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Prevalence and risk factors of headache in Chinese with stroke: a cross-sectional study based on CHARLS

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Abstract

Background Stroke ranks as the second leading cause of death worldwide. Meanwhile, headaches are considered the second leading cause of disability, and they often occur as a stroke complication. However, insufficient attention has been given to the treatment and rehabilitation of headaches among stroke patients, and the research on the epidemiology and risk factors of headaches in stroke patients in China is limited. Therefore, in this study, China Health and Retirement Longitudinal Study (CHARLS) data were utilized for a cross-sectional analysis to estimate the prevalence of headaches in stroke patients and identify the associated risk factors.

Method This study utilized data, which included those of participants aged 45 and above from 28 provinces across China, from the nationally representative CHARLS 2018 database. A total of 876 stroke patients and 17,469 non-stroke patients were considered in this work. Stroke diagnosis and headache status were determined based on self-reported questionnaire responses. Cross-sectional analysis determined the prevalence of headaches in patients with strokes and those without through quantification of individuals diagnosed with headaches. Categorical variables were presented as percentages and counts, and univariate and multivariate logistic regression models were used to calculate the odds ratios (OR) for the risk factors associated with headaches in stroke patients.

Results In the 2018 data, 328 individuals with stroke-related headaches were screened and compared with 4,249 individuals without the condition. Overall, a cross-sectional survey revealed that the headache prevalence among stroke patients reached 37.44% (95% confidence interval (CI): 34.23%-40.74%), which was higher than the overall headache prevalence among nonstroke patients 24.32% (95% CI: 23.69%-24.97%). Headaches were considerably more common in women (45.95%; 95% CI: 41.31%-50.58%) than in men (26.70%; 95% CI: 24.44%-32.97%; gender difference, $p < 0.001$). According to multifactorial logistic regression analysis, the risk factors for stroke-related headaches included being female (OR: 1.45, 95% CI: 1.02–2.07), residency in Central (2.50, 1.37–4.54), Eastern (1.87, 1.07–3.27), and Northwest China (2.49, 1.06–5.84), Very poor self-health (4.06, 1.90–8.68), diabetes (1.85, 1.11–3.07), shoulder pain (4.01, 2.77–5.81), back pain (2.01, 1.32–3.05), and chest pain (2.51, 1.55–4.06).

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Conclusion Enhancement of self-awareness of health, effective management of diabetes, and minimization of the physical discomfort in the shoulders, back, and chest may contribute to the decreased occurrence of headaches. Therefore, targeted prevention and treatment of headaches are necessary.

Keywords Stroke, Headache, Risk factors, Cross-sectional, CHARLS

Introduction

Stroke refers to an acute neurological impairment potentially caused by hemorrhage or ischemia; it persists for more than 24 h or results in death [1]. This condition ranks as the second leading cause of death globally [2]. The Global Burden of Disease Report 2019 states that the burden of stroke-related disorders climbed from fifth place in 1990 to third place in 2019 [3]. In addition, according to predictions, if no measures are implemented, 7 to 8 million global deaths due to stroke will be recorded by 2030 [4]. China has been identified as having the highest stroke incidence globally and the greatest burden of the condition on a worldwide scale [5]. Stroke has long been a major cause of death in China; it accounts for over one-third of all stroke-related deaths worldwide [6]. Therefore, in China, stroke prevention and the identification of stroke risk factors are crucial to alleviating the economic burden on families and the nation.

Headache is a symptom characterized by discomfort in the head, neck, and face. Headaches may affect the ability to work of individuals who suffer from physical and neurological conditions [7]. Headaches rank second worldwide in terms of causes of disability, and it affects over a billion people. More people than all other neurological disorders combined suffer from headaches, which cause 45.1 million years of disability and 5.6% of the world's disease burden [8]. The 2018 International Classification of Headache Disorders, Third Edition (ICHD-3) distinguishes between two types of headaches: primary and secondary headaches. Primary headaches mostly include migraine, tension-type headaches, and trigeminal autonomic headaches; secondary headaches often result from head-and-neck injuries, cranial brain trauma, stroke, or infection [9]. Headaches shows an association with many diseases, including mental disorders, high blood pressure, stroke, and other chronic conditions. Previous meta-analyses, which include various case–control and cohort studies, have demonstrated a connection between headache and stroke [10–12]. The primary priorities following a stroke include the restoration of the neurological function and reduction of the likelihood of recurrence; nevertheless, consequences, such as headaches, are occasionally disregarded and not given adequate treatment [13]. Therefore, the prevention of complications, such as headaches, in the population at risk of stroke is crucial to alleviating the suffering of stroke patients and improving their quality of life.

The research on the prevalence of concurrent headaches and their associated risk factors in Chinese stroke patients is limited. Previous studies used limited sample sizes and lacked investigation of headache risk factors in the Chinese population with stroke [14]. A cross-sectional study was performed utilizing data from the 2018 China Health and Retirement Longitudinal Study (CHARLS), which are nationally representative. This study aimed to find the frequency and independent risk variables for headache in Chinese stroke patients, which are beneficial for the development of effective measures for the prevention of neurological complications after stroke and lay the groundwork for academic research on the aging population in China.

Materials and methods

Study sample

This study involved the investigation of the prevalence and risk factors of stroke associated with headaches, which is the first cross-sectional investigation that used the 2018 CHARLS database. This survey is a nationally representative study that targeted individuals aged 45 and above in China. Standardized questions and methodologies, such as in-person and proxy interviews, were used in the survey to collect thorough and high-quality data regarding the health condition of the population 45 aged years and older. A stratified multistage probability proportional to size random sampling approach was used with the CHARLS data. This strategy was used to obtain social demographic, health-related, and socioeconomic status information from residents aged 45 years and above in Mainland China. Sampling was designed to be nationally representative and reflective of urban and rural areas in China. Moreover, previous researchers have studied the CHARLS database and provided detailed information [15]. To date, five years of publicly available CHARLS data, which cover survey data from 2011, 2013, 2015, 2018, and 2020, respectively, have been collected. The fourth wave of baseline surveys covered 150 areas in 28 provinces nationwide, including 450 villages/urban communities. The surveys encompassed 10,257 households and 19,817 individuals belonging to

the middle-aged and elderly population (increasing from 17,708 individuals in the first wave sample in 2011 to 19,817 individuals in the subsequent fourth wave in 2018). The CHARLS website (http://www.charls.pku.edu.cn/en) provides public access to data from the five waves of CHARLS conducted in 2011, 2013, 2015, 2018, and 2020.

The eligibility criteria for this study included the following: (1) participants who aged 45 years old or older; (2) self-reported history of stroke in the questionnaire; (3) clear history of headaches reported in the questionnaire. The exclusion criteria comprised the following: (1) lack of age-related data; (2) lack of stroke-related data; (3) lack of headache-related data; (4) lack of hypertension-related data.

The 2018 CHARLS database was utilized in this study. A total of 19,816 participants were interviewed in the 2018 CHARLS survey. Among the participants, 1,471 were excluded due to the lack of information on age ($n=50$), stroke ($n=517$), headache information ($n=10$), and hypertension ($n=894$). Ultimately, this study considered 18 345 participants, with 876 individuals having a history of stroke and 17,469 individuals reporting no history of stroke.

All individuals who consented to participate in the CHARLS survey signed four informed consent forms: one for the primary field study, a second for nonblood biomarkers, another for the collection of blood samples, and a final one for the storage of blood samples for analysis in the future. All CHARLS surveys received ethical authorization from the Institutional Review Board (IRB) at Peking University (permission number: IRB00001052-11015). Furthermore, an independent IRB permission was obtained for the biomarker collection (IRB00001052-11014).

Assessment of stroke status

In the health module of the CHARLS household questionnaire, stroke-related information was obtained by posing the following question to assess self-reported stroke (posed to new respondents or those who lacked a doctor-diagnosed chronic disease at the last visit): "Have you ever been diagnosed with a stroke (including cerebral infarction and cerebral hemorrhage) by a doctor?" The response options are "yes" and "no." If the answer is "yes," it is considered a case of stroke, and vice versa. The population of stroke patients was derived from respondents' answers to the questionnaire in the 18-year CHARLS survey.

