



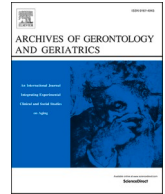
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Impact of the COVID-19 pandemic lockdown on hospitalizations for cerebrovascular disease and related in-hospital mortality in China: A nationwide observational study

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ABSTRACT

Background and purpose: The aim of this nationwide study was to assess the impact of the COVID-19 pandemic on cerebrovascular disease hospitalization rates, out-of-pocket rates, and in-hospital case fatality rates.

Methods: All hospitalizations for cerebrovascular disease from 1599 hospitals from 2019 to 2020 were selected using the International Classification of Diseases, 10th revision, in the Hospital Quality Monitoring System (HQMS). We defined 2019 as the pre-pandemic group and 2020 as the post-pandemic group. Multivariate analyses were done to assess the association between the pandemic and patient outcomes and out-of-pocket rate with odds ratios (OR) and 95% CIs presented.

Results: In total, 9 640 788 patients with the cerebrovascular disease were recruited (mean age was 65.7 [SE.0.004] years, and 55.7% were male), and data is available for 5145358 patients in 2019 (pre-epidemic) and 4495430 patients in 2020(post-pandemic), indicating a 12.6% decrease. Out-of-pocket rate increase of 9.3% (2020 vs 2019: 34.1% vs 31.2% [absolute difference, 2.9% {95% CI, 1.3% to 4.5%}, odd ratio {OR}, 1.1{95% CI, 1.0 to 1.1}). The epidemic has led to an 18.0% increase in in-hospital mortality (2020 vs 2019: 1.1% vs 0.9% [absolute difference, 0.2% {95% CI, 0.1% to 0.2%}, odd ratio {OR}, 1.1{95% CI, 1.1 to 1.2}). The epidemic has led to significantly increased in-hospital mortality for patients with stroke but had no significant impact on other cerebrovascular diseases.

Conclusions: During the COVID-19 pandemic lockdown, patients hospitalized for stroke fell by 12.6%, and there were substantial increases in out-of-pocket rates (9.3%) and in-hospital case fatality rates (18.0%).

1. Key points

Question Does China implementing a strict COVID-19 epidemic clearance policy impact the inpatient outcomes of hospitalized patients with cerebrovascular disease?

Findings In this nationwide observational study Of 9 640 788 patients with cerebrovascular disease, during the COVID-19 pandemic lockdown, rates of patients hospitalized fell by 12.6%, and there were substantial increases in both out-of-pocket rates (an increase of 9.3%) and in-hospital case fatality rates (an increase of 18.0%).

Meaning Findings of this study suggest that China neurologists and stroke specialists share what has been learned so far to plan strategies to ensure stroke treatment and care in the future and upcoming

challenging times.

2. Introduction

COVID-19, which originated two years ago, has spread rapidly and enveloped most countries, becoming a once-in-a-century global health crisis (Cao et al., 2020). As the first country stricken by the COVID-19 pandemic, China deployed a policy mix comprised of traditional measures, i.e., strict community lockdown and cross-jurisdictional mobilization of resources contributed to the eventual effectiveness of China's response to the pandemic (Mei, 2020). However, most other countries take mitigation measures (Wang et al., 2021).

Xiao et al. (2021) suggested that inpatient and outpatient health

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services utilization in China declined significantly after the COVID-19 outbreak. The two-to-three-month home isolation has had mixed effects on adult health behaviors in China (Wang et al., 2020). Liu et al. (2021) showed that the expected averted premature deaths due to air pollution declines are around 99,270 to 146,649 among 76 countries during the COVID-19 lockdown. The COVID-19 pandemic lockdown significantly reduced the number of admissions for stroke and transient ischemic attack (Altersberger et al., 2021; Kristoffersen et al., 2020). A nationwide observational study in France suggested that there were substantial increases in both in-hospital and out-of-hospital 30-day case fatality rates for stroke (Gabet et al., 2021). China implements a strict COVID-19 epidemic clearance policy, but the impact of this policy on the inpatient outcomes of hospitalized patients with the cerebrovascular disease has not been effectively evaluated. In addition, cerebrovascular disease is the leading cause of death and disability in China, and the burden of stroke has increased over the past decade (Chao et al., 2021; Tu et al., 2022). The aim of this nationwide study was to assess the impact of the COVID-19 pandemic on cerebrovascular disease hospitalization rates, out-of-pocket rates, and in-hospital case fatality rates.

