Prevalence and risk factors of stroke in China: a national serial cross-sectional study from 2003 to 2018

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ABSTRACT
Stroke imposes a substantial burden worldwide. With the rapid economic and lifestyle transition in China, trends of the prevalence of stroke across different geographic regions in China remain largely unknown. Capitalizing on the data in the National Health Services Surveys (NHSS), we assessed the prevalence and risk factors of stroke in China from 2003 to 2018. In this study, data from 2003, 2008, 2013, and 2018 NHSS were collected. Stroke cases were based on participants’ self-report of a previous diagnosis by clinicians. We estimated the trends of stroke prevalence for the overall population and subgroups by age, sex, and socioeconomic factors, then compared across different geographic regions. We applied multivariable logistic regression to assess associations between stroke and risk factors. The number of participants aged 15 years or older were 154,077, 146,231, 230,067, and 212,318 in 2003, 2008, 2013, and 2018, respectively, among whom, 1435, 1996, 3781, and 6069 were stroke patients. The age and sex standardized prevalence per 100,000 individuals was 879 in 2003, 1100 in 2008, 1098 in 2013, and 1613 in 2018. Prevalence per 100,000 individuals in rural areas increased from 669 in 2003 to 1898 in 2018, while urban areas had a stable trend from 1261 in 2003 to 1366 in 2018. Across geographic regions, the central region consistently had the highest prevalence, but the western region has an alarmingly increasing trend from 623/100,000 in 2003 to 1898/100,000 in 2018 (P<0.001), surpassing the eastern region in 2013. Advanced age, male sex, rural area, central region, hypertension, diabetes, depression, low education and income level, retirement or unemployment, excessive physical activity, and unimproved sanitation facilities were significantly associated with stroke. In conclusion, the increasing prevalence of stroke in China was primarily driven by economically underdeveloped regions. It is important to develop targeted prevention programs in underdeveloped regions. Besides traditional risk factors, more attention should be paid to nontraditional risk factors to improve the prevention of stroke.

INTRODUCTION
Stroke is a leading cause of disability and mortality worldwide and imposes a severe global burden.1,2 The Global Burden of Disease (GBD) Study showed the cases and deaths due to stroke markedly increased between 1990 and 2019 across the world.2 With the wide implementation of stroke prevention strategies and good health services, the burden of stroke has decreased in high-income countries. However, reversed trends have been found in low-income and middle-income countries.2 Accompanied by the fast-growing economies and urbanisation, the burden of stroke in China has also changed substantially in the past decades. Recently, stroke has surpassed cancer and coronary heart disease as the top cause of death in China.3 The prevalence of stroke in China in 2013 was more than three times that in the 1990s.4 Thus, monitoring the epidemiological features of stroke has important implications for public health in China. A few epidemiological surveys on the prevalence of stroke and associated risk factors had been completed in China, but most of these studies were either outdated, local or small samples based, or suffered from selection bias.5–8 Prior studies have also noticed regional variations in stroke prevalence before 2013. Most prominent among them is rural–urban difference, to the disadvantage of rural areas.8,9 However, there is no most up-to-date study on the changes of prevalence of stroke across China. While traditional stroke risk factors such as old age, male, hypertension, diabetes, smoking and cardiac causes, collectively explain the majority of the population attributable risks of stroke,10 there was evidence indicating excessive stroke risk unaccounted by these traditional risk factors.11 Meanwhile, several strategies for preventing these traditional stroke risk factors, such as health screenings for elderly, hypertension and diabetes management, tobacco control, and cardiovascular diseases therapy have been implemented in China to control stroke,12–14 yet stroke burden continue to grow. As a result, a better understanding of the potentially
modifiable non-traditional factors is critically important to formulate strategies for stroke prevention.

Using the most updated data from the National Health Services Surveys (NHSS), a large-scale population-based health status screening project in China, we evaluate the national trends of stroke prevalence and the associated risk factors in China from 2003 to 2018, with a focus on identifying potentially modifiable risk factors.

METHODS
Data sources and study sample
This study obtained data from the NHSS system, which is a series of national observational cross-sectional studies covering all 31 provinces, autonomous regions and municipalities in mainland China conducted every 5 years since 1993. The NHSS is representative of national geographical distribution, socioeconomic status and basic characteristics of the population, providing important information about the health status of the Chinese population. In this survey series, we used a multistage stratified cluster sampling procedure, which was described in online supplemental appendix 1. We divided mainland China into three regions: west, central, and east, and then sampled counties stratified by urban and rural areas from each region. Covering 0.02% of the total population with a 5% non-response rate, each country required at least 90 counties and 600 households. The 2003 survey selected 95 counties at random, with 28 counties from urban areas and 67 counties from rural areas; the 2008 survey selected the same 94 counties as the 2003 survey, with one country not selected due to administrative division changes; the 2013 survey selected 62 other counties in addition to those surveyed in 2008; while the 2018 survey selected 84 counties from urban areas and 72 counties from rural areas, taking into account China’s urbanisation transition. Then, from each county, five streets (from urban areas) or townships (from rural areas) were selected, and two communities or villages were selected from each street or township. Finally, 60 households were selected at random from each village or community. In addition, we selected 10 standby households at random in each village or community; if we were unable to interview the initially selected households, we could go on to 1 of 10 standby households. The investigation was open to all members of the selected household.

The detailed interview processes have previously been reported. In brief, local healthcare workers were recruited and trained to conduct interviews in person. Participants aged 15 years or older were questioned after reading a statement explaining the objective of the survey and obtaining consent. Each round used the same stringent quality control programme. All investigators and research staff underwent unified procedure and data collecting training. The interviewers ensured that the questionnaire was completed at the end of each interview, and the questionnaires were checked daily by the supervisors. Five per cent of the total households with completed surveys were randomly selected to be reinterviewed.

Assessment of stroke and related risk factors
Stroke was assessed based on participants’ self-report in the questionnaire according to the International Classification of Diseases 10 at each round of the survey. We began the questionnaire by asking the respondents whether they had any chronic diseases that had been diagnosed by doctor. If they answered they had stroke, we inquired when they were diagnosed and whether they had been treated within the previous 6 months (online supplemental appendix 2). As proof of the diagnosis, medical records or prescriptions from medical institutions were necessary. These diagnoses were included in the survey data under the supervision by doctors from township or higher-level hospitals, and the investigator then documented them in the questionnaire.

The NHSS questionnaire provided us with data on stroke related factors (online supplemental appendix 2). We assessed demographic (age and sex) and geographical characteristics (residence and region), socioeconomic status (educational level, occupation, gross annual income and marital status), lifestyle (smoking, alcohol consumption and physical activity), health status (hypertension, diabetes and depression) and household environment (sanitation facilities) in each round. At each round of the survey, participants were asked to self-report their history of hypertension and diabetes, and confirmation of the diagnosis was required in the form of medical records or prescriptions from medical institutions. Depression was measured using a quality of life questionnaire and self-perceived health. Participants who had smoked a total of at least 100 cigarettes in their lifetime and either continued or ceased smoking during the survey were classified as smokers; that is, both ex-smokers and current smokers are counted as smokers in the analyses. Participants who had an alcoholic drink in the 12 months prior to the survey were considered as alcohol consumption. Physical activity was defined as participating in physical activity (including tai chi, jogging, dancing, swimming, ball sports, aerobics and apparatus exercise) at least once a week in the previous month. Unimproved sanitation facility is defined as not ensuring hygienic separation of human excreta from human contact and open defecation. Improved sanitation facility is defined as likely to ensure hygienic separation of human excreta from human contact. Online supplemental appendix 3 presents a detailed definition of each risk factor.

Statistical analysis
All data were recorded on a printed questionnaire and double entered into an online system provided by the National Health Commission of the People’s Republic of China. A database was established using Access software. The overall population’s stroke prevalence was determined, as well as subgroups stratified by age, sex,
residential area and geographical region. We also assessed socioeconomic factors such as education level, occupation, income and marital status. The age-standardised prevalence of stroke was standardised for age and sex using the 2010 Chinese census for both the overall population and subgroups. To analyse trends in stroke prevalence across time, we used the one-sided (increasing trend) Cochran-Armitage trend test. The Pearson $\chi^2$ test was used to assess between-group differences in stroke prevalence. We also compared the evolution of stroke prevalence between urban and rural areas by sex and geographical subgroups. To estimate the ORs and 95% CIs of all recorded factors potentially associated with stroke, we constructed multiple logistic regression models involving age, sex, residence, region, educational level, occupation, income, marital status, hypertension, diabetes, depression, smoking, alcohol consumption, physical activity and sanitation facilities, separately for each survey (online supplemental appendix 4). Meta-analyses were performed for OR value of risk factors from serial surveys. We assessed heterogeneity using the $F$ statistic. Individuals with missing values did not have their values imputed. SAS V.9.4 software was used for all statistical analyses.

RESULTS

We sampled 57 023, 56 456, 93 613 and 94 076 households in 2003, 2008, 2013 and 2018, respectively. A total of 154 077, 146 231, 230 067 and 212 318 participants in 2003, 2008, 2013 and 2018, respectively, were included in the final analysis. Overall, 1435 (0.93%), 1996 (1.36%), 3781 (1.64%) and 6069 (2.86%) people had stroke in 2003, 2008, 2013 and 2018, respectively. The age-standardised and sex-standardised prevalence of stroke per 100 000 people in China was 879 (95% CI 834 to 924) in 2003, 1100 (95% CI 1052 to 1147) in 2008, 1098 (95% CI 1063 to 1133) in 2013 and 1613 (95% CI 1572 to 1655) in 2018, respectively (table 1).

