Prevalence of stroke in China, 2013—2019: A population-based study

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Summary

Background The stroke burden in China has increased during the past 40 years. The present study aimed to determine the recent trends in the prevalence of stroke from 2013 to 2019 stratified by sociodemographic characteristics, including sex, age, residence, ethnicity, and province within a population-based screening project in China.

Methods We made use of data generated from 2013 to 2019 in the China Stroke High-risk Population Screening Program. All living subjects with confirmed stroke at interview were considered to have prevalent stroke. All analyses of prevalence of stroke were weighted and results were presented as percentage and 95% confidence interval (CI).

Findings A total of 4229,616 Chinese adults aged ≥40 years from 227 cities in the 31 provinces were finally included. The enrollment rate ranged from 58.8% (2017) to 67.8% (2013). The weighted prevalence of stroke increased annually from 2013 to 2019, being 2.28% (95% CI: 2.28—2.28%) in 2013, 2.34% (2.34—2.35%) in 2014, 2.43% (2.43—2.43%) in 2015, 2.48% (2.48—2.48%) in 2016, 2.52% (2.52—2.52%) in 2017, 2.55% (2.55—2.55%) in 2018, and 2.58% (2.58—2.58%) in 2019 (*p* for trend <0.001). The weighted prevalence of stroke was higher for male sex, older age, and residence in rural and northeast areas.

Interpretation The prevalence of stroke in China and most provinces has continued to increase in the past 7 years (2013—2019). These findings, especially in provinces with high stroke prevalence, can help public health officials to increase province capacity for stroke and related risk factors prevention.

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Keywords: Stroke; Prevalence; China; Sociodemographic

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Introduction

The stroke burden in China has increased during the past 40 years. In 2017, stroke was the leading cause of death, years of life lost, and disability-adjusted life-years at the national level in China.[1] In 2013, a nationally

Research in context

Evidence before this study

We searched PubMed from inception to January 31, 2021, for studies that had investigated the prevalence of stroke in China, using the search terms ("stroke" or "Ischemic stroke" or "hemorrhagic stroke" or "Chinese" and "Prevalence") in articles published in English. Previous studies on prevalence of stroke in China were mainly cross-sectional studies in a single year or a few provinces, and lacked both ongoing research and subgroup analyses such as ethnicity and province.

Added value of this study

This study performed the first comprehensive assessment of the trends in prevalence of stroke in China from 2013 to 2019 stratified by sociodemographic characteristics. The findings showed large disparities in the prevalence of stroke by sex, age, residence, ethnicity, and province. During the 7-year study period, the weighted prevalence of stroke increased significantly from 2.28% to 2.58%. The three provinces of Shaanxi, Shandong, and Xinjiang had the most obvious increasing trends (all >20%). Furthermore, a nearly 2.5-fold difference in estimated prevalence of stroke was observed between northeast areas and southeast coastal areas.

Implications of all the available evidence

We conclude that stroke is one of the major public health challenges in China. The prevalence of stroke in China has continued to increase in the past 10 years and warrants a broad-based nationwide strategy for improved prevention as well as greater efforts in screening and more effective and affordable interventions.

representative door-to-door survey that included 480,687 adults aged ≥20 years showed that the age-standardized prevalence and incidence rate of stroke were 1114.8/100,000 people and 246.8/100,000 person-years, respectively.[2]

Ferri et al.[3] reported that the prevalence of stroke in urban Chinese areas was nearly as high as that in industrialized countries. Wang et al.[4] evaluated 15,438 residents from a township in Tianjin, and demonstrated that the incidence of stroke in rural China was increasing rapidly. Previous studies on prevalence of stroke in China were mainly cross-sectional studies in a single year or a few provinces, and lacked both ongoing research and subgroup analyses such as ethnicity and province.[2,3–5] The present study aimed to determine the recent trends in prevalence of stroke from 2013 to 2019 stratified by sociodemographic characteristics, including sex, age, residence, ethnicity, and province within the population-based CSHPSIP in China.

Methods

To meet the challenge of stroke, the China Stroke Prevention Project Committee (CSPPC) was established in April 2011 in the Ministry of Health of China.[6] The CSPPC launched the China Stroke High-risk Population Screening and Intervention Program (CSHPSIP) as a critical national project in 2011.[6] Since 2013, the program has covered all 31 provinces across mainland China. We made use of data generated from January 2013 to December 2019 in the CSHPSIP, an ongoing population-based screening project that enrolled around 0.8 million community-dwelling adults aged ≥40 years each year from all 31 provinces in mainland China. Around 0.8 million community-dwelling adults aged ≥40 years was enrollment separately at each year from 2013 to 2019 through CSHPSIP (covering 0.15% of the target population across the country each year). The participating hospitals and screening sites in each province were determined according to the economic development status, population size, and work foundation. The enrollment criteria of community-dwelling adults were: (1) community residents aged ≥40 years (residence for >6 months) and (2) provision of informed consent. The demographic information (age, gender, and residence [urban and rural]) of participants among every province and city should be consistent with the 2010 Population Census of China.

Data were obtained from the Bigdata Observatory platform for Stroke of China (BOSC, formerly known as the China Stroke Data Center data reporting platform), and the data collection process was reported previously.[5–7] Briefly, a two-stage stratified cluster sampling method was adopted for screening. In the first stage of sampling, a county/district proportional to the population size of that area was selected in each of the survey sites. In the next stage, in each selected location, at least one communities/villages with a total population of at least 4000 residents were selected by using the random sampling method. Participants completed a face-to-face interviewer-administered questionnaire on sociodemographic characteristics (age, sex, body weight, height, abdominal circumference, marital status, education level, social healthcare insurance status, living condition, number of siblings or children), lifestyle factors (history of alcohol drinking and smoking, diet, consumption of vegetables and fruits), personal and family medical history (overweight, hypertension, dyslipidemia, diabetes mellitus, atrial fibrillation, transient ischemic attack [TIA], family history of stroke, physical inactivity), and current medications at the screening point by trained technicians using calibrated instruments with standard protocols. Physical inactivity was defined according to WHO recommendations standard (at least 150 min of moderate-intensity, or 75 min of vigorous-intensity physical activity per week, or any equivalent combination of the two). The CSHPSIP performs stroke screening nationwide each year and follow-up

interventions for screened populations every 2 years (Supplementary methods and Table S1-2). The staff involved in the survey were trained in the program and evaluated by theoretical and practical tests.[7] The Ethics Committee of Capital Medical University Xuanwu Hospital approved the trial protocol according to the Declaration of Helsinki (No. 2012045). Written informed consent was obtained from all participants before entering the study.

Living subjects with confirmed stroke at interview were considered to have prevalent stroke. All patients with stroke (ischemic stroke [IS, I63{ICD-10}], intracerebral hemorrhage [ICH, I61], subarachnoid hemorrhage [SAH, I60], stroke of undetermined type) were recorded. Individuals with suspected stroke were reinterviewed by trained neurologists. The diagnosis of stroke required the investigator to provide a diagnosis certificate and/or an imaging certificate (CT/MRI) from a secondary or higher medical unit (Level II and above hospitals). TIA was defined as G45,[8] and participants with TIA were excluded from the stroke group.

Physical activity was defined as regular physical exercise performed for >1 year, >2 times per week, and at least 30 minutes each time, or heavy physical labor. Obesity was defined as body mass index ≥ 28 kg/m² in accordance with the guidelines established for Chinese adults.[9] Hypertension was defined as: (1) systolic blood pressure ≥ 140 mm Hg and/or diastolic blood pressure ≥ 90 mm Hg; (2) self-reported hypertension; (3) use of antihypertension medications. Diabetes mellitus was defined as: (1) fasting plasma glucose ≥ 7.0 mmol/L; (2) self-reported diabetes mellitus; (3) use of oral hypoglycemic agents or insulin injections. Dyslipidemia was defined as: (1) abnormal fasting plasma markers (triglycerides ≥ 2.26 mmol/L, total cholesterol ≥ 6.22 mmol/L, high-density lipoprotein cholesterol <1.04 mmol/L, low-density lipoprotein cholesterol ≥ 4.14 mmol/L); (2) self-reported dyslipidemia; (3) use of anti-dyslipidemia medications.[10] Atrial fibrillation was defined as self-reported history of persistent atrial fibrillation or electrocardiogram (ECG) results (Supplementary methods).

Statistical analysis

We summarized continuous variables as mean with standard deviation and categorical variables as frequency and percentage. We assessed the characteristics of all participants according to participation year. Prevalence rate calculations were performed separately by sex (men/women), locality of residence (urban/rural), age (five groups), ethnic group (6 groups) and province region (31 groups). When results were not stratified by age, sex−and age−standardised rates were weighted to represent the overall national population. Sampling weights were multiplied by design (age, geographic location [central, east, west], and geographical area [urban, rural]), nonresponse, and post−stratification weights. Post−stratification weights were adjusted for residence (rural or urban), geographic location (northeast, north, northwest, southwest, south, central, or east), sex (male or female), and age (40−49, 50−59, 60−69, 70−79, and ≥ 80 years) using the 2010 China census data. Weighted prevalence of stroke among different provinces in 2019 stratified by stroke type (IS, ICH and SAH), sex(men/women) and residence(rural/urban) was further assessed. All analyses accounted for complex sample design, including clustering, stratification, and sample weights (Supplementary methods) and results were presented as percentage and 95% confidence interval (CI).

Linear trends across study periods were assessed using orthogonal polynomial coefficients, and results with a p-value <0.05 were considered significant. For ordinal categorical variables, Rao−Scott $\chi 2$ tests were used to assess differences. The prevalence rates between the different groups were compared and results were expressed as absolute difference (95%CI) and odds ratio (OR, 95%CI). A p−value of <0.05 was considered statistically significant. All statistical analyses were done in SAS software (SAS Institute Inc, Cary, North Carolina, version 9.4), and data was visualized in R version 4.0.0 (R Foundation for Statistical Computing, Vienna, Austria).

Data sharing

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Role of funding source

The funders of the study had no role in the design or conduct of the study, including data collection, management, analysis, or interpretation of the results; preparation, review, or approval of the manuscript; or the decision to submit the manuscript for publication.

Results

A total of 4,229,616 Chinese adults aged ≥ 40 years from 223 cities in the 31 provinces were finally included (Tables S3−S4). The total number of enrolled people ranged from 513,147 (2016) to 723,571 (2013). The enrollment rate ranged from 58.8% (2017) to 67.8% (2013).

In provinces level, the enrollment rate ranged from 43.6% (Tianjin) to 85.7% (Jiangsu), Table S5. The sample size in the provinces ranged from 400 (Tibet, 2013) to 80,332 (Shandong, 2013). Characteristics of the study participants including from 2013 to 2019 are summarized in the Table 1.