Assessment of headache

Headaches were determined using the CHARLS health status module questionnaire. The assessment of headaches was completed through the question, "Which areas of the body are experiencing pain? Please provide a list of all affected regions." The sixteen possible options included the following: head and shoulders, arms, wrists, fingers, chest, abdomen, back, lower back, hips, thighs, knees, ankles, toes, neck, and other areas (please specify). If the respondent selected "head" as one of the options, they were considered a part of the headache population.

Assessment of covariates

Based on previous research indicating the risk factors for stroke and headaches and the content of the CHARLS questionnaire, we collected information using a semi-structured survey form. The selected risk factors and sociodemographic information included the following: age, gender (female/male), residence (rural/urban), education level (illiterate/elementary education and above/college and above), marital status (married/divorced or living alone/others), and ethnicity (Han/minority). China is divided into the following geographical regions: North, Central, East, South, Northeast, Northwest, and Southwest China. Health-related information included the following: self-reported health status (good/fair/poor/very poor), disability status, hypertension status, abnormal blood lipid status, diabetes status, brain injury status, shoulder pain status, chest pain status, back pain status, smoking status, alcohol consumption status, length of sleep ($\leq$7 h, 7–9 h, or $\geq$9 h), daytime nap duration (no nap/$\leq$30 min/30–60 min/$\geq$60 min), depression status, hip pain status, and chronic disease status. Socioeconomic status information: annual income (<5,000/5,000–10,000/10,000–20,000/>20,000), engagement in agricultural activities, and insurance coverage.

Statistical analyses

Categorical variables were represented using counts and proportions, and the statistical significance of differences was evaluated via the Pearson chi-square test. A logistic regression model was used to investigate the relationship between headache and stroke, and odds ratios (OR) with 95% confidence intervals(CI) were computed. Univariate logistic regression was first performed to investigate the relationship between factors present in stroke patients and headaches. Binary variables were dummy coded, and based on previous research [16], the following reference categories were set: male gender, urban residence, illiteracy, married status, Han ethnicity, North China region, good health status, nonengagement in agriculture, annual income < 5,000, no disability, no abnormal blood lipids, no diabetes, no brain injury, no shoulder pain, no chest pain, no back pain, no insurance, sleep duration $\leq$7 h, no daytime nap, no depression, no hip pain, and no chronic disease. Subsequently, the multivariable logistic regression model included the variables that

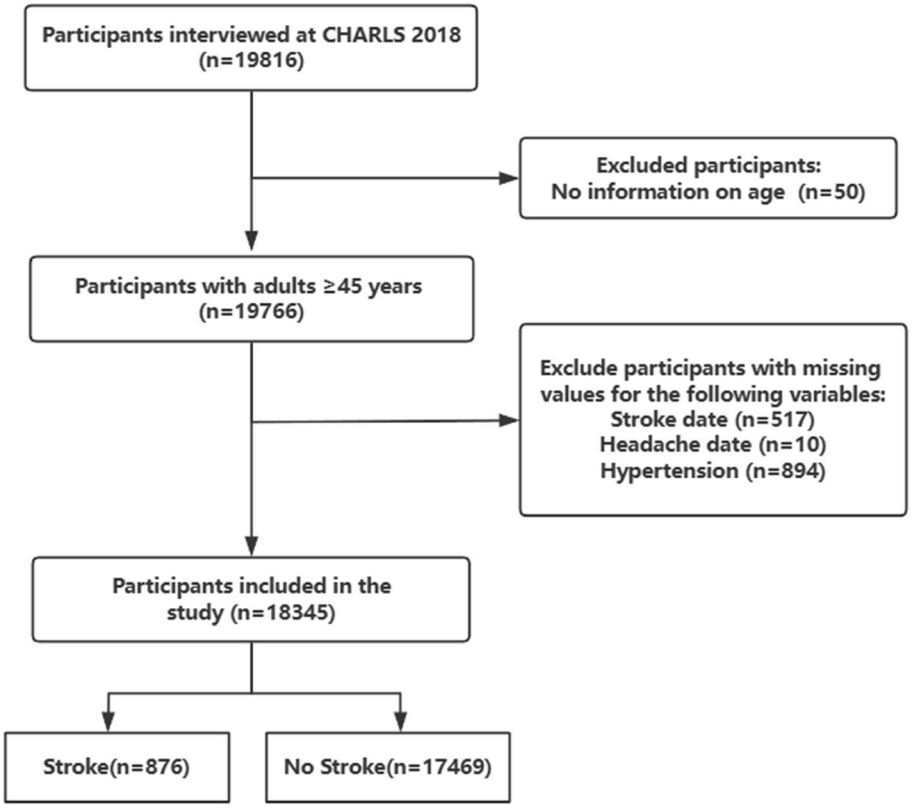

Fig. 1 Cross-Sectional Flowchart

met the significance threshold of $p < 0.20$ in the univariate analysis [17, 18]. In the univariate analysis, additional stratified analyses were performed to control the potential confounding factors based on variables with $p < 0.20$. Stratification was conducted based on sociodemographic (gender, education level, ethnicity, and national region) and health-related information (self-reported health status, abnormal blood lipids, diabetes, shoulder pain, chest pain, back pain, midnight sleep duration, and hip pain) while examining the prevalence of stroke and risk factors. All statistical analyses employed a two-tailed estimate, and a *p*-value threshold of less than 0.05 indicated statistical significance. Statistical analyses were conducted using IBM SPSS Statistics version 27.0.1 and R 4.2.3 (R Foundation for Statistical Computing). GraphPad Prism 8.0.1 was used to create forest plots for single and multiple factors.

Result

Participants characteristics

This study utilized data from the 2018 fourth wave of the CHARLS database, which encompassed 19,816 participants. Among the participants, 50 who lacked age information were excluded, along with 517, 10, and 894 participants who lacked stroke, headache, and hypertension data. Thus, the cross-sectional study comprised 18,345 people aged 45 years and above, of which 876 were stroke patients, and 17,469 were not (Fig. 1).

A total of 876 stroke patients and 17,469 nonstroke patients were included in this work (Table 1). Exactly 328 stroke patients experienced headaches (37%), and 548 individuals were nonheadache patients (63%). Stroke patients experiencing headaches comprised more females, illiterates, ethnic minorities, those with very poor self-health, individuals with brain injuries, disabilities, hypertension, abnormal blood lipids, diabetes, and nighttime sleep duration ≤ 7 h, and those with depression. Compared with the population of nonstroke participants that experienced headaches, the population of stroke patients that reported suffering from headaches was also more likely to be female, illiterate, a part of minority ethnic groups, with self-reported poor health status, disabled, suffering from hypertension, having lipid abnormalities, having diabetes, having suffered brain injury, experiencing shoulder pain, chest pain, and back pain, having nighttime sleep duration ≤ 7 h, experiencing depression, and having hip pain among the participants.

Table 1 Demographics of the Study Population Aged 45 Years or Older with Stroke in 2018

