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Cardiac history and post-stroke depression association in Chinese stroke survivors: a cross sectional study

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A substantial body of evidence indicates that stroke is a primary cause of death and disability on a global scale. The presence of post-stroke depression has been demonstrated to exert a substantial influence on the prognosis of stroke patients, underscoring the imperative for the identification and early prevention of post-stroke depression. The objective of this study was to examine the association between cardiac history and post-stroke depression (PSD) in Chinese stroke patients, with the aim of identifying high-risk groups, promoting early intervention strategies, and enhancing patient prognosis. This study was based on data from the 2020 China Health and Retirement Longitudinal Study (CHARLS), which included 933 respondents with a history of stroke. Univariate and multivariate logistic regression analyses were used to assess the effects of cardiac history and other variables on post-stroke depression (PSD). The results indicated a correlation between cardiac history and post-stroke depression (PSD). In addition, the data showed that gender, activities of daily living (ADLs), cognitive functioning, and life satisfaction also had an effect on post-stroke depression (PSD). The findings presented here indicate that patients with a history of cardiac disease are more likely to develop post-stroke depression. This provides valuable insights into the clinical management of stroke patients and the prevention of post-stroke depression. The emotional health assessment of such patients should be emphasized in clinical management, and appropriate psychological support and interventions should be provided to improve their overall prognosis.

Keywords Post-stroke depression, Cardiovascular disease history, Stroke, Cross-sectional study, Depression, Charls, Risk factors, Chinese patients

Stroke is one of the leading causes of death and disability worldwide, imposing a substantial health and economic burden on individuals and society. Research indicates that over 15 million people globally experience a first-time stroke each year, with approximately one-third of patients facing long-term disability[1]. This exacerbates the global disease burden, placing a significant strain on families, healthcare systems, and socioeconomic structures[2]. Post-stroke depression (PSD) is a common complication among stroke survivors. It refers to depressive symptoms that emerge following a stroke, typically within weeks to months after the event, and may persist for an extended period. It is estimated that approximately 25% to 30% of stroke patients experience these symptoms[3,4]. The clinical manifestations of post-stroke depression (PSD) are varied and encompass depressed mood, loss of interest, anxiety, suicidal ideation, sleep disturbances, and behavioral changes[5,6]. Despite advancements in therapeutic interventions for PSD, significant challenges persist in its diagnosis and clinical management For instance, PSD symptoms frequently overlap with other post-stroke complications, complicating differential diagnosis[7]. Furthermore, the long-term sequelae of PSD include increased mortality risk, reduced quality of life, and prolonged hospitalization periods[8]. Early initiation of antidepressant therapy in PSD has demonstrated efficacy in promoting both physical and cognitive recovery post-stroke, with evidence suggesting sustained

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survival benefits for up to ten years following the index stroke event[9]. Studies have shown that PSD hinders patient recovery, reduces quality of life, and increases the risk of recurrent stroke and mortality[3]. However, there are currently no definitive methods for the early identification and prevention of PSD, making it crucial to identify high-risk populations for early intervention, which can significantly improve patient outcomes[10].

In recent years, with the advent of big data analysis and multicenter studies, research on PSD has gradually deepened. Most studies emphasize the importance of early screening and intervention[11]. At this stage, it has been found that predictors for post-stroke depression are multidimensional. These include stroke severity, stroke site, cognitive impairment, physical disability, social support, gender, and age. There may be interactions between these factors, which together influence the onset and progression of post-stroke depression[12–14]. Although the risk factors for PSD have been increasingly reported, there remains a lack of medical evidence. If some of these risk factors can be avoided or mitigated, preventive measures could facilitate early diagnosis, timely treatment, and enhanced quality of life. The prevalence of depression has been found to be higher in patients with heart disease in modern clinical studies[15]. However, whether this finding holds true in specific populations remains uncertain. Some studies suggest that a history of heart disease may be a risk factor for PSD among stroke patients[16], with complex pathophysiological mechanisms involving inflammatory responses, neuroendocrine changes, and vascular dysfunction[10,16].

However, the association between cardiovascular disease history and PSD has not been fully established, necessitating further studies to establish a causal link[17]. Against this background, this study sought to investigate the pathophysiological relationship between pre-existing cardiovascular conditions and PSD among stroke patients. Data were derived from the China Health and Retirement Longitudinal Study (CHARLS) database, a nationally representative longitudinal cohort of middle-aged and older Chinese adults. Containing comprehensive health and lifestyle metrics, the CHARLS database offered a robust epidemiological foundation for examining risk factors contributing to post-stroke depression in this population. Through multivariate analyses, this research seeks to elucidate the underlying mechanisms linking cardiovascular comorbidities to PSD, ultimately informing evidence-based clinical interventions.

Methods

Data source

The data for this study were obtained from the China Health and Retirement Longitudinal Study (CHARLS). CHARLS is a nationally representative longitudinal survey of Chinese individuals aged 45 and above and their spouses. The survey used a multi-stage probability sampling approach with implicit stratification (stratification indicators included region, urban–rural attributes, and per capita GDP). The nationwide baseline survey was conducted in 2011–2012, covering 28 provinces, 150 counties/districts, and 450 villages/township-level communities. Subsequent follow-up surveys were conducted in 2013, 2015, 2018, and 2020. CHARLS assessed the social, economic, and health status of the target population using standardized questionnaires that collected data on sociodemographic information, lifestyle factors, and health-related variables[18]. All participants in the CHARLS study were enrolled voluntarily and provided informed consent before participation. The original CHARLS study received ethical approval from the Peking University Institutional Review Board in June 2008 (IRB00001052-11015)[19]. The methods employed in this study were in accordance with the relevant guidelines and regulations.

In this study, we used data from the 2020 survey to conduct a cross-sectional analysis. A total of 19,395 individuals participated in the 2020 survey. The inclusion criteria for this study were as follows: (1) age greater than 45 years; (2) a history of stroke; (3) complete responses to the CES-D-10 questionnaire; and (4) no history of mental disorders. From the 2020 data, we identified 1,381 individuals with a history of stroke. We excluded 113 individuals with mental disorders and 333 individuals with incomplete questionnaire responses. We further excluded individuals younger than 45 years of age, resulting in a final sample of 933 respondents who met the inclusion criteria and were included in the cross-sectional study. A flowchart illustrating the process of sample selection, including inclusion and exclusion criteria, is provided below (Fig. 1).

Research variables

Depression

Depression symptoms were assessed using the 10-item short form of the Center for Epidemiologic Studies Depression Scale (CES-D-10). The Chinese version of the CES-D-10 has demonstrated high accuracy in classifying depressive symptoms among participants[10]. CES-D-10 is a widely used self-reported measure of depressive symptoms in population-based studies[20]. It includes 10 items related to depressive symptoms: (1) I was bothered by things that don't usually bother me, (2) I had trouble keeping my mind on what I was doing, (3) I felt depressed, (4) I felt everything I did was an effort, (5) I felt hopeful about the future, (6) I felt fearful, (7) My sleep was restless, (8) I was happy, (9) I felt lonely, and (10) I could not get "going." Responses are scored on a scale from 0 to 3: 0 (rarely), 1 (sometimes; 1–2 days per week), 2 (occasionally; 3–4 days per week), and 3 (most of the time; 5–7 days per week). The total score ranges from 0 to 30, with higher scores indicating more severe depressive symptoms. A score of 10 or higher was used to identify individuals with depressive symptoms[21].

