


Loss of life expectancy due to stroke and its subtypes in urban and rural areas in China, 2005–2020

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ABSTRACT

Stroke is characterised by high mortality and disability rate in China. This study aimed to explore the temporal trends in years of life lost (YLL) and loss of life expectancy due to stroke and its subtypes in urban and rural areas in China during 2005–2020. Data were obtained from China National Mortality Surveillance System. Abbreviated life and stroke-eliminated life tables were generated to calculate loss of life expectancy. The YLL and loss of life expectancy due to stroke in urban and rural areas at both national and provincial level during 2005–2020 were estimated. In China, the age-standardised YLL rate due to stroke and its subtypes were higher in rural areas than in urban areas. The YLL rate due to stroke showed a downward trend in both urban and rural residents from 2005 to 2020, decreased by 39.9% and 21.5%, respectively. Loss of life expectancy caused by stroke decreased from 1.75 years to 1.70 years from 2005 to 2020. During which, loss of life expectancy due to intracerebral haemorrhage (ICH) decreased from 0.94 years to 0.65 years, while that of ischaemic stroke (IS) increased from 0.62 years to 0.86 years. A slightly upward trend was observed in loss of life expectancy caused by subarachnoid haemorrhage (SAH), from 0.05 years to 0.06 years. Loss of life expectancy due to ICH and SAH was always higher in rural areas than in urban areas, whereas that of IS was higher in urban areas than in rural areas. Rural males suffered the greatest loss of life expectancy due to ICH and SAH, while the highest loss of life expectancy caused by IS was found in urban females. Furthermore, Heilongjiang (2.25 years), Tibet (2.17 years) and Jilin (2.16 years) were found to have the highest loss of life expectancy caused by stroke in 2020. Loss of life expectancy caused by ICH and SAH was higher in western China, while the disease burden of IS was heavier in northeast China. Stroke remains a major public health problem in China, although the age-standardised YLL rate and loss of life expectancy due to stroke decreased. Evidence-based strategies should be conducted to reduce the premature death burden caused by stroke and prolong life expectancy in Chinese population.

INTRODUCTION

Stroke is characterised by high mortality and disability rate worldwide. The Global Burden of Diseases, Injuries and Risk Factors Study 2019 (GBD 2019) indicated that stroke was the second-leading cause of death (COD) and the third-leading cause of disability-adjusted

life years (DALYs) globally in 2019.¹ The total number of deaths due to stroke in China accounted for 33.4% of that in the world, and the age-standardised mortality rate of stroke in China was 1.5-fold higher than the global average in 2019 (127.2 vs 84.2/100 000).^{1,2} In addition to the evidence showing the high mortality for stroke in Chinese population, years of life lost (YLL) have been more and more commonly used to characterise premature death and disease burden as it takes the death count and life expectancy at death into consideration and assigns higher weights to deaths occurred at younger ages.³ A recent study based on GBD data estimated the YLL of stroke in China and its provinces in 2019.² However, the urban–rural differences were not explored in the GBD.

Life expectancy is an integrated indicator frequently used to reflect overall health of a population.⁴ The evaluation of cause-eliminated life expectancy could reflect the contributions of specific diseases on life expectancy and has important implications from policy-makers' perspective, particularly in China where the resources are limited and unevenly distributed. The loss of life expectancy caused by stroke in urban and rural areas in different provinces remains unclear in China.

In this study, we aimed to estimate the trend of YLL and loss of life expectancy due to stroke and its subtypes from 2005 to 2020, by using data from China National Mortality Surveillance System (NMSS). In addition, we explored the differences of loss of life expectancy due to stroke and its subtypes by sex, urban and rural areas and provinces during the study period.

MATERIALS AND METHODS

Data source

Data for mortality of stroke and its subtypes were obtained from the NMSS in China, which covers over 300 million individuals (about

24% of the Chinese population) from 605 surveillance points in urban or rural areas in 31 provincial administrative regions that provide reliable mortality data at both national and provincial level. The definition of urban and rural area was based on the permanent residence address of the deceased person. Urban areas included districts in municipalities or prefecture-level cities, and rural areas included counties and county-level cities. Details about this system have been described elsewhere.⁵ Under-reporting is an important issue of population-based NMSS and we used under-reporting rate (URR) to adjust the crude mortality rate to obtain the true mortality level in China. URR was obtained by the under-reporting field surveys which were implemented regularly in NMSS every 3 years. We used data from under-reporting field survey in 2009, 2012, 2015 and 2018 to retrospectively acquire URR in 2006–2008, 2009–2011, 2012–2014 and 2015–2017, respectively. By comparing the death data between field survey system and the routine online surveillance system, URR was calculated based on the propensity score weighting method. And URR at national level on average for every 3 years were 12.9%, 17.1%, 22.7% and 9.4%, respectively. The detailed descriptions of under-reporting field surveys have been reported previously.⁶ Data for under-5 mortality rate at county level were separately obtained from the GBD Study, considering higher URR among children in NMSS.⁷ Data for surveillance population and socioeconomic covariates were acquired from China National Bureau of Statistics.