Variables	Total ($n=18,345$)	Total ($n=18,345$)			No Stroke ($n=17,469$)			Stroke ($n=876$)		
		Headache ($n=4577$)	No headache ($n=13,768$)	*P*	Headache ($n=4249$)	No headache ($n=13,220$)	*P*	Headache ($n=328$)	No headache ($n=548$)	*P*
Gender				**< 0.01**			**< 0.01**			**< 0.01**
Male	**8598 (46.90%)**	**1414 (16.40%)**	**7184 (83.60%)**		**1290 (15.00%)**	**6876 (80.00%)**		**124 (1.40%)**	**308 ((3.60%)**	
Female	**9747 (53.10%)**	**3163 (32.50%)**	**6584 (67.50%)**		**2959 (30.40%)**	**6344 (65.10%)**		**204 (2.10%)**	**240 (2.50%)**	
Age				**0.50**			**0.40**			**0.03**
45–59	**8272 (45.09%)**	**2039 (24.60%)**	**6233 (75.40%)**		**1964 (23.70%)**	**6117 (73.90%)**		**75 (0.90%)**	**116 (1.40%)**	
60–69	**6034 (32.89%)**	**1503 (24.90%)**	**4531 (75.10%)**		**1354 (22.40%)**	**4322 (71.60%)**		**149 (2.50%)**	**209 (3.50%)**	
≥ 70	**4039 (22.02%)**	**1035 (25.60%)**	**3004 (74.40%)**		**931 (23.10%)**	**2781 (68.90%)**		**104 (2.60%)**	**223 (5.50%)**	
Residence location				**< 0.01**			**< 0.01**			**0.31**
Urban	**5041 (27.50%)**	**1030 (20.40%)**	**4011 (79.60%)**		**940 (18.60%)**	**3843 (76.20%)**		**90 (1.80%)**	**168 (3.30%)**	
Rural	**13,304 (72.50%)**	**3547 (26.70%)**	**9757 (73.30%)**		**3309 (24.90%)**	**9377 (70.50%)**		**238 (1.80%)**	**380 (2.90%)**	
Education level				**< 0.01**			**< 0.01**			**< 0.01**
Illiterate	**4371 (23.80%)**	**1438 (32.90%)**	**2933 (67.10%)**		**1324 (30.30%)**	**2799 (64.00%)**		**114 (2.60%)**	**134 (3.10%)**	
Compulsory education and above	**13,032 (71.00%)**	**3012 (23.10%)**	**10,020 (76.90%)**		**2810 (21.60%)**	**9639 (74.00%)**		**202 (1.60%)**	**381 (2.90%)**	
University and above	**942 (5.10%)**	**127 (13.50%)**	**815 (86.50%)**		**115 (12.20%)**	**782 (83.00%)**		**12 (1.30%)**	**33 (3.50%)**	
Marry status				**< 0.01**			**< 0.01**			**0.08**
Married	**14,459 (78.80%)**	**3499 (24.20%)**	**10,960 (75.80%)**		**3250 (22.50%)**	**10,554 (73.00%)**		**249 (1.70%)**	**406 (2.80%)**	
Divorced or living alone	**1531 (8.30%)**	**391 (25.50%)**	**1140 (74.50%)**		**370 (24.20%)**	**1113 (72.70%)**		**21 (1.40%)**	**27 (1.80%)**	
Others	**2355 (12.9%)**	**687 (29.20%)**	**1668 (70.80%)**		**629 (26.70%)**	**1553 (65.90%)**		**58 (2.50%)**	**115 (4.90%)**	
Nation				**< 0.01**			**< 0.01**			**0.01**
Han	**16,917 (92.20%)**	**4130 (24.40%)**	**12,787 (75.60%)**		**3841 (22.70%)**	**12,277 (72.60%)**		**289 (1.70%)**	**510 (3.00%)**	
Minority	**1428 (7.80%)**	**447 (31.30%)**	**981 (68.70%)**		**408 (28.60%)**	**943 (66.00%)**		**39 (2.70%)**	**38 (2.70%)**	
National region				**< 0.01**			**< 0.01**			**< 0.01**
North China	**2265 (12.30%)**	**462 (20.40%)**	**1803 (79.60%)**		**420 (18.50%)**	**1704 (75.20%)**		**42 (1.90%)**	**99 (4.40%)**	
Central China	**2834 (15.40%)**	**968 (34.20%)**	**1866 (65.80%)**		**903 (31.90%)**	**1790 (63.20%)**		**65 (2.30%)**	**76 (2.70%)**	
East China	**5273 (28.70%)**	**1282 (24.30%)**	**3991 (75.70%)**		**1198 (22.70%)**	**3861 (73.20%)**		**84 (1.60%)**	**130 (2.50%)**	
South China	**1935 (10.50%)**	**317 (16.40%)**	**1618 (83.60%)**		**308 (15.90%)**	**1571 (81.20%)**		**9 (0.50%)**	**47 (2.40%)**	
Northeast	**1507 (8.20%)**	**316 (21.00%)**	**1191 (79.00%)**		**287 (19.00%)**	**1134 (75.20%)**		**29 (1.90%)**	**57 (3.80%)**	
Northwest	**1491 (8.10%)**	**403 (27.00%)**	**1088 (73.00%)**		**386 (25.90%)**	**1064 (71.40%)**		**17 (1.10%)**	**24 (1.60%)**	
Southwest	**3040 (16.60%)**	**829 (27.30%)**	**2211 (72.70%)**		**747 (24.60%)**	**2096 (68.90%)**		**82 (2.70%)**	**115 (3.80%)**	
Health status				**< 0.01**			**< 0.01**			**< 0.01**
Good	**4804 (26.2%)**	**511 (10.60%)**	**4293 (89.40%)**		**496 (10.30%)**	**4209 (87.60%)**		**15 (0.30%)**	**84 (1.70%)**	
Fair	**8869 (48.30%)**	**2066 (23.30%)**	**6803 (76.70%)**		**1971 (22.20%)**	**6579 (74.20%)**		**95 (1.10%)**	**224 (2.50%)**	

Table 1 (continued)

Variables	Total ($n=18,345$)	Total ($n=18,345$)			No Stroke ($n=17,469$)			Stroke ($n=876$)		
		Headache ($n=4577$)	No headache ($n=13,768$)	*P*	Headache ($n=4249$)	No headache ($n=13,220$)	*P*	Headache ($n=328$)	No headache ($n=548$)	*P*
Poor	3648 (19.90%)	1483 (40.70%)	2165 (59.30%)		1338 (36.70%)	1977 (54.20%)		145 (4.00%)	188 (5.20%)	
Very poor	1024 (5.60%)	517 (50.50%)	507 (49.50%)		444 (43.40%)	455 (44.40%)		73 (7.10%)	52 (5.10%)	
Self-employed agricultural				< 0.01			< 0.01			0.45
Yes	8351 (45.50%)	2186 (26.20%)	6165 (73.80%)		2048 (24.50%)	5920 (70.90%)		138 (1.70%)	245 (2.90%)	
No	9994 (54.50%)	2391 (23.90%)	7603 (76.10%)		2201 (22.00%)	7300 (73.00%)		190 (1.90%)	303 (3.00%)	
Annual income				< 0.01			< 0.01			0.63
< 5000	14,563 (79.40%)	3740 (25.70%)	10,823 (74.30%)		3483 (23.90%)	10,378 (71.30%)		257 (1.80%)	445 (3.10%)	
5000–10000	481 (2.60%)	95 (19.80%)	386 (80.20%)		90 (18.70%)	375 (78.00%)		5 (1.00%)	11 (2.30%)	
10,000–20000	937 (5.10%)	225 (24.00%)	712 (76.00%)		204 (21.80%)	682 (72.80%)		21 (2.20%)	30 (3.20%)	
> 20,000	2364 (12.90%)	517 (21.90%)	1847 (78.10%)		472 (20.00%)	1785 (75.50%)		45 (1.90%)	62 (2.60%)	
Disability				< 0.01			< 0.01			0.26
Yes	1018 (5.50%)	337 (33.10%)	681 (66.90%)		281 (27.60%)	603 (59.20%)		56 (5.50%)	78 (7.70%)	
No	17,327 (94.50%)	4240 (24.50%)	13,087 (75.50%)		3968 (22.90%)	12,617 (72.80%)		272 (1.60%)	470 (2.70%)	
Hypertension				< 0.01			< 0.01			0.18
Yes	5498 (30.00%)	1545 (28.10%)	3953 (71.90%)		1376 (25.00%)	3645 (66.30%)		169 (3.10%)	308 (5.60%)	
No	12,847 (70.00%)	3032 (23.60%)	9815 (76.40%)		2873 (22.40%)	9575 (74.50%)		159 (1.20%)	240 (1.90%)	
Dyslipemia				< 0.01			< 0.01			0.05
Yes	2066 (11.30%)	706 (34.20%)	1360 (65.80%)		616 (29.80%)	1241 (60.10%)		90 (4.40%)	119 (5.80%)	
No	16,279 (88.70%)	3871 (23.80%)	12,408 (76.20%)		3633 (22.30%)	11,979 (73.60%)		238 (1.50%)	429 (2.60%)	
Diabetes				< 0.01			< 0.01			0.05
Yes	1057 (5.80%)	352 (33.30%)	705 (66.70%)		304 (28.80%)	649 (61.40%)		48 (4.50%)	56 (5.30%)	
No	17,288 (94.20%)	4225 (24.40%)	13,063 (75.60%)		3945 (22.80%)	12,571 (72.70%)		280 (1.60%)	492 (2.80%)	
Brain injury				< 0.01			< 0.01			0.24
Yes	602 (3.30%)	268 (44.50%)	334 (55.50%)		211 (35.00%)	255 (42.40%)		57 (9.50%)	79 (13.10%)	
No	17,743 (96.70%)	4309 (24.30%)	13,434 (75.70%)		4038 (22.80%)	12,965 (73.10%)		271 (1.50%)	469 (2.60%)	
Shoulder pain				< 0.01			< 0.01			< 0.01
Yes	4769 (26.00%)	2660 (55.80%)	2109 (44.20%)		2458 (51.50%)	2011 (42.20%)		202 (4.20%)	98 (2.10%)	
No	13,576 (74.00%)	1917 (14.10%)	11,659 (85.90%)		1791 (13.20%)	11,209 (82.60%)		126 (0.90%)	450 (3.30%)	
Chest pain				< 0.01			< 0.01			< 0.01
Yes	1876 (10.20%)	1288 (68.70%)	588 (31.30%)		1175 (62.60%)	550 (29.30%)		113 (6.00%)	38 (2.00%)	
No	16,469 (89.80%)	3289 (20.00%)	13,180 (80.00%)		3074 (18.70%)	12,670 (76.90%)		215 (1.30%)	510 (3.10%)	
Back pain				< 0.01			< 0.01			< 0.01

