Improved treatment capacity and quality of care: the effectiveness of the stroke prevention and treatment system in Shanghai, China from 2012-2017

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Abstract: Because of the high mortality, recurrence, and rate of disability of stroke, a stroke prevention and treatment system was instituted in Shanghai in 2012; this system includes 11 municipal hospitals, 25 district hospitals, and 240 community health centers. Community health centers focus on early screening in the community, health management of high-risk individuals, and secondary prevention and rehabilitation of stroke patients. Residents' health profiles are utilized by community health centers to proactively identify the population at higher risk. District hospitals are responsible for screening for vascular lesions in high-risk individuals, including carotid artery and intracranial artery screening, and standardized treatment of stroke patients. Municipal hospitals concentrate on complex and emergency care for acute onset stroke. The system specifies care for all stages of stroke management. The development of the system has improved the capacity of and quality of care for stroke patients. The rate at which patients undergo intravenous thrombolysis and the percentage of patients with a door-to-needle time of less than 60 minutes have increased significantly. However, the primary and secondary prevention of stroke is insufficient, the stroke rehabilitation system is incomplete, and the quality of care in primary healthcare facilities is limited. An evaluation system and payment mechanisms are needed to incentivize healthcare personnel to fulfill their responsibilities and to ensure the system's operation.

Keywords: stroke, integrated care, treatment network

Introduction

Stroke, also known as a cerebrovascular accident or CVA, is an acute cerebrovascular disease. It happens when a blood vessel in the brain bursts or is blocked, thus obstructing the flow of blood into the brain and causing damage to brain tissues. There are two types of stroke: ischemic and hemorrhagic stroke. The former is also known as cerebral infarction, and it accounts for 85% percent of all stroke incidents. Stroke has become a global health problem due to its high incidence, mortality, recurrence, and rate of disability.

The 2017 Global Burden of Disease (GBD) Study indicated that cardiovascular diseases are the top killers around the world, and stroke became the leading cause of death and the leading cause of years of life lost in China in 2017 (*1*). The GBD Study suggested that stroke had a prevalence of 2,394/100,000 population, an incidence of 301/100,000 population, and a mortality of 149/100,000 population in China in 2017 (*1,2*). Data from China's Stroke Prevention and Treatment Report

(2015) indicated that 15% of people over 40 are at high risk of stroke. In Europe and the US, the incidence of stroke is declining while it is increasingly worsening in China, with the incidence of stroke rising at an average rate of 8.7% every year (*3*). Moreover, the mean age at stroke is decreasing in China. Studies have indicated that the average age at stroke is 63 in China but 73.2 in the US (*4*).

In China, 2.7 million more people develop cerebrovascular diseases every year, and 1.3 million die of these diseases. A new stroke incident occurs every 12 seconds, and someone dies of stroke every 21 seconds (*5*). When a stroke occurs, it often develops too fast for patients to receive timely treatment, which means they are highly unlikely to recover completely, and the aftermath of the stroke will be with them for life. Stroke is also the leading cause of disability in Chinese adults. About 75% of stroke patients survive with varying degrees of disability, and 40% of those are severely disabled (*6*). Their quality of life is thus significantly diminished. Stroke patients suffer from physical and

motor impairments as well as from linguistic, cognitive, and emotional problems (7). Studies have indicated that risk factors for stroke include high blood pressure, diabetes, atrial fibrillation (8), hyperlipidemia, smoking (9), overconsumption of alcohol (10), aging, and hereditary factors (11). High blood pressure is the single most dangerous risk factor (12,13).

According to estimates, potentially modifiable risk factors are associated with almost 90% of the stroke burden (14) and effective interventions to control risk factors could reduce 75% of this burden (15). Hence, effective primary and secondary prevention is vital to reducing the incidence and mortality of stroke. Evidence-based medicine has proven that timely rehabilitation is the most effective way to prevent disability, and it is also an essential part of the organized management of stroke (16). Clinical research has indicated that early rehabilitation can help patients recover their limb function and it can reduce their likelihood of suffering complications like joint contracture, deformity, joint dislocation, or stroke-induced sarcopenia. It can thus enhance their quality of life. Therefore, assessing limb function in patients is essential to the treatment and management of their disease (17,18).

