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ORIGINAL RESEARCH

Risk Factors for Recurrent Stroke and the Impact of Targeted Health Management

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Objective: This study aimed to identify the characteristics and risk factors associated with stroke recurrence in a Chinese patient population and to assess the effectiveness of targeted interventions addressing common stroke risk factors to inform stroke health management strategies.

Methods: A total of 1072 stroke patients who were hospitalized in Huai'an First People's Hospital from January 2018 to November 2020 were included in this study. Patients with recurrent stroke were assigned to the observation group (815 cases), while those experiencing a first-ever stroke were assigned to the control group (257 cases). The observation group received health intervention measures targeting the risk factors of stroke in the Chinese population. A one-year follow-up was conducted to compare the recurrence rates of stroke between the two groups. From November 2020 to February 2021, targeted health intervention measures were implemented for the patients who were hospitalized (ie, the intervention group). These intervention measures aimed to address modifiable risk factors and involved a one-year follow-up for the participants to assess the impact of the health intervention on stroke patients.

Results: The mean age of patients in the observation group was significantly higher than that of the control group. An increased recurrence rate was observed among those with a family history of diabetes. A significantly higher proportion of patients in the observation group engaged in regular physical exercise and adhered to a low-salt, low-fat diet compared to the control group. However, the prevalence of sleep-related snoring and sleep-disordered breathing was also significantly higher in the observation group. Additionally, the observation group had a significantly higher proportion of patients with a history of hypertension, diabetes, and heart disease. After one year of follow-up, stroke recurrence was lower among those who had undergone targeted risk factor management, although the difference did not reach statistical significance.

Conclusion: Comprehensive and targeted management of sleep-disordered breathing, diabetes, hypertension, and heart disease may contribute to a reduction in stroke recurrence among individuals in China. However, further validation through multi-center studies with larger sample sizes is necessary to establish definitive conclusions.

Keywords: health management, recurrence, risk factors, secondary prevention, stroke

Introduction

Stroke is an acute cerebrovascular disease caused by disorders in the brain's blood circulation. It is classified clinically as ischemic type (accounting for 87%) and hemorrhagic type (accounting for 13%).[1] According to data from the World Health Organization in 2024, approximately 15 million new stroke patients are added globally each year. Among them, the number of patients in China exceeds 30%, and the incidence rate is continuously increasing at an annual rate of 8.7%. Domestic epidemiological studies show that stroke has become the leading cause of death among Chinese residents, with an annual mortality rate of up to 140.3 per 100,000 people and a disability rate of over 75%. Patients often suffer from sequelae such as limb paralysis and language disorders. Direct medical costs account for more than 60% of the annual household income. In addition, long-term care costs and labor loss add to the annual social and economic burden of over 200 billion yuan.[2] With the intensification of population aging, stroke not only threatens individual health but also

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becomes a persistent challenge for the public health system. It is urgent to optimize the management strategies from prevention, treatment to rehabilitation throughout the entire process.

Previous studies have conducted extensive research on the treatment and rehabilitation of stroke. In terms of treatment, for ischemic stroke, thrombolytic drugs can be used to dissolve blood clots within 4.5 hours after the onset; if the time window is exceeded, endovascular interventional therapy or drug treatment can be adopted. For hemorrhagic stroke, it is necessary to control blood pressure, prevent rebleeding, and undergo corresponding surgical treatment. Rehabilitation treatment includes physical therapy, speech therapy, occupational therapy, etc. It can also adopt methods such as hyperbaric oxygen, traditional Chinese acupuncture, physical therapy, nerve electrical stimulation, drug treatment, music therapy, etc. The research results show that timely and effective treatment and rehabilitation training can reduce mortality, reduce complications, and promote functional recovery of patients.[3] However, there are some problems and deficiencies in current research. For example, the limitation of the treatment time window means that many patients miss the best treatment opportunity; the effect of rehabilitation treatment is affected by various factors, and the rehabilitation conditions of different patients vary greatly, and there is a lack of unified, standardized, and personalized rehabilitation plans; the research on the prevention and intervention measures for stroke recurrence is not deep and comprehensive enough.