Table 1 (continued)

Variables	Total ($n=18,345$)	Total ($n=18,345$)			No Stroke ($n=17,469$)			Stroke ($n=876$)		
		Headache ($n=4577$)	No headache ($n=13,768$)	*P*	Headache ($n=4249$)	No headache ($n=13,220$)	*P*	Headache ($n=328$)	No headache ($n=548$)	*P*
Yes	3446 (18.80%)	2058 (59.70%)	1388 (40.30%)		1905 (55.30%)	1322 (38.40%)		153 (4.40%)	66 (1.90%)	
No	14,899 (81.20%)	2519 (16.90%)	12,380 (83.10%)		2344 (15.70%)	11,898 (79.90%)		175 (1.20%)	482 (3.20%)	
Smoke				< 0.01			< 0.01			< 0.01
Yes	7465 (40.70%)	1400 (18.80%)	6065 (81.20%)		1279 (17.10%)	5797 (77.70%)		121 (1.60%)	268 (3.60%)	
No	10,880 (59.30%)	3177 (29.20%)	7703 (70.80%)		2970 (27.30%)	7423 (68.20%)		207 (1.90%)	280 (2.60%)	
Drink				< 0.01			< 0.01			0.04
Yes	6214 (33.90%)	1152 (18.50%)	5062 (81.50%)		1088 (17.50%)	4921 (79.20%)		64 (1.00%)	141 (2.30%)	
No	12,131 (66.10%)	3425 (28.20%)	8706 (71.80%)		3161 (26.10%)	8299 (68.40%)		264 (2.20%)	407 (3.40%)	
Insurance				0.02			< 0.01			0.18
Yes	17,792 (97.00%)	4415 (24.80%)	13,377 (75.20%)		4089 (23.00%)	12,838 (72.20%)		326 (1.80%)	539 (3.00%)	
No	553 (3.00%)	162 (29.30%)	391 (70.70%)		160 (28.90%)	382 (69.10%)		2 (0.40%)	9 (1.60%)	
Nighttime sleep, hour				< 0.01			< 0.01			0.04
≤ 7	13,068 (71.20%)	3522 (27.00%)	9546 (73.00%)		3268 (25.00%)	9163 (70.10%)		254 (1.90%)	383 (2.90%)	
7–9	3694 (20.10%)	710 (19.20%)	2984 (80.80%)		665 (18.00%)	2877 (77.90%)		45 (1.20%)	107 (2.90%)	
≥ 9	1583 (8.60%)	345 (21.80%)	1238 (78.20%)		316 (20.00%)	1180 (74.50%)		29 (1.80%)	58 (3.70%)	
Nap time, minute				< 0.01			< 0.01			0.33
NO nap	7046 (38.40%)	1915 (27.20%)	5131 (72.80%)		1796 (25.50%)	4948 (70.20%)		119 (1.70%)	183 (2.60%)	
≤ 30	3242 (17.70%)	838 (25.80%)	2404 (74.20%)		777 (24.00%)	2319 (71.50%)		61 (1.90%)	85 (2.60%)	
30–60	311 (1.70%)	69 (22.20%)	242 (77.80%)		66 (21.20%)	234 (75.20%)		3 (1.00%)	8 (2.60%)	
≥ 60	7746 (42.20%)	1755 (22.70%)	5991 (77.30%)		1610 (20.80%)	5719 (73.80%)		145 (1.90%)	272 (3.50%)	
Depression				< 0.01			< 0.01			0.33
Yes	7416 (40.40%)	1970 (26.60%)	5446 (73.40%)		1823 (24.60%)	5219 (70.40%)		147 (2.00%)	227 (3.10%)	
No	10,929 (59.60%)	2607 (23.90%)	8322 (76.10%)		2426 (22.20%)	8001 (73.20%)		181 (1.70%)	321 (2.90%)	
Hip pain				< 0.01			< 0.01			< 0.01
Yes	1656 (9.00%)	1045 (63.10%)	611 (36.90%)		946 (57.10%)	563 (34.00%)		99 (6.00%)	48 (2.90%)	
No	16,689 (91.00%)	3532 (21.20%)	13,157 (78.80%)		3303 (19.80%)	12,657 (75.80%)		229 (1.40%)	500 (3.00%)	
Chronic disease				0.66			0.66			0.48
Yes	10,183 (55.50%)	2528 (24.80%)	7655 (75.20%)		2356 (23.10%)	7381 (72.50%)		172 (1.70%)	274 (2.70%)	
No	8162 (44.50%)	2049 (25.10%)	6113 (74.90%)		1893 (23.20%)	5839 (71.50%)		156 (1.90%)	274 (3.40%)	

The quantities of variables are expressed in terms of frequency (n) and percentage. Statistical significance between groups was determined using the χ^2 test, with $p < 0.05$ indicating a statistically significant difference. The provinces are categorized according to China's geographical regions: North China, Central China, East China, South China, Northeast China, Northwest China, and Southwest China

Prevalence of headache in the stroke population

Table 2 shows the prevalence of headaches in stroke patients compared with the nonstroke once. Stroke patients showed higher prevalence of headaches ($n=328$, 37.44%) compared with nonstroke patients ($n=4,249$, 24.32%). Regardless of stroke occurrence, females experienced a higher prevalence of headaches than males (stroke patients: females 45.95% vs. males 28.7%; nonstroke patients: females 31.81% vs. males 15.80%). Moreover, stroke patients, regardless of gender, exhibited a greater prevalence of headaches compared with those without stroke (males: 28.70% vs. 15.80%; females: 45.95% vs. 31.81%), which highlights a notable gender disparity. Regardless of stroke occurrence, rural residents presented a higher prevalence of headaches compared with urban residents (38.51% vs. 34.88% for stroke patients; 26.08% vs. 19.65% for nonstroke patients). Furthermore, stroke patients experienced a greater prevalence of headaches compared with nonstroke individuals, irrespective of residence (urban: 34.88% vs. 19.65%; rural: 38.51% vs. 26.08%). Headache prevalence in the Central region significantly exceeded that in the Southern region, regardless of stroke status (stroke: 46.10% vs. 16.07%; nonstroke: 33.53% vs. 16.39%), and its value is the highest compared with those in other regions. Regardless of ethnicity, marital status, education level, health status, agricultural occupation, income level, disability, the presence of hypertension, dyslipidemia, diabetes, shoulder pain, chest pain, back pain, smoking, alcohol consumption, night sleep duration, napping time, depression, hip pain, and chronic diseases, headaches are more prevalent in stroke patients than in those without a stroke. Stroke patients with characteristics, such as age of 60–69 years (41.62%), illiteracy (45.97%), minority ethnicity (50.65%), very poor self-reported health status (58.40%), disability (41.79%), dyslipidemia (43.06%), diabetes (46.15%), brain injury (41.91%), night sleep duration ≤ 7 h (39.87%), and depression (39.30%), exhibited a higher prevalence of headaches.

Subgroup analysis by gender (Table S1) revealed that regardless of stroke occurrence, females displayed a significantly higher prevalence of headaches than males across most variables. Subgroup analyses by residence (Table S2), hypertension (Table S3), and dyslipidemia (Table S4) indicated significant differences in headache prevalence across most variables for stroke and nonstroke patients. These findings are consistent with the overall headache prevalence reported in Table 2.

