Exploring the Evolution Trend of Stroke Disease Burden in China from 1990 to 2021 Based on the GBD Database

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Abstract: Objective: To clarify the long-term evolutionary trends and gender differences of the stroke disease burden in China from 1990 to 2021, and to reveal the correlation between the age-standardized incidence rate (ASIR) and the Socio-demographic Index (SDI), so as to provide a scientific basis for formulating precise prevention and control strategies. **Methods:** Based on the data from the China Sub-database of the Global Burden of Disease (GBD) 2021, the four core indicators of stroke death counts, Disability-Adjusted Life Years (DALYs), prevalence, and incidence were extracted. Descriptive statistics and gender-stratified analysis were used to sort out the distribution characteristics of the indicators. The Joinpoint regression model was used to analyze time trends and calculate the Average Annual Percent Change (AAPC). Pearson correlation analysis was used to explore the correlation between ASIR and SDI. **Results:** From 1990 to 2021, the overall stroke disease burden in China showed a significant upward trend, with the highest increase in prevalence (145.40%) and the second highest in incidence (142.60%). The absolute values, growth rates, and annual growth rates of all disease burden indicators for males were higher than those for females, and in 2021, the male prevalence rate overtook that of females. The age-standardized rates showed a fluctuating upward trend, and it is predicted that from 2021 to 2040, male ASIR and ASMR will remain higher than those of females. There are significant regional differences in stroke incidence and prevalence rates, showing a regional clustering feature. ASIR and SDI show a significant negative correlation (r=-0.554, P<0.001). **Conclusion:** The stroke disease burden in China continues to increase, with males as the key population for prevention and control, and the problem of unbalanced regional prevention and control is prominent. It is necessary to formulate differentiated prevention and control measures based on gender differences and regional epidemiological characteristics.

Keywords: Stroke; Disease Burden; Gender Difference; Socio-demographic Index; ge-standardized Incidence Rate

1. Introduction

Stroke, as one of the most severe neurological diseases globally, is characterized by its high incidence rate, high mortality rate, high disability rate, and high recurrence rate [1]. Even against the backdrop of fluctuations in the global disease spectrum, stroke has consistently remained among the leading causes of death, and the importance of its prevention and control has never diminished [2]. In both developed and developing countries, the disease burden of stroke presents a complex

evolutionary trend. Its epidemiological characteristics and influencing factors are intricately intertwined with multiple factors such as population structure, socio-economic development, lifestyle changes, and the level of medical security, showing significant regional disparities [3]. As the world's most populous country, China is affected by multiple factors, including the accelerating process of population aging, changes in residents' lifestyles and dietary structures, and the continuous evolution of the disease spectrum [3]. Among all types of neurological diseases in China, stroke is one of the primary causes of health loss, posing a significant challenge to the public health system [4]. During the period from 1990 to 2021, China experienced rapid socio-economic development, the gradual improvement of the medical and health system, and the continuous enhancement of national health awareness. This unique historical context provides a special research setting for the changes in the burden of stroke, making the evolutionary trajectory of its key indicators of significant value for public health research.

Gender difference is one of the core dimensions that has received considerable attention in stroke epidemiological research. Differences between genders in physiological characteristics, behavioral habits, and exposure to risk factors may lead to different patterns of change in the incidence, prevalence, mortality, and disability impacts of stroke [5]. This difference is particularly pronounced in younger populations and is closely associated with gender-specific physiological factors [6]. Clarifying this difference is crucial for formulating gender-differentiated precise prevention and control strategies and can also provide direction for optimizing the allocation of stroke medical services for male and female populations.

Based on this, this study focuses on the evolution of the disease burden of stroke in China from 1990 to 2021, systematically outlining the changing patterns of core burden indicators, with a particular emphasis on gender differences and key influencing factors. By incorporating relevant standardized rate characteristics and trend prediction results, it provides a comprehensive assessment of the current status and development trajectory of the stroke burden in China. This study aims to provide solid evidence-based medical support for optimizing stroke prevention and control strategies, reducing the harm of the disease to individuals and society, and improving the overall health of the population.