Intervening in stroke requires close collaboration among healthcare providers, preventive care, emergency care, clinical treatment, and rehabilitation services. The North Karelia Program enhanced primary prevention of and health education regarding stroke, resulting in 134 fewer expected fatal strokes or myocardial infarction in the first 5 years (19). Medical facilities in London were reorganized in 2010 to provide centralized acute stroke care. Patients with acute onset stroke are sent to a stroke unit for assessment and treatment and once stable are transferred to a nursing home or sent home for community rehabilitation. After the system was instituted, the risk-adjusted mortality 3, 30, and 90 days after admission decreased significantly (20). However, these services are physically separated in Shanghai's healthcare system. For instance, risk factor management and primary prevention are provided by community health centers under the technical guidance of centers for disease control, while clinical treatment and emergency care are provided by hospitals, and specialized nursing hospitals are responsible for rehabilitation. These facilities are operated separately without collaboration and are unable to provide a continuum of care as the condition progresses.

Because of the high mortality, recurrence, and rate of disability of stroke, the preventability of predictors of stroke, and the fragmented care delivery system, a stroke prevention and treatment system (denoted here simply as the System) was instituted in Shanghai in 2012. The key issues that concerned people in the establishment of the System were: how to reduce the incidence of stroke, how to increase the rate of standardized treatment within 60 minutes of stroke onset, and how to decrease recurrence,

disability, and mortality. Here, the operation of the Systems and its effectiveness are described.

Stroke prevention and treatment system

Structure of the system

Shanghai's system of stroke prevention and treatment incorporates stroke prevention, intervention, and treatment. The System includes 11 stroke clinical treatment centers at the municipal level, 25 such centers at the district level, and 240 community health centers (Figure 1). These facilities have been assigned different roles depending on their functions and capabilities:

First, a stroke prevention and treatment center has been established at Huashan Hospital, and an expert committee on stroke prevention and treatment has been created. As the core of technical support for the entire system, the center is responsible for devising standards and formulating policies related to stroke prevention and treatment and for technical training, quality control, and overall supervision.

Second, 11 municipal-level tertiary general hospitals in Shanghai have been selected to serve as stroke clinical treatment centers. These clinical centers provide standardized facilities and services, which include acute stroke monitoring equipment, a neuroimaging platform, an acute stroke treatment protocol, a consultation system, and a referral and consultation system for critically ill patients. In addition, a specialized support mechanism has also been created in accordance with administrative divisions to create a care network for medical interventions targeting high-risk populations and emergency transfer of stroke patients. These 11 clinical centers can accept high-risk individuals referred from district-level stroke treatment centers and perform therapeutic interventions, including intravenous thrombolysis within a certain time period, subarachnoid hemorrhage treatment, endovascular intervention, and carotid endarterectomy. At the same time, they are also responsible for providing technical support to district-level treatment centers, mainly in areas where secondary facilities are weak at, which include neurosurgery, vascular surgery, and neuro-intervention.