3. Methods

This study was a multicenter retrospective study. In December 2021, we performed hospital information matching between the Hospital Quality Monitoring System (HQMS, launched in 2011 by the National Health Commission of the People's Republic of China and is an official data collection system covering all tertiary hospitals) and the Bigdata Observatory Platform for Stroke of China (BOSC, was established in 2011 by the Ministry of Health China Stroke Prevention Project Committee (CSPPC) with the support of the National Population and Health Science Data Sharing Platform) (Shen et al., 2020; Tu et al., 2022; Wang et al., 2022). We found that a total of 1599 hospitals co-existed on both platforms. Therefore, between 2019 and 2020, all patients with the first medical record with the diagnosis of cerebrovascular disease (ischemic stroke [IS, I63], intracerebral hemorrhage [ICH, I61], subarachnoid hemorrhage [SAH, I60], transient ischemic attack [TIA, G45.9], unruptured aneurysm [UA, I67.1] and carotid artery stenosis [CAS, I65.29]) from those 1599 hospitals were extracted from HQMS. The Aerospace Center Hospital Ethics Committee reviewed and approved this study, and informed consent was waived. Patients or the public WERE involved in the design, conduct, reporting, or dissemination plans of our research.

In this study, the information about demographics (sex, age, and race), financial information (Hospitalization expenditures, out-of-pocket expenses, and rehabilitation expenditures), length of hospital stays, using a ventilator (Yes or no), and discharge outcome (medical discharge; medical order transfer; medical order transfer to grass-roots hospitals; discharge against medical advice; death; other) were collected.

3.1. Statistical analysis

Results were presented as number (percentage) for categorical variables and the mean value (standard error [SE]) for continuous variables. Wuhan began to be closed on January 23, 2020, after which the epidemic broke out across the country. We defined 2019 as the pre-pandemic group and 2020 as the post-pandemic group. With all comparative outcomes, cumulative incidences and absolute differences with 95% CIs were presented. Multivariate analyses were done to assess the association between pandemic and patient outcomes and out-of-pocket rate, adjusting for age, sex, race, financial information, length of hospital stays, and using a ventilator (Yes or no) with odds ratios (OR) and 95% CIs were presented. All statistical analyses were performed using SAS (SAS Institute), version 9.0.

3.2. Data sharing

The data are available from the corresponding author upon reasonable request.

4. Results

In total, 9 640 788 patients with cerebrovascular disease from 1599 hospitals from HQMS were recruited (mean age was 65.7[SE.0.004] years, and 55.7% were male). The mean length of hospital stay for patients during the study period was 13.9(0.04) days. The rates of discharge against medical advice and in-hospital mortality were 6.8% (6.8%-6.8%) and 1.0% (1.0%-1.0%).

As shown in Table 1, data is available for 5145358 patients in 2019 (pre-epidemic) and 4495430 patients in 2020(post-pandemic), indicating a 12.6% decrease. Patients from 2020 had a shorter hospital stay (10.7 vs. 16.7 days), suggesting a decrease of 35.9% compared to 2019. In addition, the utilization rate of ventilators has increased significantly, from 0.06% in 2019 to 1.2% in 2020. The epidemic increased 8.7% and 18.8% in hospitalization expenses and out-of-pocket expenses of hospitalized patients, respectively. Out-of-pocket rate increase of 9.3% (2020 vs 2019: 34.1%% vs 31.2% [absolute difference, 2.9% {95% CI, 1.3% to 4.5%}; odd ratio {OR}, 1.1{95% CI, 1.0 to 1.1}). The epidemic has led to an 18.0% increase in in-hospital mortality (2020 vs 2019: 1.1%% vs 0.9% [absolute difference, 0.2% {95% CI, 0.1% to 0.2%}, odd ratio {OR}, 1.1{95% CI, 1.1 to 1.2}).

