Disease Burden of and Risk Factors for Stroke in Yunnan Province of Southwest China, from 1990 to 2017

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Abstract

Background

There is an overall decreasing trend in stroke incidence and an increasing trend in its prevalence. Disease burden of stroke continues to increase with an increase in the absolute number. In-depth analysis of stroke burden trends in remote areas is extremely important. Our aim was to describe the disease burden of and risk factors for stroke in Yunnan, from 1990 to 2017.

Methods

The methodological framework and analytical strategies adopted in the 2017 Global Burden of Disease study were used.

Results

Age-standardized mortality associated with stroke decreased from 153.4% per 100,000 in 1990 to 113.8% per 100,000 in 2017. The prevalence of stroke in Yunnan province increased from 344 per 100,000 in 1990 to 870 per 100,000 in 2017, especially after 2010. The age-standardized rates of Years of life lost (YLLs), Years lived with Disability(YLDs), and Disability-Adjusted Life Years (DALYs) decreased more significantly for women than for men. The age-standardized rates of DALYs and YLLs of stroke decreased by 24.3% and 28.4%, respectively, from 1990 to 2017, and the rate of YLDs increased by 32.5%. The top three risk factors for stroke were dietary risks, high systolic blood pressure, and tobacco consumption, and their percentage contributions to the DALYs were 67.5% (95% Uncertainty Interval (UI): 60.7–73.4%), 51.5% (95% UI: 43.3–59.0%), and 29.1% (95% UI: 25.4–32.7%), respectively.

Conclusions

Disease burden of stroke was similar to that in developing countries and most risk factors associated with stroke were modifiable. Health institutions need to pay more attention to the education and public awareness among rural residents of Yunnan and allocate medical resources rationally.

Background

Stroke is defined as sudden death of brain cells in a localized area due to inadequate blood flow. According to the Stroke International Working Group, stroke is classified into three categories: ischemic stroke, intracerebral hemorrhage, and subarachnoid hemorrhage[1]. There are many sequelae of stroke including aphasia, hemiplegia, and mental and intellectual disorders[2]. Moreover, stroke can also increase the burden on patients' families and social economy. The number of stroke patients worldwide reached an estimated figure of 80 million in 2016. However, age-standardized mortality associated with stroke has shown a downward trend worldwide[3]. Morbidity decreased in most of the regions but increased in Asia. A possible reason for this finding is that the majority of Asian countries are developing countries[4].The incidence of stroke is decreasing, especially in low-income and middle-income countries[4]. Some studies have indicated that elderly individuals are more likely to have a stroke[5] and women have a higher risk of death from stroke than men[6].

Due to the large population of China, stroke has become the most common cause of death in China, contributing to the greatest burden of stroke worldwide[7]. The number of strokes is increasing by more than 2 million each year. Moreover, stroke was the main cause of YLLs in 2017. The prevalence and incidence of stroke have increased significantly over the

last decade[8]. China has the highest risk of stroke worldwide (39.3% stroke risk among Chinese residents)[9]. There is a trend of high prevalence and mortality of stroke in the north and low prevalence and mortality in the south[9]. Social development has brought prosperity, but it has also increased the risk of stroke. With economic prosperity, the possibility of a section of population engaging in unhealthy behaviors has increased, especially in China's remote mountainous regions[4].

Yunnan is located in Southwest China, mainly in the plateau mountains and it is still an underdeveloped region. From 2005 to 2018, life expectancy in Yunnan increased by 5.27 years, ranking second among the provinces[10]. Thus, lifestyle and the percentage of aging population in Yunnan have changed greatly in recent years. Most of the studies in this region have focused on infectious diseases such as hepatitis B, hepatitis C, and human immunodeficiency virus infection[11–13]. Therefore, it is necessary to pay greater attention to the burden of chronic non-infectious diseases in this region. Smoking, drinking, high blood pressure, and overweight are common risk factors for stroke[14]. Yunnan ranks fourth among all provinces in terms of per capita alcohol consumption[15]. In addition, the prevalence of smoking in Yunnan is higher than the national average, with a smoking rate of over 30%[16]. We have discussed the risk factors for stroke in the present study to provide targeted measures for stroke prevention.

This study aimed to reveal the burden of stroke in Yunnan province, a remote area of China, under the background of rapid economic development. We have also discussed the incidence, prevalence, DALYs and risk factors for stroke. This study focused on the trend of stroke development in remote areas of developing countries. It aimed to confirm whether there was an excessive disease burden of stroke in these areas and to provide an important understanding of stroke prevention measures, public awareness, education, and policy making in Yunnan from the perspective of disease burden at the provincial level.

Methods

Data source

Demographic data were obtained from the National Bureau of Statistics and a Bayesian hierarchical model was used to estimate the population size of 34 provinces to ensure maximum internal consistency. Data related to death were obtained from the Disease Surveillance Point System, Maternal and Child Detection System, China Cancer Registry system, and Chinese Center for Disease Control and Prevention Cause-of-Death Reporting System[18]. Distribution of the prevalence and incidence of stroke causes was based on national survey data including the Chronic Disease and Risk Factor Surveillance System, the fifth National Health Service Survey and the Chronic Disease and Risk Factor Surveillance System, cancer registries, inpatient data, and published studies[18].

Statistical analysis

This study used the methods established by the 2017 Global Burden of Disease (GBD) study to assess the health status of the population in Yunnan. The analysis was based on the DisMod-MR 2.1 model proposed in the GBD study. It is a meta-analysis tool consisting of an interval model structure and a series of differential equations that are used to estimate the prevalence of non-fatal diseases and the severity of their disease burden. The age-standardized rates in the present study were calculated with reference to the global population.