Third, a management network has been created to screen and intervene in high-risk populations. The network is centered around district-level hospitals and includes community health centers and district centers for disease control (CDCs). The intent is to create a medical network for stroke prevention and intervention within a particular administrative area. The network has the following components: i) Establishing district stroke clinical treatment centers around district central hospitals. These centers are responsible for screening for vascular lesions in high-risk individuals, including carotid artery and intracranial artery screening, for providing standardized treatment to stroke patients (early
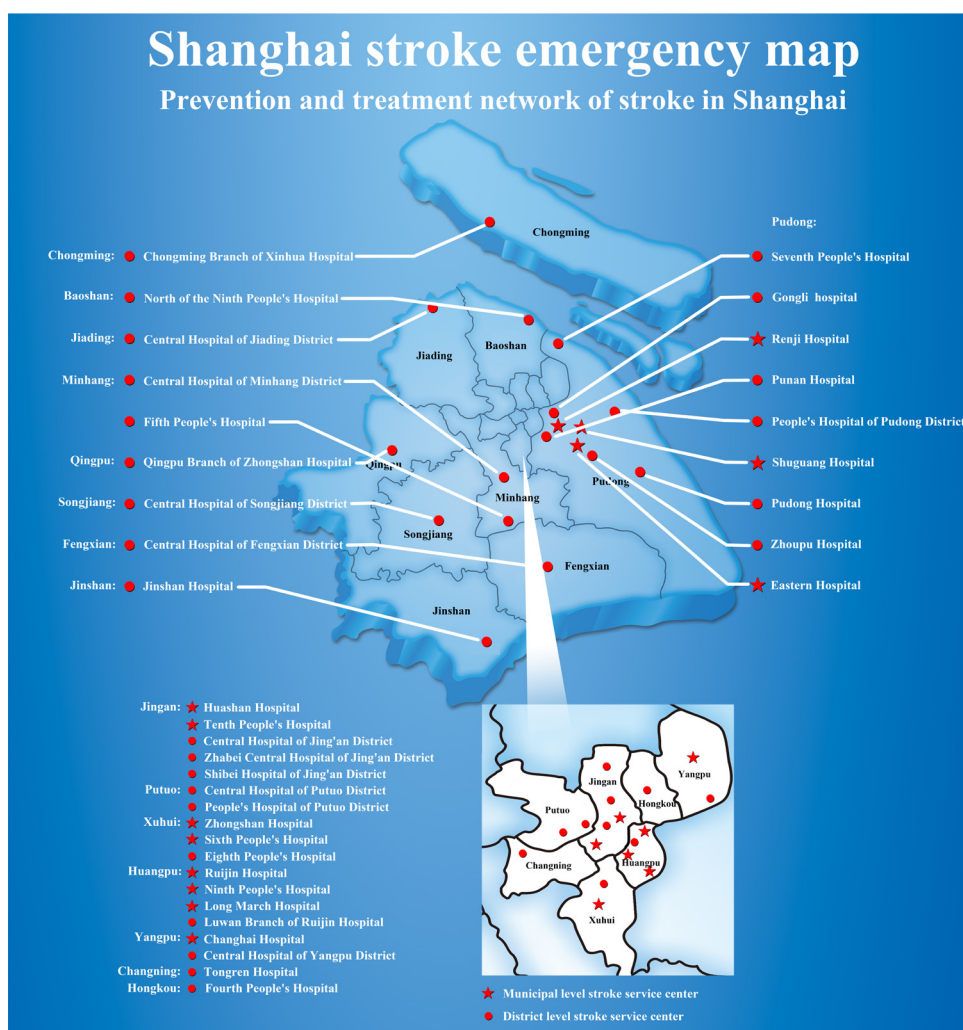
Figure 1. Hospitals participating in Shanghai's stroke prevention and treatment system.

thrombolysis or referral, cerebral hemorrhage surgery, and early rehabilitation), and for referring patients to corresponding municipal hospitals. *ii*) Providing stroke consulting services at community health centers. General practitioners and public health physicians are responsible for identifying high-risk individuals according to the "A-B-C-D" preliminary screening method (a validated predictor of stroke). The screening process also relies on residents' health profiles, outpatient consulting services, and health management (including chronic disease and family doctor services). Community health centers are also responsible for performing primary prevention including risk factor management, giving referral advice to high-risk individuals depending on screening results, and proactively using preventive care with traditional Chinese medicine (TCM) to provide stroke patients with means to recover from sequelae (Figure 2).

Cooperation with and support from professional facilities is also highly encouraged: the Shanghai CDC has officially incorporated stroke into its chronic disease management system, it has improved and standardized the screening process of high-risk populations, and it has established a reporting system for cerebrovascular

diseases in Shanghai. Moreover, the Shanghai Medical Emergency Center has improved the system for transportation and allocation of patients with acute stroke, and it has also standardized its system for first-aid training. Furthermore, the Shanghai Health Education Institute, through its "12320" hotline, is promoting knowledge about stroke recognition and its management.

