The Burden of Stroke in The Municipality of Chongqing, China, From 1990 To 2016

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Abstract

Background: The burden of stroke varies substantially across regions in China. However, comprehensive comparisons between regions are lacking. This study aims to analyze variations in stroke burden in the municipality of Chongqing, Western China, from 1990-2016.

Methods: Data on prevalence, years lived with disability (YLDs), mortality, years of life lost (YLLs), and disability-adjusted life years (DALYs) by age, sex, location, and year were extracted from the 2016 Global Burden of Disease Study (GBD 2016) of China between 1990-2016. The datasets were compared to examine the temporal trends in stroke burden in the last two decades.

Results: In 2016, there were 670,438 cases of stroke, 41,022 deaths, and 847,437 DALYs due to stroke in Chongqing. Age-standardized mortality and DALY rates of IS and HS were higher in men whereas age-standardized prevalence rates of IS were higher in women. From 1990 to 2016, age-standardized prevalence rates of overall stroke increased by 33.29%, whereas mortality rates and DALYs decreased by 34.51% and 34.79%, respectively. YLLs were the main contributor to DALYs; however, the YLL/YLD ratio decreased over time. During the study period, the overall burden of stroke decreased, whereas the prevalence rate of IS increased in all age groups.

Conclusions: Despite a decrease in mortality rates, the increase in the prevalence of stroke in Chongqing stresses the need to allocate more health resources. Special attention should be paid to discrepancies in the estimation of the type of stroke according to gender and age to determine mechanisms that explain the causes of stroke.

Background

As the main causes of death have transitioned to non-communicable diseases, such as stroke and heart disease¹, the increasing burden of stroke has become a global problem. Stroke (classified as ischemic stroke [IS] or hemorrhagic stroke [HS]) is a major contributor to death and disability globally². The quality of life of stroke patients is significantly impaired, resulting in significant financial losses^{3,4}. According to the Global Burden of Disease Study (GBD), stroke is the second leading cause of death⁵ and the third main cause of disability-adjusted life years (DALYs) worldwide⁶. In China, approximately 1.8 million people died from stroke in 2016, accounting for one-fifth of all-cause deaths and one-third of global stroke deaths, corresponding to 38 million DALYs (33% of total DALYs in globe)⁷.

The GBD showed substantial variations in stroke burden across countries, with a higher decrease in burden in high-income countries than in low- and middle-income countries⁸. Similarly, the stroke burden in China varied greatly between provinces/cities⁹; however, trends in specific regions are unclear. Chongqing, a large city with over 30 million people in 2018, is one of four municipalities and a financial and economic center in China. Rapid industrialization and urbanization improved socioeconomic conditions in Chongqing over the past two decades. Current studies mainly focused on deaths from all causes¹⁰ or communicable diseases¹¹. Nonetheless, the comprehensive comparison of stroke burden between regions is limited. Based on the data on stroke in Chongqing between 1990 and 2016, we comprehensively compared stroke burden by sex and age and analyzed the temporal trends in indicators of prevalence, mortality, and DALYs¹². This study provides relevant information on the current stroke burden in Western China, and the results can serve as a reference for studies conducted in other regions of China.

Methods

Overview

The datasets were obtained from GBD 2016 estimates for China at the sub-national level. GBD 2016 is a continuous effort to comprehensively and systematically provide estimates on prevalence, mortality, and DALYs for 264 causes of death, 328 diseases and injuries, and 84 risk factors at the global, regional, national, and sub-national level from 1990 to 2016 by integrating all available data¹³⁻¹⁶. Stroke was defined according to the WHO clinical criteria¹⁷. IS (G45-G46.8, I63-I63.9, I65-I66.9, I67.2-I67.3, I67.5-I67.6, I69.3) and HS (I60-I62.9, I67.0-I67.1, I68.1-I68.2, I69.0-I69.2) were defined as the cause of disease according to the Tenth Revision of the International Classification of Diseases (ICD-10).

Data analysis

The indicators of prevalence, mortality, and DALYs were used to measure the burden of stroke. The Cause of Death Ensemble modeling (CODEm) was used to estimate all-cause and cause-specific mortality. The DisMod-MR model was adopted to estimate non-fatal diseases. The methods used to measure all-cause and cause-specific mortality in GBD 2016 were described previously^{18,19}. Data on mortality and prevalence were obtained by searching systematic reviews, population surveys, and registries, such as mortality surveillance, chronic diseases and risk factors surveillance survey, maternal and child surveillance, national health services survey, and population census of China²⁰. DALYs were measured as the sum of years of life lost prematurely (YLLs) and years lived with disability (YLDs). YLLs were calculated by multiplying the stroke deaths in each age group by global age-specific reference life expectancy, and YLDs were estimated by multiplying the number of stroke cases by the disability weight^{6,21,22}. The rates were age-standardized using the global population to adjust for the effects of age. The percentage change for each indicator from 1990 to 2016 was calculated to determine temporal trends over time.