The elderly were more likely to be affected, especially those aged 70 years or older, of whom 8137 per 100 000 had a stroke in 2018. The subgroup aged 50–59 years experienced a rapid increase in stroke prevalence, from 1228 per 100 000 people in 2003 to 2448 in 2018. Comparing residential areas (figure 1, table 2), the prevalence of stroke was significantly higher in urban (1261/100 000) than in rural areas (669/100 000) in 2003, but the difference diminished by 2008 (1159/100 000 in urban vs 1052/100 000 in rural areas). Furthermore, the prevalence of stroke in rural areas (1898/100 000) had surpassed that of urban areas (1365/100 000), by 2018. Similarly, while the prevalence increased in all regions in China, the western region has a more dramatic increase (from 623/100 000 in 2003 to 1439/100 000 in 2018) than the eastern region (from 918/100 000 in 2003 to 1306/100 000 people in 2018). We also estimated stroke prevalence in different provinces of China (online supplemental appendix 5), among which the Jiangxi province experienced the most rapid increase from 253 cases per 100 000 people in 2003 to 1133 in 2018. While most provinces displayed a significant increasing trend in stroke prevalence ($P_{trend}<0.05$), four provinces had stabilised prevalence, including Liaoning, Hainan, Henan and Xinjiang Uygur Autonomous region.

Table 2 shows the disparity of stroke prevalence between Chinese urban and rural areas by age, sex and geographical regions from 2003 to 2018. Stroke prevalence was higher in urban than in rural areas in 2003 for all geographical regions. However, the prevalence was greater in rural than urban areas in 2018 across all geographical regions. Furthermore, in the western region, the prevalence of stroke increased in both urban and rural areas in the past decades. Similarly, for each age or sex subgroup, the prevalence of stroke significantly increased in rural areas during this period. A different trend was observed in urban areas.

Table 3 summarises the risk factors for stroke in 2003, 2008, 2013 and 2018, respectively. We found that advanced age, as well as males, was associated with an increased prevalence of stroke. People in the rural area and central regions had higher stroke prevalence than those in urban areas and western regions. Retired or unemployed people tended to be associated with higher stroke prevalence compared with employed people. We also observed the prevalence of stroke was also associated with hypertension and diabetes. Meanwhile, a higher prevalence of stroke was found in people with severe depression, with the highest OR values. Interestingly, we found unimproved sanitation facilities were consistently associated with a high risk of stroke. The meta-analysis of serial surveys also showed that advanced age, male sex (OR 1.41, 95% CI 1.34 to 1.47), rural area (OR 1.16, 95% CI 1.10 to 1.21), central region (OR 1.37, 95% CI 1.31 to 1.43), retirement (OR 1.78, 95% CI 1.67 to 1.90) or unemployment (OR 1.74, 95% CI 1.65 to 1.82), hypertension (OR 1.79, 95% CI 1.71 to 1.87), diabetes (OR 1.79, 95% CI 1.71 to 1.87), depression (moderate: OR 2.71, 95% CI 2.59 to 2.83; severe depression: OR 4.01, 95% CI 3.53 to 4.49) and unimproved sanitation facilities (OR 1.38 95% CI 1.32 to 1.44) were associated with an increased prevalence of stroke. Furthermore, people with high income and having a college education were protective against stroke. Cigarette smoking was not proven to be a risk factor (OR 1.01, 95% CI 0.97 to 1.06), but alcohol consumption was found to be a protective factor against stroke. Excessive physical activity was also associated with a higher risk of stroke in 2003 (OR 1.22, 95% CI 1.04 to 1.43) and 2013 (OR 1.27, 95% CI 1.16 to 1.40). Results of the analyses stratified by urban and rural areas are shown in online supplemental appendices 6 and 7, respectively. Similar to the overall population, advanced age, male sex, central region, retirement or unemployment, hypertension, diabetes, depression and unimproved sanitation facilities were risk factors for stroke in both urban and rural areas. Risk factors did not differ between urban and rural areas.
**Table 1** Prevalence of stroke by age, sex and socioeconomic factors in China from 2003 to 2018

|                | 2003                  | 2008                  | 2013                  | 2018                  | Rates/100 000 (95% CI) | P value for trend† |
|----------------|-----------------------|-----------------------|-----------------------|-----------------------|------------------------|---------------------|
|                | No of Participants    | Rates/100 000 people  | No of Participants    | Rates/100 000 (95% CI)| No of Participants    | Rates/100 000 (95% CI)|
| Overall        | 154 077               | 879 (834 to 924)      | 146 231               | 1100 (1052 to 1147)   | 230 067                | 1098 (1063 to 1133)  |
|                |                       |                       |                       |                       |                        |                     |
| Age            |                       |                       |                       |                       |                        |                     |
| < 30 years     | 38 424                | 36 (17 to 56)         | 32 368                | 34 (14 to 54)         | 41 312                 | 38 (19 to 57)        |
| 30–39 years    | 34 367                | 112 (77 to 147)       | 26 449                | 139 (94 to 184)       | 33 173                 | 122 (85 to 160)      |
| 40–49 years    | 30 953                | 426 (353 to 498)      | 29 495                | 536 (452 to 619)      | 49 622                 | 556 (491 to 622)     |
| 50–59 years    | 24 077                | 1228 (1089 to 1367)   | 28 360                | 1691 (1541 to 1842)   | 44 903                 | 1661 (1543 to 1780)  |
| 60–69 years    | 14 696                | 2822 (2555 to 3089)   | 16 017                | 3687 (3395 to 3979)   | 35 952                 | 3506 (3315 to 3699)  |
| ≥ 70 years     | 11 560                | 4650 (4267 to 5034)   | 13 542                | 5305 (4928 to 5683)   | 25 105                 | 5748 (5460 to 6035)  |
| Sex            |                       |                       |                       |                       |                        |                     |
| Female         | 77 282                | 815 (753 to 878)      | 74 236                | 1059 (992 to 1126)    | 117 830                | 1088 (1038 to 1137)  |
| Male           | 76 792                | 941 (876 to 1007)     | 71 955                | 1139 (1070 to 1208)   | 112 235                | 1109 (1059 to 1159)  |
| Education      |                       |                       |                       |                       |                        |                     |
| College        | 8774                  | 1308 (986 to 1631)    | 9563                  | 769 (547 to 991)      | 25 522                 | 723 (592 to 855)     |
| Senior high    | 22 864                | 1363 (1110 to 1616)   | 23 365                | 1206 (1027 to 1385)   | 42 325                 | 971 (874 to 1069)    |
| Junior high    | 52 575                | 1106 (946 to 1266)    | 51 891                | 1235 (1096 to 1374)   | 79 492                 | 1221 (1141 to 1302)  |
| Primary        | 40 661                | 887 (792 to 982)      | 38 589                | 1134 (1041 to 1226)   | 55 629                 | 1158 (1088 to 1229)  |
| None           | 28 964                | 803 (692 to 914)      | 22 591                | 1044 (925 to 1164)    | 27 051                 | 1013 (912 to 1115)   |
| Occupation     |                       |                       |                       |                       |                        |                     |
| Employed       | 117 169               | 573 (526 to 621)      | 99 625                | 787 (724 to 851)      | 151 692                | 820 (769 to 870)     |
| Retired        | 11 788                | 1438 (1200 to 1676)   | 13 942                | 1478 (1064 to 1892)   | 31 383                 | 1244 (1038 to 1449)  |
| Unemployed     | 14 870                | 1452 (1256 to 1648)   | 22 042                | 1756 (1596 to 1917)   | 36 328                 | 1823 (1687 to 1959)  |
| Income         |                       |                       |                       |                       |                        |                     |
| High           | 53 259                | 907 (827 to 986)      | 50 492                | 1087 (1004 to 1170)   | 78 765                 | 1010 (952 to 1069)   |
| Middle         | 50 691                | 844 (765 to 923)      | 48 251                | 1092 (1007 to 1177)   | 75 792                 | 1098 (1035 to 1160)  |
| Low            | 50 127                | 895 (816 to 974)      | 47 488                | 1134 (1050 to 1217)   | 75 510                 | 1207 (1143 to 1271)  |
| Marital status |                       |                       |                       |                       |                        |                     |
| Married        | 115 086               | 925 (867 to 982)      | 109 292               | 1138 (1073 to 1204)   | 181 364                | 1103 (1061 to 1145)  |
| Single         | 27 738                | 680 (592 to 1069)     | 23 349                | 920 (594 to 1245)     | 29 738                 | 913 (636 to 1189)    |
| Divorced       | 1649                  | 789 (627 to 1311)     | 2021                  | 736 (341 to 1131)     | 32 142                 | 1280 (851 to 1710)   |
| Widowed        | 9504                  | 700 (550 to 849)      | 10 409                | 1274 (950 to 1598)    | 15 453                 | 1156 (843 to 1470)   |

*All estimates were age and sex standardised to the 2010 Chinese census. Presence of stroke was based on participants’ self-report of a previous diagnosis by medical institution. tP value for trend calculated using one-sided (increasing trend) Cochran-Armitage trend test.
DISCUSSION

This study involves serially collected participants representative of all regions in mainland China with the largest sample size to date, enabling accurate estimation of the trend of stroke prevalence over time and across the country. We observed distinct trends in the stroke prevalence between underdeveloped (rural, western) and developed (urban, eastern) regions in China, with the curves resembling the shape of scissors (figure 1). Furthermore, we identified advanced age, male sex, rural area, central region, hypertension, diabetes, depression, low education and income level, retirement or unemployment, excessive physical activity, and unimproved sanitation facilities as risk factors for stroke.