Standards and specified care

The System has set up specific care for all stages of stroke management (Figure 3), from first aid to emergency care, hospitalization (including early rehabilitation after acute stroke), outpatient and specialized follow-up care, and rehabilitation as well as community stroke consulting services and management of high-risk populations and stroke patients. This specified care includes: *i*) Standardized outpatient screening. Stroke risk assessment is used to identify high-risk individuals during regular service of related departments (including a physical exam); special attention is paid to patients with H-type hypertension and carotid artery disease. *ii*) Standardized care for
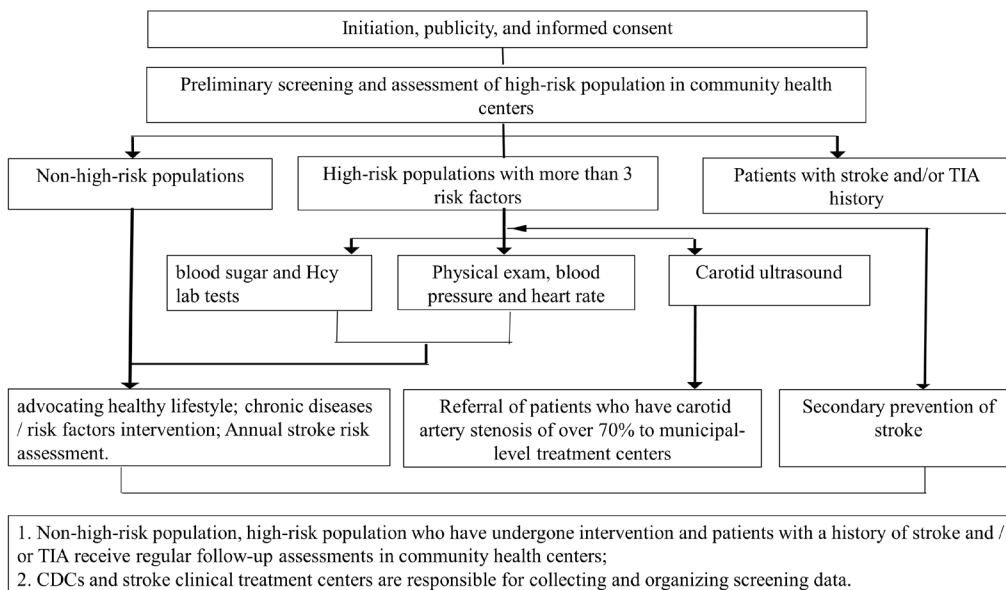
Figure 2. Process of screening and intervention in populations at high risk for stroke in Shanghai. TIA: transient ischemic attack; Hcy: homocysteine; Risk factors for stroke include: *i*) history of hypertension (≥ 140/90 mmHg) or is taking antihypertensive drugs; *ii*) atrial fibrillation or highly irregular pulse; *iii*) smoking; *iv*) abnormal blood lipids or unknown levels; *v*) diabetes; *vi*) lack of physical exercise; *vii*) overweight/obese (BMI ≥ 26 kg/m^2); *viii*) family history of stroke. A person with more than 3 risk factors is considered high-risk.
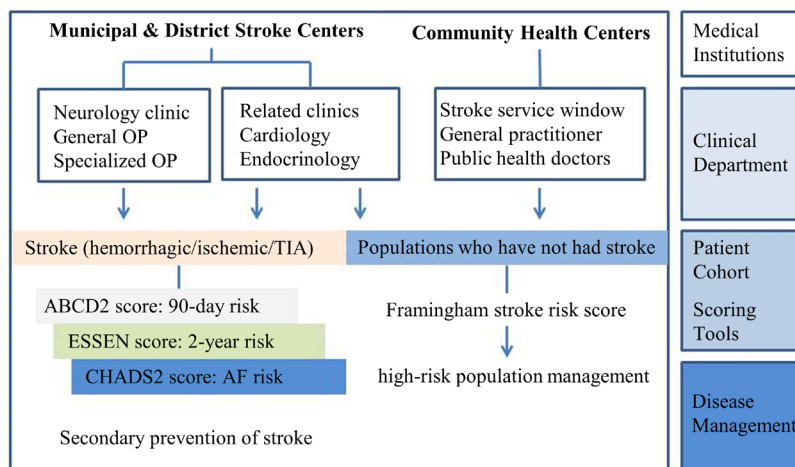

Figure 3. Specified care under the Shanghai Stroke Prevention and Treatment System. OP: outpatient; TIA: Transient Ischemic Attack; AF: atrial fibrillation; ABCD2 score: a validated risk stratification tool to identify patients at high risk of stroke following a TIA; ESSEN score: a risk score to predict recurrent cardiovascular events; CHADS2 score: predictors of the risk of stroke in patients with AF.

high-risk individuals in the community. Community health centers mainly perform primary prevention, using the "A-B-C-D" preliminary screening method to exam health profiles. "A" stands for an age over 55, "B" stands for blood pressure exceeding 140/90 mmHg, "C" stands for plasma homocysteine equal to or exceeding 10 μmol/L and low density lipoprotein cholesterol (LDL-C) over 3.2 mmol/L, and "D" stands for fasting blood sugar over 6.1 mmol/L. After identifying high-risk individuals, the Framingham Risk Score is rigorously used to assess and manage their health. The Framingham Risk Score includes age (over 55), systolic blood pressure, diabetes, smoking, atrial fibrillation (AF), and left ventricular hypertrophy (LVH). These parameters are used to identify individuals with a ten-year risk between 6% and 10%. These individuals will then receive primary prevention, namely a daily dose of aspirin 100 mg. *iii*) Standardized first aid. A 60-minute circle of life has been built based on Shanghai Emergency Center's transit route – the "green channels" – in order to raise the rate of standardized treatment. First aid is required to increase its 60 minutes' reach