Uncertainty interval

95% uncertainty intervals (UIs) at the 2.5th and 97.5th percentiles were determined in the GBD 2016 by taking 1000 draws in the modeling process to test the normality of the variables²⁴⁻²⁶. Any two estimates with non-overlap of their 95% UIs are significantly different.

Results

Stroke burden in 2016

In 2016, there were 670,438 (95% UIs, 613,408–734,103) cases of stroke in Chongqing, including 556,458 (493,812–623,272) cases of IS and 139,690 (125,005–157,618) cases of HS. The age-standardized prevalence rates of IS and HS were significantly higher in women and men, respectively.

It was estimated that 41,022 (35,976–46,151) people died from stroke in 2016, including 11,621 (10,162–13,156) deaths from IS (28.33%) and 29,401 (25,674–33,093) deaths from HS (71.67%). Men had significantly higher mortality from IS and HS than women. In total, there were 847,437 (751,051–948,683) DALYs caused by stroke, including 288,260 (247,237–329,020) from IS (34.02%) and 559,178 (487,336–6313,06) from HS (65.98%). The age-standardized DALYs due to IS and HS were higher in men than in women (Table 1).

Table 1
The number and age-standardized rates of prevalence, death, DALY from stroke, IS and HS

disease and both genders	Prevalence[95%UI]			Prevalence rate(per 100000) [95%UI]			Deaths[95%UI]			death
	1990	2016	%change	1990	2016	%change	1990	2016	%change	1990
Stroke										
male	68106.19 (74518.76-62159.69)	282035.75 (315401.43-253287.90)	314.11	1115.61 (1221.89-1022.55)	1475.19 (1633.66-1337.99)	32.23	9109.90 (10727.67-7781.70)	25246.51 (29500.71-21457.60)	1.77	209.7 (244.1-181.1)
female	89332.83 (96977.70-82274.51)	388402.53 (425601.53-355382.99)	334.78	1505.89 (1632.13-1389.36)	2019.77 (2201.61-1855.95)	34.12	7561.04 (10345.07-6056.92)	15775.82 (18690.42-13138.47)	1.09	159.4 (219.1-128.5)
both sexes	157439.02 (170250.45-145467.77)	670438.28 (734103.02-613407.81)	325.84	1311.67 (1419.61-1213.65)	1748.38 (1904.40-1611.89)	33.29	16670.94 (20578.35-14425.83)	41022.33 (46150.99-35975.93)	1.46	182.2 (226.1-158.6)
Ischemic stroke										
male	49318.72 (55090.84-44003.48)	216237.67 (250178.45-189325.21)	338.45	798.50 (897.96-707.52)	1135.12 (1307.00-999.46)	42.16	1716.92 (2030.93-1422.05)	6917.94 (8148.00-5776.13)	3.03	44.14 (52.0-37.07)
female	74113.87 (81224.70-67053.65)	340220.70 (380658.87-300535.44)	359.05	1242.76 (1363.89-1123.09)	1768.26 (1968.71-1572.79)	42.29	1529.19 (2139.35-1195.57)	4703.05 (5589.62-3917.09)	2.08	34.37 (48.4-27.21)
both sexes	123432.58 (135584.91-111549.21)	556458.37 (623271.98-493812.35)	350.82	1022.40 (1127.36-922.21)	1452.53 (1618.34-1299.71)	42.07	3246.10 (4000.05-2780.20)	11620.99 (13156.16-10161.78)	2.58	38.73 (48.4-33.21)
Hemorrhagic stroke										
male	21215.34 (23563.52-19314.81)	76268.19 (86334.53-67644.85)	259.50	355.44 (395.09-323.27)	400.03 (448.66-357.90)	12.54	7392.98 (8784.03-6309.08)	18328.57 (21461.48-15401.53)	1.48	165.6 (195.1-143.1)
female	18341.95 (20390.34-16396.87)	63421.88 (71302.59-56747.18)	245.77	314.97 (352.34-280.15)	335.59 (374.27-303.85)	6.55	6031.85 (8144.30-4823.44)	11072.77 (13228.50-9173.17)	0.84	125.0 (170.1-100.1)
both sexes	39557.29 (43580.73-35947.00)	139690.06 (157618.16-125005.07)	253.13	334.67 (370.28-303.48)	367.91 (410.80-331.55)	9.93	13424.84 (16590.19-11578.75)	29401.34 (33092.64-25673.71)	1.19	143.5 (178.1-124.5)
Legend: Table 1 shows the number and age-standardized rates of prevalence, death, DALY.										

