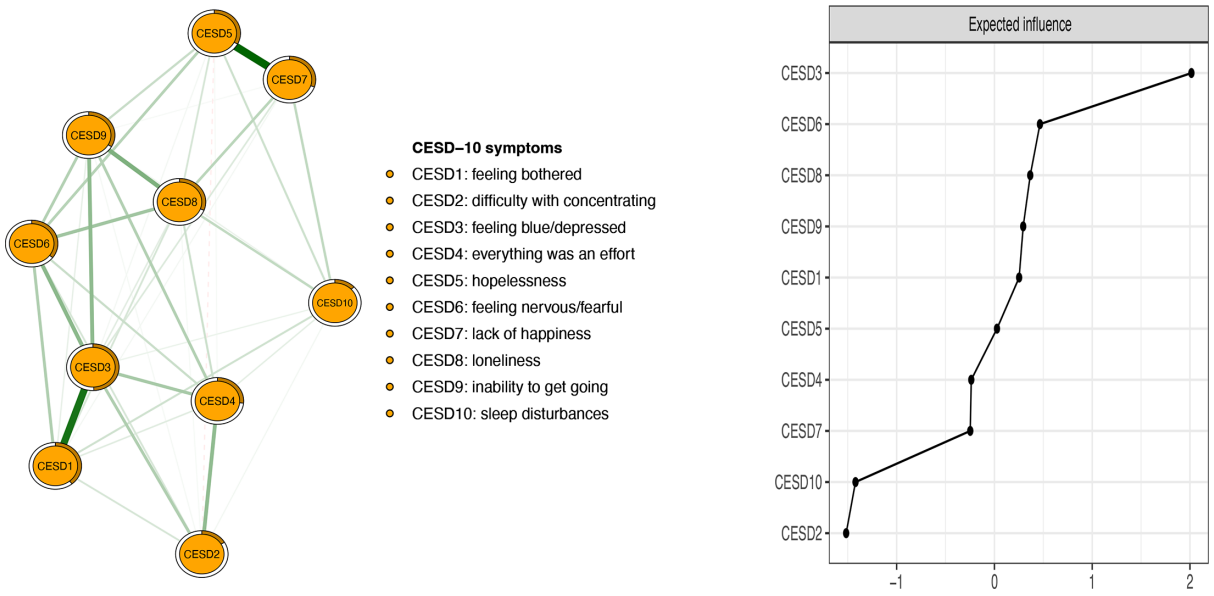

Figure 2 Network structure of depressive symptoms among older adults with stroke. CESD, Centre for Epidemiological Studies Depression Scale.

duration of disability, cognitive impairment and family and social support.[59 60] Further studies on strategies to prevent and reduce the PSD prevalence are urgently needed.

In this study, having limitations in ADL, higher GAD-7 total scores and heart diseases were associated with a higher risk of depression. A Swedish cross-sectional study found that the severity of impaired ADL was associated with the risk of developing PSD among stroke survivors.[61] Significant limitations in ADL would indicate greater functional impairment and reduced participation in social activities, both of which could lead to more severe