This study aims to identify the characteristics and risk factors associated with stroke recurrence in Chinese patients, and to evaluate the effectiveness of targeted intervention measures for common stroke risk factors, thereby providing information for stroke health management strategies. By clarifying the recurrence characteristics and risk factors, it is possible to conduct more precise screening and intervention for high-risk populations, enhancing the specificity and effectiveness of prevention. Evaluating the effectiveness of targeted intervention measures can provide a basis for formulating scientific and reasonable health management strategies, which will help reduce the stroke recurrence rate in Chinese patients, alleviate their suffering and social burden, and improve their quality of life and health level.

Study Participants and Methods

Study Participants

From January 2018 to November 2020, a total of 1072 stroke patients admitted to the Neurology Department of Huai'an First People's Hospital were included in this study. The patients were divided into the control group (815 patients who had their first stroke) and the observation group (257 patients who had a recurrence of stroke) based on whether they had their first stroke. Among all patients, 638 were male and 434 were female, with ages ranging from 22 to 96 years (mean age: 65.682 ± 12.439 years). From November 2020 to February 2021, targeted health intervention measures were implemented for the 815 control group patients (ie, the intervention group). These intervention measures aimed to address modifiable risk factors and involved a one-year follow-up for the participants to assess the impact of the health intervention on stroke patients.

Inclusion criteria:

1. Meets the diagnostic criteria revised at the 4th National Conference on Cerebrovascular Diseases in 1995 and is confirmed by cranial CT and/or MRI;
2. Presents with focal neurological signs such as hemiplegia, hemisensory disturbance, aphasia, ataxia, etc;
3. Those who can cooperate are included in the study.

Exclusion criteria:

1. Patients who are unable to take care of themselves;
2. Patients or their family members are illiterate;
3. Those who cannot operate a smart phone.

Study Methods

A standardized electronic questionnaire was conducted for both the observation group and the control group patients. The questionnaire was filled out by the patients themselves or by their closest family members who were most familiar with their medical history and lifestyle. The collected data included basic demographic information, history of stroke, hypertension, hyperlipidemia, diabetes, family history, smoking and drinking status.

For the control group patients after discharge, a unified standard electronic questionnaire was distributed to them. The content of the questionnaire was designed by the health education team members, guided by the brain and heart health managers, and filled out by the patients themselves or by their closest family members who were most familiar with their medical history and lifestyle. The collected data included whether the medication was taken correctly, whether rehabilitation exercises could be continued, whether the rehabilitation plan and reasonable diet could be implemented, whether good living habits were established, whether regular follow-ups were conducted, whether recurrence occurred, and the recurrence situation.

The head nurse, brain-heart health manager, and 3 senior specialized nurses established a health education group. For patients in the intervention group, the brain-heart health manager provided the entire process of health management at the time of admission, and the members of the health education group provided discharge guidance based on the specific conditions of the patients after discharge and conducted regular telephone follow-ups.

Statistical Analysis

Only cases with successfully submitted questionnaires and complete data records were included in the analysis. Risk factors were categorized into controllable and uncontrollable factors for statistical analysis. Data analysis was performed using SPSS Statistics 17.0 software. The data were analyzed using the chi-square test.

Results

Factors Influencing Stroke Recurrence

There were no statistically significant differences between the two groups with respect to uncontrollable factors such as sex, occupation, and family medical history. However, there were significant differences in age and family history of diabetes.

Regarding controllable factors, no statistically significant differences were found between the two groups in terms of smoking, body mass index (BMI), intracranial and extracranial artery stenosis, peripheral vascular disease, migraine, chronic inflammation, or infectious diseases. However, the differences between the groups in factors such as physical activity levels, dietary habits, presence of sleep-disordered breathing, and medical history were statistically significant (Table 1).