Table 1. Quality of and capacity for stroke treatment in Shanghai from 2015 to 2017

Indicators	2015	2016	2017
Number of patients suffering an ischemic stroke	5,240	7,506	6,955
Number of patients undergoing intravenous thrombolysis in 11 municipal stroke centers	639	944	1,045
Number of patients undergoing intravenous thrombolysis in Shanghai	≥ 1,400	≥ 1,800	2,443
Median DNT in 11 municipal stroke centers (minutes)	65	65	59
Median DNT in Shanghai (minutes)	87	70	65
Percentage of patients with a DNT of less than 60 minutes (%)	41	40	50

to stroke treatment centers at all levels; physicians with emergency medical training are also needed to identify acute stroke. Treatment centers in the area need to be informed so that they can make preparations, and the vital signs of patients need to be continuously monitored. *iv*) Standardized emergency care for stroke. Stroke treatment centers at all levels should be able to finish overall assessment and make a treatment decision concerning an acute onset stroke within 60 minutes. All stages of clinical treatment should be more effective: lab tests should take no more than 45 minutes and a head CT scan should take less than 30 minutes so that patients who have had a cerebral infarct up to 4.5 hours earlier can receive a timely assessment and the chance to undergo intravenous thrombolysis and/or timely referral to Neurosurgery or to another hospital. Emergency physicians need to be trained to diagnose and treat acute stroke. *v*) Standardized hospitalization. In order to reduce complications and facilitate early prevention of stroke recurrence, key indicators of quality are used in accordance with the Chinese Guidelines for Secondary Prevention of Stroke and treatment guidance in the acute phase. The requirements of China's National Center for Stroke Care Quality Control and Management should also be followed. *vi*) Standardized outpatient care for stroke. Stroke outpatient centers should use inpatient assessment tools to provide care, including the ABCD2 score, Essen stroke risk score, and CHADS2 score for stroke risk in AF. Stroke risk scores are used to screen and manage individuals with no history of cardiovascular disease.

Separation of functions

First, municipal treatment centers provide district hospitals with technical assistance regarding neurosurgery, vascular surgery, and rehabilitation using TCM. They are also responsible for vascular neurosurgery, intracranial and extracranial surgery, and intravascular intervention.

Second, district treatment centers are equipped with stroke care teams of no less than 5 people, mainly consisting of neurologists but also including emergency physicians, neurosurgeons, and TCM practitioners. Specialized outpatient care for stroke is offered at least once a week, and 24-hour emergency green channels and vascular screening for high-risk individuals are provided. District centers also receive technical training

from the Shanghai Stroke Prevention and Treatment Center and municipal treatment centers.

Last, community health centers provide stroke consulting services consisting of general practitioners, public health physicians, and TCM practitioners (no less than 5 people). Under the guidance of CDCs, community health centers manage high-risk individuals by means of community health profiles, standardized secondary prevention of stroke, and rehabilitation from stroke sequelae. Community health centers receive technical training from the Shanghai Stroke Prevention and Treatment Center and treatment centers at all levels.

Effectiveness of the system

Since 2011, the System has improved the capacity and quality of emergency care and care at the 36 stroke treatment centers in Shanghai. According to statistics from the Shanghai Stroke Prevention and Treatment System, the rate at which patients undergo intravenous thrombolysis and the percentage of patients with a door-to-needle (DNT) time of less than 60 minutes have increased from 41% in 2015 to 50% in 2017 (Table 1). The median DNT time at medical facilities of Shanghai dropped from 87 minutes to 65 minutes. The mortality of hospitalized stroke patients declined from 2.39% in 2016 to 2.1% in 2017.

Conclusion

Establishment of the System has enhanced the treatment capacity and homogeneity of care for stroke at different facilities, enabling patients to receive continuous services. However, primary and secondary prevention of stroke is lacking. High-risk population screening is not actively implemented in communities, and the overall quality of rehabilitation is still below par. An outcome-oriented evaluation system and a more sustainable funding mechanism should be devised to incentivize healthcare personnel to fulfill their responsibilities and to ensure the system's operation.

Acknowledgements

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