Stroke mortality estimation

We first estimated all-cause mortality during 2005–2020 and the detailed methods have been reported in previous publications.^{8–10} Briefly, we adjusted all-cause mortality rate by using URR annually for each age-sex stratum among all surveillance sites during 2006–2017. Provincial age-sex all-cause mortality rates from population-weighted counts in each site from 2005 to 2018 were derived, followed by the estimation of probabilities of death for children aged under 5 years (5q0) and adults aged 15–60 years (45q15) at provincial level. We used a new relational model life table system with flexible standard based on two parameters of 5q0 and 45q15 to generate a full set of age-sex-specific mortality rate for 31 provinces during 2005–2018.¹¹ Generalised linear model over time was used to predict all-cause mortality in 2019 and 2020.

Second, accurate COD analysis is essential for determining public health intervention priorities and assessing the health status of the population. For NMSS, we coded and classified the COD through International Classification of Diseases 10th Edition (ICD-10). However, not all death cases could be coded into explicit COD clearly. Garbage codes were defined as deaths with non-specific codes, deaths that could not be underlying COD, or deaths assigned to intermediate but not underlying COD. The proportion of the garbage codes was 6.17% (urban 7.32%, rural 5.49%) in NMSS in 2020. Therefore, we redistributed the garbage codes and estimated the mortality

for stroke and its subtypes with underlying COD based on ICD-10 (ICD-10 codes: stroke: I60–I63.9, I65–I67.9, I69–I69.8; intracerebral haemorrhage (ICH): I61–I62.9, I69.1–I69.2; ischaemic stroke (IS): I63–I63.9, I65–I66.9, I67.2–I67.3, I67.5–I67.6, I69.3; subarachnoid haemorrhage (SAH): I60–I60.9, I69.0), by using the methods developed by Naghavi *et al.* The detailed process of garbage codes redistribution was made in three different approaches: (1) redistributed according to proportions of target codes; (2) redistributed according to determinate coefficients and (3) redistributed according to coefficients estimated from NMSS data modelling.¹² The proportion of COD due to Communicable, maternal, neonatal and nutritional diseases, Chronic diseases, Injuries in 2020 were 1.81%, 85.25%, 5.98%, respectively. After garbage codes redistribution, the proportion of COD due to the three major groups of disorders changed to 2.98%, 90.41% and 6.61%, respectively. Furthermore, the proportion of COD due to cardiovascular diseases changed from 46.89% to 49.15%. Stroke mortality rate by location-year-sex-age group was calculated by multiplying by all-cause mortality rate generated previously and proportion of stroke. In terms of a steady change for stroke mortality, we used generalised linear model to predict stroke mortality in 2019 and 2020.

YLL and cause-eliminated life expectancy estimation

YLLs due to premature death were computed by the number of deaths at each age multiplied by a standard life expectancy at that age.¹³ We used a theoretical minimum risk reference life table in YLL computation for stroke and its subcategories during 2005–2020.¹⁴

Life expectancy was referred to life expectancy at birth in the abbreviated life table. Stroke eliminated life expectancy was the life expectancy after eliminating deaths caused by stroke and was calculated by compiling an abbreviated life expectancy table removing all deaths caused by stroke from each of the age group. Loss of life expectancy due to stroke was then calculated by subtracting life expectancy from stroke eliminated life expectancy for each year during the study period.

Statistical analysis

Age-standardised mortality and YLL rates were calculated using the sixth national census of China as standard population. In this study, all statistical analyses were carried out with SAS V.9.4 (SAS Institute).