Our results highlight a marked increase in the age-adjusted prevalence of stroke in 2018 (1613 cases per 100,000 people) compared with that in 2003 (879 cases per 100,000 people), consistent with previous studies. According to the National Epidemiological Survey of Stroke in China, the age-standardised stroke prevalence had reached 1115 cases per 100,000 people in 2013. The China National Stroke Screening and Prevention Project, done between 2014 and 2015, showed higher stroke prevalence (2450 cases per 100,000 people) in adults aged 40 years or older. The age-standardised prevalence of stroke reported in the GBD Study increased by 13.2% from 1990 to 2019 in China, reaching 1469 cases per 100,000 people. It was still significantly higher than in previous comparable surveys, suggesting a substantial increase in stroke incidence over the past three decades. Moreover, in comparison with results in 1990, the age-standardised stroke mortality rate fell by 39.8%, reaching 127 cases per 100,000 people in 2019. Improvements in emergency services, stroke prevention and treatment decreased the stroke mortality rate and increased length of survival after stroke. Finally, another possible explanation for the heightened prevalence of stroke could be the improvement in access to diagnosis, such as the use of better diagnostic methods. Together, these factors could have led to the rapid increase in stroke prevalence in China.

There are largely geographical and regional variations in stroke burden in China. Epidemiological studies have reported a north-south gradient, with the highest stroke prevalence in northern China and the lowest in the southern region. However, less research has focused on the eastern, central and western regions. We found that the age-standardised and sex-standardised prevalence of stroke in the eastern was consistently higher than that in the western region up to 2008, but became lower than in the western region in 2018. Historically, China has had a higher stroke burden in urban areas than in rural areas.

A large-scale Chinese population survey in 1986 indicated that stroke prevalence was much higher in cities than in rural areas. In our study, stroke prevalence was also significantly higher in urban than in rural participants in 2003, but this difference became smaller over time, and the trend has reversed in 2018. The ‘scissors phenomenon’ describes vividly the disparity of stroke prevalence between underdeveloped and developed regions in China from 2003 to 2018. This phenomenon was also supported by several epidemiological studies. Recent studies have reported a higher stroke incidence in rural China, and that the stroke mortality in rural regions has surpassed that of urban areas. Thus, the current
Table 2  Prevalence of stroke in urban and rural areas by age, sex and region in China from 2003 to 2018

|                | 2003      | 2008      | 2013      | 2018      |
|----------------|-----------|-----------|-----------|-----------|
|                | No of Participants | Rates/100 000 (95% CI) | No of Participants | Rates/100 000 (95% CI) | No of Participants | Rates/100 000 (95% CI) | No of Participants | Rates/100 000 (95% CI) |
| Urban areas    |           |           |           |           |
| Overall        | 42796     | 1261 (1168 to 1354) | 40975     | 1159 (1073 to 1245) | 115114     | 1052 (1005 to 1100) | 113519     | 1365 (1312 to 1417) |
| Age <30 years  | 8730      | 33 (0 to 70)  | 7727      | 27 (0 to 65)  | 20147      | 43 (15 to 71)  | 14284      | 21 (0 to 45)  |
| Age 30-39 years| 8691      | 100 (55 to 166) | 6957      | 71 (9 to 134) | 17729      | 94 (49 to 139) | 17748      | 64 (26 to 101) |
| Age 40-49 years| 9127      | 448 (311 to 584) | 7917      | 521 (362 to 680) | 23263      | 433 (348 to 518) | 20870      | 601 (496 to 707) |
| Age 50-59 years| 6598      | 1699 (1387 to 2011) | 8171      | 1421 (1164 to 1677) | 21944      | 1519 (1356 to 1682) | 22943      | 2085 (1899 to 2271) |
| Sex Female     | 22058     | 1138 (1013 to 1264) | 21321     | 1087 (971 to 1203) | 59816      | 1012 (946 to 1078) | 59113      | 1209 (1141 to 1276) |
| Sex Male       | 20735     | 1380 (1244 to 1517) | 19645     | 1229 (1103 to 1356) | 55297      | 1092 (1022 to 1161) | 54406      | 1520 (1440 to 1600) |
| Region Eastern | 17666     | 1256 (1116 to 1396) | 16804     | 1170 (1038 to 1302) | 39468      | 833 (762 to 903)  | 45155      | 1161 (1086 to 1236) |
| Central        | 13290     | 1626 (1433 to 1819) | 12765     | 1612 (1427 to 1797) | 38467      | 1243 (1152 to 1334) | 34167      | 1714 (1606 to 1822) |
| Western        | 11837     | 818 (668 to 968)  | 11406     | 596 (480 to 713)  | 37179      | 1103 (1015 to 1190) | 34197      | 1261 (1170 to 1352) |
| Rural areas    |           |           |           |           |
| Overall        | 111281    | 669 (620 to 718)  | 105256    | 1052 (957 to 1109) | 114953     | 1135 (1084 to 1187) | 98799      | 1899 (1833 to 1964) |
| Age <30 years  | 29694     | 37 (15 to 59)  | 24641     | 37 (13 to 60)  | 21165      | 33 (9 to 58)  | 12614      | 40 (5 to 75)  |
| Age 30-39 years| 25767     | 116 (74 to 157) | 19492     | 163 (107 to 220) | 15444      | 155 (93 to 216) | 11782      | 169 (95 to 143) |
| Age 40-49 years| 21824     | 417 (331 to 502) | 21578     | 541 (443 to 639) | 26399      | 665 (567 to 764) | 19421      | 987 (848 to 1125) |
| Age 50-59 years| 17479     | 1052 (901 to 1203) | 20189     | 1802 (1619 to 1986) | 22959      | 1800 (1628 to 1972) | 22998      | 2813 (2599 to 3027) |
| Sex Male       | 56075     | 706 (636 to 776)  | 52310     | 1083 (1002 to 1164) | 56938      | 1117 (1045 to 1188) | 48770      | 1872 (1779 to 1964) |
| Sex Female     | 55224     | 631 (563 to 699)  | 52915     | 1020 (940 to 1101) | 58014      | 1155 (1081 to 1229) | 50029      | 1929 (1835 to 2023) |
| Region Eastern | 34726     | 683 (600 to 766)  | 33604     | 995 (901 to 1089) | 38636      | 1053 (969 to 1136) | 28533      | 1533 (1422 to 1643) |
| Central        | 29859     | 819 (712 to 925)  | 28461     | 1399 (1272 to 1526) | 36386      | 1344 (1246 to 1442) | 33523      | 2486 (2360 to 2611) |
| Western        | 46896     | 547 (476 to 618)  | 43191     | 845 (762 to 927)  | 39931      | 1009 (922 to 1095) | 36743      | 1605 (1502 to 1707) |
| Table 3  | Risk factors for stroke among overall population in China from 2003 to 2018 |
|---------|---------------------------------------------------------------|
|         | 2003 OR (95% CI) P value                                     | 2008 OR (95% CI) P value                                     | 2013 OR (95% CI) P value                                     | 2018 OR (95% CI) P value                                     | Meta-analysis† OR (95% CI) P value                           |
| Age     |                                                              |                                                              |                                                              |                                                              |                                                             |
| < 30 years | 1 (ref)                                                      | 1 (ref)                                                      | 1 (ref)                                                      | 1 (ref)                                                      | 1 (ref)                                                     |
| 30–39 years | 1.92 (0.97 to 3.80)                                           | 3.21 (1.48 to 6.99)                                           | 2.59 (1.40 to 4.81)                                           | 2.85 (1.27 to 6.42)                                           | 2.40 (1.46 to 3.34)                                         |
| 40–49 years | 6.49 (3.46 to 12.19)                                           | 11.25 (5.47 to 23.13)                                          | 9.11 (5.24 to 15.84)                                           | 18.67 (8.91 to 39.16)                                          | 8.46 (5.38 to 13.54)                                         |
| 50–59 years | 15.67 (8.42 to 29.14)                                          | 28.94 (14.21 to 58.95)                                         | 20.04 (11.60 to 34.64)                                         | 49.55 (23.75 to 103.40)                                       | 19.82 (12.65 to 26.98)                                      |
| 60–69 years | 26.84 (14.26 to 49.76)                                          | 48.75 (23.88 to 99.65)                                         | 29.10 (16.82 to 50.36)                                         | 93.41 (44.75 to 194.99)                                       | 31.58 (19.91 to 52.84)                                      |
| ≥70 years  | 38.69 (20.6 to 72.69)                                          | 53.74 (26.15 to 110.44)                                       | 38.86 (22.39 to 67.44)                                         | 121.73 (58.24 to 254.42)                                      | 42.93 (27.34 to 58.53)                                      |
| Sex      |                                                              |                                                              |                                                              |                                                              |                                                             |
| Female   | 1 (1.40 to 1.83)                                              | 1.46 (1.30 to 1.64)                                             | 1.40 (1.29 to 1.53)                                             | 1.36 (1.27 to 1.45)                                             | 1.41 (1.34 to 1.47)                                          |
| Male     |                                                              |                                                              |                                                              |                                                              |                                                             |
| Residence|                                                              |                                                              |                                                              |                                                              |                                                             |
| Urban    | 0.83 (0.70 to 1.00)                                            | 1.06 (0.90 to 1.25)                                            | 1.14 (1.05 to 1.25)                                            | 1.28 (1.20 to 1.36)                                            | 1.16 (1.10 to 1.21)                                          |
| Rural    |                                                              |                                                              |                                                              |                                                              |                                                             |
| Region   |                                                              |                                                              |                                                              |                                                              |                                                             |
| Western  | 1 (1.58 to 2.10)                                               | 2.10 (1.85 to 2.37)                                            | 1.16 (1.07 to 1.26)                                            | 1.43 (1.34 to 1.53)                                            | 1.37 (1.31 to 1.43)                                          |
| Central  | 1.42 (1.23 to 1.63)                                             | 1.52 (1.34 to 1.72)                                            | 0.88 (0.80 to 0.96)                                            | 0.98 (0.91 to 1.05)                                            | 1.01 (0.96 to 1.05)                                          |
| Eastern  |                                                              |                                                              |                                                              |                                                              |                                                             |
| Education|                                                              |                                                              |                                                              |                                                              |                                                             |
| College  | 0.91 (0.69 to 1.20)                                             | 1.35 (1.01 to 1.81)                                            | 1.23 (1.01 to 1.50)                                            | 1.21 (0.93 to 1.56)                                            | 1.19 (1.04 to 1.33)                                          |
| Senior high | 0.84 (0.65 to 1.08)                                             | 1.45 (1.10 to 1.93)                                            | 1.56 (1.29 to 1.88)                                            | 1.39 (1.08 to 1.79)                                            | 1.12 (0.97 to 1.26)                                          |
| Junior high | 0.87 (0.67 to 1.13)                                             | 1.49 (1.12 to 1.98)                                            | 1.49 (1.23 to 1.81)                                            | 1.45 (1.12 to 1.86)                                            | 1.21 (1.06 to 1.37)                                          |
| Primary  | 0.82 (0.62 to 1.08)                                             | 1.29 (0.95 to 1.74)                                            | 1.32 (1.07 to 1.62)                                            | 1.34 (1.04 to 1.74)                                            | 1.14 (1.00 to 1.28)                                          |
| None     |                                                              |                                                              |                                                              |                                                              |                                                             |
| Occupation|                                                              |                                                              |                                                              |                                                              |                                                             |
| Employed | 2.40 (1.97 to 2.92)                                             | 1.98 (1.66 to 2.37)                                            | 1.64 (1.46 to 1.84)                                            | 1.77 (1.62 to 1.95)                                            | 1.78 (1.67 to 1.90)                                          |
| Unemployed| 1.93 (1.63 to 2.29)                                             | 1.73 (1.52 to 1.96)                                            | 1.70 (1.55 to 1.87)                                            | 1.73 (1.61 to 1.86)                                            | 1.74 (1.65 to 1.82)                                          |
| Income†  |                                                              |                                                              |                                                              |                                                              |                                                             |
| Medium   | 0.98 (0.86 to 1.13)                                             | 0.98 (0.87 to 1.11)                                            | 1.08 (0.99 to 1.18)                                            | 1.22 (1.13 to 1.31)                                            | 1.11 (1.06 to 1.17)                                          |
| Low      | 1.05 (0.92 to 1.21)                                             | 0.92 (0.81 to 1.03)                                            | 1.09 (1.00 to 1.19)                                            | 1.37 (1.27 to 1.49)                                            | 1.09 (1.04 to 1.15)                                          |
| Marital status|                                                               |                                                              |                                                              |                                                              |                                                             |
| Married  | 0.58 (0.36 to 0.95)                                             | 0.80 (0.57 to 1.13)                                            | 0.68 (0.51 to 0.90)                                            | 0.75 (0.58 to 0.96)                                            | 0.71 (0.60 to 0.82)                                          |
| Single   | 0.85 (0.47 to 1.53)                                             | 0.81 (0.49 to 1.32)                                            | 1.15 (0.85 to 1.56)                                            | 1.27 (1.04 to 1.57)                                            | 1.11 (0.93 to 1.29)                                          |