2. Materials and Methods

2.1 Research Design

This study employs a population-based retrospective trend analysis method, focusing on the disease burden of stroke in the Chinese population from 1990 to 2021. It primarily investigates the long-term trends in the number of deaths, Disability-Adjusted Life Years (DALYs), prevalence, and incidence, and analyzes the differential characteristics between different sexes, to provide data support for the precise prevention and control of stroke.

2.2 Data Source

The research data are sourced from the China regional subset of the Global Burden of Disease Study (GBD) 2021 database [7]. This database integrates multi-source information, including population censuses, disease surveillance, and cause-of-death registration, and has been constructed through standardized case definitions, data cleaning, and model adjustment. The reliability and comparability of the data have been verified through internationally recognized quality assurance processes. We extracted sex-stratified data for core burden indicators of stroke for 1990 and 2021 (for

males, females, and both combined), including the original values of each indicator, the percentage change (PC), the average annual percentage change (AAPC), and their uncertainty intervals (UI).

2.3 Research Indicators and Definitions

Core indicator definitions reference the GBD research standards: ① Deaths: The total number of deaths caused by stroke in the study year; ② DALYs: The sum of Years of Life Lost due to premature mortality and Years Lived with Disability, comprehensively reflecting the impact of the disease on life and health; ③ Prevalence: The total number of new and existing stroke cases at a specific point in time in the study year; ④ Incidence: The total number of new stroke cases occurring in the study year. For trend analysis indicators, the PC calculation formula is (2021 indicator value - 1990 indicator value) / 1990 indicator value × 100%, and AAPC_UI is used to quantify the average annual change trend and reliability of the indicators.

2.4 Statistical Analysis Methods

Data was processed using SPSS 26.0 software, and extreme outliers beyond ±3 standard deviations from the mean for the same indicator and gender within each stratum were excluded[8]. Piecewise linear regression models were fitted using the Joinpoint Regression Program [4.9.1.0][9], and the AAPC and its 95% UI were calculated, with P<0.05 considered statistically significant. Related rate indicators were age-standardized using the world standard population recommended by the World Health Organization to eliminate the interference of population structure differences on the results.

2.5 Quality Control

During the data inclusion phase, the consistency of case diagnosis criteria was strictly verified to ensure the homogeneity of data across different years. Cross-validation of gender-stratified data was conducted to guarantee logical coherence in the data. The entire process adhered to the GBD database quality control specifications to ensure data accuracy and result reliability.

3. Result

3.1 Overall Change Trend of the Disease Burden of Stroke in China from 1990 to 2021

In the 31 years from 1990 to 2021, the overall disease burden of stroke in China showed a comprehensive and significant upward trend, with the four core disease burden indicators achieving growth to varying degrees, reflecting the continuous aggravation of the impact of stroke on the health of the Chinese population.

In 1990, the total number of stroke deaths in China was 1,530,590, which increased to 2,591,647 in 2021. Over the 31-year period, there was a net increase of 1,061,057 cases, a percentage change (PC) of 69.30%, and an average annual percentage change (AAPC_UI) of 1.59%, indicating that the number of stroke deaths has been continuously climbing at a stable annual growth rate, and the burden of mortality is gradually increasing. The total DALYs in 1990 were 38,003,357, rising to 53,190,691 in 2021, a net increase of 15,187,334, with a growth magnitude of 40.00% and an average annual growth rate of 0.98%. Although the growth magnitude of this indicator is lower than that of other indicators, due to its comprehensive inclusion of health losses caused by both death and disability, it still highlights the expanding scope of harm posed by stroke to the overall health of the population. The total prevalence in 1990 was 10,731,080, which soared to 26,335,403 in 2021, a net increase of

15,604,323, with a percentage change as high as 145.40% and an average annual percentage change of 2.93%, making it the indicator with the largest growth magnitude among all indicators. This suggests a sharp increase in the prevalence of stroke in the population, with the cumulative effect of the disease being particularly significant. The total incidence rate in 1990 was 1,685,762, increasing to 4,090,480 in 2021, a net increase of 2,404,718, with a growth magnitude of 142.60% and an average annual percentage change of 2.64%. This is only slightly lower than the growth rate of the prevalence rate, indicating that the risk of new stroke cases in the Chinese population continues to increase and the trend of the disease's occurrence is becoming increasingly severe.