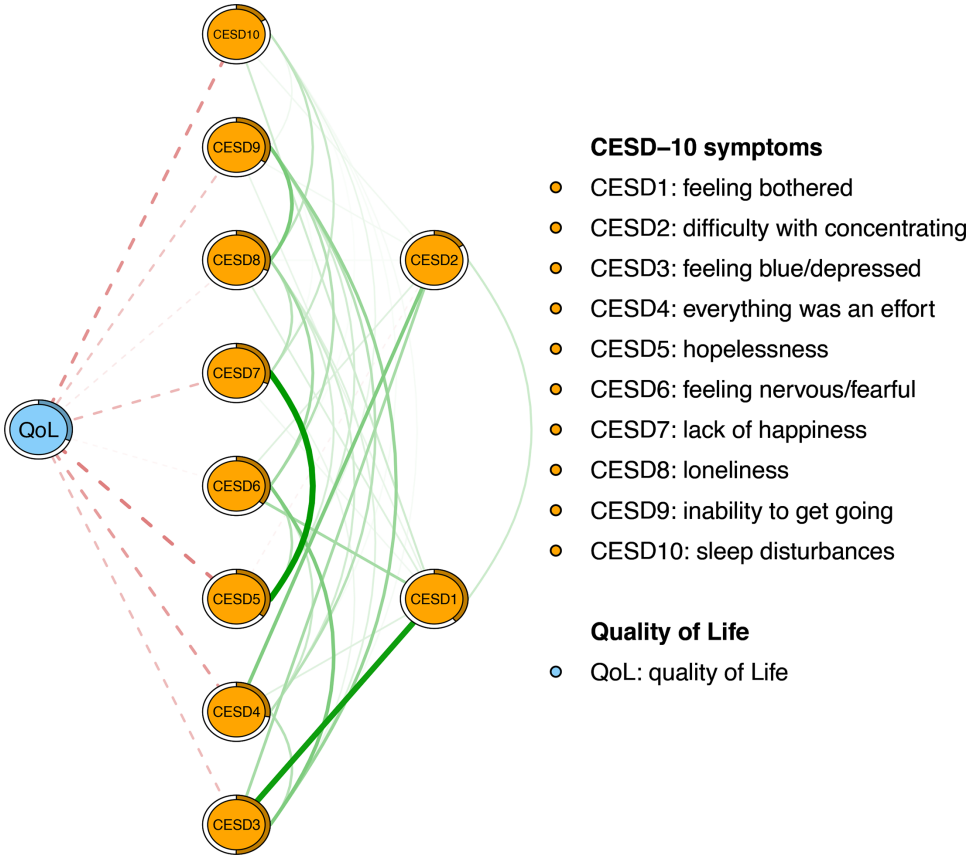

Figure 3 Flow network of quality of life and depressive symptoms. CESD, Centre for Epidemiological Studies Depression Scale.

depression after a stroke.[62 63] Post-stroke anxiety (PSA) appears to be another correlate of PSD. A retrospective study found that PSA was associated with higher levels of depression, which is consistent with our findings.[64] Stroke survivors in the recovery stage often worry about the possibility of stroke recurrence and may thus experience increased risk of anxiety, leading to decreased QoL.[65] Further, we found that having heart diseases was associated with a higher risk of PSD, which is consistent with a recent case–control study showing that ischaemic heart disease (adjusted OR=9.97; 95% CI 3.40 to 29.22) was associated with more severe PSD.[66] Previous research revealed that hypothalamic–pituitary–adrenal dysregulation, reduced heart rate variability and altered blood platelet function might represent underlying mechanisms that link depression to heart diseases.[67] High prevalence of depression was identified among individuals with heart diseases,[68] thus indicating that comorbid heart diseases with stroke might increase the risk of depression.

In contrast, male gender, sufficient financial support and recent physical exercises were significantly associated with a lower risk of depression in our study. The association of male gender with PSD is consistent with past research.[66] Gender differences in terms of recovery and basic ADL performance among stroke survivors have been widely reported in previous studies.[69 70] Males tended to have a lower risk of developing PSD than females, possibly due to having better functionality after stroke recovery and less dependency on their ADL.[63] The association of financial status with PSD in our study supports previous findings that socioeconomic status was significantly related to PSD.[71] Severe PSD could lead to increased mental healthcare services, particularly in the first year post-stroke.[72] Consequently, adequate financial support might increase access to necessary mental healthcare services that could potentially lower the risk of developing PSD. Furthermore, a population-based study showed that regular physical exercise was significantly associated with a lower risk of depression,[73] which is consistent with our findings. Stroke survivors having regular physical exercise were more likely to rebuild their self-esteem[74] and strengthen resilience by promoting positive emotions and enhancing their psychological well-being,[75 76] resulting in a lower risk of PSD. Thus, to decrease PSD risks, our findings underscore the importance of improving ADL, alleviating anxiety, ensuring sufficient financial support and engaging in regular physical exercise.

We found that older stroke survivors with PSD had lower QoL compared with those without PSD, which is in line with the findings of a previous longitudinal study.[77] Stroke survivors with PSD usually exhibited less recovery from functional disabilities compared with those without PSD, leading to restrictions in ADL, which could further reduce QoL.[78] Psychological factors (eg, hope and optimism) following stroke might reflect the way stroke survivors cope with stressful conditions,[79] which could affect QoL. Depressed stroke survivors tended to perceive more negative emotions like hopelessness or pessimism than non-depressed survivors, which could further lead to poorer QoL.[80]

Our network analysis indicated that 'feeling blue/depressed' (CESD-3), 'feeling nervous/fearful' (CESD-6) and 'loneliness' (CESD-8) were the most central symptoms for understanding the depression patterns in older stroke survivors. Within the network structure of depression, 'feeling blue/depressed' was the most central symptom, consistent with a recent study showing that being 'depressed' was one of the most central symptoms in the depressive network among older adults with stroke in the USA.[27] This could partly be explained by lesions in frontal/anterior areas or in the basal ganglia, limited social support and marked disability following stroke.[20] Moreover, anxiety, lower QoL, dysfunction in speech and language, feeling despair and poor treatment adherence are common in stroke survivors, all of which could contribute to feeling blue/depressed.[81 82]