RESULTS

The estimated number of YLL due to stroke increased from 30 997 261 (10 878 877 in urban, 20 118 384 in rural) in 2005 to 35 801 420 (12 438 749 in urban, 23 362 671 in rural) in 2020 in China, while the age-standardised YLL rate had decreased by 29.2%, from 2788.6/100 000 to 1974.5/100 000. Overall, age-standardised YLL rate due to stroke and its subtypes were higher in rural areas than in urban areas. The YLL rate due to stroke in urban and rural areas was 1637.1/100 000 and 2217.8/100 000 in

Table 1 Estimated YLLs of stroke and its subtypes in China, by region, 2005 and 2020

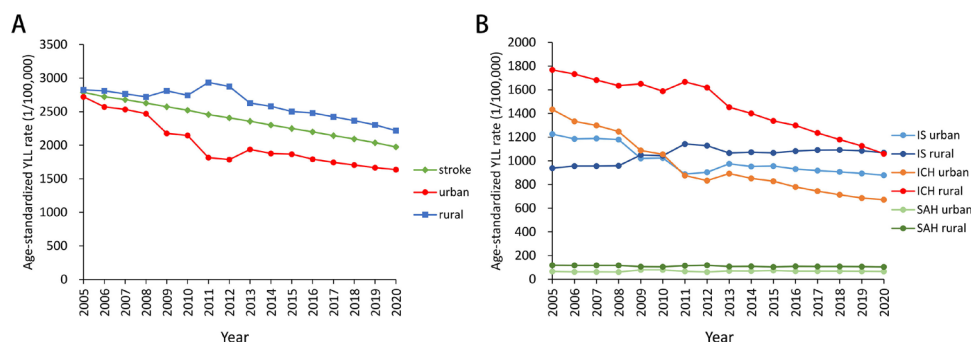
	Number of YLL			Age-standardised YLL rate (1/100 000)		
	2005	2020	Percentage change, 2005–2020	2005	2020	Percentage change, 2005–2020
Stroke						
Total	30997261	35801420	15.5%	2788.6	1974.5	–29.2%
Urban	10878877	12438749	14.3%	2721.9	1637.1	–39.9%
Rural	20118384	23362671	16.1%	2826.0	2217.8	–21.5%
Intracerebral haemorrhage						
Total	18454084	15872535	–14.0%	1647.9	897.5	–45.5%
Urban	5772397	4979457	–13.7%	1433.6	671.9	–53.1%
Rural	12681687	10893078	–14.1%	1768.2	1060.2	–40.0%
Ischaemic stroke						
Total	11404827	18384625	61.2%	1041.6	988.6	–5.1%
Urban	4825666	6847139	41.9%	1225.7	878.7	–28.3%
Rural	6579161	11537486	75.4%	938.2	1067.9	13.8%
Subarachnoid haemorrhage						
Total	1138350	1544261	35.7%	99.1	88.4	–10.8%
Urban	269142	483011	79.5%	65.2	66.0	1.2%
Rural	869207	1061250	22.1%	118.2	104.6	–11.5%

YLL, years of life lost.

2020, respectively (table 1). The age-standardised YLL rate due to stroke showed a downward trend in both urban and rural residents from 2005 to 2020, decreased by 39.9% and 21.5%, respectively. The ratio of YLL rate in rural compared with urban areas increased from 1.04 in 2005 to 1.35 in 2020, while the YLL rate in rural and urban areas decreased broadly in parallel during 2013–2020. However, a different pattern was observed between 2009–2012 and 2013–2020, which might be attributed to the data noise or fluctuations during 2012–2013, particularly in rural areas (figure 1A). A marked reduction of YLL rate was observed in ICH in both urban and rural areas. The YLL rate due to IS had decreased by 28.3% in urban areas from 2005 to 2020, while the rate in rural areas increased by 13.8%. However, the YLL rate due to IS in both urban and rural areas remained fairly stable

during 2013–2020. Furthermore, the YLL rate due to SAH showed a relatively flat trend from 2005 to 2020 (figure 1B).

Overall, life expectancy at birth of Chinese population progressively increased from 73.00 years in 2005 to 77.74 years in 2020. Potential gains in life expectancy after eliminating deaths from stroke decreased from 1.75 years to 1.70 years during 2005–2020. Life expectancy was up to 79.44 years in 2020 in the absence of deaths from stroke (figure 2). Loss of life expectancy caused by stroke in urban areas decreased from 1.82 years in 2005 to 1.68 years in 2020, while the loss years in rural areas fell back to approximately that in 2005 after a slight rise. Rural residents always suffered greater loss of life expectancy due to stroke than urban residents since 2009 (figure 3). As for the subtypes, loss of life expectancy caused by ICH


Figure 1 Age-standardised YLL rate due to stroke (A) and its subtypes (B) in China, by region, 2005–2020. YLL, years of life lost; IS, ischaemic stroke; ICH, intracerebral haemorrhage; SAH, subarachnoid haemorrhage.