3.2 Gender Differences Characteristics of Stroke Disease Burden

From 1990 to 2021, the disease burden of stroke for both men and women in China showed an upward trend, but there were significant gender differences in absolute values, growth magnitude, and annual growth rate. The disease burden of stroke in men was overall heavier than in women, and the growth was more rapid.

In 1990, the number of stroke deaths in males was 796,977, increasing to 1,506,012 in 2021, a net increase of 709,035, representing a percentage change of 89% and an average annual percentage change of 2.03%. In females, the number of deaths in 1990 was 733,613, rising to 1,085,635 in 2021, a net increase of 352,022, with a percentage change of 48% and an average annual percentage change of 1.03%. The baseline value and 2021 value for male deaths were both higher than those for females, with the magnitude of increase being 1.85 times greater and the annual growth rate 1.97 times higher, indicating a significant disparity in the growing burden of mortality. In 1990, male DALYs were 20,613,875, increasing to 31,862,593 in 2021, a net increase of 11,248,718, representing a percentage change of 54.60% and an average annual percentage change of 1.39%. Female DALYs in 1990 were 17,389,482, rising to 21,328,098 in 2021, a net increase of 3,938,616, with a percentage change of only 22.60% and an average annual percentage change of 0.42%. The baseline and current values for male DALYs were significantly higher than those for females, with the magnitude of increase being 2.42 times greater and the annual growth rate 3.31 times higher, reflecting that the comprehensive health loss due to stroke in males is far greater than in females. In 1990, the baseline prevalence for females (5,409,633) was slightly higher than for males (5,321,447), but in 2021, male prevalence (13,719,379) surpassed that of females (12,616,024). The net increase in male prevalence was 8,397,932, a percentage change of 157.80% and an average annual percentage change of 3.17%, while the net increase for females was 7,206,391, a percentage change of 133.20% and an annual growth rate of 2.67%. Male prevalence grew at a faster rate, making this group a high-risk population for the condition. In 1990, the incidence rate in males was 900,161, increasing to 2,305,942 in 2021, a net increase of 1,405,781, representing a percentage change of 156.20% and an average annual percentage change of 2.91%. In females, the incidence rate in 1990 was 785,601, rising to 1,784,539 in 2021, a net increase of 998,938, with a percentage change of 127.20% and an annual growth rate of 2.31%. The baseline value, current value, magnitude of increase, and annual growth rate for male incidence were all higher than for females, indicating a persistent gender disparity in the risk of new-onset cases.

Table 1: Burden Indicators and Trends of Stroke in China Between 1990 and 2021 (By Sex).

Indicator	Sex	1990 Value	2021 Value	PC	AAPC_UI
Deaths	Male	796977	1506012	89%	2.03%
Deaths	Female	733613	1085635	48%	1.03%

Deaths	Both	1530590	2591647	69.30%	1.59%
DALYs	Male	20613875	31862593	54.60%	1.39%
DALYs	Female	17389482	21328098	22.60%	0.42%
DALYs	Both	38003357	53190691	40%	0.98%
Prevalence	Male	5321447	13719379	157.80%	3.17%
Prevalence	Female	5409633	12616024	133.20%	2.67%
Prevalence	Both	10731080	26335403	145.40%	2.93%
Incidence	Male	900161	2305942	156.20%	2.91%
Incidence	Female	785601	1784539	127.20%	2.31%
Incidence	Both	1685762	4090480	142.60%	2.64%