'Feeling nervous/fearful' was also an important central symptom in the depressive network. Among stroke survivors, feeling fearful was significantly associated with fear of stroke recurrence and fear of falling.[83 84] More than half of stroke survivors had reported a fear of stroke recurrence,[85] which could result in more severe disabilities and even mortality.[84] In addition, 'feeling nervous/fearful' in stroke survivors could be due to fear of falling, which was related to certain factors such as female sex, impaired postural control, balance impairments, use of a walking aid, and a history of falls.[86]

'Loneliness' was another central symptom identified in the network. Loneliness, within the context of depressive symptoms, is defined as a distressing feeling that arises when one perceives that their social needs are not being met by either the quantity or particularly the quality of their social relationships.[87] According to the epidemiological literature, loneliness could have a synergistic effect on other depressive symptoms and reduce well-being in older adults, which aligns with our findings.[88] Stroke survivors might experience disabilities caused by age-related health conditions, such as cognitive deficits, contributing to reduced opportunities for social engagement and increased feelings of loneliness.[89]

In clinical practice, treatments for PSD typically include pharmacological options, such as selective serotonin reuptake inhibitors, and psychosocial interventions.[59 90] According to network theory, targeting appropriate interventions on the most central symptoms identified may enhance treatment efficacy and provide a more tailored clinical management plan for stroke survivors.[27]

The flow network in this study examined the association between depressive symptoms and QoL, which found that 'hopelessness' (CESD5), 'sleep disturbances' (CESD10) and 'everything was an effort' (CESD4) were the top symptoms with the strongest negative association with QoL. This is in line with previous findings that identified a close association between depression and QoL in older adults.[91] 'Hopelessness' is defined as a subjective state in which one perceives limited or a lack

of alternatives, and being unable to muster the energy for their own sake.[92] In our study, 'hopelessness' was the strongest negative symptom associated with QoL within the flow network structure. Stroke survivors experiencing hopelessness tended to perceive having impaired physical and social functioning as well as a dependency on others for assistance with ADL, leading to a lower QoL.[80 92] Further, 'sleep disturbances' was the second strongest negative symptom. Sleep problems were common among individuals with PSD and were found to be positively associated with PSD in a recent Chinese study.[93] Stroke survivors experiencing both PSD and sleep disturbances (eg, insomnia) were more likely to have poorer QoL due to impairment in physical strength, memory, communication, emotion control and mobility.[94] These factors might ultimately prolong the rehabilitation and recovery process after stroke.[94]

'Everything was an effort' was another symptom that was negatively associated with QoL. In the CESD-10, 'everything was an effort' might indicate a higher level of fatigue.[33 95] Prior network analysis from the English Longitudinal Study of Ageing highlighted the feeling 'everything was an effort' as arising from fatigue that could be due to pain or reduced mobility among elderly people.[96] The severity of post-stroke fatigue appeared to be a significant factor for both ADL and stroke-related QoL, with higher fatigue severity indicating worse physical dysfunction and contributing to poorer QoL.[97] Thus, the findings of the flow network model suggest that interventions targeting depressive symptoms (eg, 'hopelessness', 'sleep disturbances' and 'everything was an effort') might have the potential to improve QoL in older stroke survivors with PSD. For instance, cognitive-behavioural therapy was shown to be effective in addressing PSD, particularly by targeting cognitive distortions and emotional distress.[98] Additionally, mindfulness-based stress reduction might be a potential treatment for alleviating feelings of depression after stroke and enhancing overall well-being.[99]

Strengths and limitations

The strengths of this study included the nationwide, representative sample, large sample size and the use of a network approach to investigate the network structure of PSD and the interplay between PSD symptoms and QoL among older stroke survivors. However, the study also had limitations. First, no data on different stroke phases (eg, acute or chronic stroke phase), stroke severity or subtypes (eg, ischaemic or haemorrhagic stroke) were recorded. Therefore, their influence on the findings of this study could not be examined. Second, as the network analysis in this study was generated from cross-sectional data, any causal inference between depressive symptoms and between PSD and QoL was not possible. Third, the depressive symptoms were assessed based on self-report, which might result in recall bias.

Implications

This study highlighted the need for targeted interventions addressing the most influential central PSD symptoms like 'feeling blue/depressed', 'feeling nervous/fearful' and 'loneliness' to enhance treatment efficacy. Managing symptoms that were strongly associated with QoL, such as 'hopelessness', 'sleep disturbances' and 'everything was an effort', is critical for improving QoL among stroke survivors. Preventive strategies for enhancing ADL, reducing anxiety, ensuring financial support and promoting regular physical exercise are also essential. Future longitudinal studies and biomarker integration are recommended to clarify changes in PSD over time and the underlying mechanisms.