Continued
### Table 3 Continued

|          | 2003     |          | 2008     |          | 2013     |          | 2018     |          | Meta-analysis† |
|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------------|
|          | OR (95% CI)* | P value | OR (95% CI) | P value | OR (95% CI) | P value | OR (95% CI) | P value | P value |
| Widowed  | 0.74 (0.63 to 0.87) | <0.001 | 0.88 (0.77 to 1.00) | 0.06 | 0.92 (0.83 to 1.01) | 0.08 | 0.98 (0.91 to 1.06) | 0.01 | 0.91 (0.86 to 0.96) | 0.01 |
| Hypertension‡ | No | 1 (ref) | 1 (ref) | 1 (ref) | 1 (ref) | 1 (ref) | 1 (ref) | 1 (ref) | 1 (ref) |
|           | Yes | 1.41 (1.20 to 1.64) | <0.001 | 2.17 (1.95 to 2.42) | <0.001 | 3.38 (3.14 to 3.62) | <0.001 | 1.55 (1.46 to 1.65) | <0.001 | 1.79 (1.71 to 1.87) | <0.001 |
| Diabetes¶ | No | 1 (ref) | 1 (ref) | 1 (ref) | 1 (ref) | 1 (ref) | 1 (ref) | 1 (ref) | 1 (ref) |
|           | Yes | 1.57 (1.20 to 2.05) | 0.001 | 1.28 (1.03 to 1.58) | 0.03 | 1.43 (1.29 to 1.59) | <0.001 | 1.33 (1.19 to 1.48) | <0.001 | 1.38 (1.28 to 1.47) | 0.54 |
| Depression** | No | 1 (ref) | 1 (ref) | 1 (ref) | 1 (ref) | 1 (ref) | 1 (ref) | 1 (ref) | 1 (ref) |
|           | Moderate | 3.37 (3.00 to 3.79) | <0.001 | 3.98 (3.56 to 4.46) | <0.001 | 2.73 (2.50 to 2.97) | <0.001 | 2.43 (2.27 to 2.59) | <0.001 | 2.71 (2.59 to 2.83) | <0.001 |
|           | Severe | 10.67 (8.48 to 13.43) | <0.001 | 9.73 (7.71 to 12.28) | <0.001 | 5.26 (4.22 to 6.54) | <0.001 | 3.07 (2.57 to 3.67) | <0.001 | 4.01 (3.53 to 4.49) | <0.001 |
| Cigarette smoking†† | Never | 1 (ref) | 1 (ref) | 1 (ref) | 1 (ref) | 1 (ref) | 1 (ref) | 1 (ref) | 1 (ref) |
|           | Smoker | 0.89 (0.78 to 1.02) | 0.10 | 0.92 (0.82 to 1.04) | 0.19 | 1.11 (1.01 to 1.21) | 0.03 | 1.05 (0.98 to 1.13) | 0.18 | 1.01 (0.97 to 1.06) | 0.01 |
| Alcohol consumption (times per week)‡‡ | Never | 1 (ref) | 1 (ref) | 1 (ref) | 1 (ref) | 1 (ref) | 1 (ref) | 1 (ref) | 1 (ref) |
|           | <3 | 0.51 (0.41 to 0.64) | <0.001 | 0.44 (0.30 to 0.65) | <0.001 | 0.61 (0.53 to 0.69) | <0.001 | 0.56 (0.51 to 0.60) | <0.001 | 0.56 (0.52 to 0.60) | 0.26 |
|           | ≥3 | 0.46 (0.36 to 0.59) | <0.001 | 0.44 (0.35 to 0.48) | <0.001 | 0.41 (0.35 to 0.48) | <0.001 | 0.41 (1.00 to 1.23) | 0.06 | 0.53 (0.49 to 0.58) | <0.001 |
| Physical activity (times per week)§§ | Never | 1 (ref) | 1 (ref) | 1 (ref) | 1 (ref) | 1 (ref) | 1 (ref) | 1 (ref) | 1 (ref) |
|           | <1 | 1.47 (0.79 to 2.75) | 0.22 | 1.15 (0.78 to 1.68) | 0.48 | 1.02 (0.76 to 1.37) | 0.91 | 1.07 (1.01 to 1.14) | 0.03 | 1.07 (1.01 to 1.13) | 0.83 |
|           | 1–2 | 0.71 (0.39 to 1.32) | 0.28 | 1.01 (0.80 to 1.29) | 0.92 | 1.04 (0.89 to 1.22) | 0.59 | 1.05 (0.95 to 1.16) | 0.37 | 1.03 (0.95 to 1.11) | 0.57 |
|           | 3–5 | 0.90 (0.68 to 1.18) | 0.44 | 0.99 (0.79 to 1.23) | 0.90 | 1.02 (0.89 to 1.18) | 0.75 | 0.95 (0.85 to 1.06) | 0.36 | 0.97 (0.89 to 1.05) | 0.82 |
|           | ≥6 | 1.22 (1.04 to 1.43) | 0.01 | 1.07 (0.92 to 1.25) | 0.40 | 1.27 (1.16 to 1.40) | <0.001 | 1.04 (0.82 to 1.31) | 0.77 | 1.19 (1.10 to 1.27) | 0.15 |
| Sanitation facilities | Improved¶¶ | 1 (ref) | 1 (ref) | 1 (ref) | 1 (ref) | 1 (ref) | 1 (ref) | 1 (ref) | 1 (ref) |
|          | Unimproved*** | 1.36 (1.18 to 1.58) | <0.001 | 1.31 (1.15 to 1.50) | <0.001 | 1.39 (1.27 to 1.51) | <0.001 | 1.39 (1.30 to 1.47) | <0.001 | 1.38 (1.32 to 1.44) | 0.87 |