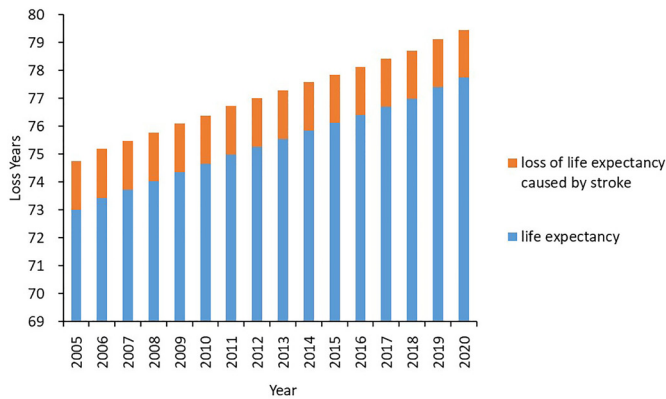


Figure 2 Life expectancy after eliminating deaths from stroke in China, 2005–2020.

showed a marked downward trend, which decreased from 0.94 years to 0.65 years, while that of IS increased from 0.62 years to 0.86 years. Besides, a slightly upward trend was observed in loss of life expectancy caused by SAH, which increased from 0.05 years to 0.06 years (figure 4A). Otherwise, loss of life expectancy caused by stroke subtypes in urban and rural areas during 2005–2020 was observed in figure 4B. Loss of life expectancy due to ICH and SAH was always higher in rural areas than in urban areas, whereas that of IS was higher in urban areas than in rural areas.

There were notable sex-specific differences in loss of life expectancy due to subtypes of stroke in urban and rural areas. Overall, loss of life expectancy due to stroke was higher in rural areas than in urban areas and males suffered greater loss of life expectancy caused by stroke than females. Females exhibited a larger decline in potential gains in life expectancy after removing deaths from stroke than did males from 2005 to 2020 (3.92% vs 1.98%), with a males to females ratio of 0.99:1 in 2005 and 1.01:1 in 2020. Since 2013, loss of life expectancy caused by stroke in rural areas was higher in males than in females, whereas that in urban areas was higher in females than in males (figure 5A). Interestingly, rural

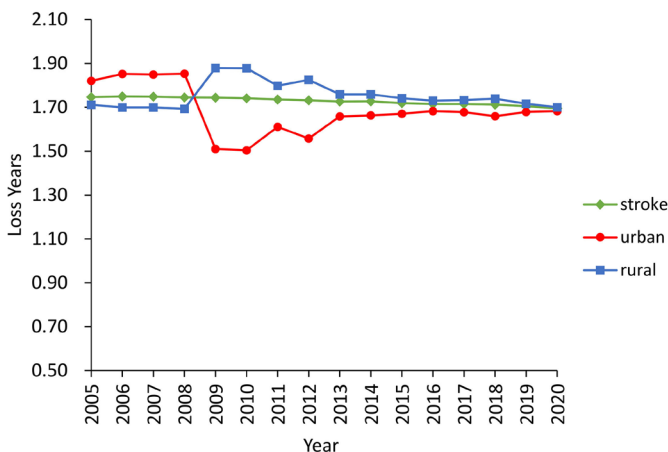


Figure 3 Loss of life expectancy caused by stroke in China, by region, 2005–2020.

males suffered the greatest loss of life expectancy due to ICH and SAH, while the highest loss of life expectancy caused by IS was found in urban females (figure 5B–D).

Characteristics of geographical differences of loss of life expectancy caused by stroke and its subtypes in figure 6A showed that it was higher in the north than in the south. Of all provinces examined, Heilongjiang (2.25 years), Tibet (2.17 years) and Jilin (2.16 years) were found to have the highest loss of life expectancy caused by stroke in 2020, while Xinjiang (1.20 years), Hunan (1.23 years) and Jiangxi (1.27 years) had the lowest loss of life expectancy. Besides, loss of life expectancy caused by IS had been found the highest in northeast China. It appeared the highest values in Heilongjiang (1.41 years), Tianjin (1.31 years) and Jilin (1.25 years) (figure 6B). Furthermore, loss of life expectancy caused by ICH was higher in western China than in eastern China. Qinghai (1.26 years), Tibet (1.20 years), Henan (0.86 years) were the top three provinces holding the highest loss of life expectancy (figure 6C). Loss of life expectancy caused by SAH remained western regions dominated, which was similar to that of ICH. Interestingly, loss of life expectancy due to SAH in Tibet (0.49 years), which ranked the first, was nearly 3.77-fold higher than that in Jilin (0.13 years), which had the lowest loss of life expectancy due to SAH (figure 6D).