In conclusion, this study found that PSD was common in older stroke survivors, particularly in those having limited ADL, heart diseases or more severe anxiety. Future interventions targeting the central symptoms and those symptoms closely associated with QoL might be effective in the prevention and treatment of PSD, as well as the improvement of QoL in older stroke survivors.

Author affiliations
[1]Unit of Psychiatry, Department of Public Health and Medicinal Administration, & Institute of Translational Medicine, Faculty of Health Sciences, University of Macau, Macao, China
[2]Beijing Key Laboratory of Mental Disorders, National Clinical Research Center for Mental Disorders & National Center for Mental Disorders, Beijing Anding Hospital, Capital Medical University, Beijing, China
[3]School of Nursing, Hong Kong Polytechnic University, Hong Kong, China
[4]Stillwater High School, Stillwater, Oklahoma, USA
[5]Section of Psychiatry, University of Notre Dame Australia, Fremantle, Western Australia, Australia
[6]Division of Psychiatry, School of Medicine, University of Western Australia, Perth, Western Australia, Australia
[7]Department of Psychiatry, The Melbourne Clinic and St Vincent's Hospital, University of Melbourne, Richmond, Victoria, Australia

Correction notice This article has been corrected since it was first published. Author names and their affiliations have been updated.

Acknowledgements The authors are grateful to all participants and clinicians involved in this study.

Contributors Study design: QZ, CHN, YTX. Data collection, analysis and interpretation: MRZ, PC, LZ, YF, TC, GSU. Drafting of the manuscript: MRZ, NXX, YTX. Critical revision of the manuscript: CHN. Approval of the final version for publication: all co-authors.

Funding The study was supported by Beijing High Level Public Health Technology Talent Construction Project (Discipline Backbone- 01- 028), the Beijing Municipal Science & Technology Commission (No. Z181100001518005), the Capital's Funds for Health Improvement and Research (CFH 2024- 2- 1174), the University of Macau (MYRG- GRG2023- 00141- FHS; CPG2025- 00021- FHS) and the Science and Technology Plan Foundation of Guangzhou (No.202201011663).

Competing interests None declared.

Patient consent for publication Not applicable.

Ethics approval The CLHLS research protocol was approved by the Ethics Committee of Peking University (IRB00001052–13074). Written informed consent was obtained from all participants. We have introduced this information in our manuscript.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement No data are available.

ORCID iDs
Mu-Rui Zheng http://orcid.org/0000-0001-5856-0930
Pan Chen http://orcid.org/0000-0001-7185-9363