The weighted prevalence of stroke increasing annually from 2013 to 2019, being 2.28% (95% CI: 2.28 −2.28%) in 2013, 2.34% (2.34−2.35%) in 2014, 2.43%

Characteristics	2013	2014	2015	2016	2017	2018	2019
Participants	7,23,571	6,70,603	6,99,459	5,13,147	5,32,443	5,50,975	5,39,418
Mean age (SD), years	58±11.43	58±11.50	59±11.42	60±10.90	60±10.90	60±10.95	60±10.95
Age groups							
40−49	2,14,596 (29.66)	1,99,657 (29.77)	1,73,388 (24.79)	1,20,936 (23.57)	1,06,639 (20.03)	1,11,619 (20.26)	1,02,680 (19.04)
50−59	2,07,677 (28.7)	1,94,421 (28.99)	2,05,055 (29.32)	1,50,304 (29.29)	1,54,467 (29.01)	1,63,645 (29.7)	1,63,937 (30.39)
60−69	1,80,945 (25.01)	1,63,683 (24.41)	1,87,078 (26.75)	1,41,431 (27.56)	1,63,125 (30.64)	1,61,199 (29.26)	1,55,229 (28.78)
70−79	91,651 (12.67)	84,000 (12.53)	97,944 (14)	73,561 (14.34)	82,521 (15.5)	88,394 (16.04)	92,112 (17.08)
≥80	28,702 (3.97)	28,842 (4.3)	35,994 (5.15)	26,915 (5.25)	25,691 (4.83)	26,118 (4.74)	25,460 (4.72)
Sex-Men	3,30,053 (45.61)	3,10,636 (46.32)	3,19,706 (45.71)	2,34,639 (45.73)	2,28,987 (43.01)	2,34,633 (42.59)	2,25,551 (41.81)
Residence-urban	3,72,814 (51.52)	33,9970 (50.7)	3,67,547 (52.55)	2,59,307 (50.53)	2,66,750 (50.1)	2,80,487 (50.91)	2,85,663 (52.96)
Mean BMI (SD), kg/m^2	24.0±3.32	24.2±4.02	24.0±3.40	24.3±3.51	24.3±3.51	24.5±3.51	24.5±3.48
BMI group							
<18.5 kg/m^2	17,468 (2.41)	14,137 (2.11)	16,692 (2.39)	10,019 (1.95)	12,044 (2.26)	11,084 (2.01)	11,374 (2.11)
18.5−23.9 kg/m^2	3,71,399 (51.33)	3,44,638 (51.39)	3,63,196 (51.93)	2,60,116 (50.69)	2,51,835 (47.3)	2,54,260 (46.15)	2,44,865 (45.39)
24.0−27.9 kg/m^2	2,64,144 (36.51)	2,44,691 (36.49)	2,55,108 (36.47)	1,90,297 (37.08)	2,04,848 (38.47)	2,14,432 (38.92)	2,13,569 (39.59)
>=28.0 kg/m^2	70,560 (9.75)	67,137 (10.01)	64,463 (9.22)	52,715 (10.27)	63,716 (11.97)	71,199 (12.92)	69,610 (12.9)
Ethnicity							
Han	7,02,930 (97.15)	6,46,569 (96.42)	6,73,765 (96.33)	4,87,790 (95.06)	5,08,396 (95.49)	5,23,939 (95.09)	5,19,747 (96.35)
Zhuang	739 (0.10)	666 (0.10)	5578 (0.80)	5259 (1.02)	4463 (0.84)	4054 (0.74)	3353 (0.62)
Hui	56,51 (0.78)	5022 (0.75)	3445 (0.49)	4549 (0.89)	3333 (0.63)	4531 (0.82)	2775 (0.51)
Manchu	675 (0.09)	879 (0.13)	995 (0.14)	1153 (0.22)	1196 (0.22)	1274 (0.23)	970 (0.18)
Uygur	1034 (0.14)	2677 (0.4)	1705 (0.24)	1567 (0.31)	758 (0.14)	1776 (0.32)	1328 (0.25)
Education							
Compulsory education	3,59,264 (76.00)	3,22,719 (78.31)	5,43,274 (77.94)	4,02,892 (78.52)	4,12,993 (77.57)	4,29,446 (77.94)	4,05,925 (75.26)
High School	76,058 (16.09)	62,103 (15.07)	1,06,308 (15.25)	81,138 (15.81)	82,074 (15.42)	85,797 (15.57)	88,332 (16.38)
College and above	37,411 (7.91)	27,287 (6.62)	47,442 (6.81)	29,053 (5.66)	37,360 (7.02)	35,725 (6.48)	45,108 (8.36)
Missing	250838	258494	2435	64	16	7	53
Annual income, CNY							
<5000	982 (26.28)	2791 (55.86)	1,97,267 (28.3)	1,48,046 (29.03)	1,47,014 (27.61)	1,50,167 (27.26)	1,32,006 (24.47)
5000−10,000	699 (18.71)	510 (10.21)	1,18,184 (16.96)	88,560 (17.36)	82,350 (15.47)	86,481 (15.7)	81,478 (15.1)
10,000−20,000	537 (14.37)	413 (8.27)	1,25,005 (17.94)	79,737 (15.63)	86,961 (16.33)	85,724 (15.56)	83,953 (15.56)
>20,000	1518 (40.63)	1282 (25.66)	2,56,517 (36.8)	1,93,701 (37.98)	2,16,094 (40.59)	2,28,581 (41.49)	2,41,976 (44.86)
Missing	7,19,835	6,65,607	2486	3103	24	22	5
MI: own expense	7529 (1.26)	4509 (0.92)	7509 (1.07)	2965 (0.58)	2088 (0.39)	2586 (0.47)	1634 (0.30)
Marital status							
Married	4,57,442 (95.19)	3,97,006 (94.71)	6,56,608 (94.1)	4,86,044 (94.73)	4,94,505 (92.88)	5,13,864 (93.27)	4,97,976 (92.74)

Table 1 (Continued)

Characteristics	2013	2014	2015	2016	2017	2018	2019
Single	1046 (0.22)	3350 (0.8)	5844 (0.84)	3601 (0.7)	4983 (0.94)	4898 (0.89)	4045 (0.75)
Widowed	18,436 (3.84)	15,958 (3.81)	30,826 (4.42)	19,545 (3.81)	27,889 (5.24)	27,127 (4.92)	29,802 (5.55)
Missing	2,43,007	2,51,416	1661	69	10	37	2486
Vascular risk factors							
Smoking status							
Nonsmokers	6,05,493 (83.68)	5,67,071 (84.56)	5,83,880 (83.48)	4,33,859 (84.55)	4,50,197 (84.55)	4,67,543 (84.86)	4,58,539 (85.01)
Past smokers	9644 (1.33)	6499 (0.97)	12,826 (1.83)	9877 (1.92)	8745 (1.64)	7965 (1.45)	8015 (1.49)
Current smokers	1,08,434 (14.99)	97,033 (14.47)	1,02,753 (14.69)	69,411 (13.53)	73,501 (13.80)	75,467 (13.70)	72,864 (13.51)
Consumption of alcohol	29,372 (13.19)	24,481 (16.02)	82,571 (11.8)	56,683 (11.05)	85,831 (16.21)	90,555 (16.44)	90,307 (16.74)
Family history of stroke	55,459 (7.66)	47,250 (7.05)	81,494 (11.65)	40,485 (7.89)	51,294 (9.63)	55,168 (10.01)	53,850 (9.98)
Hypertension[b]	2,81,850 (38.95)	2,67,116 (39.83)	2,81,408 (40.23)	2,08,965 (40.72)	2,40,567 (45.18)	2,50,459 (45.46)	2,46,178 (45.64)
Diabetes[b]	1,14,304 (15.8)	1,07,861 (16.08)	1,14,157 (16.32)	83,862 (16.34)	1,14,256 (21.46)	1,19,902 (21.76)	1,17,205 (21.73)
Hyperlipidemia[b]	2,47,329 (34.18)	2,34,903 (35.03)	2,46,239 (35.2)	1,80,821 (35.24)	2,14,915 (40.36)	2,23,692 (40.6)	2,21,574 (41.08)
Atrial fibrillation	7769 (1.07)	7228 (1.08)	6701 (0.96)	5376 (1.05)	5732 (1.08)	5986 (1.09)	6399 (1.19)
Obesity[c]	70,181 (9.7)	66,882 (9.97)	64,183 (9.18)	52,499 (10.23)	63,254 (11.88)	70,879 (12.86)	69,247 (12.84)
Lack of exercise	1,89,339 (26.17)	1,40,942 (21.02)	2,17,003 (31.02)	1,54,214 (30.05)	1,51,030 (28.37)	1,49,891 (27.2)	1,47,580 (27.36)
TIA	11,949 (1.65)	11,992 (1.79)	12,480 (1.78)	9748 (1.9)	9731 (1.83)	9912 (1.8)	9842 (1.82)
Stroke	19,402 (2.68)	19,291 (2.88)	20,894 (2.99)	16,574 (3.23)	18,277 (3.43)	18,791 (3.41)	19,466 (3.61)

Table 1: **Characteristics of the Study Participants (≥40 Years), 2013−2019[a].**

[a] The results were presented as n (percentages) for categorical variables and as mean (Standard deviation, SD) for continuous variables. The 2010 China Census data: male ratio: 51.27%; age stratification (40−49, 50−59, 60−69, 70−79, ≥80years): 38.2%, 28.2%, 18.9%, 10.7%, 4.0%; urban population ratio: 49.68%.

[‡] Diagnostic criteria were a self-reported diagnosis from 2013 to 2016.

[††] Obesity was defined as BMI≥28.0 kg/m².

BMI, Body Mass Index; CNY, Chinese Yuan Renminbi; TIA, Transient Ischemic Attack; MI, Medical insurance; SD, Standard Deviation.

Articles

Characteristic	2013			2014			2015		
	All	Stroke	% (95%CI)	All	Stroke	% (95%CI)	All	Stroke	% (95%CI)
Total	7,25,332	19,402	2.28 (2.28,2.28)	6,70,603	19291	2.34 (2.34,2.35)	6,99,459	20,894	2.43 (2.43,2.43)
IS		16,876	1.91 (1.91−1.91)		16,785	1.96 (1.95−1.96)		18,180	2.05 (2.05−2.05)
ICH		2325	0.30 (0.29−0.30)		2301	0.30 (0.30−0.30)		2495	0.31 (0.31,0.31)
SAH		286	0.05 (0.05−0.05)		282	0.04 (0.04−0.04)		306	0.04 (0.045,0.04)
Sex									
Male	3,29,858	9797	2.49 (2.49,2.50)	3,10,636	9756	2.53 (2.53,2.54)	3,19,706	10,507	2.62 (2.62,2.62)
Female	3,95,474	9605	2.07 (2.06,2.07)	3,59,967	9535	2.15 (2.15,2.15)	3,9,753	10,387	2.23 (2.23,2.23)
P	<.0001			<.0001			<.0001		
Residence									
Rural	3,52,181	9119	2.32 (2.32,2.32)	3,30,633	9876	2.48 (2.48,2.48)	3,31,912	9757	2.56 (2.55,2.56)
Urban	3,73,151	10,283	2.21 (2.21,2.22)	3,39,970	9415	2.15 (2.15,2.15)	3,67,547	11,137	2.26 (2.26,2.26)
P	<.0001			<.0001			<.0001		
Age, years									
40−49	2,14,375	1332	0.62 (0.62,0.62)	1,99,657	1168	0.58 (0.57,0.58)	1,73,388	1096	0.60 (0.60,0.60)
50−59	2,07,600	4259	2.14 (2.13,2.14)	1,94,421	4189	2.14 (2.14,2.14)	2,05,055	3961	2.19 (2.19,2.19)
60−69	1,81,663	7683	4.24 (4.23,4.24)	1,63,683	7923	4.62 (4.61,4.62)	1,87,078	8099	4.47 (4.47,4.48)
70−79	91,474	4894	5.30 (5.30,5.31)	84,000	4809	5.51 (5.50,5.51)	97,944	5905	6.03 (6.03,6.04)
≥80	28,656	1234	4.06 (4.05,4.07)	28,842	1202	3.87 (3.86,3.88)	35,994	1833	4.69 (4.68,4.70)
P	<.0001			<.0001			<.0001		
Ethnic group									
Han	7,04,629	18,787	2.27 (2.27,2.27)	6,46,569	18644	2.36 (2.36,2.37)	6,73,765	20,352	2.47 (2.46,2.47)
Zhuang	739	9	0.99 (0.97,1.02)	666	11	1.04 (1.03,1.07)	5578	72	1.07 (1.06,1.07)
Hui	5657	146	2.38 (2.36,2.39)	5022	141	2.29 (2.28,2.31)	3445	92	2.34 (2.32,2.35)
Manchu	2991	134	3.18 (3.15,3.20)	6110	262	3.50 (3.48,3.52)	2985	139	4.50 (4.48,4.53)
Uyghur	1034	25	1.14 (1.14,1.16)	2677	41	1.05 (1.03,1.06)	1705	26	1.14 (1.13,1.15)
Mongolian	4337	132	3.31 (3.29,3.33)	3852	161	3.48 (3.45,3.50)	2784	106	3.35 (3.33,3.37)
P	<.0001			<.0001			<.0001		
Provinces									
Beijing	38,626	1105	2.47 (2.46,2.48)	25,170	765	2.56 (2.54,2.57)	15,648	460	2.60 (2.59,2.61)
Tianjin	19,448	555	2.51 (2.49,2.52)	16,281	494	2.58 (2.57,2.60)	10,848	323	2.62 (2.61,2.64)
Hebei	46,326	1180	2.82 (2.81,2.83)	49,172	1516	2.93 (2.93,2.94)	32,970	1259	3.04 (3.04,3.05)
Shanxi	28,805	800	2.54 (2.53,2.55)	41,021	957	2.61 (2.61,2.62)	27,322	784	2.69 (2.68,2.70)
IM	20,355	689	3.38 (3.37,3.39)	14,599	546	3.51 (3.50,3.52)	15,166	613	3.57 (3.56,3.58)
Liaoning	27,962	1213	3.39 (3.38,3.39)	32,920	1430	3.50 (3.49,3.51)	28,048	1194	3.57 (3.56,3.58)
Jilin	23,869	926	3.46 (3.45,3.47)	30,320	1379	3.56 (3.55,3.57)	23,660	518	3.63 (3.62,3.64)
Heilongjiang	25,565	952	3.53 (3.53,3.54)	28,511	1234	3.65 (3.64,3.66)	33,946	1151	3.74 (3.73,3.75)