DISCUSSION

Using a representative data from China NMSS, our study explored the trend of YLL and loss of life expectancy caused by stroke in urban and rural areas in China during 2005–2020. The results showed a downward trend in age-standardised YLL rate due to stroke. The YLL rate due to stroke and its subtypes in rural areas was higher than that in urban areas. A slightly downward trend was observed in loss of life expectancy caused by stroke, with ICH decreased by 30.6%, while that of IS and SAH increased by 38.9% and 15.5%, respectively. Rural males suffered the greatest loss of life expectancy due to ICH and SAH, while the highest loss of life expectancy caused by IS was found in urban females. Otherwise, loss of life expectancy caused by ICH and SAH was higher in western China, whereas that of IS was higher in northeast China.

Data from GBD 2019 had shown the YLL and age-standardised YLL rate of stroke in China and its provinces.² However, the urban–rural differences were not explored in the GBD as there was no universal definition of urban and rural areas across the globe. In China, the urban–rural disparity is an important topic due to the substantial differences in urban and rural areas, particularly for stroke as the leading COD in China. In addition, although GBD estimated the life expectancy at subnational level in China, the loss of life expectancy caused by specific diseases was not explored. We offered the first study of urban–rural disparity of stroke and its subtypes in China during 2005–2020, assessed by YLL and loss of life expectancy. Our findings provided evidence to identify

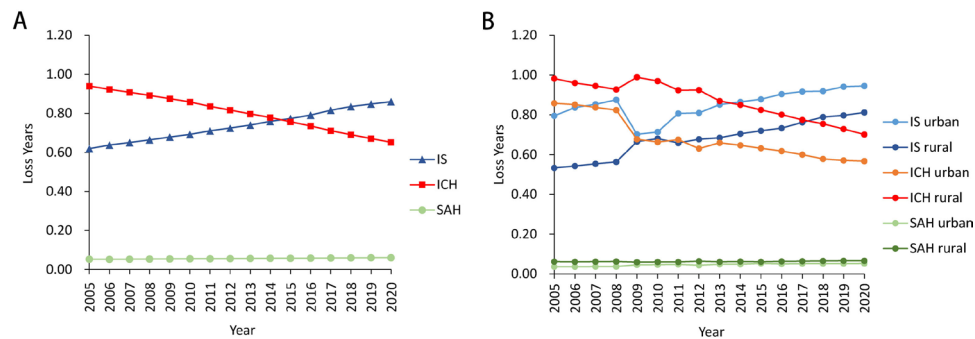


Figure 4 Loss of life expectancy caused by subtypes of stroke (A) in China, by region (B), 2005–2020. IS, ischaemic stroke; ICH, intracerebral haemorrhage; SAH, subarachnoid haemorrhage.

targeted population and would help to develop tailored intervention strategy and health resource allocation on stroke prevention in China. In general, the burden of stroke and its subtypes in rural areas were higher than that observed in urban areas. Consistent with our study, data from National Epidemiological Survey of Stroke in China (NESS-China) showed that the YLL rate due to stroke was 1.28-fold higher in rural areas than in urban areas during 2012–2013 (1964 vs 1533/100 000).¹⁵ The urban–rural disparity in stroke burden might be explained by the differences in medical conditions, as well as the awareness of stroke, emergency department visits and hospitalisation rates.^{15 16} Furthermore, the awareness, treatment and control rate of risk factors of stroke were significantly higher in urban areas than in rural areas.¹⁷ Notably, stroke-related factors such as the prevalence of overweight, obesity and atrial fibrillation were higher in urban areas than in rural areas.¹⁸ Therefore, further studies are needed to clarify the risk factors for the urban–rural differences, which were beneficial to implement targeted public health prevention programmes. In addition, our

findings also showed that the overall rural–urban gap in age-standardised YLL rate and loss of life expectancy caused by stroke remained relatively constant during 2013–2020, suggesting that targeted interventions should be continuously conducted to minimise the urban–rural differences. At present, there were no definite explanations for the different pattern observed between 2009–2012 and 2013–2020. The main reason might be due to the integration of previous vital registry system managed by Ministry of Health and the disease surveillance point system managed by Chinese Center for Disease Control and Prevention in 2013. The reporting procedure was new to some of the sites in NMSS and caused data noise or fluctuations during 2012–2013, particularly in rural areas.