3.3 Age-standardized Rate Trends and Future Predictions

During the period from 1990 to 2020, The disability-adjusted life years rate (DALYs Rate) for stroke exhibited a significant and continuous declining trend, decreasing from nearly 5000 per 100,000 in 1990 to approximately 2600 per 100,000 in 2020, indicating a substantial reduction in the overall disease burden. The age-standardized prevalence rate (ASPR) fluctuated within the range of 1100–1300 per 100,000 and did not demonstrate a clear trend. Furthermore, both the age-standardized incidence rate (ASIR) and the age-standardized mortality rate (ASMR) remained at low levels below 300 per 100,000, with minimal fluctuations during the study period. After age standardization, the trends of these indicators remained clear and stable, which eliminated the interference of age structure differences on the metrics, demonstrating that the population's risk of stroke onset and mortality remained relatively stable during this period (Figure 1). Based on actual data from 1990 to 2021, it is predicted that from 2021 to 2040, the ASIR and ASMR for both males and females in China will continue to show an upward trend. Among them, the actual and predicted values of male ASIR and ASMR are always higher than those of females, and the gender gap does not show a narrowing trend during the prediction period, suggesting that males will still be the key population for stroke prevention and control in the future, and the gender-specific characteristics of the stroke disease burden may exist for a long time (Figure 2).
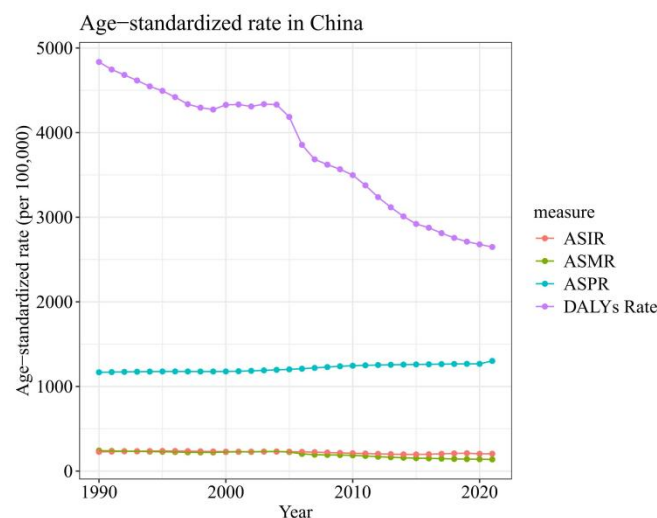

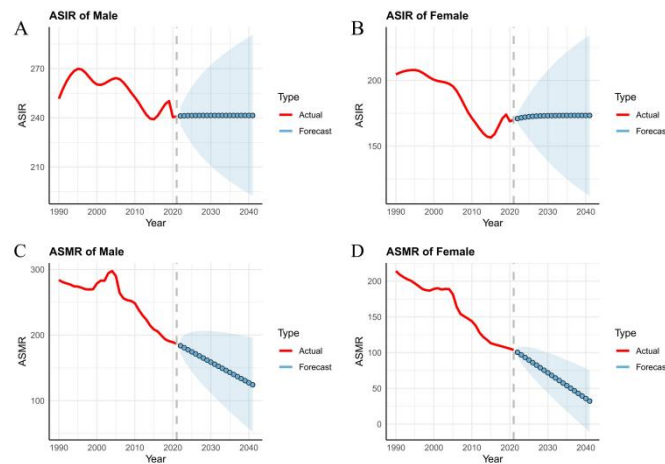**Figure 1:** Trend in Age-standardized Rate of a Certain Disease in China, 1990-2020.

Figure 2: Changes and Projections of Age-standardized Rates for Stroke by Gender From 1990 to 2040.

3.4 Regional Distribution Characteristics of Stroke Onset and Prevalence.

The regional distribution of China's crude incidence rate (CIR) for stroke shows significant variation. CIR values across different regions range from 47.46 to 215.39 per 100,000, with some areas exceeding 215.39 per 100,000, displaying a clear geographical clustering characteristic (Figure 3). This reflects substantial differences in the risk of stroke onset among populations in different regions. The regional distribution of the crude prevalence rate (CPR) also exhibits significant heterogeneity, with a range of 458.61 to 1851.03 per 100,000. Some regions have CPR values exceeding 1851.03 per 100,000, indicating marked disparities in the prevalence of stroke across different areas and highlighting prominent issues in the imbalanced prevention and control of the disease between regions (Figure 4).
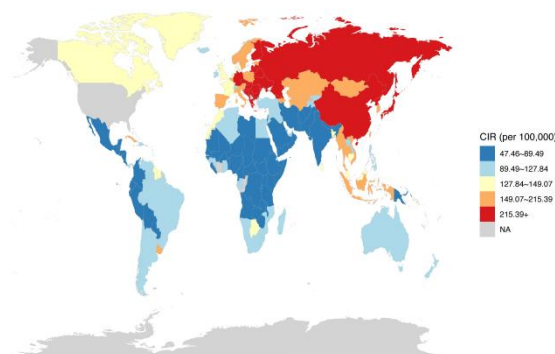