Estimation of mortality and non-fatal health loss

We estimated the cause-specific mortality and deaths based on cause-based databases to assess and improve the quality of cause-of-death data. Age-specific and sex-specific mortality rates for Yunnan were calculated using the Cause-Of-Death Ensemble model. A mixed effects linear model and spatiotemporal Gaussian process regression model were used to

calculate the risk score and mortality rates[20]. Specific methods for each step can be found in the appendix of the GBD 2017 cause-of-death document[17].

DALYs consist of YLLs and YLDs. We used the incidence, prevalence, course of disease, and external factors of the disease into the DisMod-MR 2.1 model to estimate the YLLs and YLDs after adjusting the weight of region, gender, and group disability. DALYs were obtained from the YLLs and YLDs[18,20].

Risk factors

We relied on the Contamination Risk Assessment (CRA)framework to estimate the exposure contribution of different risk factors (behavioral, metabolic, environmental, or occupational) to the DALYs. The CRA framework compares the defined distribution of a risk factor in a specific population with the theoretical minimum risk exposure distribution when the exposure levels of other independent risk factors remain unchanged. Thus, it obtains the proportion of disease burden caused by a particular risk factor. This proportion is called the Population Attributable Fractions (PAFs)[19-20]. Finally, DALYs related to stroke were multiplied by the PAFs of each risk factor to obtain the disease burden caused by the respective risk factor[19].

The formula for PAFs with the risk factors as continuous variables is as follows:

$$PAFs = \frac{\int_{x=0}^{m} RR(x)P_1(x)dx - \int_{x=0}^{m} RR(x)P_2(x)dx}{\int_{x=0}^{m} RR(x)P_1(x)dx}$$

RR(x) indicates the relative risk when the exposure level was x, $P_1(x)$ indicates the current exposure distribution of a population, $P_2(x)$ indicates the theoretical minimum risk exposure distribution, and m indicates the highest exposure level.

The formula for PAFs with the risk factors as categorical variables is as follows:

$$PAFs = \frac{\sum_{i=1}^{n} P_i(RR_i - 1)}{\sum_{i=1}^{n} P_i(RR_i - 1) + 1}$$

RR_i indicates the relative risk when the exposure level was i, P_i indicates the exposure rate of the population when the exposure level was i, and n indicates the number of exposure levels.

Uncertainty intervals

We quantified and propagated the uncertainty into final estimates by calculating the UI of stroke for cause-specific estimation components calculated on 1000 draws from the posterior distribution[17]. We reported the mean values and the 25th and 75th values as the range of intervals. The 95% UI was limited sample size, mortality, mortality model specifications, etc.

Results

Mortality

Age-standardized mortality showed a significant decline in Yunnan. Age-standardized mortality associated with stroke decreased from 153.4% per 100,000 in 1990 to 113.8% per 100,000 in 2017, changing by 25.8% per 100,000. The age-standardized mortality rate associated with stroke decreased more significantly in women than in men (Figure 1).

Intracerebral hemorrhage accounted for the majority of stroke deaths. However, age-standardized mortality for ischemic stroke in men increased by 22.7% per 100,000 from 37.5% per 100,000 in 1990 to 46% per 100,000 in 2017 (Table 1).

Table 1
Deaths and age-standardized mortality rates in Yunnan by gender and subcategory in 1990 and 2017

Category	Deaths (in thousands) (95% uncertainty intervals)			Age-standardized mortality rate per 1,00,000 (95% uncertainty intervals)		
	1990	2017	Change (%)	1990	2017	Change (%)
Both genders						
stroke	31 (27–38)	58 (50–68)	84.0	153.4 (131.8–188.4)	113.8 (97.7–132.7)	−25.8
Ischemic stroke	7 (6–9)	19 (16–23)	156.7	40.2 (33.0–52.6)	38.8 (32.9–45.9)	−3.5
Intracerebral hemorrhage	20 (17–25)	36 (31–42)	83.7	93.1 (78.9–119.5)	69.6 (59.2–81.8)	−25.2
Subarachnoid hemorrhage	4 (3–5)	3 (2–4)	−35.0	20.1 (12.9–24.3)	5.4 (4.4–7.4)	−73.1
Males						
stroke	15 (12–18)	34 (28–42)	130.0	147.7 (124.4–178.6)	137.8 (114.5–166.9)	−6.7
Ischemic stroke	3 (3–4)	11 (9–13)	224.9	37.5 (30.0–46.8)	46.0 (37.6–55.5)	22.7
Intracerebral hemorrhage	10 (8–12)	22 (18–27)	126.3	92.2 (75.1–115.2)	85.2 (70.0–104.0)	−7.6
Subarachnoid hemorrhage	2 (1–3)	2 (1–2)	−11.6	18.0 (8.9–24.7)	6.6 (5.1–9.4)	−63.3
Females						
stroke	17 (14–21)	24 (19–30)	42.7	154.9 (126.8–154.9)	90.8 (72.1–113.7)	−41.4
Ischemic stroke	4 (3–6)	8 (6–10)	100.6	41.4 (32.2–57.6)	32.0 (25.5–40.8)	−22.7
Intracerebral hemorrhage	10 (8–14)	14 (11–18)	43.2	92.0 (74.4–125.8)	54.5 (42.5–68.5)	−40.8
Subarachnoid hemorrhage	2 (1–3)	1 (1–2)	−53.6	21.5 (13.3–27.3)	4.2 (3.2–6.5)	−80.3

Stroke Cases And Prevalence

The prevalence of stroke in Yunnan increased from 344 per 100,000 in 1990 to 870 per 100,000 in 2017, especially after 2010 when the prevalence of stroke began to rise rapidly (Table 2, Figure 2). Age-standardized prevalence of stroke in men was higher than that in women. Age-standardized prevalence in men increased from 1206.0 to 1579.1 per 100,000 from 1990 to 2017 and it increased from 1238.7 to 1475.0 per 100,000 in women. A significant decline was observed in intracerebral and subarachnoid hemorrhage, but ischemic stroke increased by 42.7% from 1990 to 2017 (Table 2 and Figure 3).