Overall, life expectancy of Chinese population had progressively increased during 2005–2020. According to World Health Statistics 2021, life expectancy in China was 77.4 years in 2019, which was higher than the global average (73.3 years), but was much lower than that in Japan (84.3 years), Switzerland (83.4 years) and Korea

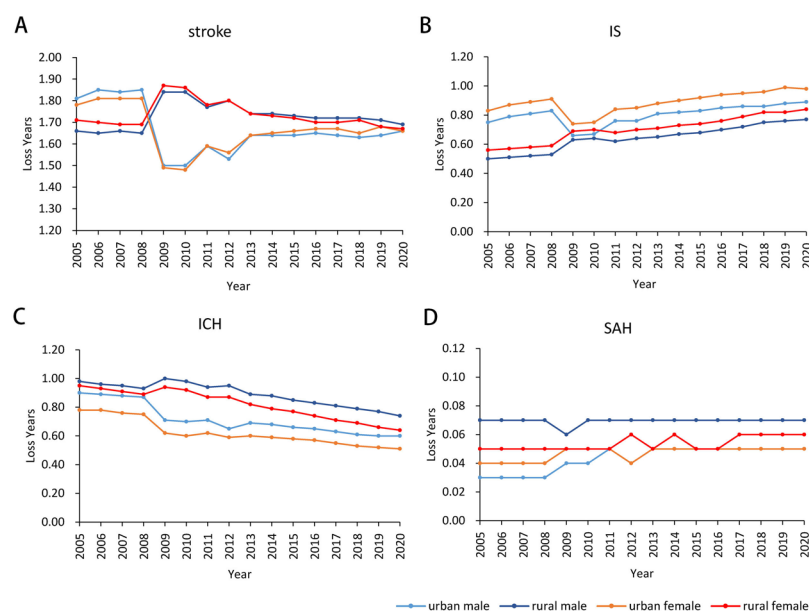


Figure 5 Loss of life expectancy caused by stroke and its subtypes in China, by sex and region, 2005–2020. IS, ischaemic stroke; ICH, intracerebral haemorrhage; SAH, subarachnoid haemorrhage.