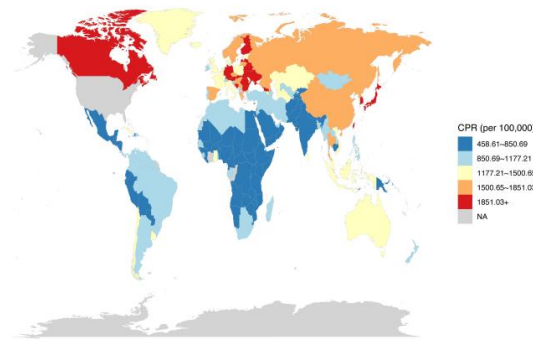**Figure 3:** Geographical Distribution of Age-standardized Incidence Rates (CIR) of Stroke Globally.

Figure 4: Geographical Distribution of Age-standardized Prevalence Rate (CPR) of Stroke Globally.

3.5 Correlation between ASIR and Socio-demographic Index (SDI)

The correlation analysis results indicate that China's ASIR of stroke is significantly negatively correlated with the SDI (r=-0.554, p<0.001), which implies that in regions with a lower SDI, the ASIR of stroke is relatively higher (Figure 5). This suggests that SDI indicators related to social and economic development levels and the accessibility of medical and health resources may have a close association with the risk of stroke onset, providing an important reference for the regional prevention and control of stroke.
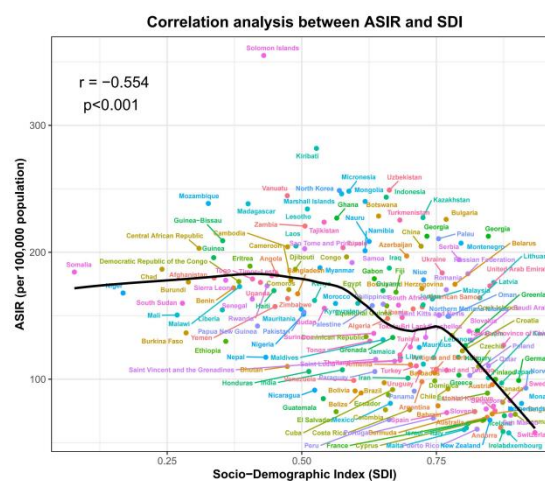

Figure 5: Correlation analysis of the ASIR of stroke with the SDI.

4. Discussion

Stroke represents a critical global public health challenge, and research into its burden in China is of considerable importance both domestically and internationally due to the country's unique context. Drawing upon prior authoritative studies, this discussion addresses background correlations, literature comparisons, mechanistic explorations, and the significance of our research findings. A pronounced regional heterogeneity characterizes the global burden of stroke, with a marked increase observed in low- and middle-income countries [10]. Research by Zhu et al. in China has established a distinct geographical and demographic pattern of higher prevalence in northern and rural areas compared to the south and cities [11], a finding consistent with our study's focus. Common drivers of this global burden evolution, such as population aging and lifestyle transitions, provide a theoretical foundation for our work.

Gender-based disparities in stroke incidence and outcomes constitute a key area of scholarly inquiry. Chapa et al. demonstrated that higher mortality and disability rates among males are linked to adverse lifestyle factors [12] while Carrasquilla et al. uncovered that the increased stroke risk in postmenopausal women is associated with dyslipidemia resulting from the loss of estrogen's protective effects [13]. These studies offer a basis for understanding the underlying logic of these differences and are complementary to our primary research dimensions.