Table 2
Overall prevalence and age-standardized prevalence rate in Yunnan by gender and subcategory in 1990 and 2017

	All-age prevalence per 1,00,000 (95% uncertainty intervals)			Age-standardized prevalence rate per 1,00,000 (95% uncertainty intervals)	
Category	**1990**	**2017**	**Change (%)**	**1990**	**2017**
Both					
Stroke	344 (322–366)	870 (806–937)	152.6	1224.8 (1146.2–1302.6)	1535.7 (1424.4–1657.9)
Ischemic stroke	220 (203–239)	674 (612–739)	205.9	827.3 (762.5–901.3)	1217.4 (1108.0–1333.5)
Intracerebral hemorrhage	116 (105–126)	192 (170–216)	66.3	366.4 (333.7–399.8)	325.2 (290.4–362.7)
Subarachnoid hemorrhage	24 (22–27)	41 (37–46)	70.6	80.3 (72.8–89.9)	69.1 (62.3–77.2)
Males					
Stroke	168 (157–181)	450 (416–485)	167.0	1206.0 (1126.4–1294.4)	1597.1 (1472.9–1720.8)
Ischemic stroke	109 (100–119)	344 (311–376)	215.6	834 (763.0–912.0)	1262.8 (1141.3–1388.2)
Intracerebral hemorrhage	56 (51–62)	104 (92–117)	86.2	344.9 (312.8–378.9)	342.9 (305.0–382.9)
Subarachnoid hemorrhage	12 (11–14)	22 (19–24)	77.2	79.9 (72.4–89.1)	72.3 (65.1–80.7)
Females					
Stroke	175 (164–188)	420 (386–456)	138.9	1238.7 (1153.8–1322.1)	1475.0 (1351.3–1602.0)
Ischemic stroke	112 (102–122)	331 (296–367)	196.5	818.3 (747.7–895.4)	1175.4 (1054.6–1301.2)
Intracerebral hemorrhage	59 (54–65)	88 (77–99)	47.6	385.5 (351.8–422.9)	305.0 (269.1–343.8)
Subarachnoid hemorrhage	12 (11–13)	19 (17–22)	63.7	79.9 (72.2–89.9)	65.6 (58.4–74.1)

Disability-adjusted Life Years

Table 3 compares the age-standardized rates of YLLs, YLDs, and DALYs of stroke in 1990 and 2017 by gender in Yunnan. The age-standardized rates of DALYs and YLLs of stroke in Yunnan decreased by 24.3% and 28.4%, respectively from 1990 to 2017, while the age-standardized rate of YLDs increased by 32.5% (Table 3), suggesting a reduction in the mortality and disease burden of stroke. We also noted that the age-standardized rates of YLLs, YLDs, and DALYs decreased more significantly in women than in men. YLLs of stroke constituted a major part of the disease burden. Notably, the age-standardized rate of YLDs increased in case of ischemic stroke from 135.9 (96.7–176.4) per 100,000 in 1990 to 208.5 (149.0–270.6) per 100,000 in 2017.

Table 3
Age-standardized rate of years lived with disability, years of life lost, and disability-adjusted life years per 100,000 in Yunnan by gender and subcategory in 1990 and 2017

	1990			2017			Percentage change (%)		
Category	YLDs (UIs)	YLLs (UIs)	DALYs (UIs)	YLDs (UIs)	YLLs (UIs)	DALYs (UIs)	YLDs (UIs)	YLLs (UIs)	DALYs (UIs)
Both genders									
stroke	206.5 (148.4–264.1)	2883.1 (2484.2–3496.6)	3089.6 (2692.9–3712.1)	273.7 (195.8–353.6)	2065.4 (1763.9–2442.1)	2339.1 (2010.8–2725.5)	32.5	−28.4	−24.3
Ischemic stroke	135.9 (96.7–176.4)	634.8 (528.3–812.2)	770.7 (654.4–945.5)	208.5 (149.0–270.6)	606.9 (513.8–719.4)	815.4 (696.8–940.2)	53.4	−4.4	5.8
Intracerebral hemorrhage	57.5 (41.5–74.6)	1818.8 (1531.8–2335.7)	1876.3 (1589.4–2394.3)	53.9 (38.1–71.0)	1337.7 (1134.9–1578.2)	1391.6 (1187.3–1634.4)	−6.3	−26.5	−25.8
Subarachnoid hemorrhage	13.1 (9.1–17.3)	429.5 (291.2–522.9)	442.6 (303.5–534.7)	11.3 (7.9–15.1)	120.8 (98.7–158.9)	132.1 (109.6–171.9)	−13.7	−71.9	−70.2
Males									
stroke	196.6 (141.2–249.9)	2946.8 (2430.4–3594.6)	3143.3 (2637.9–3782.7)	277.4 (197.4–361.4)	2647.1 (2151.8–3270.8)	2924.5 (2435.4–3558.2)	41.1	−10.2	−7.0
Ischemic stroke	132.1 (94.4–169.8)	629.0 (501.3–790.4)	761.1 (623.1–923.1)	210.3 (149.9–274.4)	756.4 (617.1–933.1)	966.8 (806.6–1154.0)	59.2	20.1	27.0
Intracerebral hemorrhage	52.1 (37.4–68.0)	1907.4 (1545.1–2412.9)	1959.5 (1595.7–2467.0)	55.8 (39.2–73.4)	1735.4 (1409.9–2147.2)	1791.2 (1470.6–2209.6)	7.1	−9.0	−8.6
Subarachnoid hemorrhage	12.4 (8.6–16.6)	410.4 (210.5–560.7)	442.8 (221.8–572.7)	11.3 (7.7–15.2)	155.3 (119.4–210.8)	166.6 (131.1–233.1)	−8.9	−62.2	−62.4
Females									
stroke	215.4 (154.6–277.4)	2775.4 (2263.1–3506.2)	2990.8 (2459.6–3725.0)	270.2 (193.6–347.4)	1489.8 (1172.1–1862.2)	1760 (1431.6–2158.0)	25.4	−46.3	−41.2
Ischemic stroke	139.0 (98.5–181.0)	628.2 (492.4–847.1)	767.2 (619.9–985.1)	207.3 (147.7–269.3)	462.9 (369.1–590.9)	670.2 (546.3–814.7)	49.1	−26.3	−12.6