*Multiple logistic regression models included age, sex, residence, region, educational level, occupation, income, marital status, hypertension, diabetes, depression, smoking, alcohol consumption, physical activity and sanitation facilities.
†The meta estimates of serial surveys.
‡Categorised into high, middle and low levels. High level presented top third of annual per capita income in the sampled county at the survey year, the second third was middle level and others belonged to low level.
§Self-reported for ever being diagnosed with hypertension by medical institution.
¶Self-reported for ever being diagnosed with diabetes by medical institution.
**Self-perceived health according to quality of life questionnaire.
††Participants have smoked a total of at least 100 cigarettes and either continued or ceased smoking at the survey contact and open defecation.
***Likely to ensure hygienic separation of human excreta from human contact.
Ref, reference.
burden of stroke in China appears to be more serious in the central and western regions, as well as rural areas. The regional variations in stroke prevalence may be attributed to the rapid transformations in socioeconomic conditions, and lifestyle over the past decades in China, especially in underdeveloped regions. As a result of urbanisation and economic boom, the main risk factors for stroke, such as hypertension and diabetes, are becoming more prevalent in rural areas than in urban areas. In addition, coupled with the advancement of diagnostic tools, the adoption of CT and MRI ensured the accuracy of stroke diagnosis in underdeveloped regions. All these changes could be linked to the dramatic rise in stroke prevalence in rural areas and western regions. An increase in stroke prevalence likely reflects the change in lifestyle and socioeconomic status. The significance of socioeconomic risk factors as predictors of stroke burden has already been discussed. Overall, people with lower socioeconomic level tended to have a higher prevalence of stroke. Our results confirmed previous observations that people with higher income and the highest level of education have a lower risk of stroke. However, it is unclear what explains the association between socioeconomic status and stroke prevalence. Traditional stroke risk factors such as older age, male, hypertension and diabetes may help to explain why people with lower socioeconomic status have a higher rate of stroke, as a larger burden of stroke risk factors was found in people with lower socioeconomic status. Moreover, we identified occupational status as the most reliable risk factor for stroke; a higher prevalence was seen in unemployed or retired individuals. Of the few studies that have investigated the relationship between occupational status and stroke, one reported that unemployed/retired Japanese women could be at risk for stroke, and another from Finland also suggested that occupation status is one of the most common health indicators. As far as those who were retired, they generally lost their jobs because of age or poor health, including possible stroke or other diseases. For those who were unemployed, financial stress, depression and social stigma could have triggered unhealthy behaviours and poor mental health. Our findings suggest that, of all the socioeconomic factors, occupational status is the strongest risk factor for stroke among the Chinese population. As such, encouraging individuals to work or further study may help minimise the risk of sustaining a stroke. Occupational status is certainly also influenced by education, income and marital status; their independent impacts cannot be separated altogether. We should thus consider all these factors together during analysis, instead of just focusing on one.

It is generally known that modifiable lifestyles, such as smoking, alcohol consumption, diet and physical activity, have been consistently linked to stroke risk. However, the link between some of these factors and stroke is yet unclear. Several studies have shown drinking is associated with a higher stroke burden, due to increased blood pressure caused by alcohol, whereas other studies have reported a null or inverse association and still others reported a J-shaped relationship. In our study, drinking was consistently associated with low stroke prevalence. A plausible explanation is that alcohol raises high-density lipoprotein cholesterol levels while reducing platelet aggregation and fibrinolytic activity. Although alcohol consumption may be beneficial in terms of stroke prevention, high intake is linked to an increased risk of alcohol-related cancers and injuries. Therefore, estimating the health influence of drinking is essential. Physical activity is considered beneficial for stroke prevention by reducing hypertension and diabetes. However, high-intensity physical activity was shown to be associated with an increased risk of stroke in this study. These mirrors findings from a Japanese public health centre-based prospective study. Several studies have suggested that high-intensity physical activity may cause haemorrhagic stroke by triggering a sudden and short-lasting increase in blood pressure. Moreover, greater physical activity might enhance the effect of the increased risk of stroke due to longer exposure to polluted air in developing countries. Thus, high-intensity physical activity might not be suitable for the prevention of stroke in China. Depression is highly prevalent not only in China but also worldwide, imposing a huge burden on public health. Several prospective studies have confirmed that in developed countries, depression is related with a considerably increased risk of stroke. In general, the development of poststroke depression is well recognised, but the function of depression as a risk factor for stroke is less well studied in China. Depression was found to be a significant risk factor for stroke in our study. This suggests that as in developed countries, depression may have a significant influence in stroke prevalence in China. Interestingly, we found people living with unimproved sanitation facilities have a higher risk of stroke, particularly in rural areas. In low-income and middle-income countries, unimproved sanitation facilities are more commonly used in rural areas compared with urban areas. It is likely that poor sanitation is a surrogate for the low socioeconomic status, which is often related to poor access to care. Many diseases have been linked to inadequate sanitation such as malnutrition, diarrhoea, intestinal nematode infections and trachoma. Nonetheless, no prior research has looked into the association between poor sanitation and stroke. The mechanism through which unimproved sanitation facilities contribute to stroke risk is unknown. Infection and alteration of gut microbiota caused by poor sanitation might increase stroke risk through pathways such as platelet hyperreactivity and immunomodulation. It is recognised that the gut microbiota-brain axis affects the brain’s pathophysiology. A prospective clinical study also showed intestinal microbiota-dependent metabolism of phosphatidylcholine was associated with an increased risk of stroke. Furthermore, a study from India indicated over a third of stroke occurred in toilets because...
squatting could increase blood pressure and thus trigger stroke. Most people living with unimproved sanitation facilities perform their ritual in the squatting posture, which might explain why unimproved sanitation was associated with significantly higher stroke risk. Overall, we speculate that improving socioeconomic status and sanitation may help lower stroke risk in rural areas of China, as well as other developing countries.

There are some limitations in our study. First, due to the cross-sectional nature of this study’s methodology, we cannot infer causality from the findings. Also, the self-reported questionnaire may cause recall bias. Second, several well-documented contributing factors that may affect stroke prevalence, such as hyperlipidaemia, dietary factors and obesity, were not included in the questionnaire, making it impossible to analyse their relationship to stroke prevalence. Third, people with stroke risk factors like hypertension and diabetes were likely to have better access to medical care due to their current morbidity and hence more likely to be diagnosed with stroke and this association may be due to a care-seeking bias. Furthermore, risk factors such as lifestyle and health status may have changed after suffering stroke, which may introduce bias. This bias may explain some results such as alcohol consumption which is found to be a protective factor, and high-intensity physical activity might not be suitable for the prevention of stroke. Finally, our study only analysed stroke prevalence, with no data on the incidence and mortality. In the future, we plan to prospective follow-up participants, investigate stroke incidence and collect information about mortality.

CONCLUSIONS

In summary, our study presents updated estimates of the prevalence and risk factors of stroke from 2003 to 2018 in China. In the past decade, the scissors phenomenon of stroke prevalence occurred in China. These novel findings indicate that the stroke prevalence may continue to increase in rural areas, and in western and central regions without interventions. Therefore, it is important to develop targeted programmes for stroke prevention in these regions. In addition to traditional risk factors of stroke, more attention should be given to nontraditional risk factors in the public health policies for stroke prevention.

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Acknowledgements

We thank the Centre for Health Statistics Information, National Health Commission of the People’s Republic of China, which provided outstanding support in the data collection and analysis of this study.

Contributors

WW, D-ST and C-CL conceived the idea for the study and managed the project. WW, XL, S-BX, D-JP and J-PH designed the study. D-ST, C-CL, C-LW, CO, M-HW, W-HL, JI, H-WZ, R-GZ, S-KW, X-XZ and LW collected the data, performed the statistical analyses and wrote the statistical analysis plan. D-ST, C-CL and C-LW wrote the manuscript. WW had full access to all of the data in the study and took full responsibility for the integrity of data and the accuracy of the analyses. WW is responsible for the overall content as guarantor. All authors read and approved the final manuscript.

Funding

The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests

None declared.

Patient consent for publication

Not applicable.

Ethics approval

The NHSS was approved by the institutional review board of the Chinese National Bureau of Statistics.

Provenance and peer review

Not commissioned; externally peer reviewed.

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

Supplemental material

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Tian D-S, et al. Stroke & Vascular Neurology 2023;8:e001598. doi:10.1136/svn-2022-001598

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Appendix 1. Flow Diagram of the Study Population

Abbreviation: NHSS, National Health Service Survey.
### Appendix 2. The Information Extracted in Our Survey from The Whole Questionnaire of NHSS

#### Family information

| No. | Question                                                                 | Answer                                                                 |
|-----|--------------------------------------------------------------------------|------------------------------------------------------------------------|
| 1   | How many people have lived in your home in the past 6 months? (Including relatives and friends, nannies, etc. who have lived for over 6 months) |                                                                                        |
| 2   | Which type of fuel used in your home: (1) Electricity; (2) Gas/natural gas/liquefied petroleum gas; (3) Marsh gas; (4) Kerosene; (5) Coal; (6) Firewood; (7) Others |                                                                                        |
| 3   | Which type of sanitation facilities used in your home: (1) Integrated flushing toilet; (2) Urine-faces division toilet; (3) Three link biogas toilet; (4) Dual-urn funnel toilet; (5) Three-septic-tank toilet; (6) Alternating dual-pit toilet; (7) Ventilated improved pit latrine; (8) Attic type latrine; (9) Deep pit latrine; (10) Pit latrines with slab; (11) Pit latrines without a slab or platform; (12) Bucket latrines; (13) Open defecation; (14) Others. |                                                                                        |
| 4   | What was the total annual income of your family in the previous year? (yuan) |                                                                                        |