Heart disease

Heart disease events were assessed based on the standardized question: "Has a doctor ever told you that you have heart disease (such as myocardial infarction, coronary heart disease, angina, congestive heart failure, or other heart conditions)?" Participants who reported having heart disease during follow-up were defined as having a history of heart disease[22].

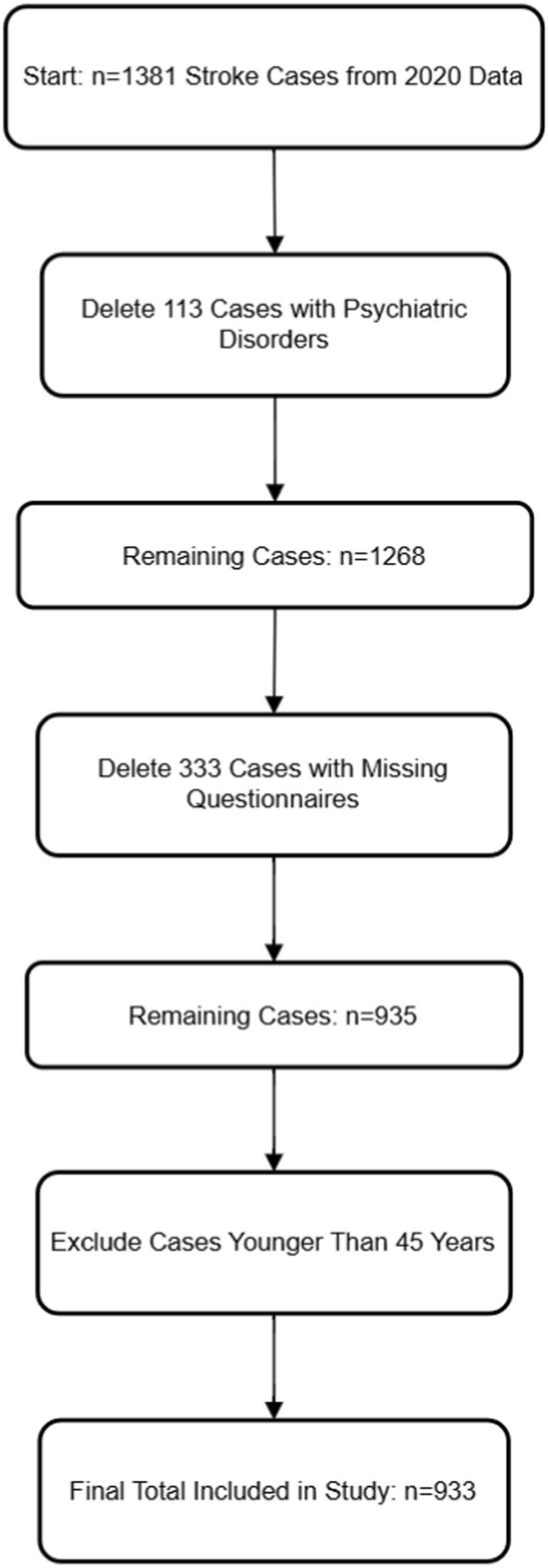

Fig. 1. Flowchart of inclusion and exclusion criteria.

Sociodemographic information

During the course of the survey, trained interviewers used a structured questionnaire to collect information on sociodemographic and health-related factors. The questionnaire covered age, gender, marital status, education level, and residence. Education levels were categorized as below primary school, primary school, middle school, and high school or above. Marital status was classified as married or unmarried. Age was categorized into three groups: 45–60 years, 60–80 years, and over 80 years. Smoking, alcohol consumption, physical exercise, and social activities were classified into two groups: yes and no.

Health-related factors

This study included self-reported current smoking and alcohol consumption status, self-reported physician-diagnosed medical conditions (hypertension, diabetes, dyslipidemia, cancer, heart disease, stroke), exercise, social activities, and activities of daily living (ADL). Social activities were defined as participation in social engagements, and individuals were classified as actively participating if they engaged in any of the following activities: volunteer or charity work, helping family, friends, or neighbors, participating in sports, or attending a social club or other type of club within the past month. ADL abilities were assessed by asking participants if they had difficulty with activities such as bathing, eating, getting in and out of bed, dressing, using the toilet, continence, doing housework, cooking, etc. Each activity was scored on a 4-point scale: (1) No, I have no difficulty; (2) I have difficulty, but can still do it; (3) Yes, I have difficulty and need help; (4) I cannot do it[23]. Participants were classified as having an ADL impairment if they had difficulty with any of these activities. Cognitive function was assessed through evaluations of mental status and episodic memory, including memory, executive function, and orientation. Three composite measures were used for cognitive scoring: a word recall test, the Telephone Interview for Cognitive Status (TICS-10), and a figure drawing test. In the word recall test, participants were read 10 unrelated Chinese words, and the number of words recalled immediately (immediate recall) and after 4 min (delayed recall) was counted to assess memory function. Each word recalled correctly in either the immediate or delayed recall task scored 1 point (0 to 20 points). Mental status was evaluated by assessing orientation (date cognition), calculation, and drawing ability, including subtracting 7 consecutively from 100 (up to five times), identifying the date (month, day, year), day of the week, and season of the year, and asking participants to redraw two overlapping pentagons. The scores were summed to derive a mental integrity index ranging from 0 to 11. The overall cognitive score ranged from 0 to 21, with higher scores indicating better cognitive function[24–26].

Living conditions

The occurrence of depressive symptoms is closely related to patients' living conditions and family support. Therefore, variables such as health insurance, pension insurance, retirement status, life satisfaction, household income, number of surviving children, and financial support for children were included in the analysis. Total household income was defined as the combined income from all sources for the respondent and their family, including wages, company benefits, agricultural and business income, income from other family members, and transfer payments. Life satisfaction was assessed through a standardized questionnaire asking participants, "Overall, how satisfied are you with your life?" with responses categorized into five levels: extremely satisfied, very satisfied, somewhat satisfied, not very satisfied, and not at all satisfied. Health insurance, pension insurance, and retirement status were classified as yes or no based on participants' responses. Parental financial support for children was defined as the total amount of money parents gave their children in the past year, including regular living expenses, monthly utility and phone bills, mortgage or rent payments, or other regular expenses (e.g., providing snacks, groceries, clothing, or other items).