YLDs: years lived with disability, YLLs: years of life lost, DALYs: disability-adjusted life years, UIs: uncertainty intervals

	1990			2017			Percentage change (%)		
Intracerebral hemorrhage	62.6 (44.3–81.9)	1707.0 (1375.5–2276.3)	1769.6 (1433–2348.1)	51.6 (35.7–68.4)	941.1 (733.9–1178.7)	992.8 (780.8–1231.7)	−17.6	−44.9	−43.9
Subarachnoid hemorrhage	13.8 (9.3–18.6)	440.3 (283.4–555.5)	454.1 (298.5–568.3)	11.3 (7.7–15.5)	85.7 (63.8–125.9)	97.0 (74.8–136.0)	−18.1	−80.5	−78.6

YLDs: years lived with disability, YLLs: years of life lost, DALYs: disability-adjusted life years, UIs: uncertainty intervals

Risk Factors

In 2017, behavioral risks and metabolic risks accounted for 78.3% and 63.7% of the cases of stroke, respectively. However, environmental/occupational risks showed a downward trend from 25.3% (21.7–28.7) to 20.1% (16.6–23.5). Even with the developments over these 30 years, the top three risk factors for stroke were dietary risks, high systolic blood pressure, and tobacco consumption and their percentage contributions to the DALYs were 67.5% (95% UI: 60.7–73.4%), 51.5% (43.3–59.0%), and 29.1% (95% UI: 25.4–32.7%), respectively. Body Mass Index (BMI) showed the greatest increase (from eighth most common factor to fifth), with a change of 7.7% (1.7–17.3%) to 15.8% (6.4–26.1%) from 1990 to 2017.

From the perspective of gender, the top three risk factors were high BMI (116.0%), high Low-Density Lipoprotein (LDL) cholesterol (55.0%), and alcohol consumption (42.0%) in males and high BMI (91.2%), high LDL cholesterol (73.3%), and high systolic blood pressure (17.7%) in females (Table 4 and Figure 4).

Table 4
Percentage contribution of risk factors to disability-adjusted life years of stroke by gender in 1990 and 2017

Category		1990	2017	Change (%)
		Percentage	Percentage	
Both genders				
Environmental/occupational risks		25.3 (21.7–28.7)	20.1 (16.6–23.50)	−20.4
	Air pollution	17.3 (14.3–20.2)	12.3 (9.6–15.0)	−28.9
	Lead exposure	9.9 (7.0–12.9)	8.9 (6.1–11.7)	−10.0
Behavioral risks		74.4 (69.7–78.7)	78.3 (73.7–82.3)	5.2
	Tobacco	25.3 (22.1–28.6)	29.1 (25.4–32.7)	15.0
	Dietary risks	66.8 (60.3–72.7)	67.5 (60.7–73.4)	1.1
	Alcohol use	8.7 (3.5–13.9)	14.9 (7.0–22.6)	71.0
Metabolic risks		54.1 (46.6–61.4)	63.7 (56.2–70.4)	17.7
	High fasting plasma glucose	11.1 (7.6–15.7)	12.5 (8.8–17.3)	13.2
	High systolic blood pressure	43.4 (35.1–50.7)	51.5 (43.3–59.0)	18.7
	High body mass index	7.7 (1.7–17.3)	15.8 (6.4–26.1)	104.2
	Impaired kidney function	5.8 (4.7–6.9)	6.0 (5.0–7.2)	4.6
	High low-density lipoprotein cholesterol	5.3 (3.5–8.4)	8.6 (5.6–13.5)	62.1
Males				
Environmental/occupational risks		26.3 (22.5–29.9)	21.5 (17.7–25.1)	−18.2
	Air pollution	16.8 (13.7–20.0)	12.6 (9.8–15.5)	−24.8
	Lead exposure	11.7 (8.6–15.1)	10.1 (7.1–13.3)	−13.6
Behavioral risks		79.2 (75.3–82.7)	85.1 (80.9–88.4)	7.4
	Tobacco	39.1 (35.0–43.9)	42.0 (37.3–46.3)	7.2
	Dietary risk	67.5 (60.7–73.5)	70.0 (63.0–76.0)	3.6
	Alcohol use	17.6 (7.2–27.7)	25.0 (12.6–37.4)	42.0
Metabolic risks		52.3 (44.5–60.0)	62.9 (55.0–70.0)	20.3
	High fasting plasma glucose	9.8 (6.7–13.5)	12.3 (8.5–16.9)	25.8
	High systolic blood pressure	42.3 (34.5–50.5)	51.0 (42.7–58.7)	20.4
	High body mass index	7.4 (1.5–17.5)	16.1 (6.2–26.9)	116.0
	Impaired kidney function	4.9 (4.0–6.0)	5.3 (4.4–6.4)	8.5
	High low-density lipoprotein cholesterol	5.3 (3.5–8.1)	8.2 (5.4–12.6)	55.0
Females				
Environmental/occupational risks		24.3 (20.7–27.6)	18.1 (14.5–21.2)	−25.6