The changing landscape of stroke risk factors is a central driver of shifting burden dynamics. Traditional risk factors, such as hyperlipidemia, have been confirmed as significantly correlated with stroke risk [14], while the synergistic pathogenic effects of emerging factors like sleep apnea are gaining increasing attention. Systematically analyzing these patterns and mechanisms provides a scientific basis for developing multi-targeted prevention and control strategies.

This study is aligned with both global trends in stroke prevention and China's public health objectives. By integrating the World Health Organization's global vision with the goals of China's "Million Disability Reduction" initiative, our investigation into the burden's characteristics and determinants can offer valuable insights for optimizing prevention strategies, thereby possessing significant academic and practical relevance.

Despite progress, limitations in stroke research persist. The use of secondary databases, while enhancing efficiency, can be constrained by data quality and the consistency of coding standards, which may influence the validity of conclusions. Future research should incorporate multi-source primary data for validation and further explore sub-specific dimensions, such as stroke subtypes.

5. Conclusions

To sum up, the evolution of stroke burden and its prevention are pivotal issues in global public health. Grounded in China's specific national conditions and building upon prior research, this study enriches the field of stroke epidemiology by examining core issues and provides scientific support for precision prevention and control. Future multidimensional investigations are essential to further mitigate the disease burden.

References

[1] Global, regional, and national burden of stroke and its risk factors, 1990-2019: a systematic analysis for the Global Burden of Disease Study 2019. Lancet Neurol, 2021. 20(10): p. 795-820.

[2] Burden of 375 diseases and injuries, risk-attributable burden of 88 risk factors, and healthy life expectancy in 204 countries and territories, including 660 subnational locations, 1990-2023: a systematic analysis for the Global Burden of Disease Study 2023. Lancet, 2025. 406(10513): p. 1873-1922.

[3] Zhang, T., et al., Analysis of Stroke Burden in China from 1990 to 2021 and Projections for the Next Decade. Neuroepidemiology, 2025. 59(5): p. 505-516.

[4] Global burden of 288 causes of death and life expectancy decomposition in 204 countries and territories and 811 subnational locations, 1990-2021: a systematic analysis for the Global Burden of Disease Study 2021. Lancet, 2024. 403(10440): p. 2100-2132.

[5] Bai, X., et al., Gender differences in risk factors for ischemic stroke: a longitudinal cohort study in East China. BMC Neurol, 2024. 24(1): p. 171.

[6] Abdel-Fattah, A.R., et al., Gender differences in mortality of hospitalised stroke patients. Systematic review and meta-analysis. Clin Neurol Neurosurg, 2022. 220: p. 107359.

[7] Chen, S., et al., Transition and trend analysis of the burden of depression in China and different income

countries: Based on GBD database and joinpoint regression model. J Affect Disord, 2024. 362: p. 437-449.

[8]   Weaver, B. and K.L. Wuensch, SPSS and SAS programs for comparing Pearson correlations and OLS regression coefficients. Behav Res Methods, 2013. 45(3): p. 880-95.

[9]   Zaheer, S. and F. Yasmeen, Historical trends in breast cancer presentation among women in Pakistan from join-point regression analysis. Pak J Med Sci, 2024. 40(1Part-I): p. 134-139.

[10] Global, regional, and national burden of stroke and its risk factors, 1990-2021: a systematic analysis for the Global Burden of Disease Study 2021. Lancet Neurol, 2024. 23(10): p. 973-1003.

[11] Zhu, J., et al., Urban and rural disparities in stroke prediction using machine learning among Chinese older adults. Sci Rep, 2025. 15(1): p. 6779.

[12] Chapa, D.W., et al., Gender differences in stroke, mortality, and hospitalization among patients with atrial fibrillation: A systematic review. Heart Lung, 2015. 44(3): p. 189-98.

[13] Carrasquilla, G.D., et al., Postmenopausal hormone therapy and risk of stroke: A pooled analysis of data from population-based cohort studies. PLoS Med, 2017. 14(11): p. e1002445.

[14] Hoshino, T., et al., Atherogenic Dyslipidemia and Residual Vascular Risk After Stroke or Transient Ischemic Attack. Stroke, 2022. 53(1): p. 79-86.