Data analysis

We used Stata 17 for initial data processing and IBM SPSS Statistics 26.0 for further data analysis. For categorical variables, the chi-square test was used to assess the associations between multiple sociodemographic and health-related characteristics between the two patient groups. Variables analyzed included gender, marital status, rural residence, hypertension, diabetes, cancer, dyslipidemia, retirement status, life satisfaction, ethnicity, education level, exercise, insurance, pension, social activities, smoking, alcohol consumption, and age. For continuous variables, the Mann–Whitney U test was used to analyze differences between patients with and without heart disease, as they did not follow a normal distribution. We then used univariate logistic regression with depressive symptoms as the dependent variable and heart disease history as the independent variable to evaluate the association between heart disease and PSD in the stroke population. Subsequently, variables with $P < 0.1$ were included in a multivariate logistic regression analysis. To ensure model robustness, we used multiple imputation for missing data and conducted interaction analysis. Additionally, we performed stratified analysis to further investigate the impact of gender differences on the study outcomes. To control for confounding factors during the study, we excluded individuals with previous psychiatric problems. We collected detailed economic indicators (e.g., household income, education level, occupation) and included them as covariates in the multivariate analysis model. Finally, we used multivariate regression analysis to more accurately assess the relationship between the main variables. Additionally, sensitivity analysis allowed us to assess the potential impact of confounding factors on the findings, thereby maintaining the robustness of the results.

Results

Descriptive analysis

In this study, a total of 933 individuals were examined, of which 559 did not have heart disease, accounting for 59.91%, while 374 individuals had heart disease, representing 40.09%. Descriptive statistical analysis was conducted separately for both groups.

Demographic and socioeconomic variables
In terms of gender, males accounted for 54.56% of the participants, while females accounted for 45.44%. The distribution of gender between the two groups was statistically significant $p < 0.001$). Regarding educational attainment, there were no significant differences in the distribution of different educational levels across the groups ($p = 0.840$). In terms of retirement status, 76.64% of the participants were retired, and there was a significant difference between the groups ($p = 0.027$). The median income for individuals without heart disease was 9,840, whereas the median income for those with heart disease was significantly lower, at 6,000, with a statistically significant difference between the two groups ($P = 0.034$). This indicates that individuals with heart disease generally have lower incomes compared to those without heart disease, and this difference is statistically significant ($P < 0.05$).

Lifestyle habits and health status
The rural cohort constituted 40.19% of the total cohort, and no significant intergroup differences were observed. The proportion of smokers was 51.12%, while the proportion of drinkers was 29.89%. Significant intergroup differences were observed for both metrics. In the overall sample, 57.13% of subjects demonstrated normal activities of daily living (ADL), while 42.87% exhibited ADL disabilities. It is noteworthy that significant differences in ADL were observed between the two groups ($p < 0.001$).

With regard to chronic diseases, hypertension, diabetes, and dyslipidemia were present in 68.05%, 22.78%, and 48.99% of the study population, respectively. Significant intergroup differences in distribution were observed for hypertension and dyslipidemia (hypertension $p < 0.001$; dyslipidemia $p < 0.001$), whereas diabetes did not show significant differences).

The aforementioned description encapsulates the differential characteristics and statistically significant outcomes between the two groups within the study sample, underscoring the disparities in factors such as gender, hypertension, dyslipidemia, ADL, smoking, and drinking. Other variables, including marital status, rural habitation, cancer, exercise, insurance, pension, ethnicity, education level, age, number of living children, and financial support to offspring, did not demonstrate significant intergroup differences (Refer to Table 1).

Univariate logistic regression analysis

In the study, we conducted univariate regression analysis on multiple variables to evaluate their effect on the outcome variable. The statistical significance level was set at $P < 0.05$. The results of the univariate regression analysis showed that individuals with heart disease had a significantly increased likelihood of developing the outcome variable compared to those without heart disease ($P = 0.002$). This indicates that patients with heart disease are more likely to experience post-stroke depressive symptoms. Additionally, further analysis of other covariates showed that several variables (including gender, marital status, residence, self-care ability, hypertension, retirement status, self-rated health status, education level, new smokers, alcohol consumption, household income, number of children, financial support, and overall cognitive score) were significantly associated with the primary outcome variable ($P < 0.05$). Among these, gender, residence, ADL, retirement status, education level, life satisfaction, alcohol consumption, and cognitive function showed a strong effect on the occurrence of depressive symptoms ($P < 0.001$), indicating their potential importance in this outcome. However, since univariate analysis does not account for confounding factors, despite the significant associations observed, further validation is required through multivariate analysis to determine their independence and true impact. The multivariate analysis will help to identify the key factors that have an independent predictive value (Refer to Table 2, Fig. 2).

Multivariate analysis model construction

This study employed a multivariate logistic regression model to analyze the effect of heart disease history on post-stroke depression in stroke patients. The effect of each variable was evaluated by estimating coefficients (β), standard errors (SE), Z values, P values, odds ratios (OR), and their 95% confidence intervals (CI). The statistical significance level was set at $P < 0.05$. Variables demonstrating a P value < 0.1 in univariate analyses were selected for inclusion in the multivariable model. Three distinct models were developed to assess covariate effects. In Model 1, after adjusting for demographic covariates (sex, residential area, education level, and marital status), individuals with cardiac disease exhibited a significantly elevated risk of the outcome variable compared to those without cardiac disease ($P = 0.008$). This robust association underscores cardiac disease as an independent predictor of post-stroke depression. Model 2 adjusted for the effects of physical condition and behavioral factors as confounders on the outcome by incorporating hypertension[27,28], cognitive status, smoking, alcohol consumption, and ADL-related physical and life status factors into Model 1. The results showed that heart disease had a significant effect on the development of depressive symptoms ($P = 0.037$), suggesting that heart disease is a significant risk factor for the outcome variable (OR = 1.46, 95% CI: 1.02—2.09). Model 3 adjusted for lifestyle and socioeconomic factors on the basis of the above[29], including the correlations between retirement status, life satisfaction, family income, number of living children, and parental provision of support to children with the emergence of depressive symptoms. Individuals with heart disease had a significantly higher risk of the outcome variable compared to those without heart disease ($P = 0.037$, OR = 1.53), suggesting that heart disease is an important risk factor for the outcome variable, possibly due to its negative impact on overall health. By comparing these three models, Model 3 has the largest likelihood value, indicating that it fits the data best and explains the relationship between the variables more effectively (Refer to Tables 3, 4).