Category		1990	2017	Change (%)
		Percentage	Percentage	
	Air pollution	17.9 (14.8–20.7)	11.9 (9.3–14.4)	−33.7
	Lead exposure	8.0 (5.3–10.8)	7.0 (4.5–9.6)	−12.2
Behavioral risks		69.5 (63.6–75.0)	68.0 (61.9–73.3)	−2.2
	Tobacco	11.3 (8.9–14.0)	9.8 (7.7–12.1)	−13.8
	Dietary risk	66.0 (59.2–72.2)	63.7 (56.9–70.0)	−3.5
	Alcohol use	−0.3 (−1.3–0.8)	−0.3 (−1.4–1.1)	−16.7
Metabolic risks		56.0 (47.9–63.4)	64.9 (57.3–71.7)	15.9
	High fasting plasma glucose	12.4 (8.3–19.3)	12.8 (8.8–18.3)	4.0
	High systolic blood pressure	44.4 (35.3–52.4)	52.3 (43.6–59.8)	17.7
	High body mass index	8.0 (1.8–17.7)	15.3 (6.5–25.3)	91.2
	Impaired kidney function	6.6 (5.4–7.9)	7.0 (5.8–8.4)	6.8
	High low-density lipoprotein cholesterol	5.3 (3.3–8.7)	9.2 (5.7–15.2)	73.3
All factors		82.7 (80.0–85.2)	88.0 (85.2–90.5)	6.3

Discussion

From 1990 to 2017, stroke-associated mortality in Yunnan showed a declining trend, but the prevalence continued to increase, especially after 2010. This trend is similar to that in low-income and middle-income countries[8]. In 2017, age-standardized prevalence of stroke was 1537.7 per 100,000 people, which was higher than the national average of 1115 per 100,000 according to the NESS-China survey[9]. The majority of Yunnan consists of rural areas. Thus, the higher prevalence may be explained by the increased detection rate of stroke in rural areas. In addition, Yunnan has the lowest healthcare ratio per 1,000 individuals and significant differences in the distribution of medical resources[8, 9]. As the aging population continues to grow, the number of cases is expected to increase further, posing challenges for the healthcare system. Thus, we need to strengthen the healthcare system.

The disease burden of intracerebral hemorrhage was much higher than that of ischemic stroke and its rate of DALYs was also higher. According to the global age standards, DALYs of all stroke patients showed a decreasing trend from 1990 to 2017[21], but those of ischemic stroke increased by 5.8% in Yunnan, indicating the serious nature of disease burden of ischemic stroke in Yunnan. We need to pay greater attention to the trends in ischemic stroke. We observed that the rate of DALYs in stroke patients was higher in men than in women. This finding suggests that women live longer and the prevalence of smoking and alcohol consumption is much higher in men than in women from this population[22]. It is essential to strengthen the healthcare framework for early detection, early intervention, and management of patients; to improve the survival rate; and to reduce the burden of disability caused by stroke [23].

In the 2017 GBD study, risk factors were grouped into behavioral, occupational/environmental, and metabolic risk categories. We observed that dietary risks, high BMI, and tobacco consumption were the main risk factors for stroke burden in Yunnan. Dietary habits are a major source of stroke disease burden, accounting for 67.5% of the DALYs in 2017. Yunnan's per capita salt consumption is 11 g, which is significantly higher than the recommended dietary intake. Salt

intake has been linked with an increased risk of high blood pressure and stroke and adherence to a healthy diet can reduce the lifetime risk of stroke by 20%[24]. A healthy diet includes restricting the salt intake to 2–3 grams per day, limiting red meat intake, reducing the caloric intake from saturated and trans fats, and increasing fruit and vegetable intake[25].

Hypertension is the main pathogenic factor associated with the incidence and prognosis of common stroke, accounting for two-thirds of the incidence and DALYs of stroke in developing countries[26]. In this study, the rate of DALYs of hypertension in Yunnan was 51.5%. In addition, a case-control study reported that the population attributable risk or stroke ratio can be attributed to high blood pressure in 54% of the crowd[27].

A higher prevalence of blood pressure in the population is associated with a higher risk of stroke. According to previous research, the prevalence of hypertension among ethnic minorities of Yunnan is higher than that in the general population (32.5%)[28, 29]. However, it is unclear whether alcohol consumption plays a role in the disease burden of stroke among ethnic minorities of Yunnan and requires further research.

In 2017, the contribution of smoking to DALYs in Yunnan reached approximately 33%. Smoking can lead to various diseases and research has shown that passive and former smokers have a higher risk of stroke than non-smokers[30]. Moreover, there is a causal relationship between smoking and risk of ischemic stroke, but not between smoking and risk of hemorrhagic stroke[31]. The prevalence of smoking is higher in men than in women, which may increase the disease burden of stroke in men. Government should monitor tobacco use, educate the population, and provide help in smoking cessation, especially in the tobacco-growing areas of Yunnan.

Although there was little change in the risk of stroke attributable to alcohol consumption from 1990 to 2017, it is a major risk factor for the global burden of disease [32]. Increased alcohol consumption increases the risk of hypertension and stroke[33]. A meta-analysis showed that mild to moderate alcohol consumption (two cups per day) was associated with a reduced risk of ischemic stroke, but not with that of intracerebral hemorrhage or subarachnoid hemorrhage[34]. A high alcohol consumption rate among ethnic minorities might be responsible for the increased incidence of ischemic stroke in Yunnan. High alcohol intake is associated with an increased risk of all types of stroke[35]. According to a report by the Chinese Center for Disease Prevention in 2015, Yunnan has the fourth highest daily alcohol consumption rate in China, which is higher than the national average[36]. This might lead to an increased disease burden of stroke, but the relationship between local alcohol consumption and stroke requires further research.