REFERENCES

1 Saini V, Guada L, Yavagal DR. Global epidemiology of stroke and access to acute ischemic stroke interventions. *Neurology (ECronicon)* 2021;97:S6–16.
2 Feigin VL, Forouzanfar MH, Krishnamurthi R, *et al*. Global and regional burden of stroke during 1990–2010: findings from the Global Burden of Disease Study 2010. *The Lancet* 2014;383:245–55.
3 Wafa HA, Wolfe CDA, Emmett E, *et al*. Burden of stroke in Europe: thirty-year projections of incidence, prevalence, deaths, and disability-adjusted life years. *Stroke* 2020;51:2418–27.
4 Ma Q, Li R, Wang L, *et al*. Temporal trend and attributable risk factors of stroke burden in China, 1990-2019: an analysis for the Global Burden of Disease Study 2019. *Lancet Public Health* 2021;6:e897–906.
5 Gillen R, Tennen H, McKee TE, *et al*. Depressive symptoms and history of depression predict rehabilitation efficiency in stroke patients. *Arch Phys Med Rehabil* 2001;82:1645–9.
6 Mouta S, Fonseca Vaz I, Pires M, *et al*. What do we know about pseudodementia? *Gen Psychiatr* 2023;36:e100939.
7 Moretti A, Ferrari F, Villa RF. Neuroprotection for ischaemic stroke: current status and challenges. *Pharmacol Ther* 2015;146:23–34.
8 Moretti A, Gorini A, Villa RF. Affective disorders, antidepressant drugs and brain metabolism. *Mol Psychiatry* 2003;8:773–85.
9 Shi Y, Yang D, Zeng Y, *et al*. Risk factors for post-stroke depression: a meta-analysis. *Front Aging Neurosci* 2017;9:218.
10 Taylor-Rowan M, Momoh O, Ayerbe L, *et al*. Prevalence of pre-stroke depression and its association with post-stroke depression: a systematic review and meta-analysis. *Psychol Med* 2019;49:685–96.
11 Hackett ML, Pickles K. Part I: frequency of depression after stroke: an updated systematic review and meta-analysis of observational studies. *Int J Stroke* 2014;9:1017–25.
12 Salaycik KJ, Kelly-Hayes M, Beiser A, *et al*. Depressive symptoms and risk of stroke: the Framingham Study. *Stroke* 2007;38:16–21.
13 Pan A, Sun Q, Okereke OI, *et al*. Depression and risk of stroke morbidity and mortality: a meta-analysis and systematic review. *JAMA* 2011;306:1241–9.
14 Ausloos M, Brugha TS, Collaborators G. Global, regional, and national disability-adjusted life-years (DALYs) for 359 diseases and injuries and healthy life expectancy (HALE) for 195 countries and territories, 1990–2017: a systematic analysis for the Global Burden of Disease Study 2017. *The Lancet* 2018;392:1859–922.
15 Whyte EM, Mulsant BH. Post stroke depression: epidemiology, pathophysiology, and biological treatment. *Biol Psychiatry* 2002;52:253–64.
16 Bartoli F, Di Brita C, Crocamo C, *et al*. Early post-stroke depression and mortality: meta-analysis and meta-regression. *Front Psychiatry* 2018;9:530.
17 Chaturvedi P, Tiwari V, Singh AK, *et al*. Depression impedes neuroplasticity and quality of life after stroke. *J Family Med Prim Care* 2020;9:4039–44.
18 Ayerbe L, Ayis S, Wolfe CDA, *et al*. Natural history, predictors and outcomes of depression after stroke: systematic review and meta-analysis. *Br J Psychiatry* 2013;202:14–21.
19 Ramasubbu R, Robinson RG, Flint AJ, *et al*. Functional impairment associated with acute poststroke depression: the Stroke Data Bank Study. *J Neuropsychiatry Clin Neurosci* 1998;10:26–33.
20 Medeiros GC, Roy D, Kontos N, *et al*. Post-stroke depression: a 2020 updated review. *Gen Hosp Psychiatry* 2020;66:70–80.
21 Babkair LA. Risk factors for poststroke depression: an integrative review. *J Neurosci Nurs* 2017;49:73–84.
22 Wu S, Wu B, Liu M, *et al*. Stroke in China: advances and challenges in epidemiology, prevention, and management. *Lancet Neurol* 2019;18:394–405.
23 Dou D-M, Huang L-L, Dou J, *et al*. Post-stroke depression as a predictor of caregivers burden of acute ischemic stroke patients in China. *Psychol Health Med* 2018;23:541–7.
24 Ruhé HG, Dekker JJ, Peen J, *et al*. Clinical use of the Hamilton Depression Rating Scale: is increased efficiency possible? A post hoc comparison of Hamilton Depression Rating Scale, Maier and Bech subscales, Clinical Global Impression, and Symptom Checklist-90 scores. *Compr Psychiatry* 2005;46:417–27.
25 Kocalevent R-D, Hinz A, Brähler E. Standardization of the depression screener patient health questionnaire (PHQ-9) in the general population. *Gen Hosp Psychiatry* 2013;35:551–5.
26 Borsboom D. A network theory of mental disorders. *World Psychiatry* 2017;16:5–13.
27 Lau SCL, Connor LT, Lee J-M, *et al*. Depressive symptomatology and functional status among stroke survivors: a network analysis. *Arch Phys Med Rehabil* 2022;103:1345–51.
28 Borsboom D, Cramer AOJ. Network analysis: an integrative approach to the structure of psychopathology. *Annu Rev Clin Psychol* 2013;9:91–121.
29 Robinaugh DJ, Millner AJ, McNally RJ. Identifying highly influential nodes in the complicated grief network. *J Abnorm Psychol* 2016;125:747–57.
30 Wang J, Chen C, Zhou J, *et al*. Healthy lifestyle in late-life, longevity genes, and life expectancy among older adults: a 20-year, population-based, prospective cohort study. *Lancet Healthy Longev* 2023;4:e535–43.
31 Zeng Y, Feng Q, Hesketh T, *et al*. Survival, disabilities in activities of daily living, and physical and cognitive functioning among the oldest-old in China: a cohort study. *The Lancet* 2017;389:1619–29.
32 Han Y, Hu K, Wu Y, *et al*. Future life expectancy with disability among elderly Chinese individuals: a forecast based on trends in stroke and dementia. *Public Health (Fairfax)* 2021;198:62–8.
33 Radloff LS. The CES-D scale: a self-report depression scale for research in the general population. *Appl Psychol Meas* 1977;1:385–401.
34 Andresen EM, Malmgren JA, Carter WB, *et al*. Screening for depression in well older adults: evaluation of a short form of the CES-D (Center for Epidemiologic Studies Depression Scale). *Am J Prev Med* 1994;10:77–84.
35 Chen H, Mui AC. Factorial validity of the Center for Epidemiologic Studies Depression Scale short form in older population in China. *Int Psychogeriatr* 2014;26:49–57.
36 Amtmann D, Kim J, Chung H, *et al*. Comparing CESD-10, PHQ-9, and PROMIS depression instruments in individuals with multiple sclerosis. *Rehabil Psychol* 2014;59:220–9.
37 Williams MW, Li C-Y, Hay CC. Validation of the 10-item Center for Epidemiologic Studies Depression Scale post stroke. *J Stroke Cerebrovasc Dis* 2020;29:105334.
38 Spitzer RL, Kroenke K, Williams JBW, *et al*. A brief measure for assessing generalized anxiety disorder: the GAD-7. *Arch Intern Med* 2006;166:1092–7.
39 He X, Li C, Qian J, *et al*. A study on the reliability and validity of Generalized Anxiety Scale in general hospitals. *Shanghai Psychiatry* 2010;22:200–3.
40 Sun J, Liang K, Chi X, *et al*. Psychometric properties of the Generalized Anxiety Disorder Scale-7 Item (GAD-7) in a large sample of Chinese adolescents. *Healthcare (Basel)* 2021;9:1709.
41 Zhang Y, Qu B, Lun S, *et al*. Quality of life of medical students in China: a study using the WHOQOL-BREF[J]. *PLoS ONE* 2012;7:e49714.
42 Development of the World Health Organization WHOQOL-BREF Quality of life assessment. The WHOQOL Group. *Psychol Med* 1998;28:551–8.
43 Gu W, Xu Y-M, Zhong B-L. Health-related quality of life in Chinese inpatients with lung cancer treated in large general hospitals: across-sectional study. *BMJ Open* 2018;8:e019873.
44 Tong X, An D, McGonigal A, *et al*. Validation of the Generalized Anxiety Disorder-7 (GAD-7) among Chinese people with epilepsy. *Epilepsy Res* 2016;120:31–6.
45 Dai J, Zhong B-L, Xiang Y-T, *et al*. Internal migration, mental health, and suicidal behaviors in young rural Chinese. *Soc Psychiatry Psychiatr Epidemiol* 2015;50:621–31.
46 R Development Core Team. R: a language and environment for statistical computing. 2023. Available: http://www.R-project.org [Accessed 15 Dec 2023].