Interventions Addressing Risk Factors

From November 2020 to February 2021, targeted health intervention measures were implemented for the hospitalized patients (ie, the intervention group). These intervention measures aimed to address modifiable risk factors and conducted a one-year follow-up for the participants to assess the recurrence rate of stroke. Subsequently, the results were statistically analyzed. The results showed that there were no statistically significant differences in aspects such as smoking cessation, improvement of sleep-disordered breathing, regular use of antihypertensive, hypoglycemic, and anticoagulant drugs between the stroke recurrence group and the non-recurrence group (Table 2).

Discussion

Stroke is associated with high incidence, recurrence, disability, and mortality rates, making its prevention and management a key focus in clinical research. A survey conducted by the China National Stroke Registry on 7593 individuals aged 18 years and older who experienced a first-ever ischemic stroke between 2007 and 2008 revealed stroke recurrence rates of 10.9%, 13.4%, and 14.7% at 3 months, 6 months, and 1 year, respectively.[4] The INTERSTROKE study, published in *The Lancet* in 2016, analyzed data from 32 countries and reported that 90.7% of stroke cases worldwide

Table 1 Factors Influencing Stroke Recurrence in Patients

	Risk Factor	Category	Control Group (n = 815)		Observation Group (n = 257)			
			Number of Cases (Cases)	Percentage (%)	Number of Cases (Cases)	Percentage (%)		
Uncontrollable factors	Age	<60	272	33.30	52	20.3	17.848	0.000
		60_80	448	55.00	162	63.00		
		>80	95	11.70	43	16.70		
	Sex	Male	487	59.80	151	58.80	0.081	0.776
		Female	328	40.20	106	41.20		
	Occupation	Mental labor	69	8.50	22	8.60	0.068	0.966
		Physical labor	350	42.90	108	42.00		
		Both or others	396	48.60	127	49.40		
	Family history of hypertension	No	723	88.70	226	87.90	0.115	0.734
		Yes	92	11.30	31	12.10		
	Family history of diabetes	No	794	97.40	242	94.20	6.398	0.011
		Yes	21	2.60	15	5.80		
	Family history of cerebrovascular disease	No	782	96.00	248	96.50	0.155	0.693
		Yes	33	4.00	9	3.50		
	Physical activity	No	324	39.80	126	49.00	9.701	0.021
Controllable factors		Moderate exercise	412	50.60	102	39.70		
		Frequent exercise	78	9.60	29	11.30		
		High-intensity exercise	1	0.10	0	0.00		
	Dietary habits	Low salt, low fat, more vegetables	145	17.80	67	26.10	12.070	0.034
		Regular diet	45	5.50	7	2.70		
		High in sweets	56	6.90	20	7.80		
		High salt	438	53.70	121	47.10		
		High fat	108	13.30	36	14.00		
		Others	23	2.80	6	2.30		
	Smoking history	No	620	76.10	181	70.40	3.297	0.069
		Yes	195	23.90	76	29.60		
	Alcohol use	No	586	71.90	179	69.60	1.170	0.557
		Occasional alcohol consumption	161	19.80	51	19.80		
		Chronic alcohol consumption	68	8.30	27	10.50		
	BMI	Underweight	22	2.70	3	1.20	2.541	0.468
		Normal	338	41.50	102	39.70		
		Overweight	345	42.30	114	44.40		
		Obese	110	13.50	38	14.80		
	Sleep-disordered breathing	No	637	78.20	159	61.90	29.341	0.000
		Only snoring	154	18.90	85	33.10		
		Short-term apnea	21	2.60	13	5.10		
		Long-term apnea	3	0.40	0	0.00		
	History of hypertension	No	376	46.10	73	28.40	25.234	0.000
		Yes	439	53.90	184	71.60		
	History of diabetes	No	673	82.60	180	70.00	18.894	0.000
		Yes	142	17.40	77	30.00		
	History of heart disease	No heart disease	724	88.80	212	82.50	19.573	0.000
		AF	19	2.30	14	5.40		
		AF with other heart disease	5	0.60	9	3.50		
		Other heart diseases	67	8.20	22	8.60		

(*Continued*)

Table 1 (Continued).