Risk factors of headache in stroke population

Table 3 depicts the results of univariate and multivariate logistic regression analyses. Univariate analysis was performed to examine the headache-related factors for the whole population of stroke patients. The risk factors for headaches in stroke patients included the following female gender (OR = 2.11, 95% confidence interval (CI): 1.60–2.79), belonging to a minority ethnic group (OR = 1.81, 95% CI: 1.13–2.90), residency in Central China region (OR = 2.02, 95% CI: 1.24–3.29), very poor self-health status (OR = 7.86, 95% CI: 4.09–15.13), shoulder pain (OR = 7.36, 95% CI: 5.39–10.06), chest pain (OR = 7.05, 95% CI: 4.73–10.53), back pain (OR = 6.39, 95% CI: 4.56–8.94), and hip pain (OR = 4.50, 95% CI: 3.08–6.58). Having a higher level of education (OR = 0.43, 95% CI: 0.21–0.87) and adequate sleep of 7–9 h (OR = 0.63, 95% CI: 0.43–0.93) served as protective factors against headaches in individuals who have experienced a stroke.

Multivariate logistic regression analysis (Table 3) revealed that significant risk factors for headaches in stroke patients included the following: female gender (OR = 1.45, 95% CI: 1.02–2.07), residency in the Central China region (OR = 2.50, 95% CI: 1.37–4.54), residency in the East China region (OR = 1.87, 95% CI: 1.07–3.27), residency in the Northwest region (OR = 2.49, 95% CI: 1.06–5.84), poor self-health report (OR = 2.63, 95% CI: 1.35–5.15), very poor self-health report (OR = 4.06, 95% CI: 1.90–8.68), diabetes (OR = 1.85, 95% CI: 1.11–3.07), shoulder pain (OR = 4.01, 95% CI: 2.77–5.81), chest pain (OR = 2.51, 95% CI: 1.55–4.06), and back pain (OR = 2.01, 95% CI: 1.32–3.05) were identified as significant risk factors. Figure 2 illustrates the forest plots for the univariate and multivariate logistic regression analyses conducted on the stroke population. Table S5 provides the results of multivariate logistic regression analysis stratified by gender. Subgroup analysis indicated that residency in Central China, very poor self-rated health, and shoulder pain are significant risk factors for males and females ($p<0.05$). Based on residency, in the multivariate logistic regression analysis (Table S6), subgroup analysis revealed shoulder pain, chest pain, and back pain as common risk factors for headaches in rural and urban stroke populations ($p<0.05$). Table S7 displays the findings of multivariate logistic regression analysis, stratified by the state of dyslipidemia. Subgroup analysis revealed that residency in Central China, shoulder pain, and chest pain are common risk factors for headaches in stroke patients with and without dyslipidemia ($p<0.05$). Figures S1 and S2 present the multivariate logistic regression forest plots for the stroke population, stratified by gender and residency, respectively. Forest Plot of Multivariable Logistic Analysis Stratified by Dyslipidemia in Stroke Patients (Figure S3). Tables S1-S7 and Figures S1-S3 can be found in Supplement 1and Supplement 2.

Table 2 Prevalence of Headache in Patients with Stroke Aged 45 Years or Older

Variables	Stroke ($n=876$)			No stroke ($n=17,469$)		
	Frequency (n)	Prevalence (95%CI)	*P*	Frequency (n)	Prevalence (95%CI)	*P*
Total	**328**	**37.44%**		**4249**	**24.32%**	
Gender			**< 0.001**			**< 0.001**
Male	**124**	**28.70 (24.44–32.97)**		**1290**	**15.80 (15.01–16.59)**	
Female	**204**	**45.95 (41.31–50.58)**		**2959**	**31.81 (30.86–32.75)**	
Age			**0.025**			**0.399**
45–59	**75**	**39.27 (32.34–46.19)**		**1964**	**24.30 (23.38–25.23)**	
60–69	**149**	**41.62 (36.51–46.73)**		**1354**	**23.85 (22.78–24.93)**	
≥ 70	**104**	**31.80 (26.76–36.85)**		**931**	**25.08 (23.74–26.42)**	
Residence location			**0.312**			**< 0.001**
Urban	**90**	**34.88 (29.07–40.70)**		**940**	**19.65 (18.56–20.75)**	
Rural	**238**	**38.51 (34.67–42.35)**		**3309**	**26.08 (25.34–26.83)**	
Education level			**0.003**			**< 0.001**
Illiterate	**114**	**45.97 (39.77–52.17)**		**1324**	**32.11 (30.73–33.50)**	
Compulsory education and above	**202**	**34.65 (30.79–38.51)**		**2810**	**22.57 (21.85–23.29)**	
University and above	**12**	**26.67 (13.75–39.59)**		**115**	**12.82 (10.69–14.96)**	
Marry status			**0.361**			**< 0.001**
Married	**249**	**38.02 (34.30–41.73)**		**3250**	**23.54 (22.85–24.24)**	
Divorced or living alone	**21**	**43.75 (29.72–57.78)**		**370**	**24.95 (22.78–27.12)**	
Others	**58**	**33.53 (26.54–41.09)**		**629**	**28.83 (26.93–30.78)**	
Nation			**0.012**			**< 0.001**
Han	**289**	**36.17 (32.84–39.50)**		**3841**	**23.83 (23.19–24.47)**	
Minority	**39**	**50.65 (39.48–61.82)**		**408**	**30.20 (27.82–32.58)**	
National region			**0.001**			**< 0.001**
North China	**42**	**29.79 (22.24–37.34)**		**420**	**19.77 (18.13–21.41)**	
Central China	**65**	**46.10 (37.87–54.33)**		**903**	**33.53 (31.79–35.27)**	
East China	**84**	**39.25 (32.71–45.79)**		**1198**	**23.68 (22.53–24.83)**	
South China	**9**	**16.07 (6.45–25.69)**		**308**	**16.39 (14.74–18.04)**	
Northeast	**29**	**33.72 (23.73–43.71)**		**287**	**20.20 (18.17–22.22)**	
Northwest	**17**	**41.46 (26.38–56.54)**		**386**	**26.62 (24.38–28.86)**	
Southwest	**82**	**41.62 (34.74–48.51)**		**747**	**26.28 (24.71–27.84)**	
Health status			**< 0.001**			**< 0.001**
Good	**15**	**15.15 (8.74–23.76)**		**496**	**10.54 (9.68–11.45)**	
Fair	**95**	**29.78 (24.76–34.80)**		**1971**	**23.05 (22.18–23.93)**	
Poor	**145**	**43.54 (38.22–48.87)**		**1338**	**40.36 (38.77–41.95)**	
Very poor	**73**	**58.40 (49.76–67.04)**		**444**	**49.39 (46.33–52.45)**	
Self-employed agricultural			**0.447**			**< 0.001**
No	**190**	**38.54 (34.24–42.84)**		**2201**	**23.17 (22.34–23.99)**	
Yes	**138**	**36.03 (31.22–40.84)**		**2048**	**25.70 (24.77–26.64)**	
Annual income			**0.627**			**< 0.001**
< 5000	**257**	**36.61 (33.05–40.17)**		**3483**	**25.13 (24.42–25.83)**	
5000–10000	**5**	**31.25 (8.54–53.96)**		**90**	**19.35 (15.82–22.89)**	
10,000–20000	**21**	**41.18 (27.67–54.68)**		**204**	**23.02 (20.33–25.72)**	
> 20,000	**45**	**42.06 (32.70–51.41)**		**472**	**20.91 (19.27–22.55)**	
Disability			**0.258**			**< 0.001**
No	**272**	**36.66 (33.19–40.12)**		**3968**	**23.93 (23.29–24.56)**	
Yes	**56**	**41.79 (33.44–50.14)**		**281**	**31.79 (28.93–34.65)**	
Hypertension			**0.178**			**< 0.001**
No	**159**	**39.85 (35.05–44.65)**		**2873**	**23.08 (22.35–23.81)**	
Yes	**169**	**35.43 (31.14–39.72)**		**1376**	**27.40 (26.23–28.58)**	
Dyslipemia			**0.054**			**< 0.001**

Table 2 (continued)