#### Household member information

**Demographic information of each household member**

| Household members coding (01, the householder; Other members, according to the order of investigation) | 01 | 02 | 03 | 04 | 05 | … |
|---------------------------------------------------------------------------------------------------|----|----|----|----|----|----|
| 1 Name of household member: (01, name of the householder)                                                                                           |    |    |    |    |    |    |
| 2 Relationship with the householder: (1) Householder; (2) Spouse; (3) Child; (4) Grandchild; (5) rent; (6) Grandparent; (7) Brother or sister; (8) Others |    |    |    |    |    |    |
| 3 Gender: (1) Male; (2) Female                                                                                                                       |    |    |    |    |    |    |
| 4 Date of birth: (Year/Month)                                                                                                                       | /  | /  | /  | /  | /  | /  |
| 5 Marital status: (1) Single; (2) Married; (3) Divorced; (4) Widowed; (5) Others                                                                              |    |    |    |    |    |    |
| 6 Level of education: (1) None; (2) Primary school; (3) Junior middle school; (4) Senior high school/technical school; (5) Secondary specialized school; (6) Junior college; (7) University and above |    |    |    |    |    |    |
| 7 Employment status: (1) Employed; (2) Retired; (3) Student; (4) Unemployed                                                                            |    |    |    |    |    |    |

**Chronic diseases information of each household member**

| 1 Have you suffered from any chronic diseases diagnosed by doctors? (1) Yes; (2) No                                                                   |    |    |    |    |    |    |

2
| Question                                                                 | Response Options                                                                 |
|-------------------------------------------------------------------------|-----------------------------------------------------------------------------------|
| (if more than one disease, please fill in the name of disease according to the severity of disease from severe to mild) |                                                                                   |
| 2  | Name of the first disease:                                               |                                                                                   |
| 3  | The code of the first disease:                                           |                                                                                   |
| 4  | When were you diagnosed with it? (1) Over 6 months ago; (2) Within the past 6 months |                                                                                   |
| 5  | Have you been treated within the past 6 months? (1) Yes; (2) No           |                                                                                   |
| 6  | Name of the second disease:                                               |                                                                                   |
| 7  | The code of the second disease:                                          |                                                                                   |
| 8  | When were you diagnosed with it? (1) Over 6 months ago; (2) Within the past 6 months |                                                                                   |
| 9  | Have you been treated within the past 6 months? (1) Yes; (2) No           |                                                                                   |
| 10 | Name of the third disease:                                               |                                                                                   |
| 11 | The code of the third disease:                                           |                                                                                   |
| 12 | When were you diagnosed with it? (1) Over 6 months ago; (2) Within the past 6 months |                                                                                   |
| 13 | Have you been treated in the past 6 months? (1) Yes; (2) No               |                                                                                   |
| Quality of life for each household member                                |                                                                                   |
| 1  | Depression: (1) I am not depressed; (2) I am moderately depressed; (3) I am extremely depressed |                                                                                   |
| Lifestyle of each household member                                       |                                                                                   |
| 1  | Do you smoke?                                                            |                                                                                   |
|    | (1) Yes (have smoked a total of at least 100 cigarettes); (2) have quit smoking; (3) Never |                                                                                   |
| 2  | Have you had a drink containing alcohol in the past 12 months? (1) Yes; (2) No |                                                                                   |
| 3  | How many times per week do you drink? (1) 3 or more; (2) 1 to 2; (3) Less than 1 |                                                                                   |
| 4  | In the past 6 months, how many times per week do you do physical activity on average? |                                                                                   |
|    | (1) 6 or more; (2) 3 to 5; (3) 1 to 2; (4) Less than 1; (5) Never          |                                                                                   |

Notes: Chronic diseases, including hypertension, diabetes, and stroke, must be diagnosed by doctors and medical records or prescription from medical institution must be provided as evidence for diagnosis.
### Appendix 3. Definitions of risk factors for stroke

| Risk factor       | Definition                                                                                                                                 |
|-------------------|-------------------------------------------------------------------------------------------------------------------------------------------|
| Educational level | Grouped into five categories: none, primary level, junior high level, senior high level, and college level.                               |
| Occupation        | Categorized into employed, retired, student, and unemployed groups                                                                        |
| Income            | Categorized into high, middle, and low levels. High level presented top fourth of annual per capital income in the sampled county at the survey year, the bottom forth was low level, and others belonged middle level. |
| Marital status    | Categorized into married, single, divorced, and widowed status                                                                              |
| Hypertension      | Self-reported for ever being diagnosed with hypertension by medical institution.                                                           |
| Diabetes          | Self-reported for ever being diagnosed with diabetes by medical institution.                                                                |
| Depression        | Self-perceived health according to quality of life questionnaire.                                                                          |
| Smoking           | Participants have smoked a total of at least 100 cigarettes, and either continued or ceased smoking during the survey                        |
| Alcohol consumption| Participants have had an alcoholic drink in the 12 months prior to the survey                                                            |
| Physical activity | Participants have participated in physical activity (including tai chi, jogging, dancing, swimming, ball sports, aerobics, and apparatus exercise) at least once a week in the previous month. |
| Sanitation facilities | Unimproved sanitation facility is defined as not ensure hygienic separation of human excreta from human contact, and open defecation. Improved sanitation facility is defined as likely to ensure hygienic separation of human excreta from human contact. |
Appendix 4. The mathematical formula of Multiple logistic regression.

We constructed multiple unconditional logistic regression models to explore the risk factors of stroke. The formula of unconditional logistic regression is the following:

\[
\log(t(p(y = 1|x))) = \alpha + \sum_{j=1}^{m} \beta_j x_j
\]

Where \( y \) is the binary outcome (1 or 0), \( x_1, \ldots, x_m \) are independent variables, \( \alpha \) is the intercept, \( \beta_1, \ldots, \beta_m \) are coefficients of these independent variables.

The Odds Ratio (OR) along with its 95% confidence interval for each independent variable can be calculated as while other factors are constant:

\[
OR_j = \exp(\beta_j)
\]

95%CI: \( \exp(\beta_j \pm 1.96 \times SE[\beta_j]) \)

The SAS9.4 PROC LOGISTIC procedure was used to fit multiple unconditional logistic regression models and stepwise selection (sle=0.05, sls=0.10) was applied to select the optimal model.
### Appendix 5. Trends in Prevalence of Stroke by Provinces in Different Region in China from 2003 to 2018

| Region          | No. of Participants | Rates/100,000 (95% CI)<sup>a</sup> | p value for Trend<sup>b</sup> |
|-----------------|---------------------|-----------------------------------|-------------------------------|
| **Central region** |                     |                                   |                               |
| Heilongjiang    | 4893                | 2709 (2235-3182)                  | 0.64                          |
| Jilin           | 4432                | 1962 (1559-2365)                  | 0.03                          |
| Henan           | 6674                | 1703 (1394-2120)                  | 0.92                          |
| Shanxi          | 4711                | 1016 (711-1322)                   | 0.15                          |
| Anhui           | 6313                | 737 (529-945)                     | 0.01                          |
| Hunan           | 5877                | 619 (433-805)                     | 0.01                          |
| Hubei           | 5882                | 461 (296-626)                     | 0.01                          |
| Jiangxi         | 4370                | 253 (102-405)                     | 0.01                          |
| **Eastern region** |                     |                                   |                               |
| Liaoning        | 3126                | 1979 (1515-2443)                  | 0.03                          |
| Hebei           | 6464                | 1700 (1349-2052)                  | 0.03                          |
| Tianjin         | 3402                | 1387 (1039-1736)                  | 0.03                          |
| Beijing         | 2995                | 1186 (850-1522)                   | 0.03                          |
| Hainan          | 3719                | 1048 (755-1340)                   | 0.03                          |
| Shandong        | 6411                | 1027 (800-1253)                   | 0.03                          |
| Shanghai        | 2879                | 929 (660-1197)                    | 0.03                          |
| Guangdong       | 6914                | 563 (404-721)                     | 0.03                          |
| Fujian          | 4880                | 417 (235-600)                     | 0.03                          |
| Jiangsu         | 6560                | 397 (256-537)                     | 0.03                          |
| Zhejiang        | 5042                | 394 (236-551)                     | 0.03                          |

Abbreviation: NA, not applicable,
Appendix 6. Risk Factors for Stroke in Urban Areas of China from 2003 to 2018.