Multivariate Logistic Regression Results The results of the multivariate logistic regression analysis indicate that the presence of heart disease is strongly associated with the occurrence of post-stroke depressive symptoms, providing direction for future intervention strategies. Specifically, improving cardiac health may significantly

Variables	Total (n = 933)	0 (n = 559)	1 (n = 374)	Statistic	*P*
Income Total, M (Q_1, Q_3)	8660.00 (120.00, 30,220.00)	9840.00 (600.00, 32,320.00)	6000.00 (0.00, 25,600.00)	Z = -2.12	**0.034**
Child, M (Q_1, Q_3)	2.00 (2.00, 3.00)	2.00 (2.00, 3.00)	2.00 (2.00, 3.00)	Z = -0.83	0.404
Financial support for children, M (Q_1, Q_3)	200.00 (0.00, 2000.00)	100.00 (0.00, 1650.00)	200.00 (0.00, 2000.00)	Z = -0.82	0.409
Cognition, M (Q_1, Q_3)	12.50 (9.50, 14.50)	12.50 (9.50, 14.12)	12.50 (10.00, 14.50)	Z = -1.02	0.306
Gender, n (%)				χ^2 = 22.10	**< .001**
Female	424 (45.44)	219 (39.18)	205 (54.81)		
Male	509 (54.56)	340 (60.82)	169 (45.19)		
Marry, n (%)				χ^2 = 2.16	0.142
No	178 (19.08)	98 (17.53)	80 (21.39)		
Yes	755 (80.92)	461 (82.47)	294 (78.61)		
Rural, n (%)				χ^2 = 1.09	0.295
No	375 (40.19)	217 (38.82)	158 (42.25)		
Yes	558 (59.81)	342 (61.18)	216 (57.75)		
ADL, n (%)				χ^2 = 12.95	**< .001**
No	533 (57.13)	346 (61.90)	187 (50.00)		
Yes	400 (42.87)	213 (38.10)	187 (50.00)		
Hypertension, n (%)				χ^2 = 20.53	**< .001**
No	285 (30.55)	202 (36.14)	83 (22.19)		
Yes	648 (69.45)	357 (63.86)	291 (77.81)		
Diabetes, n (%)				χ^2 = 23.33	**< .001**
No	679 (72.78)	439 (78.53)	240 (64.17)		
Yes	254 (27.22)	120 (21.47)	134 (35.83)		
Cancer, n (%)				χ^2 = 0.51	0.476
No	912 (97.75)	548 (98.03)	364 (97.33)		
Yes	21 (2.25)	11 (1.97)	10 (2.67)		
Dyslipidemia, n (%)				χ^2 = 39.13	**< .001**
No	476 (51.02)	332 (59.39)	144 (38.50)		
Yes	457 (48.98)	227 (40.61)	230 (61.50)		
Retire, n (%)				χ^2 = 4.87	**0.027**
No	730 (78.24)	451 (80.68)	279 (74.60)		
Yes	203 (21.76)	108 (19.32)	95 (25.40)		
Life satisfaction, n (%)				χ^2 = 0.87	0.929
Extremely satisfied	37 (3.97)	21 (3.76)	16 (4.28)		
Very satisfied	103 (11.04)	61 (10.91)	42 (11.23)		
Comparatively satisfied	479 (51.34)	286 (51.16)	193 (51.60)		
Not very satisfied	264 (28.30)	163 (29.16)	101 (27.01)		
Not at all satisfied	50 (5.36)	28 (5.01)	22 (5.88)		
Nation, n (%)				χ^2 = 2.90	0.089
Non-Han	73 (8.10)	37 (6.84)	36 (10.00)		
Han ethnic group	828 (91.90)	504 (93.16)	324 (90.00)		
Edu, n (%)				χ^2 = 0.84	0.840
Below elementary school	406 (43.52)	250 (44.72)	156 (41.71)		
Elementary school	224 (24.01)	132 (23.61)	92 (24.60)		
Junior High School	195 (20.90)	114 (20.39)	81 (21.66)		
High school and above	108 (11.58)	63 (11.27)	45 (12.03)		
Insurance, n (%)				χ^2 = 0.40	0.525
No	45 (4.82)	29 (5.19)	16 (4.28)		
Yes	888 (95.18)	530 (94.81)	358 (95.72)		
Pension, n (%)				χ^2 = 2.11	0.146
No	145 (15.54)	79 (14.13)	66 (17.65)		
Yes	788 (84.46)	480 (85.87)	308 (82.35)		
Act, n (%)				χ^2 = 0.02	0.896
No	499 (53.48)	298 (53.31)	201 (53.74)		
Yes	434 (46.52)	261 (46.69)	173 (46.26)		
Smoke, n (%)				χ^2 = 11.70	**< .001**
No	465 (49.84)	253 (45.26)	212 (56.68)		
Continued					

Variables	Total (n = 933)	0 (n = 559)	1 (n = 374)	Statistic	*P*
Yes	468 (50.16)	306 (54.74)	162 (43.32)		
Drink, n (%)				$\chi^2 = 10.15$	**0.001**
No	654 (70.10)	370 (66.19)	284 (75.94)		
Yes	279 (29.90)	189 (33.81)	90 (24.06)		
Age, n (%)				$\chi^2 = 4.31$	0.116
45–60	212 (22.72)	140 (25.04)	72 (19.25)		
60–80	691 (74.06)	402 (71.91)	289 (77.27)		
> 80	30 (3.22)	17 (3.04)	13 (3.48)		

Table 1. Descriptive analysis. Z, Mann–Whitney test; χ^2, Chi-square test; M, Median; Q_1, 1st Quartile; Q_3, 3st Quartile. Significant values are in bold.

reduce the risk of post-stroke depression, thereby enhancing the quality of life and survival rates among stroke patients. In addition to heart disease, gender, ADL, overall cognitive level, and life satisfaction also had an impact on the outcome variable. Specifically, females had a significantly higher risk of developing depressive symptoms, while higher cognitive levels and normal self-care abilities demonstrated significant protective effects. These findings have important implications for the clinical management of stroke patients and the prevention of post-stroke depressive symptoms.

Sensitivity analysis

To further verify the robustness of the results, interaction analysis was conducted on relevant covariates, resulting in a P for interaction of <0.05 for gender, indicating that gender plays an important role in the association between heart disease and post-stroke depression (Refer to Table 5).

Therefore, stratified chi-square analysis was conducted by gender: Female: p = 0.002, OR = 1.861; Male: p = 0.757; OR = 1.060. This indicates that among female stroke patients, those with heart disease had 1.861 times the risk of developing depressive symptoms compared to those without heart disease, while among male stroke patients, those with heart disease had 1.060 times the risk of developing depressive symptoms compared to those without heart disease. There is a difference in the strength of the association between heart disease history and depressive symptoms between genders. Female stroke patients are more likely to experience depressive symptoms. If gender is not controlled as a confounder, the association between heart disease history and depressive symptoms may be overestimated in the total population. This stratified analysis helps to more precisely understand the relationship between heart disease history and depressive symptoms across different genders, providing more specific guidance for clinical interventions and research (Refer to Table 6, Figure 3).

For the missing values in the study data, including household income, cognitive ability, and ethnicity, we assumed they were missing at random and used multiple imputation to handle them. Household income and cognitive ability were imputed using the mean, while ethnicity was imputed using the mode. After processing the missing data, we reanalyzed the dataset and obtained a multivariate logistic regression result of P = 0.046, OR = 1.38 (95% CI: 1.01–1.89). The results were consistent with those obtained before handling missing values, confirming that stroke patients with a history of heart disease are more likely to experience post-stroke depressive symptoms (Appendix 2).