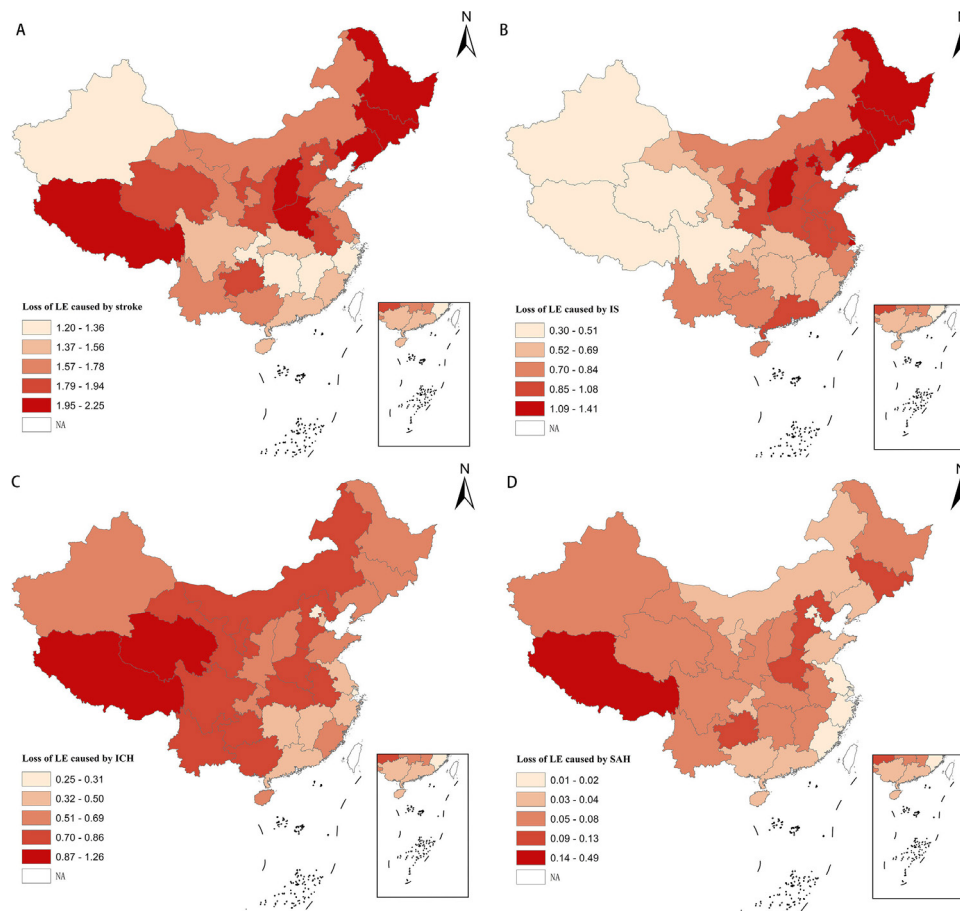


Figure 6 Loss of life expectancy caused by stroke (A), ischaemic stroke (B), intracerebral haemorrhage (C) and subarachnoid haemorrhage (D), by province, 2020. LE, life expectancy; IS, ischaemic stroke; ICH, intracerebral haemorrhage; SAH, subarachnoid haemorrhage.

(83.3 years). Nationally, loss of life expectancy caused by stroke was 2.26 years in 2010, which was ranked second after cancer (2.66 years).¹⁹ Amazingly, loss of life expectancy due to stroke in Los Angeles County was reported to be only 0.59 years for males and 0.69 years for females during the same period.²⁰ In seven Western European countries (Denmark, Finland, mainland France, the Netherlands, Norway, Sweden and England and Wales), potential gain in life expectancy after eliminating deaths from stroke was only 0.87 years for males and 1.35 years for females when averaged across all countries, which were considerably lower compared with the national average in China.²¹ Therefore, more multifactorial and targeted interventions of stroke in China are needed to reduce the impact of stroke on life expectancy. Consistent with other studies, our data displayed that loss of life expectancy caused by stroke was 1.70 years in China in 2020. However, respiratory diseases and diabetes were only associated with 0.88 years and 0.24 years of loss of life expectancy, respectively.²² Minimal research existed on loss of life expectancy caused by stroke and its subtypes in China in recent years. In our study, loss of life expectancy due to stroke showed a slightly downward trend, which decreased from 1.75 years to 1.70 years. That might be attributable to the reform of the medical and

health system, effective treatment of stroke risk factors and the development of modern diagnosis and treatment technology of stroke.^{2 23 24} Nationally, 30 demonstration advanced stroke centres and 280 advanced stroke centres had been certified by December 2018. Furthermore, we also established the stroke centre network, stroke map and stroke green channel to form a management system with Chinese characteristics to improve the stroke care quality and the outcomes of patients.

We found loss of life expectancy caused by ICH had decreased by 30.6% during 2005–2020, while that of IS and SAH had increased by 38.9% and 15.5%, respectively. Overall, the burden of ICH in China decreased year by year, but IS remained high disease burden, which was still a major public health problem. A study also showed that the age-standardised mortality of IS increased by 3.0%, while the rate of ICH decreased by 48.0% from 1990 to 2019.²⁵ The gradual standardised management of ICH might be able to explain the decline of the loss of life expectancy caused by ICH in China. Nearly two-thirds of ICH were treated with antihypertensive therapy,²⁶ 63.3% and 36.3% received neuroprotective medications and traditional Chinese medicines, respectively.²⁷ Besides, surgical intervention and new minimally invasive techniques have been recognised as effective treatments for the evacuation of

haemorrhage.²⁸ Furthermore, ICH, approximately 50% associated with hypertension, was more preventable than IS. In China, approximately 69.6% of stroke was IS. The findings from Chinese National Stroke Registry II showed that only 2.5% of patients with acute IS received intravenous thrombolysis and the median door-to-needle time (DNT) was 95 min, whereas the rate in the USA was 8.1% and the DNT was only 62 min during the same period.²⁶ Otherwise, patients with IS received antiplatelet and statin therapies had decreased from 70.7% and 38.0% at the time of hospital discharge, respectively, to 64.8% and 23.9% at 6 months.²⁷ In addition, the exposure to risk factors of stroke, such as high systolic blood pressure, ambient particulate matter pollution exposure, smoking and diet high in sodium, had not been effectively controlled. For example, 73% of the stroke burden were derived from hypertension in China,²⁹ the most significant modifiable risk factors for all kinds of stroke. According to data from the China Chronic Disease and Risk Factors Surveillance (2018), among the adults with hypertension aged 35 years and above, the standardised community management rate was 62%. However, only 11% of adults aged 18 years and above had their blood pressure controlled. Furthermore, rural hypertension patients had poor blood pressure control.³⁰ These findings stressed the potential to minimise the burden of stroke by reducing the exposure to hypertension. Therefore, effective treatment of AIS in the emergency and prevention of the risk factors of stroke awaited further improvement to lengthen life expectancy. In addition, more standardised management of IS in urban areas could effectively result in prolonged life span, while rural residents should value the prevention and treatment of ICH and SAH.