47 Beard C, Millner AJ, Forgeard MJC, *et al*. Network analysis of depression and anxiety symptom relationships in a psychiatric sample. *Psychol Med* 2016;46:3359–69.
48 Epskamp S, Cramer AOJ, Waldorp LJ, *et al*. Qgraph: network visualizations of relationships in psychometric data. *J Stat Soft* 2012;48:1–18.
49 Epskamp S, Borsboom D, Fried EI. Estimating psychological networks and their accuracy: a tutorial paper. *Behav Res Methods* 2018;50:195–212.
50 Costantini G, Epskamp S, Borsboom D, *et al*. State of the aRt personality research: a tutorial on network analysis of personality data in R. *J Res Pers* 2015;54:13–29.
51 Friedman J, Hastie T, Tibshirani R. Sparse inverse covariance estimation with the graphical lasso. *Biostatistics* 2008;9:432–41.
52 Foygel R, Drton M. Extended bayesian information criteria for gaussian graphical models. Adv Neural Inf Process Syst; 2010.
53 Haslbeck J, Waldorp LJ. Mgm: estimating time-varying mixed graphical models in high-dimensional data. *J Stat Softw* 2015;93:1–46.
54 Koo TK, Li MY. A guideline of selecting and reporting intraclass correlation coefficients for reliability research. *J Chiropr Med* 2016;15:155–63.
55 Klingbeil J, Brandt M-L, Wawrzyniak M, *et al*. Association of lesion location and depressive symptoms poststroke. *Stroke* 2021;52:830–7.
56 Lee E-J, Kwon OD, Kim SJ. Prevalence, awareness, and treatment of depression among community-dwelling stroke survivors in Korea. *Sci Rep* 2022;12:4050.
57 Zhong B-L, Xu Y-M, Xie W-X, *et al*. Depressive symptoms in elderly Chinese primary care patients: prevalence and sociodemographic and clinical correlates. *J Geriatr Psychiatry Neurol* 2019;32:312–8.
58 Li D, Zhang D, Shao J, *et al*. A meta-analysis of the prevalence of depressive symptoms in Chinese older adults. *Arch Gerontol Geriatr* 2014;58:1–9.
59 Villa RF, Ferrari F, Moretti A. Post-stroke depression: mechanisms and pharmacological treatment. *Pharmacol Ther* 2018;184:131–44.
60 Johnson JL, Minarik PA, Nyström KV, *et al*. Poststroke depression incidence and risk factors: an integrative literature review. *J Neurosci Nurs* 2006;38:316–27.
61 Brown C, Hasson H, Thyselius V, *et al*. Post-stroke depression and functional independence: a conundrum. *Acta Neurol Scand* 2012;126:45–51.
62 De Ryck A, Fransen E, Brouns R, *et al*. Poststroke depression and its multifactorial nature: results from a prospective longitudinal study. *J Neurol Sci* 2014;347:159–66.
63 Haghgoo HA, Pazuki ES, Hosseini AS, *et al*. Depression, activities of daily living and quality of life in patients with stroke. *J Neurol Sci* 2013;328:87–91.
64 Sanner Beauchamp JE, Casameni Montiel T, Cai C, *et al*. A retrospective study to identify novel factors associated with post-stroke anxiety. *J Stroke Cerebrovasc Dis* 2020;29:104582.
65 Rafsten L, Danielsson A, Sunnerhagen KS. Anxiety after stroke: a systematic review and meta-analysis. *J Rehabil Med* 2018;50:769–78.
66 Fantu E, Hailu W, Bekele N, *et al*. Determinants of post-stroke depression among stroke survivors at University of Gondar Hospital, Northwest Ethiopia: a case-control study. *BMC Neurol* 2022;22:446.
67 Grippo AJ, Johnson AK. Biological mechanisms in the relationship between depression and heart disease. *Neuroscience & Biobehavioral Reviews* 2002;26:941–62.
68 Kent LK, Shapiro PA. Depression and related psychological factors in heart disease. *Harv Rev Psychiatry* 2009;17:377–88.
69 Appelros P, Stegmayr B, Terént A. A review on sex differences in stroke treatment and outcome. *Acta Neurol Scand* 2010;121:359–69.
70 Sue-Min L, Duncan PW, Dew P, *et al*. Sex differences in stroke recovery. *Prev Chronic Dis* 2005;2:A13.
71 Saxena A, Suman A. Magnitude and determinants of depression in acute stroke patients admitted in a rural tertiary care hospital. *J Neurosci Rural Pract* 2015;6:202–7.
72 van Eeden M, van Mastrigt G, Evers S, *et al*. The economic impact of mental healthcare consumption before and after stroke in a cohort of stroke patients in the Netherlands: a record linkage study. *BMC Health Serv Res* 2016;16:688.
73 De Moor MHM, Beem AL, Stubbe JH, *et al*. Regular exercise, anxiety, depression and personality: a population-based study. *Prev Med* 2006;42:273–9.
74 Daley A. Exercise and depression: a review of reviews. *J Clin Psychol Med Settings* 2008;15:140–7.
75 Waugh CE, Koster EHW. A resilience framework for promoting stable remission from depression. *Clin Psychol Rev* 2015;41:49–60.