This study revealed a significant association between cardiac disease and post-stroke depressive symptoms in a cross-sectional analysis of 933 stroke patients. Univariate regression analysis showed that patients with cardiac disease had a 52% increased risk of depression. Multifactorial analysis using a three-stage adjusted model revealed that heart disease remained an independent predictor of depression (p = 0.037) after controlling for various types of covariates. Additionally, being female (OR = 1.86), having an ADL disorder, and having a low level of cognitive performance significantly increased the risk of depression. Stratified analysis revealed a significant gender interaction (p < 0.05). Women with cardiac disease had a 1.86 times higher risk of depression than those without the disease (p = 0.002), while there was no significant association in men (OR = 1.06, p = 0.757).This study suggests that cardiac disease is an independent risk factor for depression after stroke, with a stronger association observed in female patients. These findings emphasize the need to pay special attention to cardiac health maintenance and implement gender-specific intervention strategies in stroke management. Additionally, improving patients' cognitive function, self-care ability, and socioeconomic support may help reduce the risk of depression.

Discussion

Post-Stroke Depression (PSD), a prevalent neuropsychiatric complication among stroke survivors, significantly impairs their quality of life and functional recovery[30]. While therapeutic interventions for PSD exist in modern medicine, current clinical strategies prioritize prevention over treatment. Consequently, identifying reliable predictors of PSD warrants further research emphasis[31]. In this study, we analyzed data from Chinese stroke patients in the CHARLS database. Our analysis revealed that female stroke patients with a history of cardiac disease exhibit a higher susceptibility to post-stroke depressive symptoms.

Similar findings have been reported in other studies. Junjie Zou et al. found an association between cardiovascular health status and depressive symptoms in stroke survivors[32]. Ephrem Fantu et al. reported that patients diagnosed with ischemic heart disease using electrocardiogram and/or echocardiogram were

Variables	β	S.E	Z	*P*	OR (95% CI)
Heart disease					
No					1.00 (Reference)
Yes	0.42	0.14	3.10	**0.002**	1.52 (1.17–1.98)
Gender					
Female					1.00 (Reference)
Male	−0.76	0.13	−5.68	**<.001**	0.47 (0.36–0.61)
Marry					
No					1.00 (Reference)
Yes	−0.41	0.17	−2.40	**0.016**	0.66 (0.48–0.93)
Rural					
No					1.00 (Reference)
Yes	0.47	0.13	3.52	**<.001**	1.61 (1.23–2.09)
ADL					
No					1.00 (Reference)
Yes	1.43	0.14	10.00	**<.001**	4.19 (3.16–5.55)
Hypertension					
No					1.00 (Reference)
Yes	0.37	0.14	2.57	**0.010**	1.44 (1.09–1.91)
Diabetes					
No					1.00 (Reference)
Yes	0.17	0.15	1.12	0.262	1.18 (0.88–1.58)
Cancer					
No					1.00 (Reference)
Yes	−0.25	0.44	−0.56	0.573	0.78 (0.33–1.85)
Dyslipidemia					
No					1.00 (Reference)
Yes	0.17	0.13	1.26	0.207	1.18 (0.91–1.53)
Retire					
No					1.00 (Reference)
Yes	−0.85	0.16	−5.18	**<.001**	0.43 (0.31–0.59)
Life satisfaction					
Extremely satisfied					1.00 (Reference)
Very satisfied	−0.93	0.79	−1.18	0.238	0.40 (0.08–1.84)
Comparatively satisfied	−2.85	0.73	−3.89	**<.001**	0.06 (0.01–0.24)
Not very satisfied	−3.14	0.74	−4.25	**<.001**	0.04 (0.01–0.18)
Not at all satisfied	−3.18	0.78	−4.08	**<.001**	0.04 (0.01–0.19)
Nation					
Non−Han					1.00 (Reference)
Han ethnic group	0.37	0.25	1.50	0.135	1.44 (0.89–2.33)
Edu					
Below elementary school					1.00 (Reference)
Elementary school	−0.18	0.17	−1.09	0.277	0.83 (0.60–1.16)
Junior High School	−0.81	0.18	−4.58	**<.001**	0.44 (0.31–0.63)
High school and above	−0.92	0.22	−4.16	**<.001**	0.40 (0.26–0.61)
Insurance					
No					1.00 (Reference)
Yes	−0.37	0.31	−1.17	0.242	0.69 (0.37–1.28)
Pension					
No					1.00 (Reference)
Yes	−0.14	0.18	−0.75	0.453	0.87 (0.61–1.25)
Act					
No					1.00 (Reference)
Yes	−0.14	0.13	−1.06	0.290	0.87 (0.67–1.13)
Smoke					
No					1.00 (Reference)
Yes	−0.40	0.13	−3.06	**0.002**	0.67 (0.52–0.87)
Continued					

Variables	β	S.E	Z	*P*	OR (95% CI)
Drink					
No					1.00 (Reference)
Yes	−0.83	0.15	−5.65	**<.001**	0.44 (0.33–0.58)
Age					
45–60					1.00 (Reference)
60–80	0.16	0.16	1.00	0.319	1.17 (0.86–1.59)
> 80	−0.17	0.39	−0.44	0.661	0.84 (0.39–1.81)
Income total	−0.01	0.00	−2.33	**0.020**	0.99 (0.99–0.99)
Child	0.11	0.05	2.10	**0.036**	1.12 (1.01–1.24)
Financial support for children	−0.01	0.00	−2.68	**0.007**	0.99 (0.99–0.99)
Cognition	−0.13	0.03	−5.24	**<.001**	0.88 (0.83–0.92)

Table 2. Univariate logistic regression analysis. OR, Odds Ratio; CI, Confidence Interval. Significant values are in bold.