Table 2 (Continued)

Characteristic	2013			2014			2015		
	All	Stroke	% (95%CI)	All	Stroke	% (95%CI)	All	Stroke	% (95%CI)
Shanghai	5860	140	1.91 (1.89,1.93)	5892	128	1.97 (1.95,1.98)	4148	130	1.98 (1.97,2.00)
Jiangsu	49,281	998	1.78 (1.77,1.78)	48,101	1031	1.84 (1.83,1.84)	51,787	1297	1.88 (1.88,1.89)
Zhejiang	18,707	445	2.01 (2.00,2.02)	17,911	407	2.09 (2.09,2.10)	26,891	694	2.13 (2.12,2.14)
Anhui	26,207	904	2.28 (2.28,2.29)	30,385	1012	2.37 (2.37,2.38)	24,746	1088	2.47 (2.46,2.48)
Fujian	3744	79	1.84 (1.82,1.86)	5912	120	1.89 (1.88,1.91)	4871	153	1.94 (1.92,1.95)
Jiangxi	20,893	686	1.97 (1.96,1.98)	11,306	280	1.99 (1.99,2.00)	30,850	1095	2.06 (2.05,2.06)
Shandong	80,332	2075	2.21 (2.20,2.21)	68,342	1945	2.30 (2.30,2.30)	70,882	2083	2.39 (2.39,2.40)
Henan	66,523	2273	2.75 (2.75,2.76)	43,514	1344	2.87 (2.87,2.88)	71,513	2854	2.96 (2.95,2.96)
Hubei	39,151	754	1.98 (1.98,1.99)	20,345	552	2.06 (2.05,2.06)	32,473	843	2.11 (2.11,2.12)
Hunan	23,537	637	1.97 (1.96,1.97)	26,971	863	2.00 (2.00,2.01)	32,239	980	2.04 (2.03,2.05)
Guangdong	27,973	345	1.47 (1.46,1.47)	15,761	337	1.52 (1.51,1.53)	13,187	283	1.54 (1.54,1.55)
Guangxi	15,667	117	1.52 (1.51,1.53)	13,034	171	1.56 (1.56,1.57)	29,664	358	1.60 (1.60,1.61)
Hainan	3437	53	1.58 (1.57,1.60)	5263	118	1.65 (1.64,1.66)	2026	44	1.67 (1.65,1.68)
Chongqing	14,192	260	1.64 (1.64,1.65)	5927	117	1.71 (1.69,1.72)	12,810	246	1.75 (1.74,1.76)
Sichuan	36,544	666	1.63 (1.63,1.64)	33,307	681	1.70 (1.69,1.70)	27,884	609	1.73 (1.72,1.73)
Guizhou	762	37	1.67 (1.66,1.69)	7127	122	1.76 (1.75,1.76)	9226	162	1.79 (1.78,1.79)
Yunnan	4697	147	1.59 (1.58,1.60)	11,913	219	1.64 (1.64,1.64)	20,780	340	1.66 (1.65,1.66)
Tibet	400	9	2.01 (1.97,2.05)	578	14	2.11 (2.09,2.13)	833	20	2.18 (2.16,2.20)
Shaanxi	17,118	494	2.20 (2.19,2.21)	28,005	591	2.30 (2.30,2.31)	24,675	700	2.33 (2.33,2.34)
Gansu	15,423	396	1.98 (1.97,1.98)	13,922	442	2.05 (2.03,2.06)	5702	177	2.05 (2.03,2.06)
Qinghai	4249	112	1.94 (1.92,1.95)	6332	146	2.01 (2.00,2.02)	3531	88	2.05 (2.03,2.08)
Ningxia	9650	145	1.94 (1.93,1.96)	3680	95	2.02 (2.01,2.04)	2457	73	2.07 (2.05,2.09)
Xinjiang	8278	210	1.95 (1.94,1.96)	9081	235	2.03 (2.01,2.04)	8676	275	2.06 (2.05,2.07)
P	<.0001			<.0001			<.0001		

Characteristic	2016			2017			2018		
	All	Stroke	% (95%CI)	All	Stroke	% (95%CI)	All	Stroke	% (95%CI)
Total	5,13,147	16,574	2.48 (2.48,2.48)	5,32,243	18277	2.52 (2.52,2.52)	5,50,975	18,791	2.55 (2.55,2.55)
IS		14,697	2.16 (2.16,2.17)		16,090	2.18 (2.18,2.18)		16,414	2.19 (2.19,2.19)
ICH		1815	0.31 (0.31,0.31)		2272	0.35 (0.35,0.35)		2366	0.36 (0.36,0.36)
SAH		384	0.06 (0.06,0.06)		300	0.04 (0.045,0.04)		351	0.05 (0.05,0.05)
Sex									
Male	2,34,644	8315	2.70 (2.70,2.70)	2,29,322	8991	2.76 (2.76,2.76)	2,34,488	9279	2.85 (2.85,2.85)
Female	2,78,503	8266	2.26 (2.26,2.26)	3,02,921	9286	2.27 (2.27,2.27)	3,16,487	9522	2.25 (2.25,2.26)

Table 2 (Continued)

Articles

Characteristic	2016			2017			2018		
	All	Stroke	% (95%CI)	All	Stroke	% (95%CI)	All	Stroke	% (95%CI)
P	<.0001			<.0001			<.0001		
Residence									
Rural	2,53,843	8678	2.62 (2.62,2.63)	2,65,983	8680	2.58 (2.57,2.58)	2,70,332	8995	2.60 (2.60,2.60)
Urban	25,9304	7903	2.29 (2.29,2.29)	2,66,260	9597	2.43 (2.43,2.43)	2,80,643	9806	2.49 (2.48,2.49)
P	<.0001			<.0001			0.0005		
Age, years									
40—49	1,20,936	667	0.53 (0.53,0.53)	1,06,832	619	0.57 (0.57,0.57)	1,11,647	599	0.57 (0.57,0.57)
50—59	1,50,300	2825	2.11 (2.10,2.11)	1,54,720	2974	2.12 (2.12,2.12)	1,63,473	3154	2.09 (2.09,2.09)
60—69	1,41,432	6725	4.64 (4.64,4.65)	1,62,329	7488	4.52 (4.52,4.53)	1,61,276	7563	4.70 (4.70,4.71)
70—79	73,565	4863	6.62 (6.61,6.63)	82,637	5551	6.71 (6.71,6.72)	88,451	5826	6.81 (6.81,6.82)
≥80	26,917	1501	5.18 (5.18,5.19)	25,725	1645	5.95 (5.94,5.96)	26,128	1659	6.01 (6.00,6.02)
P	<.0001			<.0001			<.0001		
Ethnic group									
Han	4,87,797	15,982	2.54 (2.54,2.54)	5,09,130	17462	2.51 (2.51,2.51)	5,24,182	17,892	2.56 (2.56,2.56)
Zhuang	5259	86	1.15 (1.14,1.15)	4463	96	1.24 (1.23,1.25)	4054	79	1.30 (1.29,1.31)
Hui	4549	137	2.66 (2.64,2.67)	3340	142	2.72 (2.71,2.73)	4531	212	2.84 (2.82,2.85)
Manchu	5429	212	2.91 (2.89,2.92)	2285	129	4.07 (4.05,4.10)	5300	222	3.15 (3.13,3.16)
Uyghur	1567	33	1.32 (1.30,1.35)	798	18	1.75 (1.73,1.76)	1776	39	1.55 (1.54,1.57)
Mongolian	2700	102	3.24 (3.22,3.25)	2630	79	3.11 (3.09,3.13)	1933	47	2.92 (2.89,2.95)
P	<.0001			<.0001			<.0001		
Provinces									
Beijing	13,021	436	2.67 (2.66,2.69)	9411	307	2.72 (2.70,2.73)	9863	330	2.78 (2.76,2.79)
Tianjin	13,518	462	2.68 (2.67,2.70)	6666	227	2.72 (2.71,2.74)	6735	218	2.72 (2.70,2.74)
Hebei	36,568	1365	3.16 (3.16,3.17)	26,553	1331	3.23 (3.22,3.23)	36,809	1636	3.29 (3.28,3.29)
Shanxi	28,908	823	2.79 (2.79,2.80)	16,883	609	2.81 (2.80,2.81)	16,729	577	2.84 (2.84,2.85)
IM	9050	361	3.70 (3.69,3.71)	12,610	504	3.70 (3.69,3.71)	12,884	484	3.78 (3.77,3.79)
Liaoning	22,449	1132	3.68 (3.67,3.68)	26,426	1173	3.70 (3.69,3.70)	20,843	1053	3.79 (3.78,3.80)
Jilin	21,807	878	3.77 (3.76,3.78)	15,368	800	3.81 (3.80,3.82)	10,344	548	3.94 (3.93,3.95)
Heilongjiang	14,737	737	3.89 (3.87,3.90)	21,228	675	3.93 (3.92,3.94)	14,436	985	3.99 (3.98,4.00)
Shanghai	4015	90	2.03 (2.02,2.05)	4524	204	2.00 (1.99,2.02)	12,695	466	2.06 (2.05,2.06)
Jiangsu	38,990	994	1.95 (1.94,1.95)	39,431	1257	1.97 (1.97,1.98)	36,877	1100	2.01 (2.00,2.01)
Zhejiang	17,206	442	2.19 (2.19,2.20)	27,041	699	2.19 (2.18,2.20)	21,858	589	2.26 (2.25,2.26)
Anhui	17,092	572	2.58 (2.57,2.58)	23,456	1165	2.58 (2.57,2.58)	31,134	954	2.68 (2.67,2.68)
Fujian	10,019	294	2.00 (1.99,2.01)	6813	217	1.98 (1.97,1.99)	12,778	307	2.03 (2.02,2.03)
Jiangxi	11,560	318	2.15 (2.14,2.15)	17,307	647	2.15 (2.15,2.16)	15,066	592	2.15 (2.14,2.16)
Shandong	56,958	1867	2.50 (2.49,2.50)	50,833	1577	2.51 (2.50,2.51)	52,420	1714	2.59 (2.59,2.60)