	Risk Factor	Category	Control Group (n = 815)		Observation Group (n = 257)			
			Number of Cases (Cases)	Percentage (%)	Number of Cases (Cases)	Percentage (%)		
	Intracranial and extracranial arterial stenosis	No stenosis or unknown	626	76.80	186	72.40	3.821	0.281
		Intracranial	37	4.50	19	7.40		
		Extracranial	107	13.10	37	14.40		
		Intracranial + Extracranial	45	5.50	15	5.80		
	Peripheral vascular disease	No	802	98.40	250	97.30	1.359	0.244
		Yes	13	1.60	7	2.70		
	History of migraine	No	804	98.70	253	98.40	0.061	0.806
		Yes	11	1.30	4	1.60		
	Chronic inflammatory or infectious diseases	No	813	99.80	255	99.20	1.492	0.222
		Yes	2	0.20	2	0.80		

Abbreviation: BMI, Body Mass Index.

Table 2 Interventions for Major Risk Factors

			Stroke Recurrence within One Year				X^2 value	*P* value
			No		Yes			
			Number of Cases (Cases)	Percentage (%)	Number of Cases (Cases)	Percentage (%)		
Smoking	Quit smoking	No	106	52.70	33	42.90	2.173	0.189
		Yes	95	47.30	44	57.10		
Sleep apnea	Dietary modifications	No	108	70.10	57	67.10	0.242	0.662
		Yes	46	29.90	28	32.90		
	Physical activity	Rarely	71	46.10	48	56.50	3.87	0.144
		Occasionally	55	35.70	20	23.50		
		Frequently	28	18.20	17	20.00		
Hypertension	Regular medication	No	129	27.00	40	27.40	0.007	0.916
		Yes	348	73.00	106	72.60		
Diabetes	Regular medication	No	36	22.80	11	18.00	0.59	0.582
		Yes	122	77.20	50	82.00		
AF	Anticoagulant treatment	No	29	87.90	13	92.90	2.256	1
		Yes	4	12.10	1	7.10		

Abbreviation: AF, atrial fibrillation.

were linked to the following 10 modifiable risk factors: hypertension, diabetes, dyslipidemia, heart disease, smoking, alcohol use, unhealthy diet, abdominal obesity, physical inactivity, and psychological factors.[5] These findings underscore the immense potential for reducing stroke recurrence through systematic management of these risk factors.

Long-term health management and rehabilitation are crucial for improving outcomes in stroke survivors.[6,7] Enhancing health management strategies can provide patients with standardized, professional, and effective guidance for patients, significantly improving neurological function and activities of daily living while effectively reducing the recurrence.

In this study, both uncontrollable and controllable risk factors associated with stroke recurrence were analyzed.

Among the uncontrollable risk factors, advancing age is a well-established non-modifiable risk factor for both initial and recurrent stroke, primarily due to cumulative vascular damage, increased prevalence of comorbidities like hypertension and atrial fibrillation, and reduced physiological reserve. Our findings align with this, indicating that the average age

of patients in the observation group (those with recurrent stroke) was 4.25 years higher than that of the control group (those with first-ever stroke), with most patients aged between 60 and 80 years. Given that the observation group includes individuals who had experienced multiple strokes (three or more episodes), the actual age at recurrence onset may be even earlier than the mean age observed here. A nationwide study conducted between 2008 and 2009 on 2639 adults with acute ischemic stroke across 35 hospitals in China reported a one-year recurrence rate as high as 17.1%, which is consistent with our findings.[8]

As another uncontrollable factor, familial aggregation of diabetes suggests shared genetic predispositions and environmental/lifestyle factors contributing to insulin resistance and hyperglycemia, which are detrimental to vascular health and increase stroke risk. Our study found a significantly higher proportion of individuals with a family history of diabetes among those with recurrent strokes. This finding is consistent with the understanding that a familial predisposition to diabetes increases the risk of developing diabetes and insulin resistance, which are potent stroke risk factors.[9,10] Therefore, a family history of diabetes appears to serve as a marker for increased susceptibility to stroke recurrence.