Variables	Stroke ($n=876$)			No stroke ($n=17,469$)		
	Frequency (n)	Prevalence (95%CI)	*P*	Frequency (n)	Prevalence (95%CI)	*P*
No	**238**	**35.68 (32.05–39.32)**		**3633**	**23.27 (22.62–23.92)**	
Yes	**90**	**43.06 (36.35–49.78)**		**616**	**33.17 (31.14–35.20)**	
Diabetes			**0.051**			**< 0.001**
No	**280**	**36.27 (32.88–39.66)**		**3945**	**23.89 (23.25–24.52)**	
Yes	**48**	**46.15 (36.57–55.74)**		**304**	**31.90 (29.09–34.71)**	
Brain injury			**0.241**			**< 0.001**
No	**271**	**36.62 (33.15–40.09)**		**4038**	**23.75 (23.12–24.37)**	
Yes	**57**	**41.91 (33.62–50.20)**		**211**	**45.28 (41.30–49.26)**	
Shoulder pain			**< 0.001**			**0.000**
No	**126**	**21.88 (18.50–25.25)**		**1791**	**13.78 (13.20–14.36)**	
Yes	**202**	**67.33 (62.03–72.64)**		**2458**	**55.00 (53.59–56.41)**	
Chest pain			**< 0.001**			**0.000**
No	**215**	**29.66 (26.33–32.98)**		**3074**	**19.52 (18.92–20.13)**	
Yes	**113**	**74.83 (67.91–81.76)**		**1175**	**68.12 (66.01–70.22)**	
Backpain			**< 0.001**			**0.000**
No	**175**	**26.64 (23.26–30.02)**		**2344**	**16.46 (15.86–17.05)**	
Yes	**153**	**69.86 (63.79–75.94)**		**1905**	**59.03 (57.39–60.68)**	
Smoke			**< 0.001**			**< 0.001**
No	**207**	**42.51 (38.11–46.90)**		**2970**	**28.58 (27.73–29.43)**	
Yes	**121**	**31.11 (26.51–35.71)**		**1279**	**18.08 (17.20–18.95)**	
Drink			**0.035**			**< 0.001**
No	**264**	**39.34 (35.65–43.04)**		**3161**	**27.58 (26.79–28.38)**	
Yes	**64**	**31.22 (24.88–37.56)**		**1088**	**18.11 (17.15–19.06)**	
Insurance			**0.184**			**0.004**
No	**2**	**18.18 (2.28–51.78)**		**160**	**29.52 (25.72–33.32)**	
Yes	**326**	**37.69 (34.46–40.92)**		**4089**	**24.16 (23.53–24.79)**	
Nighttime sleep, hour			**0.045**			**< 0.001**
≤ 7	**254**	**39.87 (36.07–43.68)**		**3268**	**26.29 (25.53–27.04)**	
7–9	**45**	**29.61 (22.35–36.86)**		**665**	**18.77 (17.52–20.03)**	
≥ 9	**29**	**33.33 (23.43–43.24)**		**316**	**21.12 (19.11–23.13)**	
Nap time, minute			**0.331**			**< 0.001**
NO nap	**119**	**39.40 (33.89–44.92)**		**1796**	**26.63 (25.60–27.66)**	
≤ 30	**61**	**41.78 (33.78–49.78)**		**777**	**25.10 (23.60–26.59)**	
30–60	**3**	**27.27 (0.95–53.59)**		**66**	**22.00 (17.40–26.60)**	
≥ 60	**145**	**34.77 (30.20–39.34)**		**1610**	**21.97 (21.05–22.89)**	
Depression			**0.326**			**< 0.001**
No	**181**	**36.06 (31.86–40.26)**		**2426**	**23.27 (22.47–24.06)**	
Yes	**147**	**39.30 (34.35–44.25)**		**1823**	**25.89 (24.89–26.88)**	
Hip pain			**< 0.001**			**< 0.001**
No	**229**	**31.41 (28.04–34.78)**		**3303**	**20.70 (20.08–21.31)**	
Yes	**99**	**67.35 (59.77–74.93)**		**946**	**62.69 (60.36–65.02)**	
Chronic disease			**0.485**			**0.661**
No	**172**	**38.57 (34.05–43.08)**		**2356**	**24.20 (23.36–25.03)**	
Yes	**156**	**36.28 (31.73–40.82)**		**1893**	**24.48 (23.55–25.42)**	

The prevalence is expressed in terms of frequency (n) and percentage (95% CI). Statistical significance within the groups was determined using the χ^2 test, with $p < 0.05$ indicating a statistically significant difference

Table 3 Univariate and Multivariate Adjusted OR for Headache Associated with Risk Factors

	Univariate		Multivariable adjusted	
	OR (95%CI)	*P*	OR (95%CI)	*P*
Gender				
Male	**1 (Reference)**		**1 (Reference)**	
Female	**2.11 (1.60–2.79)**	**< 0.01**	**1.45 (1.02–2.07)**	**0.039**
Residence location				
Urban	**1 (Reference)**			
Rural	**1.17 (0.86–1.58)**	**0.312**		
Education level				
Illiterate	**1 (Reference)**		**1 (Reference)**	
Compulsory education and above	**0.62 (0.46–0.84)**	**0.002**	**0.82 (0.56–1.21)**	**0.317**
University and above	**0.43 (0.21–0.87)**	**0.018**	**0.72 (0.31–1.66)**	**0.435**
Marry status				
Married	**1 (Reference)**			
Divorced or living alone	**1.27 (0.70–2.29)**	**0.431**		
Others	**0.82 (0.58–1.17)**	**0.277**		
Nation				
Han	**1 (Reference)**		**1 (Reference)**	
Minority	**1.81 (1.13–2.90)**	**0.013**	**1.08 (0.60–1.93)**	**0.798**
National region				
North China	**1 (Reference)**		**1 (Reference)**	
Central China	**2.02 (1.24–3.29)**	**0.005**	**2.50 (1.37–4.54)**	**0.003**
East China	**1.52 (0.97–2.40)**	**0.069**	**1.87 (1.07–3.27)**	**0.028**
South China	**0.45 (0.20–1.00)**	**0.051**	**0.60 (0.24–1.53)**	**0.286**
Northeast	**1.20 (0.68–2.13)**	**0.535**	**1.38 (0.70–2.74)**	**0.355**
Northwest	**1.67 (0.81–3.43)**	**0.162**	**2.49 (1.06–5.84)**	**0.037**
Southwest	**1.68 (1.06–2.66)**	**0.027**	**1.52 (0.86–2.69)**	**0.154**
Health status				
Good	**1 (Reference)**		**1 (Reference)**	
Fair	**2.38 (1.30–4.33)**	**0.005**	**1.86 (0.95–3.66)**	**0.072**
Poor	**4.32 (2.39–7.80)**	**< 0.001**	**2.63 (1.35–5.15)**	**0.005**
Very poor	**7.86 (4.09–15.13)**	**< 0.001**	**4.06 (1.90–8.68)**	**< 0.001**
Self-employed agricultural				
No	**1 (Reference)**			
Yes	**0.90 (0.68–1.18)**	**0.447**		
Annual income				
< 5000	**1 (Reference)**			
5000–10000	**0.79 (0.27–2.29)**	**0.66**		
10,000–20000	**1.21 (0.68–2.16)**	**0.515**		
> 20,000	**1.26 (0.83–1.90)**	**0.279**		
Disability				
No	**1 (Reference)**			
Yes	**1.24 (0.85–1.80)**	**0.259**		
Dyslipemia				
No	**1 (Reference)**		**1 (Reference)**	
Yes	**1.36 (0.99–1.87)**	**0.055**	**0.99 (0.66–1.47)**	**0.958**
Diabetes				
No	**1 (Reference)**		**1 (Reference)**	
Yes	**1.51 (1.00–2.28)**	**0.052**	**1.85 (1.11–3.07)**	**0.018**

Table 3 (continued)