Table 2 (Continued)

Characteristic	2016			2017			2018		
	All	Stroke	% (95%CI)	All	Stroke	% (95%CI)	All	Stroke	% (95%CI)
Henan	40,419	1520	3.07 (3.07,3.08)	43,007	1594	3.11 (3.11,3.12)	44,255	1925	3.20 (3.19,3.20)
Hubei	18,046	652	2.19 (2.18,2.20)	20,814	778	2.21 (2.21,2.22)	21,470	651	2.26 (2.25,2.27)
Hunan	24,409	831	2.13 (2.13,2.14)	28,961	875	2.10 (2.10,2.11)	23,433	802	2.12 (2.11,2.12)
Guangdong	4894	105	1.58 (1.57,1.59)	11,053	264	1.58 (1.58,1.59)	13,672	287	1.62 (1.62,1.63)
Guangxi	23,799	405	1.65 (1.64,1.65)	20,959	495	1.64 (1.63,1.64)	21,278	456	1.64 (1.63,1.64)
Hainan	2973	79	1.73 (1.72,1.74)	3513	80	1.69 (1.68,1.70)	3706	120	1.75 (1.74,1.77)
Chongqing	5072	124	1.82 (1.81,1.84)	8574	214	1.83 (1.82,1.84)	8374	193	1.85 (1.83,1.86)
Sichuan	14,626	350	1.79 (1.79,1.80)	29,869	764	1.81 (1.81,1.82)	35,746	881	1.86 (1.86,1.87)
Guizhou	7347	123	1.85 (1.84,1.85)	6326	162	1.84 (1.83,1.84)	9160	154	1.87 (1.86,1.87)
Yunnan	8398	224	1.73 (1.72,1.73)	17,740	340	1.73 (1.72,1.73)	16,334	413	1.75 (1.74,1.75)
Tibet	873	21	2.28 (2.26,2.29)	1113	24	2.26 (2.25,2.27)	1177	26	2.30 (2.28,2.31)
Shaanxi	19,492	500	2.43 (2.42,2.43)	18,067	706	2.45 (2.44,2.46)	18,418	645	2.55 (2.55,2.56)
Gansu	8959	356	2.14 (2.13,2.15)	4425	157	2.15 (2.14,2.16)	7525	240	2.21 (2.19,2.22)
Qinghai	5156	141	2.14 (2.13,2.15)	3549	97	2.19 (2.17,2.20)	3417	115	2.21 (2.20,2.22)
Ningxia	6342	169	2.18 (2.17,2.19)	5533	189	2.22 (2.21,2.23)	4502	128	2.30 (2.28,2.31)
Xinjiang	6444	210	2.14 (2.13,2.16)	4190	146	2.17 (2.16,2.19)	7037	212	2.27 (2.26,2.28)
P	<.0001			<.0001			<.0001		

Characteristic	2019			A relative change from 2013 to 2019, %
	All	Stroke	% (95%CI)	
Total	5,39,418	19,466	2.58 (2.58,2.58)	13.16%
IS		17,304	2.24 (2.24,2.24)	17.28%
ICH		2232	0.35 (0.35,0.35)	16.27%
SAH		278	0.04 (0.04,0.04)	−5.05%
Sex				
Male	2,25,551	9597	2.94 (2.93,2.94)	18.07%
Female	3,13,867	9869	2.22 (2.22,2.22)	7.25%
P	<.0001			
Residence				
Rural	2,53,755	8576	2.55 (2.55,2.55)	9.91%
Urban	2,85,663	10,890	2.62 (2.61,2.62)	18.55%
P	<.0001			
Age, years				
40−49	1,02,680	562	0.53 (0.52,0.53)	−14.52%

Table 2 (Continued)

Characteristic	2019			A relative change from 2013 to 2019, %
	All	Stroke	% (95%CI)	
50−59	1,63,937	3150	2.14 (2.14,2.15)	0.00%
60−69	1,55,229	7602	4.70 (4.70,4.71)	10.85%
70−79	92,112	6413	7.00 (6.99,7.00)	32.08%
≥80	25,460	1739	6.30 (6.29,6.31)	55.17%
P	<.0001			
Ethnic group				
Han	5,19,747	18,855	2.62 (2.62,2.62)	15.42%
Zhuang	3353	78	1.43 (1.41,1.44)	44.44%
Hui	2775	106	3.02 (3.00,3.04)	26.89%
Manchu	3717	174	3.25 (3.23,3.27)	2.20%
Uyghur	1328	27	1.68 (1.66,1.70)	47.37%
Mongolian	1538	54	3.19 (3.17,3.21)	-3.63%
P	<.0001			
Provinces				
Beijing	4290	133	2.83 (2.81,2.85)	14.57%
Tianjin	6842	230	2.76 (2.74,2.77)	9.96%
Hebei	23,871	1154	3.35 (3.35,3.36)	18.79%
Shanxi	16,899	644	2.87 (2.86,2.88)	12.99%
IM	10,562	385	3.82 (3.81,3.83)	13.02%
Liaoning	26,068	1375	3.82 (3.82,3.83)	12.68%
Jilin	15,761	989	4.02 (4.01,4.03)	16.18%
Heilongjiang	21,703	1207	4.07 (4.06,4.08)	15.30%
Shanghai	5387	197	2.08 (2.06,2.09)	8.90%
Jiangsu	43,819	1364	2.02 (2.02,2.03)	13.48%
Zhejiang	21,311	693	2.30 (2.29,2.31)	14.43%
Anhui	18,214	712	2.71 (2.71,2.72)	18.86%
Fujian	10,142	283	2.04 (2.03,2.05)	10.87%
Jiangxi	18,789	634	2.16 (2.16,2.17)	9.64%
Shandong	52,966	1791	2.66 (2.66,2.67)	20.36%
Henan	44,790	1774	3.27 (3.27,3.28)	18.91%
Hubei	17,563	532	2.30 (2.29,2.31)	16.16%
Hunan	29,115	934	2.13 (2.12,2.13)	8.12%
Guangdong	18,141	438	1.66 (1.66,1.67)	12.93%
Guangxi	17,517	415	1.66 (1.65,1.66)	9.21%
Hainan	3793	73	1.80 (1.79,1.81)	13.92%
Chongqing	13,255	335	1.87 (1.86,1.88)	14.02%

Table 2 (Continued*)*

Characteristic	2019		A relative change from 2013 to 2019, %
	All	Stroke	% (95%CI)
Sichuan	35,967	962	1.87 (1.87,1.88)	14.72%
Guizhou	12,426	296	1.86 (1.86,1.87)	11.38%
Yunnan	10,625	315	1.75 (1.74,1.76)	10.06%
Tibet	940	35	2.31 (2.30,2.32)	14.93%
Shaanxi	17,504	911	2.64 (2.64,2.65)	20.00%
Gansu	8437	294	2.25 (2.24,2.26)	13.64%
Qinghai	2818	68	2.24 (2.22,2.26)	15.46%
Ningxia	4513	139	2.32 (2.31,2.33)	19.59%
Xinjiang	5390	154	2.35 (2.34,2.36)	20.51%
P	<.0001		

Table 2: Weighted prevalence of stroke among Chinese adults aged ≥ 40 years, [a] by Sex, residence, age, ethnic and provinces—China Stroke High-risk Population Screening and intervention program, 2013–2019.

[a] Standardized prevalence of stroke adjusted to the 2010 China standard population, gender, age, regions, urban and rural; weighted estimates.

IS, ischemic stroke; ICH, intracerebral hemorrhage; SAH, subarachnoid hemorrhage; IM, Inner Mongolia.

(2.43−2.43%) in 2015, 2.48% (2.48−2.48%) in 2016, 2.52% (2.52−2.52%) in 2017, 2.55% (2.55−2.55%) in 2018, and 2.58% (2.58−2.58%) in 2019 (*p* for trend <0.001). From 2013 to 2019, the prevalence of stroke increased by 13.2%, and the annual increase rate was 2.2%. During this time, the prevalence of stroke in male participants and urban areas increased significantly (male vs. female: 18.1% vs. 7.3%, *P*<0.001; urban vs. rural: 18.6% vs. 9.9%, *P*<0.001) (Table 2). The weighted prevalence of IS, ICH, and SAH in 2019 were 2.24% (95%CI, 2.24 −2.24%), 0.35% (0.35−0.35%), and 0.04% (0.04 −0.04%), respectively. The results of other years are also presented in Table 2 and Figure 1.

In 2019, the weighted prevalence of stroke was higher in male participants than in female participants (male vs. female: 2.94% vs. 2.22% [absolute difference: 0.70% {95% CI: 0.70−0.71%}; odds ratio {OR}: 1.21 {95% CI: 1.18−1.24}]). The same pattern appeared consistent from 2013 to 2018 (Figure 2A). From 2013 to 2018, the prevalence of stroke was higher in rural areas than in urban areas (rural vs. urban in 2018: 2.60% vs. 2.49% [absolute difference: 0.09% {95% CI: 0.08 −0.10%}; OR: 1.05 {95% CI: 1.04−1.06}]), but the trend was reversed in 2019 (rural vs. urban: 2.55% vs. 2.62% [absolute difference: −0.06% {95% CI: −0.07% to −0.06%}; OR: 0.92 {95% CI: 0.90−0.94}]) (Figure 2B).

The weighted prevalence of stroke was highest in persons aged 70−79 years in 2019, and a nearly 18-fold difference in estimated prevalence of stroke was observed between persons aged 70−79 years and 40 −49 years (70−79 vs. 40−49: 7.00% vs. 0.53% [absolute difference: 6.12% {95% CI: 6.07−6.16%}; OR: 18.12 {95% CI: 18.01−18.26}]). The same pattern appeared consistent from 2013 to 2018. Meanwhile, from 2013 to 2019, the prevalence of stroke in persons aged 40−49 years declined by 14.5%, while that in persons aged ≥80 years increased by 55.2% (Table 2). The weighted prevalence of stroke varied substantially by ethnicity. From 2013 to 2019, the three ethnic groups with the highest prevalence were Manchu, Mongolian, and Hui. In 2019, the respective prevalence rates were 3.25% (95% CI: 3.23 −3.27%), 3.19% (3.17−3.21%), and 3.02% (3.00 −3.04%) (Table 2).

In 2013, the weighted prevalence of stroke ranged from 1.47% (Guangdong) to 3.53% (Heilongjiang). In 2019, the weighted prevalence of stroke ranged from 1.66% (Guangdong and Guangxi) to 4.07% (Heilongjiang) (Table 2). In 2019, the provinces in China with high prevalence of stroke exceeding 3.50% were generally in the northeast, while the provinces with low prevalence of stroke below 2.00% were generally in the south (Figure 3A and Table 3). For male and female participants, the prevalence of stroke ranged from 1.74% (Shanghai and Yunnan) to 4.56%
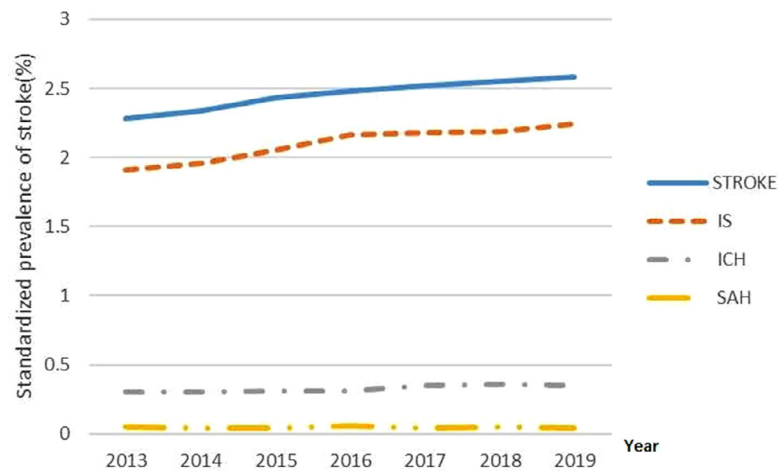
Figure 1. Weighted prevalence of stroke stratified by subtypes among Chinese adults aged ≥ 40 years from 2103 to 2019. IS, ischemic stroke; ICH, intracerebral hemorrhage; SAH, subarachnoid hemorrhage.