Among controllable risk factors, dietary habits and physical activity levels are of primary concern. Sedentary behavior contributes to obesity, dyslipidemia, hypertension, and insulin resistance. Diets high in salt and fat promote hypertension, atherosclerosis, and inflammation. Both factors are major contributors to the development and progression of cerebrovascular disease. Prior large-scale studies like INTERSTROKE have consistently identified physical inactivity and unhealthy diet as key modifiable stroke risk factors.[5,11] Findings from this study indicate that individuals experiencing recurrent stroke were less likely to engage in regular physical exercise and adhere to a low-salt, low-fat diet compared to first-ever stroke patients, suggesting that these factors contribute to an increased risk of stroke recurrence. This contrast highlights the critical role of sustained lifestyle modifications in secondary prevention, and this trend may also reflect the influence of enhanced health education initiatives on promoting healthier lifestyle choices.

In 2012, the Ministry of Health in China issued the *Management Measures for the Stroke High-Risk Population Screening and Intervention Pilot Project (Trial)*, which emphasized public education on stroke risk factors, screening and follow-up interventions, and secondary prevention education and health management across all levels of hospitals for patients who had experienced a stroke.[12] Among the recommended interventions, exercise and dietary modifications were promoted as the most accessible and feasible measures to implement. These lifestyle modifications are expected to contribute to a reduction in stroke recurrence and improve long-term health outcomes.

Smoking is a major, well-established risk factor for stroke. Nicotine and carbon monoxide cause endothelial dysfunction, promote inflammation and thrombosis, increase blood viscosity, and accelerate atherosclerosis. Meta-analyses confirm a strong, dose-dependent relationship between smoking and increased risk of both ischemic and hemorrhagic stroke.[13] In this study, a higher proportion of patients with recurrent strokes were smokers compared to the first-stroke group. Follow-up data also indicated a higher proportion of individuals who had quit smoking, likely reflecting the influence of health education. However, unlike the clear association shown in prior research, our study did not find a statistically significant difference in smoking prevalence between the recurrence and first-stroke groups. This lack of significance could be attributed to our relatively small sample size limiting statistical power, potential under-reporting of smoking habits, or the mitigating effect of health education efforts prompting smoking cessation after the initial stroke in some patients who later recurred.

Overweight and obesity are well-established risk factors for stroke.[14] In this study, no significant differences in body weight status were observed between patients with recurrent stroke and those experiencing a first-ever stroke. However, it should be noted that, sleep-disordered breathing (SDB), particularly obstructive sleep apnea, leads to recurrent hypoxia, sympathetic activation, blood pressure surges, hemodynamic instability, oxidative stress, inflammation, and hypercoagulability, all promoting stroke occurrence and recurrence.[15] Studies increasingly recognize SDB as an independent and significant risk factor for stroke and its recurrence. Our findings align with this, demonstrating a significantly higher prevalence of snoring and sleep-disordered breathing among patients with recurrent strokes compared to those with first-ever strokes. This underscores SDB as an important modifiable risk factor for recurrence. However, follow-up data revealed no significant increase in the proportion of individuals actively managing SDB (eg, with CPAP), suggesting insufficient awareness, diagnosis, or management of this condition and its risks. Enhanced screening, education, and targeted interventions for SDB are crucial.[16]

Hypertension, diabetes, and a history of heart disease are important risk factors for stroke. Hypertension causes vascular endothelial injury, accelerates atherosclerosis, and promotes small vessel disease. Diabetes induces hyperglycemia, insulin resistance, endothelial dysfunction, and accelerated atherosclerosis. Heart disease, particularly atrial fibrillation (AF), leads to cardioembolism.[17] Our study confirmed this, a significantly higher proportion of these conditions was found in the observation group (those with recurrent stroke), confirming that these are also major contributors to stroke recurrence. After one year of health education and management, the follow-up results revealed that the proportion of patients without stroke recurrence who adhered to regular medication was similar to that of patients experiencing recurrent stroke, with both exceeding 70%. This finding highlights the effectiveness of health management interventions. However, the lack of significant difference in adherence between those who recurred and those who did not suggests that medication adherence alone, while crucial, may not be sufficient; stricter control of risk factor levels (eg, achieving target BP, HbA1c) and managing specific conditions like AF might be key.