	Univariate		Multivariable adjusted	
	OR (95%CI)	*P*	OR (95%CI)	*P*
Brain injury				
No	**1 (Reference)**			
Yes	**1.25 (0.86–1.81)**	**0.242**		
Shoulder pain				
No	**1 (Reference)**		**1 (Reference)**	
Yes	**7.36 (5.39–10.06)**	**< 0.01**	**4.01 (2.77–5.81)**	**< 0.01**
Chest pain				
No	**1 (Reference)**		**1 (Reference)**	
Yes	**7.05 (4.73–10.53)**	**< 0.01**	**2.51 (1.55–4.06)**	**< 0.01**
Backpain				
No	**1 (Reference)**		**1 (Reference)**	
Yes	**6.39 (4.56–8.94)**	**< 0.01**	**2.01 (1.32–3.05)**	**0.001**
Insurance				
No	**1 (Reference)**			
Yes	**2.72 (0.58–12.68)**	**0.202**		
Nighttime sleep, hour				
≤ 7	**1 (Reference)**		**1 (Reference)**	
7–9	**0.63 (0.43–0.93)**	**0.02**	**0.96 (0.61–1.52)**	**0.86**
≥ 9	**0.75 (0.47–1.21)**	**0.242**	**1.19 (0.68–2.10)**	**0.54**
Nap time, minute				
NO nap	**1 (Reference)**			
≤ 30	**1.10 (0.74–1.65)**	**0.631**		
30–60	**0.58 (0.15–2.22)**	**0.423**		
≥ 60	**0.82 (0.60–1.11)**	**0.204**		
Depression				
No	**1 (Reference)**			
Yes	**1.15 (0.87–1.51)**	**0.326**		
Hip pain				
No	**1 (Reference)**		**1 (Reference)**	
Yes	**4.50 (3.08–6.58)**	**< 0.01**	**1.56 (0.98–2.49)**	**0.062**
Chronic disease				
No	**1 (Reference)**			
Yes	**0.91 (0.69–1.19)**	**0.485**		

The results are presented as OR (Odds Ratios) with 95% CI. The univariate and multivariate adjusted OR were analyzed for 876 stroke patients in the middle-aged and elderly population aged 45 years and older. Variables with univariate $p < 0.2$ were included in the multivariate analysis. Statistical significance in the multivariate analysis was determined with $p < 0.05$. Both univariate and multivariate adjustments excluded controversial factors such as age, and variables with small sample sizes like smoking, alcohol consumption, and hypertension

Discussion

To our knowledge, this work, utilizing the CHARLS database, is the sole study that examined the prevalence of headaches and their associated risk factors in middle-aged and elderly stroke patients in China. According to 2018 data, stroke patients exhibited a markedly higher prevalence of headaches compared with nonstroke patients. Regardless of stroke occurrence, the prevalence of headaches exhibited significant differences in terms of gender, education level, ethnicity, geographic distribution, health status, shoulder pain, chest pain, back pain, night sleep duration, and hip pain. This study is the first to document the prevalence rate of headaches among middle-aged and elderly stroke patients in 2018. In addition, according to multivariate logistic regression, the risk factors for headaches in stroke patients include female

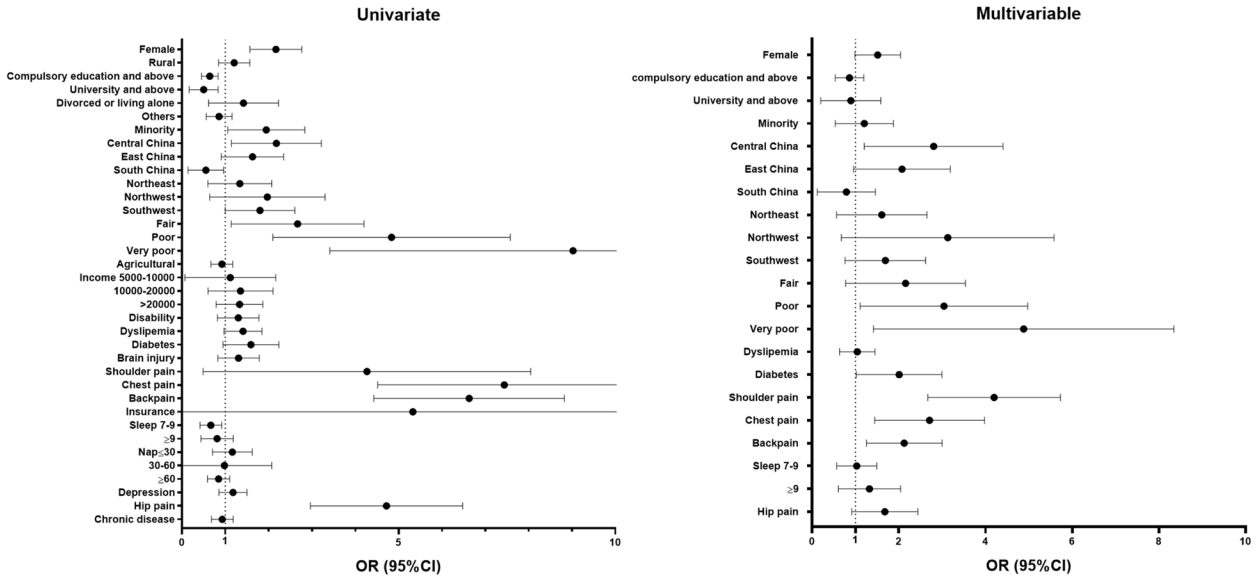

Fig. 2 Odds Ratios and 95% Confidence Intervals for Headache in Univariate and Multivariate Logistic Regression Analyses among the Stroke Population. Note: Variables with $P > 0.2$ were excluded from the multivariate analysis, including residence location, marital status, self-employment in agriculture, annual income, disability, brain injury, insurance, nap time (in minutes), depression, and chronic disease. Both univariate and multivariate adjustments excluded controversial factors such as age, and variables with small sample sizes like smoking, alcohol consumption, and hypertension. Statistical significance in the multivariate analysis was determined with $p < 0.05$

gender, residency in Central, Eastern, or Northwestern China, poor and very poor self-reported health status, diabetes, shoulder pain, back pain, and chest pain.

Overview of disease prevalence

This research involved 18,345 participants, among whom 328 and 4,249 stroke and nonstroke patients, respectively, experienced headaches. Our analysis of the 2018 data revealed that the prevalence of headaches among stroke patients in China who are middle-aged and older reached as high as 37.44%, which indicates an epidemic level, consistent with the range reported in previous studies [19]. The prevalence of headaches in nonstroke patients was 24.32%, with a significantly high correlation observed between headache occurrence and stroke incidence [20]. Moreover, accumulating pieces of evidence suggest a common genetic basis between headaches and vascular diseases [21]. In cases of posterior circulation ischemic stroke, headaches are more common. Cerebrovascular diseases can simultaneously cause stroke and headache disorders, such as cerebral venous thrombosis [22]. Headaches often present as prodromal symptoms, and early intervention is crucial to prevent serious consequences.

Stratified analysis was conducted based on sociodemographic information and health-related data. Notably, women exhibited significantly higher stroke prevalence than men; based on earlier research, female stroke patients had a 2.06-fold higher likelihood of experiencing headaches than their male counterparts [23]. Furthermore, environmental factors and physical fitness may influence changes in headache prevalence, and chronic diseases, such as diabetes, increase the likelihood of headaches. The high prevalence observed in ethnic minorities may be attributed to regional and dietary factors, with low levels of cultural awareness potentially contributing to the increased prevalence of headaches because of factors, such as overwork, irregular sleep patterns, and inadequate rest [24]. A high prevalence of headaches was also observed in individuals with poor health conditions. Such an outcome was observed because psychological factors affect self-reported health status, and an improved mental state can regulate peripheral nerves, endocrine functions, and immune factors to alleviate pain [25]. Conversely, a poor psychological state exacerbates headaches through the manifestation of a poor reported health status. Nondrinkers exhibited a higher headache prevalence than drinkers, possibly because patients experiencing headache symptoms may abstain from alcohol consumption to mitigate the exacerbation of their headaches [26]. Conversely, nonsmokers presented a higher prevalence rate of headaches than smokers, potentially because smoking helps in the management of emotional pain [27]. However, given the limitations inherent in cross-sectional studies, establishing causality between smoking and headaches remains

challenging. Future research should conduct longitudinal studies to further investigate the causal relationships between smoking, alcohol consumption, and headaches to develop targeted interventions.

Overview of risk factors

The findings reveal that the female gender, residency in central, eastern, or northwestern regions of the country, poor self-health, having diabetes, and shoulder pain, back pain, or chest pain were risk factors for headaches in stroke patients. The likelihood of suffering from a headache is notably greater in women than in men [28, 29]. This outcome may be explained by the hormonal and physiological control of proteins in females, whereby a reduction in estrogen levels may cause the upregulation of the sympathetic nervous system and downregulation of serotonergic system to be [29]. In addition, females are more susceptible to emotional fluctuations and may bear higher psychological and physiological burdens, such as depression and anxiety, compared with males. Therefore, targeted attention must be focused on the female population experiencing headaches among stroke, and relevant interventions must be offered to mitigate risk factors.