In general, females outperformed males in the prevention and control of stroke. That might be explained by more frequent exposure to vascular risk factors in males, such as smoking and alcohol consumption, as well as higher prevalence, lower levels of treatment and control of hypertension in males.³¹ Age-standardised mortality rate of stroke attributable to ambient particulate matter pollution was also higher in males than in females.³² Otherwise, Chinese males held the largest lifetime risk of stroke from age of 25 onwards (41.1%), while the global risk was only 24.7%.³³ Data from GBD 2019 had revealed that the risk of disability and death caused by stroke was higher in males and the risk of survival was higher in females.² However, females experienced worse mobility, self-care, usual activities, pain/discomfort and anxiety/depression than males after surviving a stroke.³⁴ In our study, we have offered the first study that explored loss of life expectancy due to stroke and its subtypes by sex and region, which were beneficial to implement targeted public health prevention programmes. The key population for the prevention and control of IS was urban females, whereas rural males should value the effective management of ICH and SAH to prolong life expectancy. However, there is little direct evidence to explain our results currently and further studies are

needed to clarify the sex and urban–rural differences of stroke burden.

Our findings also revealed the noticeable provincial variations of the loss of life expectancy caused by stroke in China. Consistent with previous study,³⁵ loss of life expectancy caused by stroke was higher in the north compared with that in the south. Data from NESS-China showed that the prevalence rates of stroke were 1097.1, 917.7 and 619.4 per 100 000, respectively, in the north, middle and south.¹⁶ The north-south gradient in China might be largely explained by different prevalence rate of hypertension among these regions. Nearly twofold difference in the prevalence rate of hypertension occurred between the highest in Liaoning (37.7%) and the lowest in Hainan (17.9%).³⁶ Overall, loss of life expectancy caused by haemorrhagic stroke was higher in western China, while that of IS was higher in northeast China. Additionally, nine provincial regions (Heilongjiang, Tibet, Jilin, Liaoning, Xinjiang, Hebei, Inner Mongolia, Beijing and Ningxia) in northern and western China constituted a stroke belt, where the rates of stroke incidence were higher than the areas outside the belt (236.2 vs 109.7 per 100 000).³⁷ People dwelling at high altitude have been reported to have higher risk of stroke, and the relative risk of stroke in areas above 4500 m was 10 times greater than that in plain areas. Qinghai and Tibet were found to have the highest loss of life expectancy caused by ICH. A study also found that ICH was the dominant subtype of stroke in Tibet (74.1%), which was far higher than the ratio worldwide (6.3%–41.3%).³⁸ The heavier disease burden in western China might be largely due to the unique plateau climate, the high incidence of hypertension, smoking and the unique ethnic food culture, characterised by more consumption of red meat, organ meat, salty and fried foods, but lower vitamins.³⁹ Otherwise, the Healthcare Access and Quality index of stroke was lowest in Tibet,²⁶ indicating that the poorer quality of stroke care in Tibet. Interestingly, Tibet and Heilongjiang, as the top two-stroke regions, had distinct geographical environments and distribution of stroke subtypes. A population-based cross sectional study found that nearly 91.7% of all stroke cases were IS in northeast China.⁴⁰ High prevalence of hypertension, long-term exposure to air pollution and high proportion of smoking and drinking contributed to the highest loss of life expectancy caused by IS in northeast China. In summary, lack of medical and health resources in western China and poor control of the risk factors in northeast China required due attention.

Our study had several potential limitations. First, we only presented the temporal trend of YLL and loss of life expectancy due to stroke, however, we were unable to further explain the trend due to availability of supporting data. Second, if patients suffering stroke died of other acute causes, we might underestimate the mortality and YLL due to stroke as we used underlying COD in our analysis. Finally, we used the same classification for urban and rural areas throughout the study period. There might be some areas changing from rural to urban during the past

16 years. However, it is less likely to change our results as only a small number of counties had this shift.

CONCLUSION

The significant increase of loss of life expectancy caused by IS indicated that stroke remains a major public health problem in China and all its provinces, although the age-standardised YLL rate and overall loss of life expectancy due to stroke decreased. Targeted interventions should be conducted to effectively reduce the premature death burden caused by stroke and prolong life expectancy in Chinese population.

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Patient consent for publication Not applicable.

Ethics approval The ethics committee at the National Center for Chronic and Noncommunicable Disease Control and Prevention, Chinese Center for Disease Control and Prevention, approved the study with a waiver of informed consent.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available upon request.

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