BMI was the most modifiable risk factor from 1990 to 2017. Previous studies have shown a J-type correlation between BMI and hemorrhagic stroke[37]. However, a recent narrative review suggests an obesity paradox in stroke (obese and overweight patients have lower mortality and better functional outcomes after stroke)[38]. The relationship between stroke and obesity needs to be clarified using high-quality evidence. Prevalence of obesity and hyperlipidemia is increasing in mainland China, since decades of economic development have changed people's eating habits. Moreover, urbanization and industrialization have led to a decline in physical activity, especially in rural areas. These findings may explain the sharp increase in BMI.

Conclusions

The mortality and prevalence trends of stroke in Yunnan are similar to those in developing countries. Due to economic and material prosperity, the age-standardized rates of DALYs, YLLs, and YLDs of stroke are consistent with social development in China. Most of the risk factors associated with stroke are modifiable. Controlling smoking and alcohol intake, changing the dietary habits, controlling body weight, and exercising regularly can play a key role in preventing stroke and reducing the disease burden of stroke. Health institutions need to pay a greater attention to the education and public awareness among rural residents of Yunnan and allocate medical resources rationally.

Abbreviations

DALYs Disability-Adjusted Life Years

YLLs Years of life lost

YLDs Years lived with Disability

UI Uncertainty Interval

GBD Global Burden of Disease

CRA Contamination Risk Assessment

PAFs Population Attributable Fractions

BMI Body Mass Index

LDL Low Density Lipoprotein

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

TZ was responsible for the study design, data acquisition and revising the manuscript. LL contributed to data analysis, drafting the manuscript, interpretation of results, language editions and the interpretation of the findings. YXY and YZ participated in the design of the study, drafting and revising the manuscript. All authors read and approved the final manuscript.