(Liaoning) and from 1.05% (Tibet) to 3.80% (Jilin), respectively (Figure 3B−C and Table 3). Regarding rural and urban areas, the prevalence in rural areas ranged from 1.32% (Guangxi) to 4.91% (Inner Mongolia), and the prevalence in urban areas ranged from 0.74% (Hainan) to 5.70% (Shaanxi) (Figure 3D−E and Table 3). During the entire study period from 2013 to 2019, the prevalence of stroke in all provinces increased to varying degrees (Figure 4). The three provinces with the highest increases were Shaanxi (2.20% to 2.64%; 20.00%), Shandong (2.21% to 2.66%; 20.36%), and Xinjiang (1.95% to 2.35%; 20.51%), while the three provinces with the lowest increases were Hunan (1.97% to 2.13%; 8.12%), Shanghai (1.91% to 2.08%; 8.90%), and Guangxi (1.52% to 1.66%; 9.21%) (Table 2).

As shown in the Table 3, the three provinces with the highest prevalence of IS in 2019 were Inner Mongolia (3.62%; 95%CI: 3.61−3.63%), Jilin (3.80%; 3.79−3.81%), and Heilongjiang (3.73%; 3.72,3.74%); while the three provinces with the lowest prevalence were Tibet (1.24%; 1.23−1.25%), Guangdong (1.31%, 1.31%-1.31%), and Guangxi (1.48%; 1.47−1.48%). The prevalence of ICH and SAH in 2019 stratified by provinces are presented in Table 3.

As shown in the Table 4, the most prevalent risk factors among stroke were hypertension (81.54%), hyperlipidemia (60.99%), and physical inactivity (40.09%). The least prevalent were atrial fibrillation (3.27%) and TIA (7.08%). Stroke survivors were older and more frequently were male, widowhood, living in urban, low income, and education. The prevalence of hypertension, diabetes mellitus, hyperlipidemia, atrial fibrillation, obesity, physical inactivity, TIA and family history of stroke was significantly greater in stroke than in other participants.

Discussion

This study performed the first comprehensive assessment of the trends in prevalence of stroke in China from 2013 to 2019 stratified by sociodemographic characteristics. The findings showed large disparities in the prevalence of stroke by sex, age, residence, ethnicity, and province. During the 7-year study period, the weighted prevalence of stroke increased significantly from 2.28% to 2.58%. The three provinces of Shaanxi, Shandong, and Xinjiang had the most obvious increasing trends (all >20%). Furthermore, a nearly 2.5-fold difference in estimated prevalence of stroke was observed between northeast areas and southeast coastal areas.

The current prevalence of stroke in Chinese adults aged ≥40 years is 2.58% (≈17.5 million). Interestingly, one study showed that the adjusted prevalence of stroke in adults aged ≥40 years in Argentina was 1.97%.[11] Previous data for the Chinese population indicated that the prevalence of stroke among adults aged ≥40 years was approximately twice that of adults aged ≥18 years.[5] Thus, we speculate that the prevalence of stroke among Chinese adults is about 1.29%, suggesting that the prevalence of stroke in China has exceeded that in developing countries such as India (0.56%)[12] and Sri Lanka (1.04%)[13], but remains lower than those in developed countries such as the Benin (3.22%),[14] United States (2.6%),[15] and United Kingdom (1.7%).[16] Meanwhile, another study showed that the prevalence of stroke in older adults aged ≥60 years in Singapore was 7.6%.[17] In this study, we found that the prevalence of stroke in older Chinses adults aged ≥60 years ranged from 4.68% (2013) to 5.56% (2019), which was still lower than in Singapore. These data show that the prevalence of stroke in China has not significantly exceeded the prevalence in developed countries.
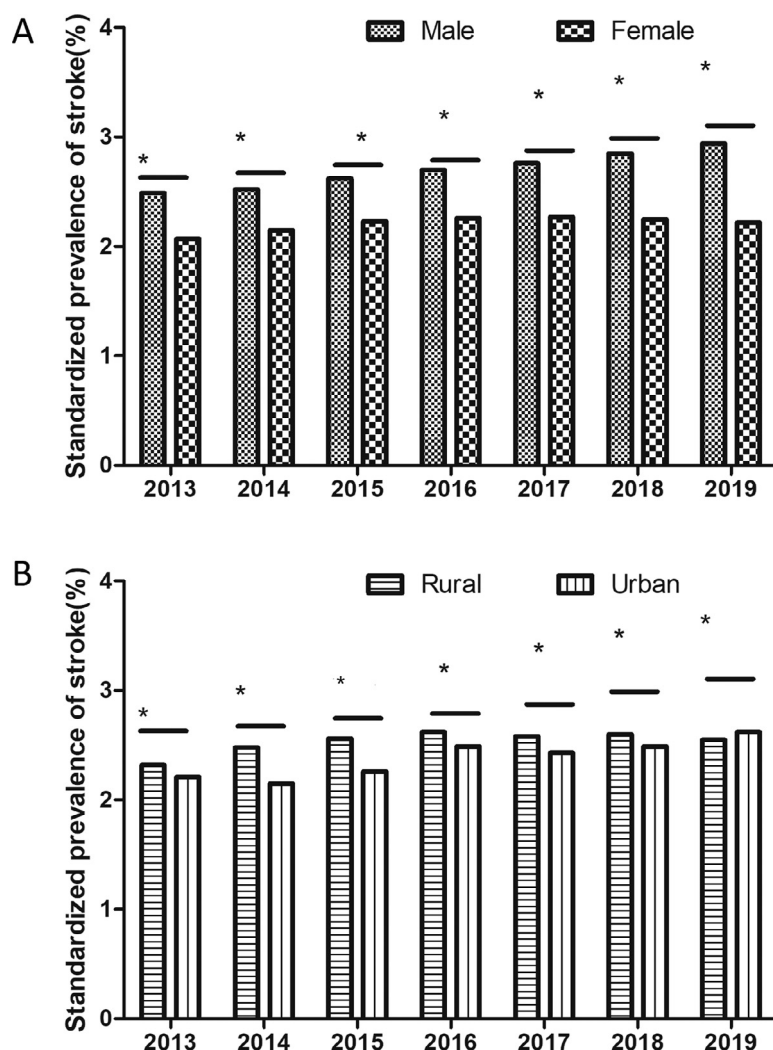
Figure 2. Weighted prevalence of stroke among Chinese adults aged ≥ 40 years stratified by sex and residence from 2013 to 2019. (A) Weighted prevalence of stroke among males and females from 2013 to 2019; (B) Weighted prevalence of stroke in urban and rural areas of China in from 2013 to 2019. * Represent. *P*<0.001.

The age-standardized prevalence of stroke in Chinese adults aged ≥20 years was 0.26% in 1986[18] and increased to 0.79% in 2008.[19] Wang et al.[2] indicated that the prevalence of stroke in Chinese adults aged ≥20 years was 1.11% in 2013. We speculate that the current prevalence of adult stroke in Chinese adults aged ≥20 years has risen to 1.29%, being 4.9, 1.6, and 1.2 times higher than the prevalence in 1986, 2008, and 2013, respectively. Findings from the 2016 Global Burden of Disease Study showed that the age-standardized prevalence rates for stroke had increased from 1.48% in 1990 to 1.89% in 2016.[20] The 2019 Global Burden of Disease Study found that the age-standardized prevalence rates for stroke was 2.24% in 2019,[21] which might be overvalued.[22] It should be noted that the prevalence and incidence of stroke have risen faster in China than in other countries.[23] The main possible reason for the increased prevalence of stroke is aging of the general population.[24] China faces an aging tsunami. By the end of 2016, the number of adults aged ≥60 years reached 230 million (16.0%).[25] Aging increases the incidence of stroke risk factors such as diabetes and hypertension,[26-27] which further increase the burden of stroke. Furthermore, the ongoing high prevalence of risk factors like hypertension and diabetes and the inadequate management act as catalysts for the occurrence of stroke.[1] In the China Hypertension Survey (2012−2015), 23.2% (≈244.5 million) of Chinese adults aged ≥18 years had hypertension, and among individuals with hypertension, 46.9% were aware of their condition, 40.7% were taking prescribed antihypertensive medications, and 15.3% had controlled
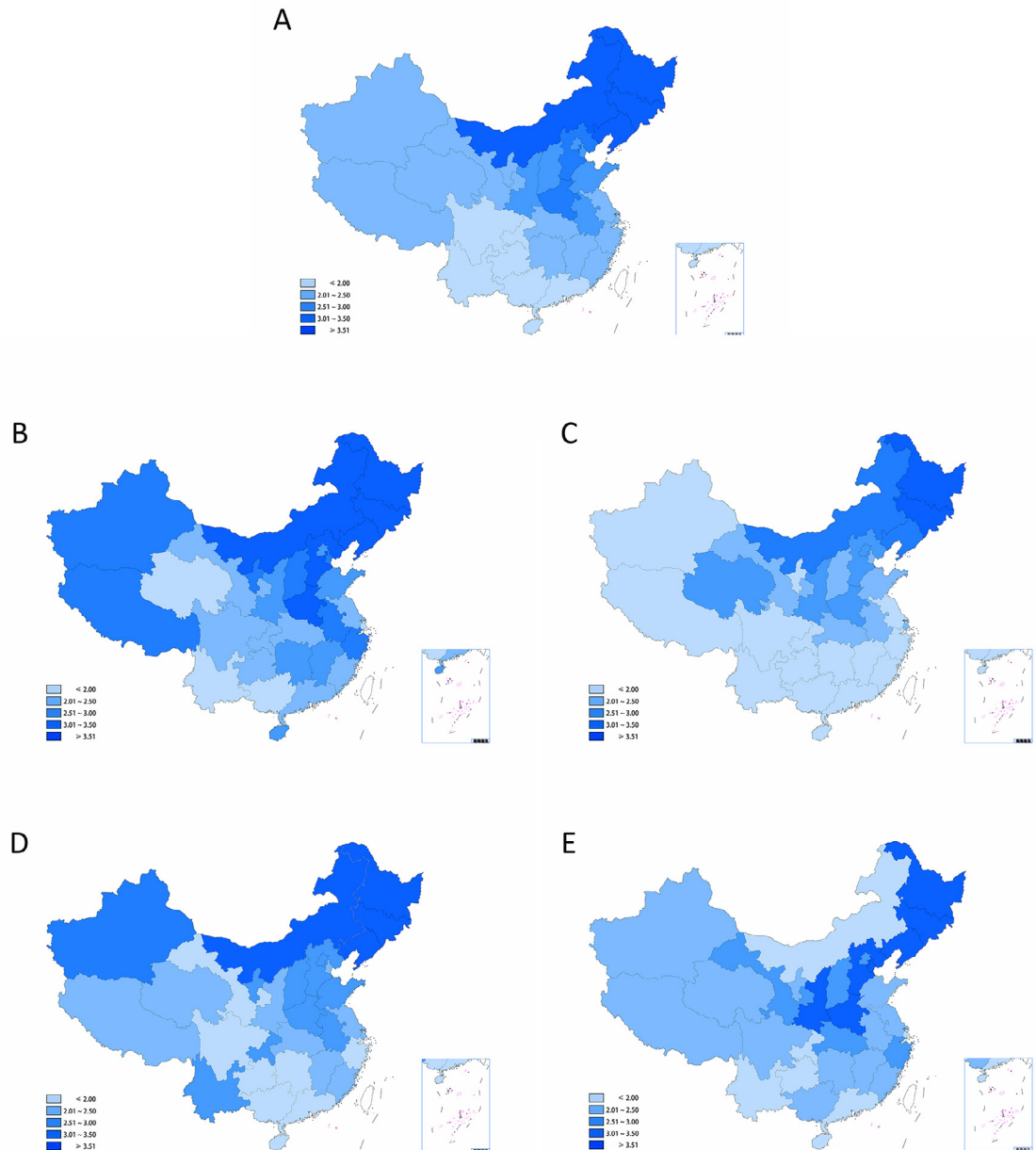
Figure 3. Weighted prevalence of stroke (%) among Chinese adults aged ≥ 40 years Stratified by sex and residence in the 31 provinces in China in 2019. (A) Weighted prevalence of stroke among Chinese adults aged ≥ 40 years (China map ID: 1012072252); (B) Weighted prevalence of stroke among males aged ≥ 40 years (China map ID: 1012051844); (C) Weighted prevalence of stroke among females aged ≥ 40 years (China map ID: 1012037076); (D) Weighted prevalence of stroke among rural residents aged ≥ 40 years (China map ID: 1012046738); (E) Weighted prevalence of stroke among urban residents aged ≥ 40 years (China map ID: 1012091064).