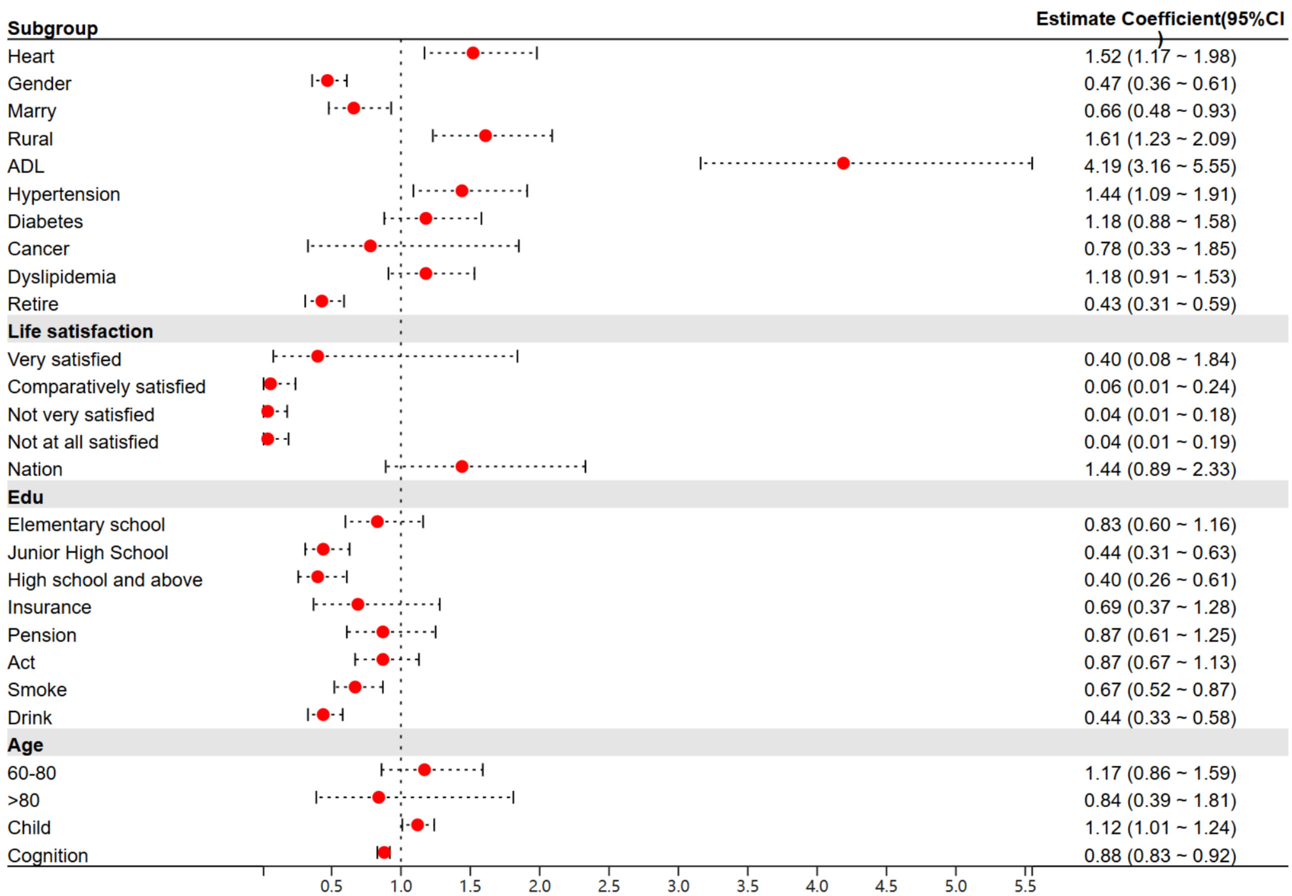

Fig. 2. Forest plot of univariate regression analysis.

significantly more likely to be diagnosed with PSD, although the underlying mechanisms remain unclear[33]. Guo Li et al. reported that the prevalence of depression in coronary heart disease (CHD) patients is more than twice that in the general population, and CHD patients are more likely to develop depression following a stroke[34]. The relationship between heart disease and depressive symptoms was first described as early as 1955[35]. Modern research often explains this relationship through inflammatory-immune or neuroendocrine pathways[4,36], with heart disease being closely linked to systemic chronic inflammation, which affects the central nervous system and induces depressive symptoms[27]. Furthermore, cardiac patients often experience excessive sympathetic activation and reduced parasympathetic function, contributing to autonomic dysfunction that affects central neurotransmitters and increases the risk of depression. Some literature also suggests a brain–heart interaction[34], where reduced cardiac output leads to cerebral hypoperfusion, especially in regions responsible for mood

	P	OR (95% CI)	Log likelihood
Model 1	0.008	1.46 (1.10–1.92)	−612.43482
Model 2	0.037	1.53 (1.03–2.29)	−399.02979
Model 3	0.037	1.46 (1.02–2.09)	−330.6585

Table 3. Multivariate analysis model construction. Model 1: Adjusted variables include gender, place of residence, education level, and marital status. Model 2: Adjusted variables include gender, marital status, place of residence, education level, hypertension, cognitive status, smoking, alcohol consumption, and Activities of Daily Living (ADL). Model 3: Adjusted variables include gender, marital status, place of residence, education level, hypertension, cognitive status, smoking, alcohol consumption, ADL, retirement status, life satisfaction, household income, number of living children, and parental support provided to offspring.

regulation, such as the frontal lobe and basal ganglia[27,37]. This ischemic-hypoxic state can impair neuronal function, increasing the risk of depression and linking chronic brain hypoxia in CHD patients to post-stroke depressive symptoms[38]. Additionally, the role of different brain regions affected by stroke in the relationship between heart disease and PSD remains an area of ongoing research without a definitive conclusion[36].

We found that women are more likely to experience post-stroke depression (PSD), which aligns with previous research[27,39–41]. This increased vulnerability to depressive symptoms in female patients is linked to a complex mix of biological, psychological, and sociocultural factors[42], particularly in the Chinese context. Hormonal changes, such as fluctuations in estrogen levels, may contribute to PSD by disrupting the body's balance and increasing serotonin production, which raises the risk of depression . In addition to these physiological factors, women are more prone to negative emotions in response to stress and life events. In traditional Chinese society, women often carry greater family responsibilities, and those with lower socioeconomic status may have limited access to mental health support, which makes them more susceptible to depression[43]. However, some studies have indicated that gender may only play a transient role in the onset of post-stroke depression, with the influence of the gender gap on post-stroke depression dissipating over a period of 0.5 to 2.5 years[39]. Consequently, further longitudinal observational studies on the impact of gender in the progression of post-stroke depression are still required to facilitate the provision of more comprehensive and individualised support.

When patients struggle with activities of daily living (ADL), they lose their independence, which significantly impacts their quality of life[44–46]. This dependency on family members for basic tasks like bathing and eating can affect their mood and self-esteem, leading to worsening depressive symptoms[16,47]. Physical limitations also reduce social interactions, diminishing their sense of purpose, increasing feelings of isolation, and raising the risk of depression[48]. Severe physical disabilities can further hinder participation in rehabilitation, slowing recovery and increasing the likelihood of depression. Life satisfaction, which reflects an individual's overall assessment of various aspects of their life, is closely tied to their functional abilities. Lower life satisfaction often correlates with higher depression levels and reduced motivation for rehabilitation, impeding both physical and mental recovery, which in turn exacerbates PSD symptoms[4]. This highlights the importance of strong family support for stroke survivors[27].

We also observed that cognitive impairment severity is closely linked to the severity of depression. Cognitive decline makes it harder for patients to handle complex situations and adapt to changes, which adds to their psychological stress[48]. Impaired cognition may also limit patients' awareness of and ability to cope with mental health challenges, worsening depressive symptoms[4]. Moreover, patients with reduced cognitive function may find it difficult to engage in social interactions, which can lead to reduced social participation, increased loneliness, and a greater sense of isolation, all of which contribute to a higher risk of depression[34].

Poststroke depression (PSD), as the most common emotional symptom in stroke survivors, profoundly impacts the recovery process, quality of life, and long-term prognosis of patients. Therefore, high attention should be paid to the screening, prevention, and intervention of PSD in order to maximize recovery outcomes and quality of life by identifying high-risk factors that can effectively predict the occurrence of PSD and by enhancing the effectiveness of interventions. In addition to focused clinical attention and psychological guidance, timely pharmacological interventions are necessary when needed[49,50]. It has been found that a recently discovered novel drug with presumed neuroprotective, cardioprotective, and antidepressant-like effects may serve as an effective therapeutic agent for the treatment of PSD in the clinical setting[51].