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Figures

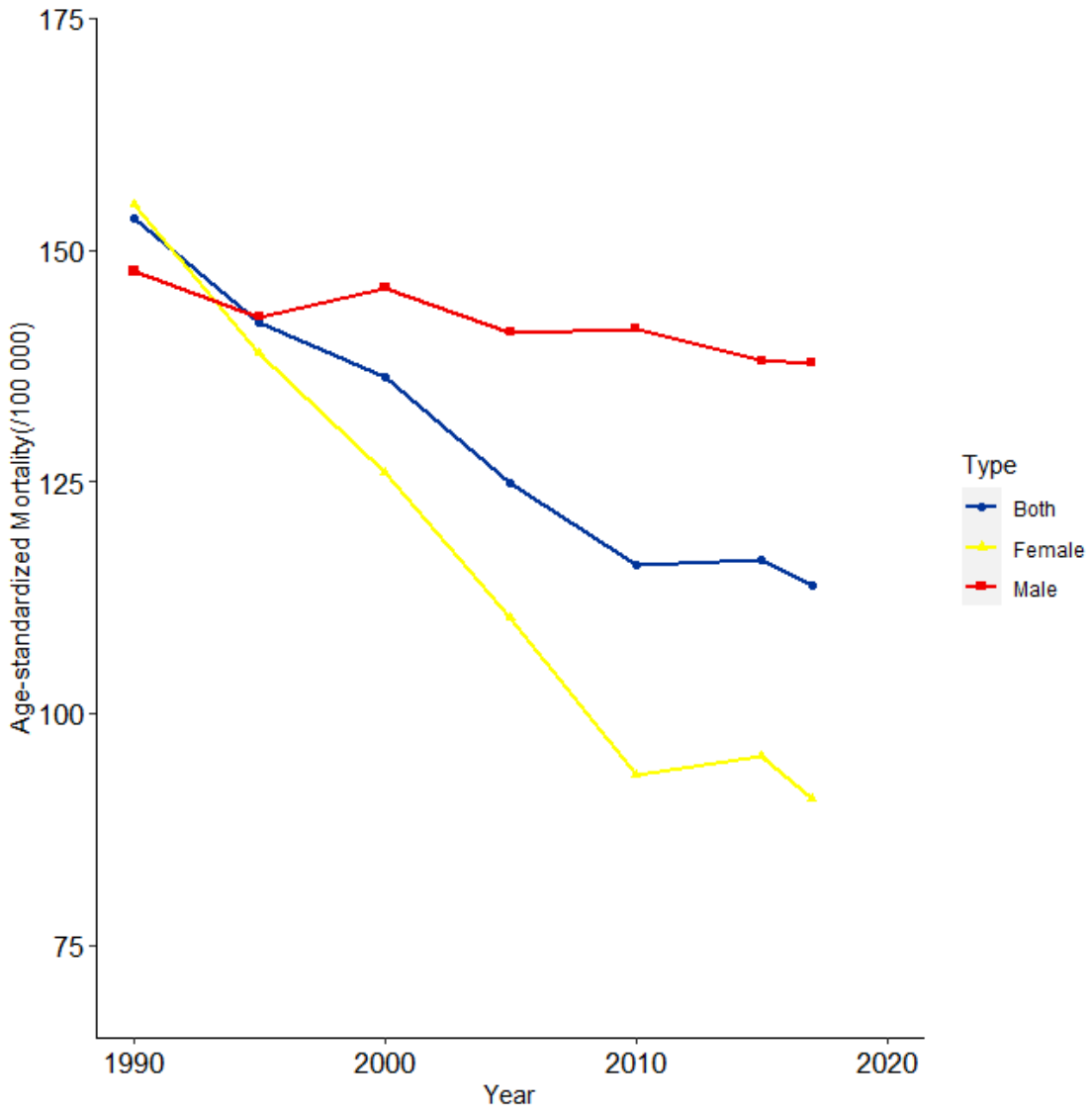

Figure 1

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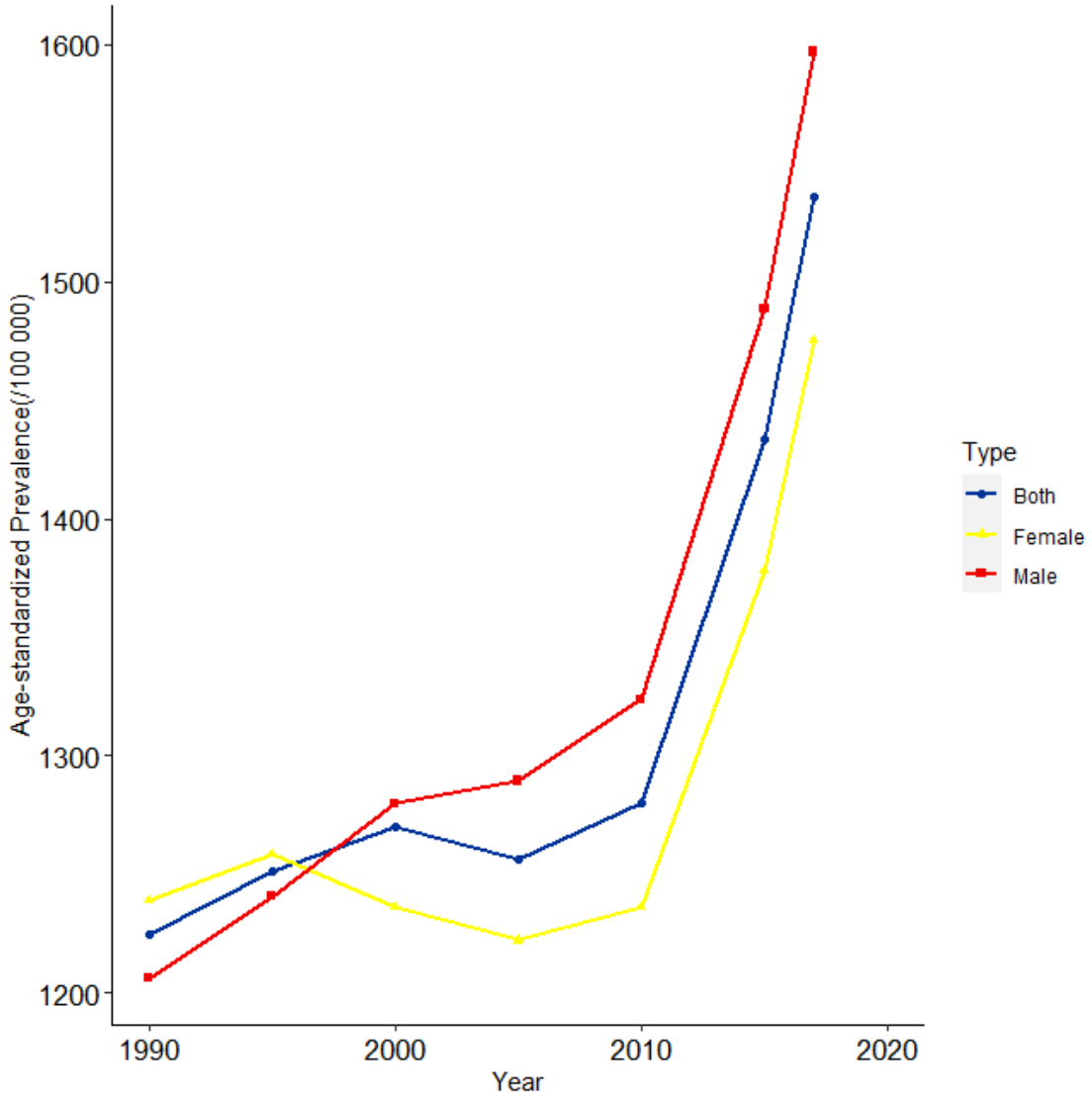