hypertension.[28] Another study on approximately 1.7 million community-dwelling adults aged 35−75 years from all 31 provinces in mainland China suggested that the rate of hypertension control was less than one in ten (7.2%).[29] Meanwhile, the prevalence of diabetes in China rose from 10.9% in 2013 to 12.8% in 2019, but its rate of control showed no significant change (49.2% vs. 49.4%).[30-31] Secondly, these upward trends may have arisen through changes toward prolonged survival and reduced mortality among stroke patients.[32] This

Provinces	All	Classification		
		IS	ICH	SAH
Beijing	2.83 (2.81,2.85)	2.75 (2.73,2.77)	0.15 (0.14,0.15)	0.14 (0.14,0.15)
Tianjin	2.76 (2.74,2.77)	2.46 (2.45,2.47)	0.30 (0.30,0.31)	0.04 (0.03,0.04)
Hebei	3.35 (3.35,3.36)	2.82 (2.82,2.83)	0.55 (0.54,0.55)	0.03 (0.03,0.03)
Shanxi	2.87 (2.86,2.88)	2.99 (2.98,3.00)	0.26 (0.26,0.26)	0.12 (0.12,0.12)
IM	3.82 (3.81,3.83)	3.62 (3.61,3.63)	0.25 (0.25,0.25)	-
Liaoning	3.82 (3.82,3.83)	3.44 (3.44,3.45)	0.46 (0.45,0.46)	0.03 (0.03,0.03)
Jilin	4.02 (4.01,4.03)	3.80 (3.79,3.81)	0.30 (0.30,0.30)	0.03 (0.03,0.03)
Heilongjiang	4.07 (4.06,4.08)	3.73 (3.72,3.74)	0.36 (0.35,0.36)	0.04 (0.04,0.04)
Shanghai	2.08 (2.06,2.09)	1.94 (1.92,1.95)	0.11 (0.10,0.11)	0.04 (0.04,0.04)
Jiangsu	2.02 (2.02,2.03)	1.82 (1.81,1.82)	0.21 (0.21,0.22)	0.04 (0.04,0.04)
Zhejiang	2.30 (2.29,2.31)	1.78 (1.77,1.79)	0.50 (0.50,0.51)	0.06 (0.06,0.06)
Anhui	2.71 (2.71,2.72)	2.40 (2.39,2.41)	0.31 (0.31,0.31)	0.09 (0.08,0.09)
Fujian	2.04 (2.03,2.05)	1.76 (1.75,1.77)	0.29 (0.28,0.29)	0.02 (0.02,0.02)
Jiangxi	2.16 (2.16,2.17)	1.81 (1.80,1.82)	0.35 (0.35,0.35)	0.03 (0.03,0.03)
Shandong	2.66 (2.66,2.67)	2.32 (2.32,2.32)	0.36 (0.36,0.36)	0.03 (0.03,0.03)
Henan	3.27 (3.27,3.28)	2.86 (2.86,2.87)	0.43 (0.43,0.43)	0.03 (0.03,0.03)
Hubei	2.30 (2.29,2.31)	1.96 (1.95,1.97)	0.36 (0.35,0.36)	0.09 (0.08,0.09)
Hunan	2.13 (2.12,2.13)	1.69 (1.69,1.70)	0.45 (0.45,0.45)	0.05 (0.05,0.05)
Guangdong	1.66 (1.66,1.67)	1.31 (1.31,1.31)	0.32 (0.32,0.32)	0.07 (0.07,0.07)
Guangxi	1.66 (1.65,1.66)	1.48 (1.47,1.48)	0.16 (0.16,0.16)	0.04 (0.04,0.05)
Hainan	1.80 (1.79,1.81)	1.57 (1.56,1.58)	0.28 (0.27,0.28)	0.00 (0.00,0.00)
Chongqing	1.87 (1.86,1.88)	1.57 (1.56,1.57)	0.30 (0.29,0.30)	0.05 (0.05,0.05)
Sichuan	1.87 (1.87,1.88)	1.52 (1.51,1.52)	0.32 (0.31,0.32)	0.07 (0.07,0.07)
Guizhou	1.86 (1.86,1.87)	1.69 (1.68,1.69)	0.22 (0.22,0.22)	0.04 (0.04,0.04)
Yunnan	1.75 (1.74,1.76)	1.51 (1.50,1.52)	0.31 (0.31,0.31)	0.01 (0.01,0.01)
Tibet	2.31 (2.30,2.32)	1.24 (1.23,1.25)	0.94 (0.93,0.94)	0.18 (0.17,0.18)
Shaanxi	2.64 (2.64,2.65)	2.36 (2.35,2.37)	0.32 (0.31,0.32)	0.02 (0.02,0.02)
Gansu	2.25 (2.24,2.26)	1.75 (1.74,1.76)	0.42 (0.42,0.43)	0.10 (0.10,0.11)
Qinghai	2.24 (2.22,2.26)	2.07 (2.05,2.09)	0.27 (0.26,0.28)	-
Ningxia	2.32 (2.31,2.33)	2.14 (2.13,2.15)	0.35 (0.34,0.35)	-
Xinjiang	2.35 (2.34,2.36)	2.02 (2.01,2.03)	0.38 (0.38,0.38)	-

| Provinces	Sex		Residence	
	Male	Female	Rural	Urban
Beijing	2.64 (2.61,2.67)	2.99 (2.96,3.01)	2.83 (2.81,2.84)	2.83 (2.81,2.85)
Tianjin	3.27 (3.24,3.29)	2.23 (2.21,2.25)	2.43 (2.41,2.44)	3.64 (3.61,3.67)
Hebei	3.74 (3.73,3.75)	2.91 (2.91,2.92)	2.92 (2.91,2.93)	4.21 (4.20,4.22)
Shanxi	3.32 (3.31,3.33)	2.42 (2.41,2.44)	2.83 (2.82,2.84)	2.95 (2.93,2.96)
Inner Mongolia	4.25 (4.24,4.26)	3.43 (3.42,3.44)	4.91 (4.89,4.92)	1.72 (1.71,1.73)
Liaoning	4.56 (4.55,4.57)	3.09 (3.08,3.10)	3.83 (3.82,3.84)	3.81 (3.80,3.82)
Jilin	4.23 (4.21,4.24)	3.80 (3.79,3.82)	3.76 (3.74,3.77)	4.22 (4.21,4.24)
Heilongjiang	4.47 (4.45,4.48)	3.66 (3.65,3.68)	4.22 (4.21,4.24)	3.77 (3.75,3.79)
Shanghai	1.74 (1.72,1.76)	2.40 (2.38,2.42)	2.35 (2.33,2.37)	1.81 (1.79,1.83)
Jiangsu	2.21 (2.20,2.21)	1.84 (1.83,1.85)	2.05 (2.04,2.06)	2.01 (2.00,2.01)
Zhejiang	3.08 (3.07,3.09)	1.55 (1.54,1.55)	1.82 (1.81,1.83)	2.84 (2.83,2.85)
Anhui	3.29 (3.28,3.30)	2.14 (2.13,2.15)	2.95 (2.94,2.96)	2.37 (2.36,2.38)
Fujian	2.40 (2.38,2.42)	1.77 (1.75,1.78)	2.04 (2.02,2.06)	2.05 (2.04,2.06)
Jiangxi	2.51 (2.50,2.52)	1.81 (1.81,1.82)	2.23 (2.22,2.23)	2.06 (2.05,2.07)
Shandong	2.87 (2.87,2.88)	2.44 (2.44,2.45)	2.77 (2.76,2.77)	2.50 (2.49,2.50)
Henan	3.71 (3.71,3.72)	2.82 (2.82,2.83)	2.84 (2.84,2.85)	4.01 (4.00,4.02)
Hubei	2.44 (2.43,2.46)	2.11 (2.10,2.13)	0.08 (0.08,0.09)	2.53 (2.52,2.54)

Table 3 (Continued)

Provinces	Sex		Residence	
	Male	Female	Rural	Urban
Hunan	2.51 (2.50,2.51)	1.73 (1.73,1.74)	2.00 (1.99,2.01)	2.37 (2.36,2.38)
Guangdong	2.09 (2.08,2.09)	1.26 (1.26,1.27)	1.76 (1.75,1.77)	1.58 (1.57,1.58)
Guangxi	1.91 (1.90,1.92)	1.41 (1.40,1.42)	1.32 (1.32,1.33)	2.20 (2.19,2.20)
Hainan	2.58 (2.56,2.60)	1.13 (1.12,1.14)	1.90 (1.89,1.91)	0.74 (0.71,0.76)
Chongqing	2.26 (2.25,2.28)	1.51 (1.50,1.52)	2.88 (2.86,2.91)	1.61 (1.60,1.62)
Sichuan	2.01 (2.00,2.01)	1.73 (1.72,1.74)	1.73 (1.72,1.74)	2.09 (2.08,2.10)
Guizhou	2.08 (2.08,2.09)	1.65 (1.65,1.66)	1.98 (1.97,1.99)	1.78 (1.77,1.78)
Yunnan	1.74 (1.73,1.75)	1.76 (1.75,1.78)	2.67 (2.65,2.69)	1.47 (1.46,1.48)
Tibet	3.23 (3.21,3.25)	1.05 (1.04,1.06)	2.01 (1.99,2.03)	2.45 (2.44,2.47)
Shaanxi	2.75 (2.74,2.76)	2.53 (2.52,2.55)	2.38 (2.37,2.38)	5.70 (5.66,5.74)
Gansu	2.37 (2.36,2.39)	2.10 (2.08,2.12)	1.95 (1.94,1.96)	2.99 (2.96,3.01)
Qinghai	1.98 (1.96,2.01)	2.53 (2.50,2.56)	2.25 (2.23,2.27)	2.20 (2.14,2.26)
Ningxia	3.42 (3.40,3.44)	1.46 (1.45,1.48)	2.52 (2.50,2.54)	2.10 (2.08,2.11)
Xinjiang	3.06 (3.04,3.08)	1.49 (1.48,1.50)	3.43 (3.40,3.46)	2.07 (2.06,2.08)

Table 3: **Weighted prevalence of stroke among different provinces in 2019[a] by classification, sex and residence(%[95%CI]).**
  [a]   Standardized prevalence of stroke adjusted to the 2010 China standard population, gender, age, regions, urban and rural; weighted estimates.
IS, ischemic stroke; ICH, intracerebral hemorrhage; SAH, subarachnoid hemorrhage; IM, Inner Mongolia.