Information on different types of cerebrovascular disease is presented in Table 2. The pandemic leads to a lower hospital stay for various cerebrovascular diseases, ranging from -41.2% for ischemic stroke to -2.6% for subarachnoid hemorrhage. The out-of-pocket rate during hospitalization has also increased in different types of cerebrovascular disease (2020 vs 2019: IS, 33.4%% vs 30.0% [absolute difference, 3.1% {95% CI, 1.6% to 4.5%}, odd ratio {OR}, 1.1{95% CI, 1.0 to 1.2}; ICH, 33.3%% vs 31.5% [absolute difference, 1.6% {95% CI, 0.8% to 2.5%}, odd ratio {OR}, 1.1{95% CI, 1.0 to 1.1}); SAH, 37.8%% vs 36.7% [absolute difference, 1.0% {95% CI, 0.4% to 1.6%}, odd ratio {OR}, 1.0{95% CI, 1.0 to 1.0}; TIA, 30.7%% vs 27.3% [absolute difference, 3.0% {95% CI, 1.1% to 4.9%}, odd ratio {OR}, 1.1{95% CI, 1.1 to 1.2}; UA, 40.2%% vs 38.1% [absolute difference, 1.8% {95% CI, 1.2% to

Table 1

Basic information of enrolled patients with cerebrovascular disease[‡]

	2019	2020	Change [†] , %
N	5145358	4495430	-12.6
Tertiary hospital	3582567(69.6)	3069352(68.3)	-1.9
Male sex	2839998(55.2)	2529682(56.3)	2.0
Han	4844937(94.2)	4235590(94.2)	0.0
Mean age, years	67.2(0.007)	67.2(0.007)	0.0
Length of hospital stay, days	16.7(0.07)	10.7(0.01)	-35.9
Patients using ventilator	3290(0.06)	54842(1.2)	1807.9
Hospitalization expenditures, RMB	15614.7(13.0)	16975.6(15.3)	8.7
Out-of-pocket expenses, RMB	4870.9(6.7)	5788.9(8.6)	18.8
Out-of-pocket rate, %(95%CI)	31.2(30.5-31.9)	34.1(33.4-34.8)	9.3
Rehabilitation expenditures, RMB	159.8(0.6)	155.6(0.5)	-2.6
Discharge against medical advice, %(95%CI)	335938(6.5 [6.5-6.6])	317958(7.1 [7.0-7.1])	8.3
In-hospital mortality, %(95% CI)	46895(0.9[0.9-0.9])	48345(1.1[1.1-1.1])	18.0

[‡]Results were presented as number (percentage) for categorical variables and the mean value (standard error [SE]) for continuous variables; cerebrovascular disease included ischemic stroke, intracerebral hemorrhage, subarachnoid hemorrhage, transient ischemic attack, unruptured aneurysm, and carotid artery stenosis.

[†]For categorical variables, the result is a change in rate.

Table 2
Different types of cerebrovascular disease[‡]