76 Kim J-H. Regular physical exercise and its association with depression: a population-based study short title: exercise and depression. *Psychiatry Res* 2022;309:114406.
77 Kim E-S, Kim J-W, Kang H-J, *et al*. Longitudinal impact of depression on quality of life in stroke patients. *Psychiatry Investig* 2018;15:141–6.
78 Hadidi N, Treat-Jacobson DJ, Lindquist R. Poststroke depression and functional outcome: a critical review of literature. *Heart Lung* 2009;38:151–62.
79 van Mierlo ML, Schröder C, van Heugten CM, *et al*. The influence of psychological factors on health-related quality of life after stroke: a systematic review. *Int J Stroke* 2014;9:341–8.
80 Scogin F, Morthland M, DiNapoli EA, *et al*. Pleasant events, hopelessness, and quality of life in rural older adults. *J Rural Health* 2016;32:102–9.
81 Ayerbe L, Ayis S, Crichton S, *et al*. The long-term outcomes of depression up to 10 years after stroke; the South London Stroke Register. *Journal of Neurology, Neurosurgery & Psychiatry* 2014;85:514–21.
82 De Ryck A, Brouns R, Fransen E, *et al*. A prospective study on the prevalence and risk factors of poststroke depression. *Cerebrovasc Dis Extra* 2013;3:1–13.
83 Walsh M, Galvin R, Horgan NF. Fall-related experiences of stroke survivors: a meta-ethnography. *Disabil Rehabil* 2017;39:631–40.
84 White CL, Barrientos R, Dunn K. Dimensions of uncertainty after stroke: perspectives of the stroke survivor and family caregiver. *J Neurosci Nurs* 2014;46:233–40.
85 Townend E, Tinson D, Kwan J, *et al*. Fear of recurrence and beliefs about preventing recurrence in persons who have suffered a stroke. *J Psychosom Res* 2006;61:747–55.
86 Xie Q, Pei J, Gou L, *et al*. Risk factors for fear of falling in stroke patients: a systematic review and meta-analysis. *BMJ Open* 2022;12:e056340.
87 Hawkley LC, Cacioppo JT. Loneliness matters: a theoretical and empirical review of consequences and mechanisms. *Ann Behav Med* 2010;40:218–27.
88 Cacioppo JT, Hughes ME, Waite LJ, *et al*. Loneliness as a specific risk factor for depressive symptoms: cross-sectional and longitudinal analyses. *Psychol Aging* 2006;21:140–51.
89 Freak-Poli R, Ryan J, Neumann JT, *et al*. Social isolation, social support and loneliness as predictors of cardiovascular disease incidence and mortality. *BMC Geriatr* 2021;21:711.
90 Mortensen JK, Andersen G. Pharmacological management of post-stroke depression: an update of the evidence and clinical guidance. *Expert Opin Pharmacother* 2021;22:1157–66.
91 Bai W, Zhang J, Smith RD, *et al*. Inter-relationship between cognitive performance and depressive symptoms and their association with quality of life in older adults: a network analysis based on the 2017-2018 wave of Chinese Longitudinal Healthy Longevity Survey (CLHLS). *J Affect Disord* 2023;320:621–7.
92 Darliana D, Aisy R. Relationship of functional status and hopelessness among stroke patients. *Aceh International Nursing Conference*; Banda Aceh, Indonesia, 2018.
93 Zhao L, Yang F, Sznajder KK, *et al*. Resilience as the mediating factor in the relationship between sleep disturbance and post-stroke depression of stroke patients in China: a structural equation modeling analysis. *Front Psychiatry* 2021;12:625002.
94 Fulk G, Duncan P, Klingman KJ. Sleep problems worsen health-related quality of life and participation during the first 12 months of stroke rehabilitation. *Clin Rehabil* 2020;34:1400–8.
95 Vestergaard S, Nayfield SG, Patel KV, *et al*. Fatigue in a representative population of older persons and its association with functional impairment, functional limitation, and disability. *J Gerontol A Biol Sci Med Sci* 2009;64:76–82.
96 Schlechter P, Ford TJ, Neufeld SAS. The development of depressive symptoms in older adults from a network perspective in the English Longitudinal Study of Ageing. *Transl Psychiatry* 2023;13:363.
97 Chen YK, Qu J-F, Xiao WM, *et al*. Poststroke fatigue: risk factors and its effect on functional status and health-related quality of life. *Int J Stroke* 2015;10:506–12.
98 Ahrens J, Shao R, Blackport D, *et al*. Cognitive -behavioral therapy for managing depressive and anxiety symptoms after stroke: a systematic review and meta-analysis. *Top Stroke Rehabil* 2023;30:368–83.
99 Duan H, Yan X, Meng S, *et al*. Effectiveness evaluation of repetitive transcranial magnetic stimulation therapy combined with mindfulness-based stress reduction for people with post-stroke depression: a randomized controlled trial. *Int J Environ Res Public Health* 2023;20:930.