In modern medical research, mental health and physical health are recognized as equally vital. Not only can heart disease influence mood alterations following a stroke, but such psychological changes may, in turn, exacerbate the progression of cardiovascular conditions[52–54]. Prioritizing PSD can facilitate the development of a holistic health management strategy that concurrently addresses mental and physical well-being. This integrated approach better aligns with the comprehensive health needs of stroke patients, moving beyond the narrow focus on motor function rehabilitation. However, current research on PSD prediction faces significant challenges, including insufficient sample sizes, limited follow-up durations, and confounding variables from multifactorial interactions[50,55–57]. To address these limitations, future efforts must leverage multidisciplinary methodologies. For instance, machine learning algorithms could be employed to synthesize multidimensional predictive factors, enabling the creation and validation of robust predictive models. Translating these findings into evidence-based clinical practices will be critical to achieving effective PSD prevention and management[42,58–61].

Variables	β	S.E	Z	*P*	OR (95% CI)
Intercept	3.38	1.18	2.86	**0.004**	29.41 (2.90–297.89)
Heart disease					
No					1.00 (Reference)
Yes	0.43	0.20	2.09	**0.037**	1.53 (1.03–2.29)
Gender					
Female					1.00 (Reference)
Male	−0.66	0.32	−2.09	**0.037**	0.52 (0.28–0.96)
Marry					
No					1.00 (Reference)
Yes	−0.17	0.27	−0.62	0.536	0.85 (0.50–1.43)
Rural					
No					1.00 (Reference)
Yes	0.30	0.23	1.33	0.185	1.35 (0.87–2.12)
Edu					
Below elementary school					1.00 (Reference)
Elementary school	0.46	0.26	1.77	0.077	1.58 (0.95–2.63)
Junior High School	−0.11	0.29	−0.38	0.707	0.90 (0.51–1.57)
High school and above	0.20	0.35	0.58	0.562	1.22 (0.62–2.41)
Hypertension					
No					1.00 (Reference)
Yes	0.21	0.21	0.98	0.329	1.23 (0.81–1.87)
ADL					
No					1.00 (Reference)
Yes	1.09	0.20	5.39	**<.001**	2.97 (2.00–4.40)
Drink					
No					1.00 (Reference)
Yes	−0.38	0.22	−1.69	0.090	0.68 (0.44–1.06)
Smoke					
No					1.00 (Reference)
Yes	0.29	0.29	0.99	0.320	1.34 (0.75–2.39)
Total Cognition	−0.11	0.03	−3.21	**0.001**	0.90 (0.84–0.96)
Retire					
No					1.00 (Reference)
Yes	−0.50	0.27	−1.89	0.058	0.60 (0.36–1.02)
Life satisfaction					
Extremely satisfied					1.00 (Reference)
Very satisfied	−0.77	1.11	−0.69	0.487	0.46 (0.05–4.09)
Comparatively satisfied	−2.49	1.06	−2.36	**0.018**	0.08 (0.01–0.66)
Not very satisfied	−3.10	1.07	−2.91	**0.004**	0.04 (0.01–0.36)
Not at all satisfied	−3.57	1.15	−3.12	**0.002**	0.03 (0.00–0.27)
Income Total	−0.00	0.00	−0.71	0.476	1.00 (1.00–1.00)
Child	0.03	0.08	0.33	0.741	1.03 (0.88–1.21)
Financial support for children	−0.00	0.00	−1.39	0.164	1.00 (1.00–1.00)

Table 4. Results of multivariate logistic regression model 3 (The results of the Model 1 Model 2 study are presented in Appendix 1). Significant values are in bold.

Limitations

This study's cross-sectional design, which only provided data from a single year, limits our ability to track the long-term relationship between cardiovascular disease and post-stroke depression. Future research should use a longitudinal design, along with clinical records or ideally interviews, to better identify depression in survivors. Additionally, some studies have suggested that depressive symptoms may serve as a risk factor for cardiovascular disease[62,63], highlighting the need for cohort studies to determine the causal relationship between the two. Future research should consider longitudinal cohort studies to establish causality and clinical trials to assess intervention effectiveness. The study sample was drawn from a specific population in China, which may limit the generalizability of the findings to other countries and cultures. The cross-sectional nature of the study also makes it challenging to determine causality.

Variables	n (%)	0	1	OR (95%CI)	*P*	P for interaction
All patients	933 (100.00)	277/559	224/374	1.52 (1.17–1.98)	**0.002**	
Gender						**0.044**
Female	424 (45.44)	125/219	146/205	1.86 (1.24–2.79)	**0.003**	
Male	509 (54.56)	152/340	78/169	1.06 (0.73–1.54)	0.757	
Marry						0.409
No	178 (19.08)	54/98	56/80	1.90 (1.02–3.54)	**0.043**	
Yes	755 (80.92)	223/461	168/294	1.42 (1.06–1.91)	**0.019**	
Rural						0.111
No	375 (40.19)	97/217	78/158	1.21 (0.80–1.82)	0.371	
Yes	558 (59.81)	180/342	146/216	1.88 (1.32–2.68)	**< .001**	
ADL						0.811
No	533 (57.13)	128/346	81/187	1.30 (0.91–1.87)	0.154	
Yes	400 (42.87)	149/213	143/187	1.40 (0.89–2.18)	0.144	
Hypertension						0.724
No	285 (30.55)	89/202	46/83	1.58 (0.94–2.64)	0.082	
Yes	648 (69.45)	188/357	178/291	1.42 (1.03–1.94)	**0.030**	
Diabetes						0.258
No	679 (72.78)	219/439	138/240	1.36 (0.99–1.87)	0.058	
Yes	254 (27.22)	58/120	86/134	1.92 (1.16–3.17)	**0.011**	
Cancer						0.541
No	912 (97.75)	273/548	218/364	1.50 (1.15–1.97)	**0.003**	
Yes	21 (2.25)	4/11	6/10	2.62 (0.45–15.31)	0.283	
Retire						0.830
No	730 (78.24)	243/451	182/279	1.61 (1.18–2.19)	**0.003**	
Yes	203 (21.76)	34/108	42/95	1.72 (0.97–3.06)	0.062	
Life satisfaction						0.125
Extremely satisfied	37 (3.97)	19/21	16/16	89,951,097.73 (0.00–Inf)	0.997	
Very satisfied	103 (11.04)	52/61	38/42	1.64 (0.47–5.74)	0.435	
Comparatively satisfied	479 (51.34)	139/286	102/193	1.19 (0.82–1.71)	0.362	
Not very satisfied	264 (28.30)	59/163	55/101	2.11 (1.27–3.49)	**0.004**	
Not at all satisfied	50 (5.36)	8/28	13/22	3.61 (1.11–11.76)	**0.033**	
Nation						0.922
No	73 (8.10)	15/37	18/36	1.47 (0.58–3.70)	0.418	
Yes	828 (91.90)	253/504	197/324	1.54 (1.16–2.04)	**0.003**	
Edu						0.584
Below elementary school	406 (43.52)	143/250	107/156	1.63 (1.07–2.49)	**0.022**	
Elementary school	224 (24.01)	68/132	60/92	1.76 (1.02–3.05)	**0.042**	
Junior High School	195 (20.90)	46/114	35/81	1.12 (0.63–2.00)	0.690	
High school and above	108 (11.58)	20/63	22/45	2.06 (0.93–4.53)	0.073	
Insurance						0.979
No	45 (4.82)	17/29	11/16	1.55 (0.43–5.64)	0.504	
Yes	888 (95.18)	260/530	213/358	1.53 (1.16–2.00)	**0.002**	
Pension						0.453
No	145 (15.54)	39/79	43/66	1.92 (0.98–3.75)	0.057	
Yes	788 (84.46)	238/480	181/308	1.45 (1.09–1.93)	**0.012**	
Act						0.685
No	499 (53.48)	154/298	122/201	1.44 (1.00–2.08)	**0.047**	
Yes	434 (46.52)	123/261	102/173	1.61 (1.09–2.38)	**0.016**	
Smoke						0.058
No	465 (49.84)	131/253	142/212	1.89 (1.29–2.76)	**< .001**	
Yes	468 (50.16)	146/306	82/162	1.12 (0.77–1.64)	0.550	
Drink						0.152
No	654 (70.10)	203/370	188/284	1.61 (1.17–2.22)	**0.003**	
Yes	279 (29.90)	74/189	36/90	1.04 (0.62–1.73)	0.892	
Child						0.607
Financial support for children						0.029
Continued						