In 2016, YLDs and YLLs accounted for 16.79% and 83.21% of DALYs, with the YLD/DALY ratio and YLL/DALY ratio being 39.63% and 60.37% for IS, and 5.02% and 94.98% for HS, respectively. The YLL/YLD ratios for stroke, IS, and HS were 5.03, 1.57, and 19.00, respectively. These results suggested that premature mortality was the main contributor to DALYs caused by stroke, especially HS (Table 2).

Table 2
Age-standardized YLL and YLD rates and YLLs/YLDs ratios for stroke, IS and HS in 1990 and 2016 in Chongqing

disease and both genders	YLLs(95%UI)			Age-standardized YLL rate(per 100000)[95%UI]			YLD(95%UI)			Age-standardized YLL/YLD ratio	
	1990	2016	%change	1990	2016	%change	1990	2016	%change	1990	2016
Stroke	361101 (311915–437094)	705147 (609261–798660)	95.28	3183.11 (3895.82–2767.48)	1881.64 (2124.44–1633.55)	-40.89	32387 (23092–41724)	142290 (99312–183280)	339.35	275.69 (354.96–195.03)	37.4 (4.26–26.6)
Ischemic stroke	59027 (50191–71871)	174031 (150549–198442)	194.83	573.46 (704.31–490.64)	469.57 (533.71–408.17)	-18.12	24595 (17043–31971)	114228 (77960–149175)	364.43	208.18 (270.72–144.57)	29.3 (3.20–20.6)
Hemorrhagic stroke	302074 (260423–364966)	531116 (459251–602779)	75.82	2609.66 (3185.48–2251.39)	1412.06 (1595.73–1228.85)	-45.89	7791 (5455–10066)	28062 (20140–36533)	260.17	67.51 (86.91–47.02)	74.9 (9.53–53.3)

Legend: Table 2 shows age-standardized YLL and YLD rates and YLLs/YLDs ratios for stroke, IS and HS.

The age-standardized prevalence, mortality, and DALYs rates increased with age and reached a peak in the age group > 70 years. However, the increase in mortality was much higher than the increase in prevalence in the age groups 50–69 years and > 70 years (Figs. 1B, 2B, and 3C).

Trends in the burden of stroke from 1990 to 2016

Age-standardized prevalence rates from stroke increased by 33.29% (42.07% for IS and 9.93% for HS), from 1311.67 (1213.65–1419.61) in 1990 to 1748.38 (1611.89–1904.40) in 2016, with a higher increase from 2010 onwards. There was no significant difference in the prevalence of stroke and IS between the sexes, whereas the rate of HS was much higher in men.

The age-standardized mortality rates from total stroke, IS, and HS decreased by 34.51%, 9.25%, and 41.33%, i.e., from 182.27 (158.67–226.31), 38.73 (33.21–48.48), and 143.54 (124.58–178.76) in 1990 to 119.37 (105.23–133.84), 35.15 (30.84–39.80), and 84.22 (73.82–94.47) in 2016, respectively, and the rates were higher among women. Although overall trends varied over time, the mortality rates from HS peaked in 2000 and then decreased. Similarly, DALYs caused by total stroke, IS, and HS decreased by 34.79%, 1.59%, and 44.48%, respectively, and were higher among women. The death rate from total stroke and HS was higher in the period 2005–2016 compared to 1990–2005 (Table 1; Figs. 1A, 2A, and 3A).

Regarding overall stroke, age-standardized YLL rates decreased by 40.89% (18.12% for IS, 45.89% for HS), and age-standardized YLD rates increased by 35.64% (43.93% for IS, 10.10% for HS). The YLL/YLD ratio for stroke (42.91% from IS and 50.85% from HS) decreased by 56.45% from 1990 to 2016. Although YLLs were higher than YLDs, the latter was the major contributor to the increase in DALYs (Table 2).

Prevalence, death rates, and DALYs due to IS and HS decreased significantly from 1990 to 2016 in the age group < 15 years. The percentage change in the burden of HS was decreased in the age group ≥15 years. The percentage change in prevalence and mortality from IS showed an increasing and decreasing trend, respectively, except in individuals aged 15–49 and > 70 years) (Figs. 1C, 2C, and 3C).

Discussion

This study is the first to estimate stroke burden by cause, sex, and age in Chongqing from 1990 to 2016. Total prevalence, mortality, and DALYs increased during the study period. Despite the improvement in mortality of HS, the prevalence of IS increased during this period. Mortality from stroke and HS increased slightly from 1990 to 2002 and decreased subsequently, which was consistent with the findings at the national level, with an increase in stroke mortality from 1988 to 2000 and a decrease from 2000 to 2004²⁷. The DALYs due to stroke and HS continued to decline from 1990 to 2016, and the decrease was more pronounced after 2005, which may be due to improvements in medical care and technology, higher access to health care, and increased health consciousness. In China, the recording, diagnosis, treatment, and rehabilitation of stroke patients have improved with economic development²⁸, the adoption of the Chinese National Stroke Registry for patients with acute cerebrovascular events²⁹, and the increased use of computer tomography and magnetic resonance imaging for stroke diagnosis³⁰.