may indicate the higher prevalence isn't necessarily a bad thing if it is that folks are living longer post-stroke. The outcomes for patients with stroke have gradually improved from 2002 to 2013 due to the improvement in the quality of stroke treatment and care,[33] and improvement in outcomes is reflected a slightly decreased mortality of stroke patients from 1985 to 2013 [1]. Cheng et al.[34] reported that from 2004 to 2019, the age-standardized mortality rate (ASMR) of stroke substantially decreased, with a reduction of 39.8%. Furthermore, *In the past 7 years (2013−2019), some specific programs for patients with stroke are implemented in the*
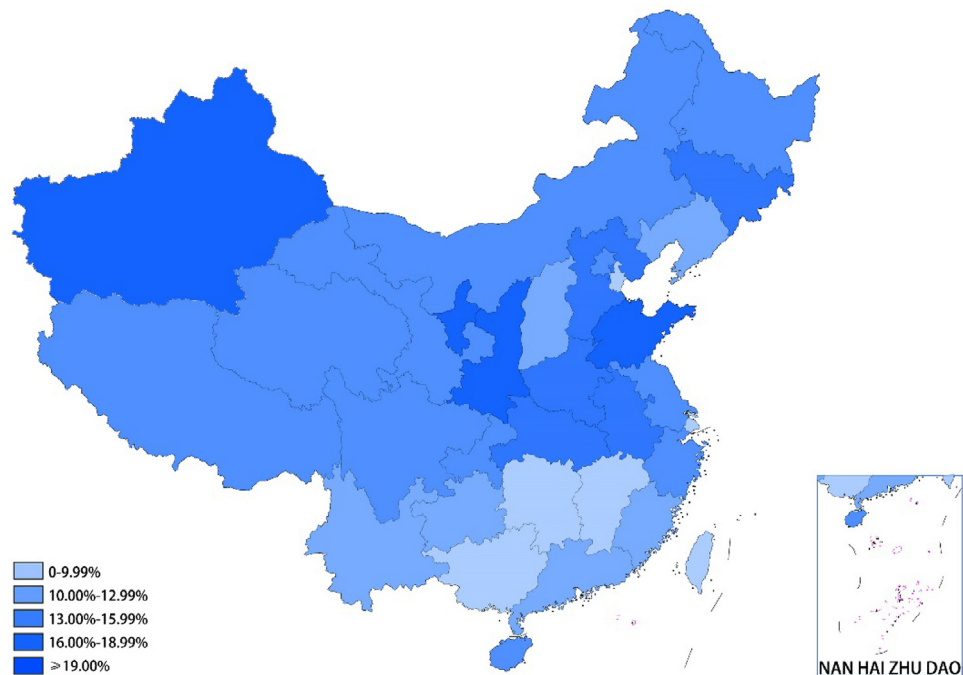
Figure 4. The relative change (%) in the weighted prevalence of stroke among Chinese adults aged ≥ 40 years from 2013 to 2019 by each province (China map ID: 1122825493).

Characteristics	All	Stroke		P
		Yes	No	
Participants, n	42,29,616	1,32,695	40,96,921	
Mean age (SD), years	59±11.28	66±9.46	59±11.25	<0.0001
Age groups				<0.0001
40−49	10,29,515 (24.34%)	6043 (4.55%)	10,23,472 (24.98%)	
50−59	12,39,506 (29.31%)	24,512 (18.47%)	12,14,994 (29.66%)	
60−69	11,52,690 (27.25%)	53,077 (40.00%)	10,99,613 (26.84%)	
70-79	6,10,183 (14.43%)	38,253 (28.83%)	5,71,930 (13.96%)	
≥80	1,97,722 (4.67%)	10,810 (8.15%)	1,86,912 (4.56%)	
Men	18,84,205 (44.55%)	66,232 (49.91%)	18,17,973 (44.37%)	<0.0001
Residence (urban)	21,72,538 (51.36%)	69,020 (52.01%)	21,03,518 (51.34%)	<0.0001
Mean BMI (SD), kg/m^2	24.2±3.53	25.0±3.73	24.2±3.52	<0.0001
BMI group				<0.0001
<18.5 kg/m^2	92,818 (2.19%)	2965 (2.23%)	89,853 (2.19%)	
18.5−23.9 kg/m^2	20,90,309 (49.42%)	50,950 (38.40%)	20,39,359 (49.78%)	
24.0−27.9 kg/m^2	15,87,089 (37.52%)	55,179 (41.58%)	1,53,1910 (37.39%)	
>=28.0 kg/m^2	4,59,400 (10.86%)	23,601 (17.79%)	4,35,799 (10.64%)	
Ethnicity				<0.0001
Han	40,63,136 (96.07%)	1,27,957 (96.43%)	39,35,179 (96.06%)	
Zhuang	24,112 (0.57%)	337 (0.25%)	23,775 (0.58%)	
Hui	29,306 (0.69%)	772 (0.58%)	28,534 (0.70%)	
Manchu	7142 (0.17%)	125 (0.09%)	7017 (0.17%)	
Uygur	10,845 (0.26%)	186 (0.14%)	10,659 (0.26%)	
Education				<0.0001
Compulsory education	28,76,513 (77.37%)	97,047 (81.35%)	27,79,466 (77.24%)	
High School	5,81,810 (15.65%)	16,261 (13.63%)	5,65,549 (15.72%)	
College and above	2,59,386 (6.98%)	5983 (5.02%)	2,53,403 (7.04%)	
Annual income, CNY				<0.0001
<5000	7,78,273 (27.42%)	33,887 (35.96%)	7,44,386 (27.12%)	
5000−10,000	4,58,262 (16.14%)	13,823 (14.67%)	4,44,439 (16.20%)	
10,000−20,000	4,62,330 (16.29%)	13,217 (14.02%)	4,49,113 (16.37%)	
>20,000	1,139,669 (40.15%)	33,317 (35.35%)	11,06,352 (40.31%)	
MI: own expense	28,820 (0.73%)	721 (0.58%)	28,099 (0.74%)	<0.0001
Marital status				
Married	35,03,445 (93.90%)	1,07,242 (89.84%)	33,96,203 (94.04%)	
Single	27,767 (0.74%)	764 (0.64%)	27,003 (0.75%)	
Widowed	1,69,583 (4.55%)	10,275 (8.61%)	1,59,308 (4.41%)	
Missing	21,353 (0.57%)	740 (0.62%)	20,613 (0.57%)	
Vascular risk factors				
Smoking status				<0.0001
Nonsmokers	35,91,302 (84.91%)	1,02,630 (77.34%)	34,88,672 (85.15%)	
Past smokers	38,851 (0.92%)	5589 (4.21%)	33,262 (0.81%)	
Current smokers	5,99,463 (14.17%)	24,476 (18.45%)	5,74,987 (14.03%)	
Consumption of alcohol	4,59,800 (14.33%)	21,679 (16.36%)	4,38,121 (14.25%)	<0.0001
Family history of stroke	3,85,000 (9.10%)	41,619 (31.36%)	3,43,381 (8.38%)	<0.0001
Hypertension[a]	17,76,543 (42.00%)	1,08,199 (81.54%)	16,68,344 (40.72%)	<0.0001
Diabetes[a]	7,71,547 (18.24%)	44,231 (33.33%)	7,27,316 (17.75%)	<0.0001
Hyperlipidemia[a]	15,69,473 (37.11%)	80,932 (60.99%)	1,48,8541 (36.33%)	<0.0001
Atrial fibrillation	45,191 (1.07%)	4343 (3.27%)	40,848 (1.00%)	<0.0001
Obesity[b]	4,57,125 (10.81%)	23,481 (17.70%)	4,33,644 (10.58%)	<0.0001
Lack of exercise	11,49,999 (27.19%)	53,195 (40.09%)	10,96,804 (26.77%)	<0.0001
TIA	75,654 (1.79%)	9397 (7.08%)	66,257 (1.62%)	<0.0001

Table 4: Characteristics of the all the study participants stratified by stroke.

[†]The results were presented as n (percentages) for categorical variables and as mean (Standard deviation, SD) for continuous variables.

[a] Diagnostic criteria were a self-reported diagnosis from 2013 to 2016.

[b] Obesity was defined as BMI≥28.0kg/m².

BMI, Body Mass Index; CNY, Chinese Yuan Renminbi; TIA, Transient Ischemic Attack; MI, Medical insurance; SD, Standard Deviation.

health care system. Stroke 1-2-0 educational programme and stroke emergency map greatly reduces prehospital rescue time.[35-36] The China Stroke Center Project, led by the CSPPC (since 2011) and the Chinese Stroke Association (since 2015),[1] has played a major role in standardizing stroke treatment and improving stroke prognosis.[37] Those programs reduce stroke mortality, which in turn leads to the increasing prevalence of stroke.

It has been reported that a belt for high incidence of stroke exists in nine provincial regions within north and west China.[38] In the present study, we confirmed that the northern and eastern regions had the highest prevalence of stroke. An 18-year prospective cohort study from 1997 to 2015 provided an extension of the current evidence on the north-to-south gradient by demonstrating that the differences varied across urban and rural China.[39] The existing evidence suggests that adherence to healthy diets (Mediterranean, DASH, or plant-based "prudent") was associated with reduced risk of stroke.[40] The geographical environments, food cultures, and dietary habits differ substantially between the southern and northern regions of China.[41] Unhealthy diets in the northern regions may cause chronic diseases such as hypertension and diabetes that can lead to the occurrence of stroke. Furthermore, PM2.5 pollution in wintertime has been worsening, especially in northern China.[42] Wellenius et al.[43] demonstrated that exposure to PM2.5 levels considered generally safe by the United States Environmental Protection Agency increased the risk of ischemic stroke onset within hours of exposure. There also have been a number papers conducted in China that have looked at acute stroke risk with air pollution,[44-46] suggesting that atmospheric PM2.5 is an independent risk factor for stroke risk. We further found that the difference in prevalence of stroke between urban and rural areas has been declining, and that the prevalence in urban areas surpassed that in rural areas in 2019. China's rapid urbanization growth during the past few decades has narrowed the urban-rural gap.[47] Moreover, increasing trends in stroke risk factors such as hypertension and diabetes were more obvious in urban populations than in rural populations.[28,30] Lastly, there are there more barriers to care or access in the north than in the south in China. The China's seventh national population census shows that the urbanization rates in the northern and southern regions of China are 63% and 65%, respectively, suggesting that these are more rural areas where resources are sparse in the Northern China.[48] In addition, the economic level and medical resources of Southern China is significantly better than that of Northern China.[49-50] These would be upstream factors that would lead to different food cultures or dietary habits as suggested.

We found that the prevalence of stroke was higher in male participants than in female in China. Truelsen et al.[51] reviewed the published data from EU countries, Iceland, Norway, and Switzerland and showed that stroke prevalence increased exponentially with age and were in most countries higher for men than for women. Similarly, in 2012, CDC reported state-specific stroke prevalence based on Behavioral Risk Factor Surveillance System (BRFSS) data for 2006-2010, showing that age-adjusted stroke prevalence was also higher for men than for women.[15] Furthermore, the prevalence of stroke and its risk factors were also higher among men in Sri Lanka.[13] Stroke incidence and mortality were higher in rural than in urban areas in North America.[52] In this study, we also found that the prevalence of stroke was higher in rural areas than in urban areas. However, Kusuima et al.[53] reported that stroke prevalence was 0.0017% in rural Indonesia, 0.022% in urban Indonesia, 0.5% among urban Jakarta adults, and 0.8% overall. Another study also showed that rural parts of South Asia have a lower stroke prevalence compared with urban areas.[54] Those different might represent varying degrees of urbanization in those countries.