	IS		ICH		SAH	
	2019	2020	2019	2020	2019	2020
N	3186232	2801380	516779	510928	104933	106124
Mean age, years	67.2(0.007)	67.2(0.007)	61.9(0.02)	62.0(0.02)	59.1(0.04)	59.3(0.04)
Length of hospital stay, days	17.8(0.09)	10.5(0.01)	21.6(0.2)	17.2(0.03)	15.1(0.2)	14.7(0.1)
Patients using ventilator	797(0.03)	14636(0.5)	1921(0.4)	26752(5.2)	304(0.3)	9905(9.3)
Hospitalization expenditures, RMB	12765.4(10.8)	13310.11(12.8)	33629.9(67.8)	34708.3(69.2)	74490.2(252.4)	81369.8(260.7)
Out-of-pocket expenses, RMB	3825.0(5.5)	4449.0(4.6)	10583.8(34.5)	11570.8(45.7)	27358.8(155.0)	30778.2(156.8)
Out-of-pocket rate, %(95%CI)	30.2(29.2-30.8)	33.4(32.6-34.2)	31.5(31.0-32.0)	33.3(32.8-33.8)	36.7(36.4-37.0)	37.8(37.5-38.2)
Rehabilitation expenditures, RMB	157.4(0.6)	153.1(0.6)	468.6(4.4)	417.5(2.5)	255.7(4.7)	417.9(23.5)
Discharge against medical advice, %(95%CI)	5.4(5.4-5.4)	5.7(5.7-5.8)	15.5(15.4-15.6)	17.2(17.1-17.3)	16.2(16.0-16.4)	17.0(16.8-17.3)
In-hospital mortality, %(95%CI)	0.6(0.6-0.6)	0.7(0.7-0.7)	4.3(4.3-4.4)	4.6(4.6-4.7)	4.1(4.0-4.3)	4.4(4.2-4.5)
	TIA		Unruptured aneurysm		CAS	
N	1238942	981939	54473	53117	43997	41942
Mean age, years	64.4(0.01)	64.3(0.01)	57.5(0.05)	57.2(0.05)	65.2(0.05)	65.3(0.05)
Length of hospital stay, days	12.3(0.1)	7.6(0.01)	11.3(0.1)	11.1(0.1)	10.6(0.2)	10.3(0.1)
Patients using ventilator	232(0.02)	562(0.06)	20(0.04)	2292(4.3)	16(0.04)	688(1.6)
Hospitalization expenditures, RMB	6919.9(5.7)	6748.4(6.4)	78211.9(347.1)	82941.3(357.4)	37275.4(18.2)	38742.5(193.3)
Out-of-pocket expenses, RMB	1886.8(3.4)	2070.1(3.7)	29809.3(222.7)	33335.9(223.5)	13031.6(115.8)	13796.9(121.4)
Out-of-pocket rate, %(95%CI)	27.3(26.2-28.3)	30.7(29.6-31.8)	38.1(37.8-38.5)	40.2(39.8-40.5)	35.0(34.5-35.4)	35.6(35.1-36.0)
Rehabilitation expenditures, RMB	27.7(0.3)	23.6(0.2)	147.0(4.3)	119.3(3.6)	76.1(4.1)	66.8(2.5)
Discharge against medical advice, %(95%CI)	5.0(4.9-5.0)	4.8(4.7-4.8)	6.4(6.2-6.6)	6.0(5.8-6.2)	2.9(2.8-3.1)	3.0(2.8-3.1)
In-hospital mortality, %(95%CI)	0.02(0.02-0.02)	0.02(0.02-0.02)	0.4(0.4-0.5)	0.4(0.4-0.5)	0.2(0.2-0.2)	0.2(0.2-0.2)

[‡]Results were presented as number (percentage) for categorical variables and the mean value (standard error [SE]) for continuous variables; IS, ischemic stroke; ICH, intracerebral hemorrhage; SAH, subarachnoid hemorrhage; TIA, transient ischemic attack; CAS, carotid artery stenosis.

2.4%), odd ratio {OR}, 1.0{95% CI, 1.0 to 1.1}; CAS, 35.6%% vs 35.0%, P=0.09].

The epidemic has led to significantly increased in-hospital mortality for patients with IS (2020 vs 2019: 0.7%% vs 0.6% [absolute difference, 0.1% {95% CI, 0.1% to 0.1%}, odd ratio {OR}, 1.1{95% CI, 1.0 to 1.1}], ICH(2020 vs 2019: 4.6%% vs 4.3% [absolute difference, 0.2% {95% CI, 0.1% to 0.3%}, odd ratio {OR}, 1.0{95% CI, 1.0 to 1.0}], and SAH(2020 vs 2019: 4.4%% vs 4.1% [absolute difference, 0.2% {95% CI, 0.0% to 0.4%}, odd ratio {OR}, 1.0{95% CI, 1.0 to 1.0}], but had no significant impact on TIA(P=0.40), UA(P=0.98) and CAS(P=0.72).

5. Discussion

To the best of our knowledge, this is the first study to investigate the nationwide impact of the COVID-19 pandemic lockdown on hospitalizations for cerebrovascular disease in China.

The results showed a 12.6% decrease in hospitalization rates for cerebrovascular disease during the lockdown, with a concomitant 18.0% increase in in-hospital case fatality rates. The in-hospital case fatality of cerebrovascular disease increased during the lockdown and was mainly caused by hemorrhagic and ischemic stroke patients. In addition, out-of-pocket rates increased by nearly a tenth. Finally, essential changes in cerebrovascular disease patient management were observed and the length of hospital stay has been dramatically reduced, and the utilization rate of ventilators has been significantly increased.