Previous studies determined stroke incidence and mortality by age group in China; however, few studies have analyzed the patterns of prevalence and DALYs by age group²⁰. Our results indicated that mortality from stroke was much higher in the age group > 70 years, and prevalence was higher in individuals aged > 50 years. Older patients with stroke had a higher risk of comorbidities, including hypertensive disease, diabetes mellitus, and peripheral artery disease; however, few guideline-recommended therapies are available to this population³¹. Since population aging has become a growing concern in China³², strengthening the provision of health care and managing public health resources are crucial.

The prevalence of stroke was higher in individuals aged > 50 years, and the percentage change in prevalence was higher in subjects aged > 15 years in Chongqing, which agrees with data from other countries^{33–36}. In addition to common vascular risk factors, such as hypertension and dyslipidemia³⁷, the increasing burden of stroke may be associated with increased working hours, cigarette smoking, and physical inactivity.

The results showed that the burden of IS increased, whereas the burden of HS decreased between 1990 and 2016 in Chongqing, which is consistent with the findings from Tianjin, China³⁸, and China National Stroke Register's study³⁹. A possible explanation is that specific risk factors for IS increased with economic

growth. Some atherosclerotic risk factors, including diets rich in fat and cholesterol, are closely related to unhealthy lifestyles^{30,40}. Moreover, cardioembolism is an important contributor to IS, and patients with atrial fibrillation are at an increased risk of acute IS^{27,36,39}.

In Chongqing, women had a higher prevalence of stroke, whereas men had higher mortality and DALYs, which agrees with a previous study³³. This result can be partly explained by the different behavioral patterns between sexes. For instance, the prevalence of smoking and alcohol consumption is higher among men. In 2015, there were 316 million smokers in China, accounting for 27.7% of the overall population, predominantly in men being 52.1%²⁵.

This study showed that age-standardized YLLs and the YLL/YLD ratio decreased over time, indicating that the prevalence of stroke increased in Chongqing. Although improvements in medical technology and rapid urbanization decreased the rescue time⁴⁰, it is difficult to completely cure stroke patients because they usually have sequelae of apoplexy, including hemiplegia, language disorders, and memory deterioration. These sequelae can partly explain the increased prevalence of stroke.

Since the results were based on the GBD 2016 estimates, the limitations of GBD¹⁴ may apply to the present study. This study estimated the stroke burden in Chongqing, China, but the available data do not allow determining differences between provinces. Second, data for non-fatal outcomes were limited, which might prevent accurately measuring YLDs. Third, as our results were based on GBD estimates for secondary use of health data, we cannot provide 95% UIs of percentage changes for the period 1990–2016.

Conclusion

The burden of stroke increased from 1990 to 2016 in Chongqing, but the age-standardized mortality rates decreased significantly, which might be due to improvements in medical care and technology, increased access to primary health care, and implementation of public health interventions. Despite decreased mortality rates from stroke, the increase in prevalence rates in the municipality of Chongqing, China, underscores the need to allocate health resources and control risk factors. In addition, discrepancies in the estimation of stroke according to subcategories (IS and HS), gender, and age should be addressed before allocating resources and formulating health policies at the provincial level.

Abbreviations

YLD: years lived with disability; YLL: years of life lost; DALY: disability-adjusted life years; GBD: Global Burden of Disease study; IS: ischemic stroke; HS: hemorrhagic stroke; ICD: International Classification of Diseases.

Declarations

Acknowledgments

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Authors' contributions

WSL and BXD conceived of the study and provided overall guidance. YSY and SR performed the data analysis. YSY prepared the initial draft. All authors critically reviewed and revised the manuscript for important content.

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Availability of data and materials

The data are based on the 2016 GBD study and available from the corresponding authors on reasonable request.

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interest

The authors declare that they have no conflict of interests.

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Figures

Figure 1

Prevalence rates by years and age groups, and percentage change in age-standardized prevalence rate between 1990 and 2016 A: prevalence rates by years. B: prevalence rates in 2016 by age groups. C: percentage change in age-standardized prevalence rate between 1990 and 2016 by age group

Figure 2

Death rates by years and age groups, and percentage change in age-standardized death rate between 1990 and 2016 A: Death rates by years. B: Death rates in 2016 by age groups. C: percentage change in age-standardized death rate between 1990 and 2016 by age group

Figure 3

DALY rates by years and age groups, and percentage change in age-standardized DALY rates between 1990 and 2016 A: DALY rates by years. B: DALY rates in 2016 by age groups. C: percentage change in age-standardized DALY rate between 1990 and 2016 by age group