Regarding heart disease, AF causes blood stasis in the atria, leading to thrombus formation and subsequent embolic stroke if anticoagulation is inadequate. Anticoagulation significantly reduces this risk. The proportion of patients with heart disease in this study was 12.59%. During follow-up, the proportion of patients diagnosed with AF in the recurrent stroke group was higher, yet only 7.1% of them received regular anticoagulation treatment. Similarly, the proportion of patients with first-ever stroke with AF receiving anticoagulation treatment was only 12.1%—a rate lower than the 18.6% reported in a 2014 study.[18] In a study conducted in 2017, the authors pointed out that the incidence of ischemic stroke associated with AF in the Chinese population increased at least 2.5 times from 1999 to 2014, with most patients not receiving anticoagulation treatment.[19] This finding is inconsistent with guideline recommendations which strongly advocate anticoagulation for stroke prevention in eligible AF patients. The low anticoagulation rates likely stem from concerns about bleeding risks (especially with older agents like warfarin), the need for frequent monitoring with warfarin, and potentially suboptimal patient or provider awareness/acceptance. The increasing availability and use of newer oral anticoagulants (NOACs), which have a better safety profile and do not require routine coagulation monitoring, offers significant potential to improve this situation and enhance stroke prevention in AF patients.

Intracranial and extracranial artery stenosis is widely recognized as a major risk factor for stroke recurrence, arterial stenosis directly reduces cerebral blood flow and is a potent source of artery-to-artery embolism. Revascularization procedures like carotid endarterectomy and carotid stenting are proven to significantly reduce stroke recurrence in patients with significant symptomatic carotid stenosis.[20] In our study, a higher recurrence rate was observed among patients with intracranial and extracranial artery stenosis, consistent with the known pathophysiology. However, unlike the strong evidence base for intervention in specific cases (eg, symptomatic carotid stenosis), our study did not find a statistically significant difference in the prevalence of stenosis between recurrence and first-stroke groups. This lack of significance is likely due to methodological limitations: reliance on self-reported questionnaire data rather than objective imaging (eg, ultrasound, MRA, CTA) to confirm and quantify stenosis, and the relatively small sample size limiting the power to detect a difference. Objective imaging assessment in future studies is essential to accurately evaluate this important risk factor.

Study Limitations and Future Directions

This study primarily used questionnaire-based data and did not incorporate assessments of various biochemical indicators such as blood lipids, blood glucose, homocysteine, or relevant biological markers. Additionally, imaging examinations were not included, limiting the comprehensiveness of the analysis. A more robust approach may involve developing a predictive model for stroke recurrence that integrates multiple risk factors, allowing for more precise and individualized risk management strategies. Implementing such a model could provide valuable guidance for stroke prevention and long-term management.

In conclusion, ischemic stroke recurrence tends to become more common with advancing age. It has been demonstrated that health management interventions have a positive impact on patients in areas such as diet, exercise, and smoking cessation. However, further efforts are needed to enhance health education for both patients and their families and to implement more diversified and personalized health management strategies. These efforts will encourage patients to prioritize their health and consciously adopt sustainable lifestyle modifications to prevent stroke recurrence. Given that

sleep-disordered breathing is a key risk factor for stroke recurrence, targeted health interventions are essential. Additionally, strict control of diabetes, hypertension, and heart disease is necessary, especially for patients with AF for whom anticoagulation treatment should be reinforced. A comprehensive examination of the risk factors and management of recurrent stroke will facilitate the development of standardized, individualized, and targeted stroke health management intervention models, ultimately reducing stroke recurrence rates.

Ethics Approval and Consent to Participate

This study was conducted in accordance with the declaration of Helsinki. This study was conducted with approval from the Ethics Committee of The affiliated Huaian No. 1 People's Hospital of Nanjing Medical university. A written informed consent was obtained from all participants.

Disclosure

The authors report no conflicts of interest in this work.

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