|                | 2003 OR (95% CI) | 2008 OR (95% CI) | 2013 OR (95% CI) | 2018 OR (95% CI) | Meta-analysisb P value |
|----------------|------------------|------------------|------------------|------------------|------------------------|
| **Age**        |                  |                  |                  |                  |                        |
| < 30 y         | 1 [Reference]    | 1 [Reference]    | 1 [Reference]    | 1 [Reference]    |                        |
| 30-39 y        | 2.18 (0.45-10.58)| 1.32 (0.23-7.46) | 1.77 (0.73-4.28) | 1.94 (0.53-6.87) | 0.33 (0.59-2.13) 0.99 |
| 40-49 y        | 8.09 (1.85-35.40)| 8.79 (2.02-38.28)| 6.05 (2.79-13.12)| 14.91 (4.70-47.36)| <0.001 6.81 (2.16, 11.46) 0.87 |
| 50-59 y        | 25.82 (5.98-111.47)| 18.34 (4.27-78.76)| 15.20 (7.10-32.53)| 39.25 (12.45-123.73)| <0.001 17.03 (5.55, 28.50) 0.85 |
| 60-69 y        | 49.56 (11.42-215.02)| 40.14 (9.31-173.08)| 22.77 (10.61-48.87)| 67.44 (21.36-212.93)| <0.001 26.02 (8.03, 44.02) 0.77 |
| ≥70 y          | 88.31 (20.30-384.08)| 50.55 (11.69-218.60)| 33.30 (15.46-71.74)| 97.84 (30.94-309.35)| <0.001 37.89 (11.52, 126.36) 0.76 |
| **Sex**        |                  |                  |                  |                  |                        |
| Female         | 1.58 (1.31-1.91) | <0.001 1.61 (1.33-1.93) | <0.001 1.52 (1.35-1.71) | <0.001 1.51 (1.37-1.68) | <0.001 1.53 (1.43, 1.64) 0.93 |
| Male           |                  |                  |                  |                  |                        |
| **Region**     |                  |                  |                  |                  |                        |
| Western        | 1 [Reference]    | 1 [Reference]    | 1 [Reference]    | 1 [Reference]    |                        |
| Central        | 2.16 (1.72-2.72) | <0.001 2.55 (2.00-3.23) | <0.001 1.04 (0.93-1.16) | 0.53 | 1.30 (1.19-1.43) | <0.001 1.22 (1.13, 1.30) <0.001 |
| Eastern        | 1.72 (1.38-2.15) | <0.001 1.96 (1.55-2.48) | <0.001 0.73 (0.65-0.83) | <0.001 0.99 (0.89-1.09) | 0.79 0.89 (0.83, 0.96) <0.001 |
| **Education**  |                  |                  |                  |                  |                        |
| College        | 1 [Reference]    | 1 [Reference]    | 1 [Reference]    | 1 [Reference]    |                        |
| Senior high    | 1.02 (0.76-1.36) | 0.90 | 1.19 (0.87-1.63) | 0.28 | 1.23 (0.99-1.53) | 0.06 | 1.20 (0.91-1.59) | 0.20 | 1.21 (1.05, 1.37) | 0.05 |
| Junior high    | 0.92 (0.69-1.22) | 0.57 | 1.28 (0.94-1.74) | 0.12 | 1.43 (1.17-1.76) | 0.001 | 1.38 (1.06-1.81) | 0.02 | 1.09 (0.92, 1.25) | 0.05 |
| Primary        | 0.73 (0.54-0.98) | 0.04 | 1.17 (0.85-1.62) | 0.33 | 1.47 (1.19-1.82) | <0.001 | 1.35 (1.03-1.78) | 0.03 | 1.06 (0.91, 1.21) | <0.001 |
| None           | 0.80 (0.57-1.11) | 0.18 | 1.15 (0.79-1.66) | 0.47 | 1.39 (1.09-1.77) | 0.008 | 1.21 (0.90-1.62) | 0.20 | 1.16 (1.00, 1.32) | 0.76 |
| **Occupation** |                  |                  |                  |                  |                        |
| Employed       | 1 [Reference]    | 1 [Reference]    | 1 [Reference]    | 1 [Reference]    |                        |
| Retired        | 1.95 (1.46-2.61) | <0.001 3.03 (2.08-4.41) | <0.001 1.61 (1.37-1.90) | <0.001 2.13 (1.85-2.46) | <0.001 1.88 (1.69, 2.06) 0.02 |
| Unemployed     | 1.56 (1.14-2.14) | 0.05 | 3.13 (2.15-4.54) | 0.05 | 1.59 (1.36-1.87) | <0.001 | 2.00 (1.75-2.29) | <0.001 | 1.79 (1.61, 1.96) | 0.02 |
| **Income**     |                  |                  |                  |                  |                        |
| High           | 1 [Reference]    | 1 [Reference]    | 1 [Reference]    | 1 [Reference]    |                        |
| Medium         | 1.01 (0.83-1.22) | 0.93 | 1.04 (0.86-1.26) | 0.70 | 1.11 (0.98-1.24) | 0.09 | 1.16 (1.05-1.29) | 0.004 | 1.17 (1.08, 1.26) | 0.008 |
| Low            | 1.05 (0.85-1.30) | 0.63 | 1.04 (0.84-1.28) | 0.74 | 1.10 (0.97-1.25) | 0.13 | 1.42 (1.26-1.60) | <0.001 | 1.11 (1.03, 1.18) | 0.55 |
| **Marital status** |            |                  |                  |                  |                        |
| Married        | 1 [Reference]    | 1 [Reference]    | 1 [Reference]    | 1 [Reference]    |                        |
| Divorced       | 0.55 (0.23-1.31) | 0.18 | 0.82 (0.43-1.56) | 0.54 | 0.63 (0.40-0.99) | 0.05 | 0.67 (0.44-1.01) | 0.06 | 0.66 (0.48, 0.84) | 0.92 |
| Widowed        | 1.05 (0.51-2.16) | 0.89 | 0.77 (0.38-1.59) | 0.49 | 1.50 (1.07-2.12) | 0.02 | 1.16 (0.88-1.51) | 0.29 | 1.16 (0.92, 1.40) | 0.35 |
| **Hypertension** |            |                  |                  |                  |                        |
| No             | 1 [Reference]    | 1 [Reference]    | 1 [Reference]    | 1 [Reference]    |                        |
| Yes            | 1.23 (1.01-1.50) | 0.04 | 2.25 (1.91-2.65) | <0.001 | 2.94 (2.66-3.26) | <0.001 | 1.39 (1.27-1.52) | <0.001 | 1.33 (1.22, 1.45) | <0.001 |
| **Diabetes**   |                  |                  |                  |                  |                        |

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| No               | 1 [Reference] | 1 [Reference] | 1 [Reference] | 1 [Reference] | 1 [Reference] | 1 [Reference] |
|------------------|--------------|--------------|--------------|--------------|--------------|--------------|
| Yes              | 1.58 (1.17-2.12) | 0.003 | 1.32 (1.02-1.71) | 0.04 | 1.37 (1.20-1.56) | <.001 | 1.26 (1.10-1.46) | <0.001 | 1.33 (1.22, 1.45) | 0.61 |

### Depression

| No               | 1 [Reference] | 1 [Reference] | 1 [Reference] | 1 [Reference] | 1 [Reference] | 1 [Reference] |
|------------------|--------------|--------------|--------------|--------------|--------------|--------------|
| Moderate         | 2.83 (2.39-3.36) | <.001 | 3.23 (2.64-3.97) | <.001 | 2.76 (2.43-3.13) | <.001 | 2.60 (2.35-2.87) | <0.001 | 2.73 (2.54, 2.91) | 0.35 |
| Severe           | 9.59 (6.68-13.78) | <.001 | 7.28 (4.49-11.83) | <.001 | 4.98 (3.57-6.93) | <.001 | 3.48 (2.72-4.45) | <0.001 | 4.18 (3.45, 4.92) | 0.002 |

### Cigarette smoking

| No               | 1 [Reference] | 1 [Reference] | 1 [Reference] | 1 [Reference] | 1 [Reference] | 1 [Reference] |
|------------------|--------------|--------------|--------------|--------------|--------------|--------------|
| Smoker           | 0.95 (0.78-1.16) | 0.62 | 0.89 (0.72-1.09) | 0.25 | 1.08 (0.95-1.22) | 0.22 | 1.12 (1.01-1.25) | 0.04 | 1.05 (0.97, 1.12) | 0.143 |

### Alcohol consumption (times per week)

| No               | 1 [Reference] | 1 [Reference] | 1 [Reference] | 1 [Reference] | 1 [Reference] | 1 [Reference] |
|------------------|--------------|--------------|--------------|--------------|--------------|--------------|
| Never            | 1 [Reference] | 1 [Reference] | 1 [Reference] | 1 [Reference] | 1 [Reference] | 1 [Reference] |
| <3               | 0.67 (0.49-0.90) | 0.008 | 0.69 (0.39-1.21) | 0.19 | 0.71 (0.59-0.85) | <.001 | 0.64 (0.54-0.68) | <0.001 | 0.64 (0.58, 0.70) | 0.58 |
| ≥3               | 0.56 (0.40-0.80) | 0.001 | 0.53 (0.36-0.77) | 0.001 | 0.40 (0.32-0.50) | <.001 | 1.15 (0.99-1.34) | 0.07 | 0.55 (0.48, 0.62) | <0.001 |

### Physical activity (times per week)

| No               | 1 [Reference] | 1 [Reference] | 1 [Reference] | 1 [Reference] | 1 [Reference] | 1 [Reference] |
|------------------|--------------|--------------|--------------|--------------|--------------|--------------|
| Never            | 1 [Reference] | 1 [Reference] | 1 [Reference] | 1 [Reference] | 1 [Reference] | 1 [Reference] |
| <1               | 1.88 (0.96-3.68) | 0.07 | 0.64 (0.37-1.11) | 0.11 | 0.72 (0.49-1.06) | 0.09 | 0.86 (0.79-0.95) | 0.002 | 0.84 (0.77, 0.92) | 0.2 |
| 1-2              | 0.49 (0.23-1.06) | 0.07 | 0.61 (0.43-0.86) | 0.005 | 0.89 (0.73-1.09) | 0.27 | 0.82 (0.70-0.95) | 0.01 | 0.79 (0.69, 0.88) | 0.11 |
| 3-5              | 0.83 (0.62-1.12) | 0.23 | 0.78 (0.60-1.02) | 0.07 | 0.81 (0.68-0.97) | 0.03 | 0.81 (0.68-0.96) | 0.01 | 0.81 (-0.72, 0.89) | 0.99 |
| ≥6               | 0.99 (0.83-1.19) | 0.93 | 0.76 (0.63-0.92) | 0.005 | 1.06 (0.95-1.19) | 0.31 | 0.90 (0.64-1.27) | 0.55 | 0.95 (0.87, 1.03) | 0.02 |

### Sanitation facilities

| No               | 1 [Reference] | 1 [Reference] | 1 [Reference] | 1 [Reference] | 1 [Reference] | 1 [Reference] |
|------------------|--------------|--------------|--------------|--------------|--------------|--------------|
| Improved         | 1.15 (0.91-1.44) | 0.24 | 1.46 (1.14-1.87) | 0.003 | 1.20 (1.03-1.40) | 0.02 | 1.26 (1.12-1.41) | <0.001 | 1.24 (1.14, 1.34) | 0.56 |

Abbreviation: OR, odds ratio; CI, confidence interval.