Murui Zheng obtained a bachelor's degree in Preventive Medicine from Sun Yat-sen University in China (2003–2008) and a master's degree in public health, specializing in Epidemiology and Biostatistics, from the University of Hong Kong (2013–2014) in China. Currently, he is pursuing a PhD in Mental Health at the University of Macau in China (since 2023). His academic journey has been driven by a deep interest in mental health research. As a PhD student at the Unit of Psychiatry within the Faculty of Health Sciences at the University of Macau, his research focuses on clinical psychiatry, evidence-based medicine, and public mental health. He aims to contribute to the field by integrating epidemiological approaches and biostatistical analysis to improve mental health outcomes. Through his research, he seeks to enhance the understanding of psychiatric disorders and develop evidence-based interventions that can inform clinical practice and public health policies. His main research interests include bridging the gap between research findings and real-world applications in psychiatry. With a strong foundation in epidemiology and biostatistics, he strives to apply rigorous research methodologies to psychiatric studies, aiming to produce high-quality evidence that supports better mental health care. His current work involves analysing clinical data, evaluating mental health interventions, and contributing to the growing body of psychiatric research. By pursuing advanced research in psychiatry, he hopes to contribute to the field of mental health, improve patient outcomes, and support the development of more effective, evidence-based psychiatric practices.