Previous studies have indicated that individuals facing economic challenges are prone to headaches. The central and eastern regions of China, which are relatively developed economically and predominantly urban, may harbor headache risk factors associated with adverse lifestyle factors, such as stress and insufficient physical activity [30]. By contrast, in regions such as the northwest, which may be characterized by relative economic underdevelopment and the lack of adequate medical environments and infrastructure, headache prevalence among stroke patients can be influenced. Moreover, abundant sunlight exposure may contribute to headache occurrence [31], which can also be affected by the participants' own physical conditions and the location of stroke lesion.

A poorer self-reported health status serves as a risk factor for headaches, and it indicates a higher awareness of self-health among individuals compared with those reported in previous studies; this finding suggests an increased self-awareness compared with those in past research [32]. Our study revealed an association between diabetes and headaches in stroke patients and an association between headaches and cardiovascular risk factors, including type 2 diabetes [33]. Common chronic conditions, such as diabetes, can increase the prevalence of headaches in stroke patients [34]. Shoulder pain ranks among the most prevalent neuropathic pain syndromes following a stroke [35]. Typically, the effects of stroke manifest on one side of the body, and a mutually exacerbating relationship exists between headaches and shoulder pain [36]. Previous studies have shown a positive correlation between lower back pain and headaches, which may be attributed to diminished dopaminergic effectiveness or deficiencies in emotional awareness. This correlation may also be linked to the calcitonin gene-related peptide in biology, which functions as a neural modulator for pain syndromes other than headaches [37]. Most patients with ischemic heart disease experience chest pain. Research indicates that rare cardiac-origin headaches can also lead to headaches. Chest pain may arise from conditions, such as angina, that can increase intracardiac pressure and trigger the release of atrial natriuretic peptide. This release, in turn, can cause vasodilation of cerebral blood vessels, which leads to headaches [38].

In stroke patients, those without hypertension, smoking, or alcohol consumption shows a higher prevalence of the disease than those with such risk factors. Consequently, in the analysis of the risk factors for headache, we excluded smoking, alcohol consumption, and hypertension due to the small sample size of stroke patients. Age emerged as a protective factor in the multivariate analysis of logistic regression. In addition, the frequency of headaches associated with stroke declines with advancing age, which is in line with earlier findings [34, 39, 40]. However, other research indicated that the highest prevalence can be observed among those aged ≥ 55 years, followed by those aged ≤ 18 years [23]. Therefore, we also excluded the controversial age factor in our logistic regression analysis. The findings revealed that residential area, diabetes, and self-reported health status are modifiable risk factors for headaches in stroke patients.

Strengths and limitations

This study exhibited several notable strengths. Primarily, this work leveraged data sourced from the 2018 CHARLS survey. The participants were selected via a rigorous multistage probability sampling procedure, which guaranteed the efficient representation of a middle-aged and older population sample that is nationally representative. Second, this study, which was conducted through a cross-sectional study design, presents the first targeted assessment of the prevalence rate and risk factors associated with concurrent headaches in patients who suffered from stroke. Ultimately, this study established a foundation for providing stroke patients with insights into modifiable risk factors linked to the occurrence of headaches and their potential complications and the development of preventive policies.

The study encountered several limitations. First, given its cross-sectional design, the causal relationships

between headaches among stroke patients and their associated risk factors was not established in this work. Second, the study relied on retrospective data reporting, which might have introduced sampling bias toward patients with mild strokes and those with adequate communication abilities, as well as being influenced by respondents' memory bias, potentially reducing the precision of the results. Third, the data did not provide detailed classifications of stroke and headache types or severities, which limits the generalizability of the study's findings to populations meeting more specific stroke criteria. Future research should incorporate objective clinical data to address the limitations of self-reports and further investigate the prevalence and risk factors of headaches in populations with varying stroke types and severities. Additionally, the over-representation of headaches in the stroke population may partly reflect the increased stroke risk in patients with migraine. This phenomenon warrants further investigation to determine whether headaches are a direct consequence of stroke or a manifestation of other comorbid conditions. Lastly, based on the available medical history, we cannot determine whether the headache was caused by the stroke. Moreover, the questionnaire did not assess whether the headache meets the definition according to ICHD-3 criteria. Future research should employ prospective cohort studies combined with the internationally standardized ICHD-3 diagnostic tool to further investigate the relationship between headaches and strokes.

Conclusions

Given the potential influence of vascular pathology and nervous system responses, stroke patients exhibit susceptibility to experiencing headaches. Therefore, more focus should be placed on headache prevention and management and other related complications in stroke populations. Enhanced health self-awareness, effective management of diabetes, and reduced of physical discomfort in the shoulders, back, and chest are modifiable risk factors that can aid in reducing the incidence of headaches among stroke patients. In addition, being female and living in Central, Eastern, or Northwestern China are risk factors that show an association with a high likelihood of headaches in stroke patients. Future studies should aim at the assessment of the prevalence and risk factors of headaches in different stroke populations in China while also examining the underlying pathological mechanisms. This work provides a theoretical basis for the development of targeted intervention and prevention strategies.

Abbreviations

CHARLS	China health and retirement longitudinal study
OR	Odds ratios
CI	Confidence interval
IRB	Institutional review board
ICHD-3	International classification of headache disorders-3rd edition

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s10194-024-01930-z.

Supplementary Material 1: Table S1. Prevalence of Headache in Patients with Stroke Aged 45 Years or Older by Gender. Table S2. Prevalence of Headache in Patients with Stroke Aged 45 Years or Older by Residency. Table S3. Prevalence of Headache in Patients with Stroke Aged 45 Years or Older by Hypertension. Table S4. Prevalence of Headache in Patients with Stroke Aged 45 Years or Older by Dyslipemia. Table S5. Multivariate Analyses of Headaches Associated with Risk Factors in the Entire Stroke Population by Gender. Table S6. Multivariate Analyses of Headaches Associated with Risk Factors in the Entire Stroke Population by Residency Table S7. Multivariate Analyses of Headaches Associated with Risk Factors in the Entire Stroke Population by Dyslipemia.

Supplementary Material 2: Figure S1. Forest Plot of Headache Risk Factors in Stroke Patients Stratified by Gender. Note:The subgroup analysis stratified by gender was performed within a multivariable logistic regression model, which included the following variables: Education level, Nation, National region, Health status, Dyslipidemia, Diabetes, Shoulder pain, Chest pain, Back pain, Nighttime sleep duration (hours), and Hip pain. Figure S2. Forest Plot of Headache Risk Factors in Stroke Patients Stratified by Residency. Note:The subgroup analysis stratified by residency was performed within a multivariable logistic regression model, which included the following variables: gender, Education level, Nation, National region, Health status, Dyslipidemia, Diabetes, Shoulder pain, Chest pain, Back pain, Nighttime sleep duration (hours), and Hip pain. Figure S3. Forest Plot of Headache Risk Factors in Stroke Patients Stratified by Dyslipidemia. Note:The subgroup analysis stratified by Dyslipidemia was performed within a multivariable logistic regression model, which included the following variables: gender, Education level, Nation, National region, Health status, Diabetes, Shoulder pain, Chest pain, Back pain, Nighttime sleep duration (hours), and Hip pain.

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Data availability

The data that support the findings of this study are available from the China Health and Retirement Longitudinal Study (CHARLS) website, subject to registration and application process. Further details can be found at http://www.charls.pku.edu.cn/en.

Authors' contributions

Conceptualization, X.-Q.W, Y.-H.Z.; data curation and analysis, M.-H.W. and L.-J.P.; validation, M.-H.W. and L.-J.P.; writing—original draft preparation, M.-H.W., Y.-H.Z.; writing—review and editing, M.-H.W., Y.-H.Z., and H.-Q.Z.; supervision, X-B.Z, X.-Q.W. All authors have read and agreed to the published version of the manuscript.

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Declarations

Ethics approval and consent to participate

All CHARLS surveys received ethical authorization from the Institutional Review Board (IRB) at Peking University (permission number: IRB00001052-11015), and all individuals who consented to participate signed four informed consent forms.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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