Figure 2

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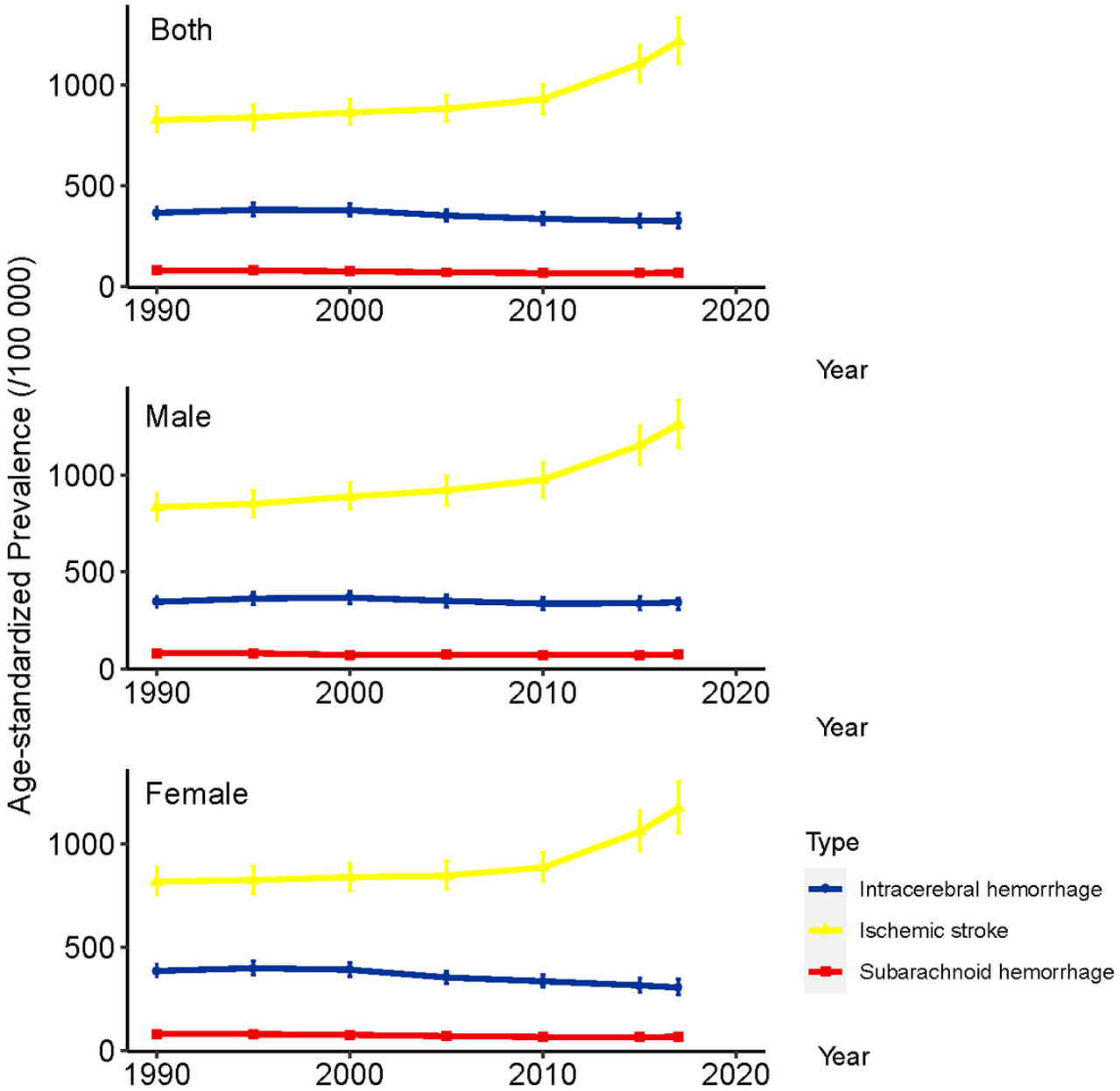

Figure 3. The trend of age-standardized prevalence of stroke in Yunnan by gender and subtype from 1990 to 2017

Figure 3

See image above for figure legend

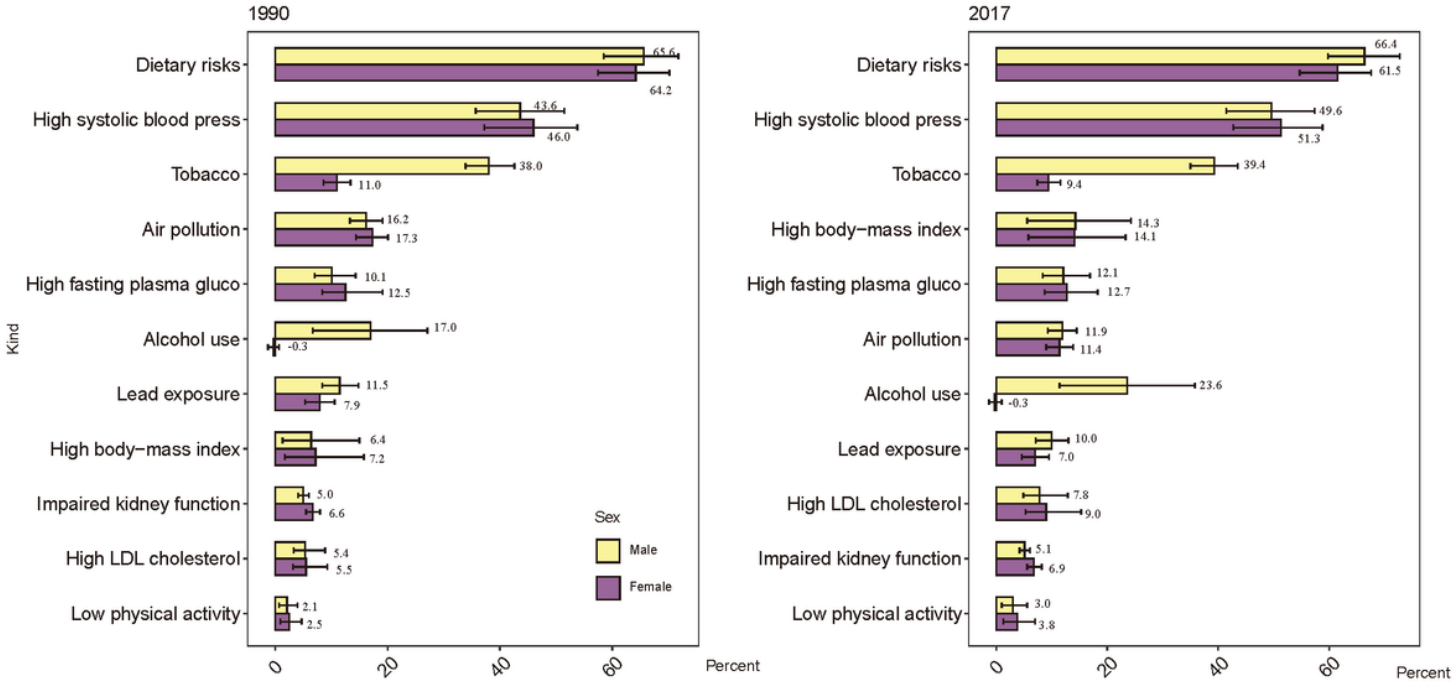

Figure 4. Percentage contribution of major risk factors to the disability-adjusted life years of stroke in Yunnan by gender in 1990 and 2017
LDL: low-density lipoprotein

Figure 4

See image above for figure legend