* Multiple logistic regression models included age, sex, residence, region, educational level, occupation, income, marital status, hypertension, diabetes, depression, smoking, alcohol consumption, physical activity, and sanitation facilities.

* The meta estimates of serial surveys.
### Appendix 7. Risk Factors for Stroke in Rural Areas of China from 2003 to 2018.

|                | 2003                      | 2008                      | 2013                      | 2018                      | Meta-analysisa |
|----------------|---------------------------|---------------------------|---------------------------|---------------------------|----------------|
| **Age**        |                           |                           |                           |                           |                |
| < 30 y         | 1 [Reference]             | 1 [Reference]             | 1 [Reference]             | 1 [Reference]             | 1 [Reference]  |
| 30-39 y        | 1.92 (0.90-4.12)          | 3.95 (1.63-9.57)          | 3.47 (1.45-8.34)          | 3.80 (1.31-11.02)         | 2.51 (1.20, 3.83)  |
| 40-49 y        | 6.56 (3.23-13.29)         | <.001                     | 12.07 (5.25-27.75)        | <.001                     | 20.83 (7.78-55.77)   |
| 50-59 y        | 13.63 (6.78-27.40)        | <.001                     | 33.95 (14.92-77.27)       | <.001                     | 52.16 (19.60-138.81) |
| ≥70 y          | 22.74 (11.23-46.04)       | <.001                     | 50.98 (21.32-116.46)      | <.001                     | 105.02 (39.45-279.54) |
| **Sex**        |                           |                           |                           |                           |                |
| Female         | 1.65 (1.36-2.00)          | <.001                     | 1.40 (1.21-1.62)          | <.001                     | 1.27 (1.15-1.40)    |
| Male           |                           |                           |                           |                           | 1.31 (1.15-1.48)    |
| **Region**     |                           |                           |                           |                           |                |
| Western        | 1.69 (1.40-2.05)          | <.001                     | 1.97 (1.70-2.28)          | <.001                     | 1.33 (1.18-1.50)   |
| Central        | 1.25 (1.03-1.51)          | 0.02                      | 1.37 (1.17-1.60)          | <.001                     | 1.07 (0.94-1.21)   |
| Eastern        |                           |                           |                           |                           | 0.87 (0.78-0.96)    |
| **Education**  |                           |                           |                           |                           |                |
| College        | 0.61 (0.21-1.81)          | 0.38                      | 6.32 (0.86-46.21)         | 0.07                      | 1.35 (0.73-2.51)   |
| Senior high    | 0.62 (0.22-1.76)          | 0.37                      | 6.16 (0.85-44.58)         | 0.07                      | 1.93 (1.06-3.50)   |
| Junior high    | 0.79 (0.28-2.23)          | 0.66                      | 6.45 (0.89-46.65)         | 0.07                      | 1.66 (0.92-3.02)   |
| Primary        | 0.70 (0.25-1.99)          | 0.50                      | 5.56 (0.77-40.38)         | 0.09                      | 1.47 (0.80-2.69)   |
| None           |                           |                           |                           |                           | 1.30 (0.60-2.81)   |
| **Occupation** |                           |                           |                           |                           |                |
| Employed       | 2.05 (1.43-2.95)          | <.001                     | 1.90 (1.46-2.47)          | <.001                     | 1.66 (1.37-2.02)   |
| Retired        | 2.35 (1.89-2.92)          | <.001                     | 1.66 (1.43-1.92)          | <.001                     | 1.78 (1.59-2.00)   |
| Unemployed     |                           |                           |                           |                           | 1.49 (1.37-1.63)   |
| **Income**     |                           |                           |                           |                           |                |
| High           | 1.10 (0.91-1.33)          | 0.32                      | 0.89 (0.77-1.04)          | 0.14                      | 1.07 (0.94-1.21)   |
| Medium         | 0.98 (0.80-1.20)          | 0.88                      | 0.98 (0.84-1.14)          | 0.78                      | 1.07 (0.95-1.21)   |
| Low            |                           |                           |                           |                           | 1.23 (1.10-1.37)   |
| **Marital status** |                           |                           |                           |                           |                |
| Married        | 0.61 (0.33-1.11)          | 0.10                      | 0.78 (0.52-1.17)          | 0.23                      | 0.73 (0.50-1.16)   |
| Divorced       | 0.70 (0.25-1.93)          | 0.49                      | 0.90 (0.46-1.77)          | 0.77                      | 0.59 (0.29-1.21)   |
| Widowed        | 0.58 (0.20-1.27)          | <.001                     | 0.84 (0.71-1.00)          | 0.05                      | 0.75 (0.65-0.86)   |
| **Hypertension** |                           |                           |                           |                           |                |
| No             | 1.67 (1.31-2.13)          | <.001                     | 2.01 (1.74-2.33)          | <.001                     | 3.79 (3.43-4.19)   |
| Yes            |                           |                           |                           |                           | 1.63 (1.49-1.77)   |

a: Meta-analysis value.
Abbreviation: OR, odds ratio; CI, confidence interval.

Multiple logistic regression models included age, sex, residence, region, educational level, occupation, income, marital status, hypertension, diabetes, depression, smoking, alcohol consumption, physical activity, and sanitation facilities.

| Depression |
|---|
| No | 1 [Reference] | 1 [Reference] | 1 [Reference] | 1 [Reference] | 1 [Reference] | 1 [Reference] |
| Yes | 1.51 (0.81-2.82) | 0.19 | 1.10 (0.74-1.64) | 0.64 | 1.54 (1.29-1.84) | <.001 | 1.24 (1.04-1.48) | 0.02 | 1.33 (1.17, 1.49) | 0.26 |

| Cigarette smoking |
|---|
| Never | 1 [Reference] | 1 [Reference] | 1 [Reference] | 1 [Reference] | 1 [Reference] | 1 [Reference] |
| Smoker | 0.83 (0.68-1.01) | 0.06 | 0.94 (0.81-1.09) | 0.43 | 1.14 (1.00-1.29) | 0.04 | 1.00 (0.91-1.11) | 0.95 | 0.99 (0.92, 1.05) | 0.04 |

| Alcohol consumption (times per week) |
|---|
| Never | 1 [Reference] | 1 [Reference] | 1 [Reference] | 1 [Reference] | 1 [Reference] | 1 [Reference] |
| <3 | 0.40 (0.29-0.56) | <.001 | 0.35 (0.21-0.58) | <.001 | 0.50 (0.41-0.62) | <.001 | 0.54 (0.48-0.60) | <.001 | 0.50 (0.46, 0.55) | 0.10 |
| ≥3 | 0.40 (0.28-0.57) | <.001 | 0.40 (0.31-0.53) | <.001 | 0.42 (0.34-0.51) | <.001 | 1.04 (0.90-1.20) | 0.57 | 0.50 (0.44, 0.56) | <.001 |

| Physical activity (times per week) |
|---|
| Never | 1 [Reference] | 1 [Reference] | 1 [Reference] | 1 [Reference] | 1 [Reference] | 1 [Reference] |
| <1 | 0.48 (0.07-3.49) | 0.47 | 2.27 (1.33-3.87) | 0.003 | 1.87 (1.06-2.62) | 0.03 | 1.47 (1.35-1.60) | <.001 | 1.48 (1.36, 1.60) | 0.38 |
| 1-2 | 1.93 (0.70-5.34) | 0.21 | 1.89 (1.35-2.63) | <.001 | 1.23 (0.95-1.61) | 0.12 | 1.34 (1.17-1.54) | <.001 | 1.35 (1.20, 1.51) | 0.32 |
| 3-5 | 0.96 (0.49-1.90) | 0.91 | 1.22 (0.83-1.81) | 0.31 | 1.36 (1.09-1.70) | 0.006 | 1.14 (0.98-1.34) | 0.09 | 1.19 (1.04, 1.33) | 0.59 |
| ≥6 | 2.36 (1.72-3.23) | <.001 | 1.73 (1.36-2.21) | <.001 | 1.74 (1.49-2.04) | <.001 | 1.11 (0.80-1.55) | 0.51 | 1.62 (1.43, 1.81) | 0.008 |

| Sanitation facilities |
|---|
| Improved | 1 [Reference] | 1 [Reference] | 1 [Reference] | 1 [Reference] | 1 [Reference] | 1 [Reference] |
| Unimproved | 1.48 (1.20-1.83) | <.001 | 1.20 (1.04-1.40) | 0.02 | 1.49 (1.34-1.66) | <.001 | 1.37 (1.27-1.48) | <.001 | 1.37 (1.30, 1.45) | 0.11 |

Multiple logistic regression models included age, sex, residence, region, educational level, occupation, income, marital status, hypertension, diabetes, depression, smoking, alcohol consumption, physical activity, and sanitation facilities.

The meta estimates of serial surveys.