The main strength of the present study is the assessment of trends in prevalence of stroke in China from 2013 to 2019. In addition, the prevalence was stratified by sociodemographic characteristics, including sex, age, residence, ethnicity, and province. These adjustments can be of great significance for the development of stroke prevention and control strategies across China and its provinces. Finally, enrolling at least 500,000 people each year made our research have extensive national coverage. The present study also has some limitations. First, we only included Chinese adults aged ≥40 years. Thus, our findings are not representative of all Chinese adults and it only show the status of the middle-aged and elderly people (≥40 years) in China. However, a previous study found that stroke patients aged <40 years accounted for <2% of all stroke patients.[2] For the high-risk population screening and intervention project, it is considered effective to select people aged ≥40 years. In addition, the screening points with a stroke prevalence of 0 will be deleted. This exclusion will lead to biased estimates, specifically the overestimation of stroke rates due to selective sampling based on our outcome of interest. Second, the northern-south gradient in prevalence of stroke across China warrants further research. Such research could be used for the adoption of stroke prevention strategies according to local conditions. Third, the study did not use representative samples because this was not possible with such rapid large-scale recruitment. The enrollment rate varied within the study period and the provinces. These disparities may have affected the estimates for prevalence and incidence of stroke. However, we used a multi-factor weighting method to calculate the prevalence of stroke, which can effectively reduce these effects. In addition, there are huge variations in the sample size between provinces. The prevalence of stroke in some provinces with limited sample size might be overestimated. And the differences across provinces may be to

some extent true, but may have been exaggerated by selection bias. Future work needs to remove these variations. Fourth, the subsequent round of the survey might include participants from the previous round and it was possible that those stroke patients may have larger motivation to participate in the study than those non-patients, which might cause potential selection bias. Fifth, minority groups in China tend to live in specific areas. The current study compared the minority groups with Han Chinese across the country, which is inappropriate. It might be more suitable to compare the minority groups with those people living in the same areas. However, at this stage, it is difficult for us to match the Han and ethnic minorities according to the place of residence. This will be a good direction for our future research. Finally, we did not obtain information on patient adherence to medications, which reduced our ability to investigate some potential reasons for suboptimal treatment. In addition, *the prevalence rate can increase with increased incidence rates as well as with reduced fatality rates. However, the change in incidence rates of this study was not obtained.*

Conclusion

The prevalence of stroke in China and most provinces has continued to increase in the past 7 years (2013−2019) and warrants a broad-based nationwide strategy for improved prevention as well as greater efforts in screening and more effective and affordable interventions. For provinces with high prevalence of stroke in particular, the present data will be useful for the Provincial Health Committee to develop targeted programs for stroke prevention and allocate medical resources.

Contributors

Dr WL had full access to all the data in the study and took responsibility for the integrity of the data and the data analysis accuracy. Study concept and design: All authors; Acquisition of data: TW, YF, BH, WL; Analysis and interpretation of data: TW, YF, ML, CL; Drafting of the manuscript: TW, YF; Critical revision of the manuscript for important intellectual content: BH, ML, CL, WL; Statistical analysis: YF, ML, CL; Administrative, technical, or material support: all authors; Obtained funding: WL, TW; Study supervision: WL.

Data sharing statement

Please contact the corresponding author (Pro. Wang) for the data request.

Declaration of interests

None.

Participating hospitals

The following hospitals took part in the China Stroke High-risk Population Screening and Intervention Program from Jan, 2013, to Dec, 2019:

The First Hospital of Hebei Medical University, Cangzhou Central Hospital, The First People's Hospital of Jingmen City, Second People's Hospital of Jiaozuo City, Anhui Provincial Hospital, Handan City First Hospital, Shuguang Hospital Affiliated to Shanghai University of Traditional Chinese Medicine, Hebei Provincial People's Hospital, Second Affiliated Hospital of Zhejiang University School of Medicine, The First People's Hospital of Huainan City, Anyang People's Hospital, Zhejiang Provincial People's Hospital, The First People's Hospital of Yibin City, Lianyungang First People's Hospital, Nanyang Nanshi Hospital, Nanjing Gulou Hospital, Luoyang Central Hospital, Affiliated Hospital of Southwest Medical University, Zhuzhou Central Hospital, The First Affiliated Hospital of Soochow University, Suzhou Municipal Hospital, Shanxi Provincial People's Hospital, Hunan Provincial People's Hospital, Shanghai Pudong Hospital, Xiangtan Central Hospital, The Second Hospital of Hebei Medical University, Yichun People's Hospital, The First People's Hospital of Huaihua City, Qingyuan People's Hospital, The First People's Hospital of Yunnan Province, Jiuquan People's Hospital, Hunan Provincial Brain Hospital, Mianyang Central Hospital, The Third People's Hospital of Datong City, Changde First People's Hospital, Yueyang First People's Hospital, 3201 Hospital, Shaoyang Central Hospital, Sichuan Provincial People's Hospital, Shengli Oilfield Central Hospital, Yongzhou Central Hospital, Xingtai People's Hospital, Chengde Central Hospital, Zhuhai People's Hospital, Changsha.

Central Hospital, Liaocheng People's Hospital, Deyang People's Hospital, Affiliated Hospital of North Sichuan Medical College, Shenzhen Second People's Hospital, Hengshui City People's Hospital, First People's Hospital of Baiyin City, Affiliated Hospital of Guizhou Medical University, Lishui Central Hospital, General Hospital of Ningxia Medical University, Shijiazhuang Third Hospital, Pingxiang City People's Hospital, Yingkou Central Hospital, The Second Affiliated Hospital of Harbin Medical University, Nantong University Hospital, Wuhan First Hospital, Three Gorges

Hospital of Chongqing University, Tongling People's Hospital, Yuncheng Central Hospital, Weihai Municipal Hospital, First Affiliated Hospital of Zhengzhou University, Yuxi City People's Hospital, Ganzhou People's Hospital, Liuyang City Jili Hospital, Shandong Provincial Hospital, Lanzhou University Second Hospital, Qingdao University Hospital, Suining Central Hospital, The First People's Hospital of Zigong City, The First People's Hospital of Shangqiu City, Nanchong Central Hospital, Baise City People's Hospital, The First Affiliated Hospital of Nanhua University, The First People's Hospital of Jining City, The First People's Hospital of Chenzhou City, Affiliated Hospital of Xuzhou Medical University, Qianfoshan Hospital of Shandong Province, Subei People's Hospital, Fuyang People's Hospital, Ningde City Hospital Affiliated to Ningde Normal University, The Second Affiliated Hospital of Kunming Medical University, Fenyang Hospital of Shanxi Province, Qinzhou Second People's Hospital, Yangmei Group General Hospital, Tianshui First People's Hospital, Linyi People's Hospital, Jiangsu Provincial People's Hospital, The Second Affiliated Hospital of Fujian Medical University, Daqing Oilfield General Hospital, Yan'an University Affiliated Hospital, Leshan City People's Hospital, People's Hospital of Dali Bai Autonomous Prefecture, Sinopharm Tongmei General Hospital, The First Affiliated Hospital of Henan University of Science and Technology, The First Affiliated Hospital of Fujian Medical University, Affiliated Hospital of Binzhou Medical University, Zhengzhou People's Hospital, Huaihe Hospital of Henan University, Beihai City People's Hospital, Henan Provincial People's Hospital, Tianjin First Central Hospital, Taihe Hospital of Shiyan City, People's Hospital of Inner Mongolia Autonomous Region, Baoding First Hospital, The Second People's Hospital of Wuhu City, Heping Hospital Affiliated to Changzhi Medical College, Liuzhou Workers Hospital, Zhoukou Central Hospital, Shaoxing People's Hospital, Tonghua Central Hospital, Dezhou People's Hospital, The First People's Hospital of Yulin City, Maanshan City People's Hospital, The Fifth Affiliated Hospital of Xinjiang Medical University, Zhanjiang Central People's Hospital, The First People's Hospital of Jiujiang City, Hangzhou First People's Hospital, Qilu Hospital of Shandong University, Liaocheng Second People's Hospital, Sanming First Hospital, Wenzhou Central Hospital, Yuebei People's Hospital, Gansu Provincial People's Hospital, Changzhou First People's Hospital, Xiangyang First People's Hospital, Sanya Central Hospital, Pingdingshan First People's Hospital, Chinese People's Liberation Army Army Characteristic Medical Center, Xuchang Central Hospital, Jiyuan City People's Hospital, Qiqihar First Hospital, Jiangxi Provincial People's Hospital, Harbin Second Hospital, The First Hospital of Qinhuangdao City, Yibin Second People's Hospital, The Fifth Affiliated Hospital of Zhengzhou University, The First Hospital of Jilin University,

Anqing Municipal Hospital, Benxi Central Hospital, Xiaogan Central Hospital, The First Affiliated Hospital of Xinxiang Medical College, Guilin People's Hospital, The Third People's Hospital of Hubei Province, Xiangya Hospital of Central South University, Mudanjiang Second People's Hospital, People's Hospital of Ningxia Hui Autonomous Region, The First Affiliated Hospital of Nanchang University, The First People's Hospital of Jingdezhen City, The First People's Hospital of Jinzhong City, The First People's Hospital of Yancheng City, The First Affiliated Hospital of Jiamusi University, Dandong Central Hospital, Affiliated Hospital of Weifang Medical College, Guizhou Provincial People's Hospital, Qingyang People's Hospital, Ordos Central Hospital, Tai'an Central Hospital, Affiliated Hospital of Yanbian University, Taizhou Hospital, West China Hospital of Sichuan University, Xiyuan Hospital of China Academy of Chinese Medical Sciences, Luohe Central Hospital, Wuzhou Red Cross Hospital, Inner Mongolia Forestry General Hospital, General Hospital of the Northern Theater of the Chinese People's Liberation Army, Huzhou Central Hospital, Peking University Third Hospital, Haikou People's Hospital, Hainan Provincial People's Hospital, Yantai Yuhuangding Hospital, Kunming Yan'an Hospital, Hebi City People's Hospital, The First Hospital of Shanxi Medical University, Nanyang Central Hospital, Xuanwu Hospital of Capital Medical University, Baotou Central Hospital, Xinyang Central Hospital, Affiliated Hospital of Inner Mongolia University for Nationalities, The First Affiliated Hospital of Xi'an Jiaotong University, The First Affiliated Hospital of Anhui Medical University, Zhongshan People's Hospital, Qinghai Provincial People's Hospital, Liaoning Provincial People's Hospital, The First People's Hospital of Qujing City, Jinzhou Central Hospital, Zhumadian Central Hospital, The Second Affiliated Hospital of Nanchang University, People's Hospital of Guangxi Zhuang Autonomous Region, Liaoyang Central Hospital, Dingzhou People's Hospital, Nanjing Brain Hospital, Shenyang First People's Hospital, Linfen Central Hospital, Beijing Anzhen Hospital, Capital Medical University, Wuxi Second People's Hospital, Heilongjiang Provincial Hospital, Chifeng City Hospital, Sanmenxia Central Hospital, Longyan First Hospital, Xinyu City People's Hospital, Chongqing People's Hospital, Affiliated Hospital of Qinghai University, Affiliated Hospital of Zunyi Medical University, Dongfang Hospital, Beijing University of Chinese Medicine; Chaoyang Central Hospital; Affiliated Hospital of Inner Mongolia Medical University; Jilin Provincial People's Hospital; Jilin Central Hospital; Sanya People's Hospital; Wuwei City People's Hospital; Tangshan Workers Hospital; The Second Hospital of Tianjin Medical University; Hanzhong Central Hospital; Dalian Central Hospital; The First Affiliated Hospital of Xiamen University; The First Affiliated Hospital of China Medical University; Puyang Oilfield General Hospital; Yulin

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