Variables	n (%)	0	1	OR (95%CI)	*P*	P for interaction
Cognition						0.458
OR, Odds Ratio; CI, Confidence Interval						

Table 5. Sensitivity analysis. Significant values are in bold.

Stratified	Whether or not you have a heart condition	Depressive symptoms	No depressive symptoms	OR (95% CI)	χ^2	P
Female						
	Yes	146 (53.9%)	59 (38.6%)	1.861 (1.243–2.787)	9.182	0.002
	No	125 (46.1%)	94 (61.4%)			
Male						
	Yes	78 (33.9%)	91 (32.6%)	1.060 (0.732–1.535)	0.096	0.757
	No	152 (66.1%)	188 (67.4%)			
Total						
	Yes	224 (44.7%)	150 (34.7%)	1.520 (1.166–1.982)	9.636	0.002
	No	277 (55.3%)	282 (65.3%)			

Table 6. Results of stratified analysis by gender.

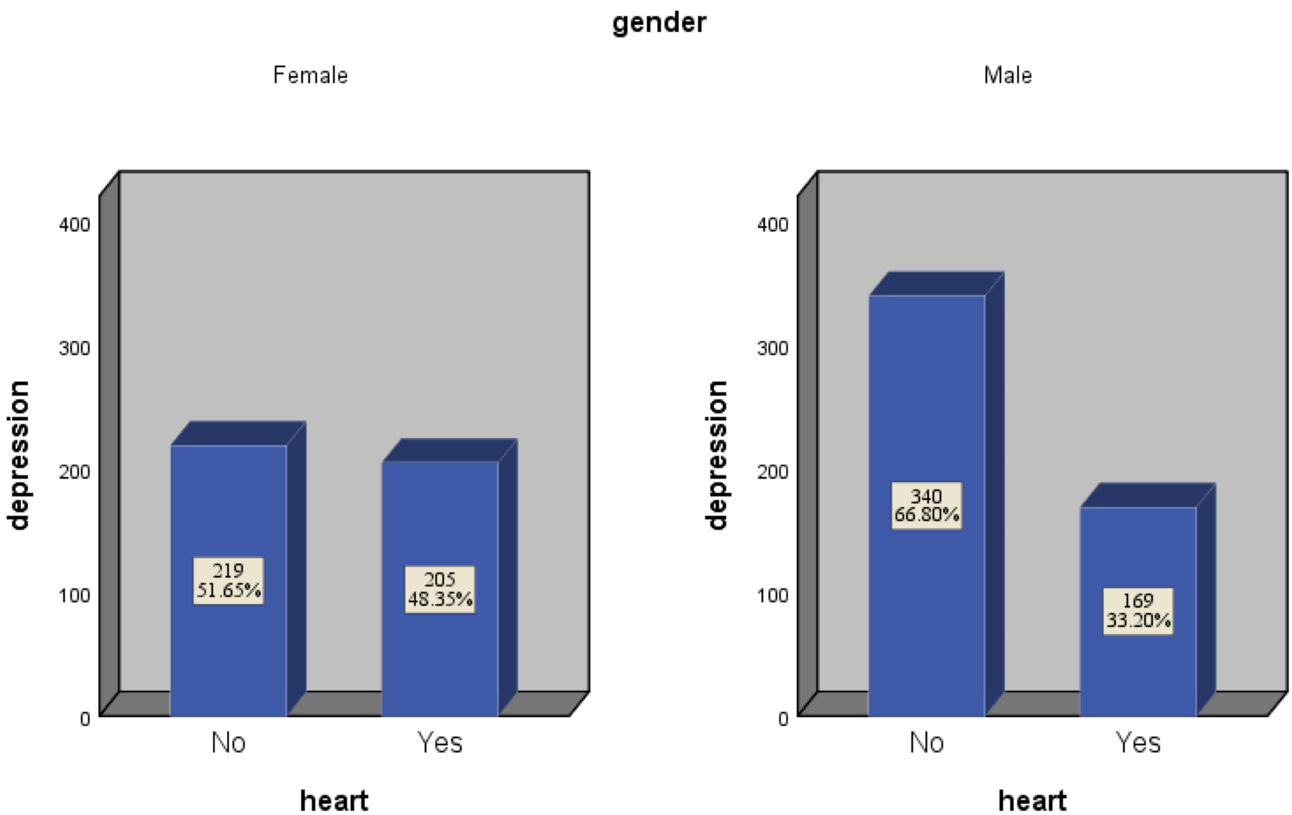

Fig. 3. Bar chart of group comparisons.

Conclusion

This study found that female stroke survivors with a history of cardiac disease were more likely to experience post-stroke depression. Additionally, patients' ability to perform activities of daily living (ADLs), life satisfaction, and cognitive ability were significantly associated with the development of post-stroke depression. These findings not only enrich our understanding of the risk factors for post-stroke depression but also provide important guidance for clinical practice. However, this study also highlights potential directions for future research. First, the biological mechanisms linking heart disease and post-stroke depression need to be further explored to reveal their underlying neurobiological basis. Second, future studies should develop more accurate risk assessment tools that incorporate multidimensional factors, thereby providing theoretical support for individualized interventions.

Data availability
Publicly available datasets were analyzed in this study. This data can be found at: http://www.isss.pku.edu.cn/sjsj/charlsxm/index.htm.

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Author contributions

All the authors were involved in the study conception and design or analysis. LL、YZ and JB collected and summarized the literature and wrote the first draft of this review. BW and PQ: reviewed and revised the paper. YC and JH revised and analyzed the relevant questions, and ZW and YZ screened and organized the data.

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Declarations

Competing interests
The authors declare no competing interests.

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