Zhao et al. (2020) reported that the COVID-19 pandemic caused a significant drop in in-person outpatient visits and inpatient services for stroke patients. Richter et al. (2021) suggested a massive decrease in absolute case numbers in patients with stroke, but those patients could continue to receive acute recanalization treatment in times of the COVID-19 pandemic in Germany. In a cohort study, Nguyen-Huynh et al. (2020) found that the COVID-19 pandemic decreased ischemic stroke discharge volumes significantly but did not change inpatient mortality. Hospitalizations for stroke or transient ischemic attacks across Italy were reduced during the worst period of the COVID-19 outbreak, and the intravenous thrombolytic treatments also decreased, while endovascular treatments remained unchanged (Sacco et al., 2020). Rinkel et al. (2021) observed a 24% decrease in suspected stroke presentations during the COVID-19 outbreak but no evidence for a decline in the quality of acute stroke care.

Overall, epidemic control can reduce the admission rate of stroke patients, but there is no unified conclusion on whether it affects the quality of medical care. Our findings showed that the medical burden of hospitalized patients increased significantly during the lockdown period, and the mortality rate of hospitalized patients increased significantly, especially for stroke patients. This may be because the mild cases cannot be admitted to the hospital during the quarantine period (government's prevention and control policy), increasing the rate of severe cases. An increase in the rate of critically ill patients naturally leads to an increase in the mortality rate. We also found an interesting phenomenon: the epidemic led to a shorter hospital stays and increased hospitalization expenses and out-of-pocket expenses. This shows that the hospitalization period was shortened during the epidemic, but the treatment was more aggressive, and hospitalization expenses and out-of-pocket costs increased.

The rate of ventilator use increased significantly after the pandemic, possibly because hospitalized stroke patients had more comorbidities and complications, especially respiratory system diseases. Stroke patients with COVID-19 may be one of the reasons. Stroke patients infected with COVID-19 will inevitably increase ventilator use (Bersano et al., 2020; Qureshi et al., 2021). It is better to have data to support such speculation, like adjustment for the rates of respiratory complications. However, in this study, we did not obtain that information. It is difficult to distinguish the impact of covid-19 factors and cerebrovascular disease factors on in-hospital mortality.

The recent outbreak of COVID-19 in Jilin and Shanghai poses specific medical and social challenges to China's "dynamic zero-COVID" policy. Therefore, when implementing strict prevention and control policies to deal with the COVID epidemic, the medical needs of patients with chronic diseases, such as cerebrovascular disease, tumor, and renal failure, must also be guaranteed. Although all countries in the world are gradually opening up against the epidemic, it is unlikely that China will fully open up in the next months. Therefore, it is essential for the China neurologists and stroke specialists to share what has been learned so far to plan strategies to ensure stroke treatment and care in the future and upcoming challenging times.

6. Conclusions

During the COVID-19 pandemic lockdown, rates of patients

hospitalized for stroke fell by 12.6%, and there were substantial increases in out-of-pocket rates (9.3%) and in-hospital case fatality rates (18.0%). The findings of this study suggest that China neurologists and stroke specialists need to share what has been learned so far to plan strategies to ensure stroke treatment and care in the future and upcoming challenging times.

Data availability

None.

Consent for publication

Not applicable.

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Ethics, consent, and permissions

Written informed consent was obtained from all patients, and, this study conformed to the principles of the Declaration of Helsinki and was approved by the Ethics Committee of the Aerospace Center Hospital.

CRediT authorship contribution statement

Wen-Jun Tu: Conceptualization, Methodology, Project administration. **Yicheng Xu:** Conceptualization, Methodology, Software, Validation, Project administration, Writing – original draft. **Hengwen Chen:** Conceptualization, Methodology. **Jilai Li:** Conceptualization, Methodology. **Jichen Du:** Conceptualization, Methodology, Supervision, Formal analysis, Visualization, Writing – review & editing.

Declaration of Competing Interest

None.

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