Iran J Public Health, Vol. 49, No.3, Mar 2020, pp.503-511

Original Article

Exploration of Epidemiological Characteristics for the Occurrence of Stroke in One Chronic Demonstration Area of Zhejiang Province in China: A Retrospective Study from 2009-2015

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(Received 10 Aug 2018; accepted 24 Jan 2019)

Abstract

Background: Fenghua County, located on the eastern coast of Zhejiang Province, showed a higher stroke incidence than other counties of Ningbo Municipality while the potential epidemiology pattern was not explored.

Methods: The study data of first-ever stroke cases were collected from the Internet-based Comprehensive Chronic Disease Surveillance System (ICDSS) in Zhejiang Province. Spatio-temporal analysis and time series model were explored and constructed to identify the epidemiological characteristics in local.

Results: A total of 10215 first-ever strokes were reported in Fenghua County from 2009 to 2015, including 8292 ischemic strokes (81.18%), 1839 hemorrhagic strokes (18.00%), and 84 unclassifiable strokes (0.82%). According to occupational distribution, peasants had the highest proportion (82.59%). Also, ischemic stroke was the main stroke subtype with a proportion of 81.18%. Space-time scan analysis, among 26 residential communities in Fenghua County from the period of 2009-2015, presented that only one most likely cluster was identified in 2009 with the relative risk (RR) value of 1.15. Besides, the ARIMA (0,1,2) model was determined as the optimal one to predict the trend of stroke.

Conclusion: Under the trend of an aging population, the stroke incidence in Fenghua County was increased with the ischemic stroke as the main subtype. Peasant groups and persons in middle age and above were the targeted objects for the control and prevention of stroke. Besides, specific interventions, like hypertension health management and health education, should be strengthened to reduce the incidence of stroke effectively in the future.

Keywords: Stroke; Epidemiology; Spatio-temporal analysis; Time series analysis

Introduction

Stroke, as one of the most devastating diseases in the field of neurological disorders, represented a considerable disease burden globally, which caused a total number of 6.0 million stroke deaths and 118.6 million disability-adjusted life-years loss (DALYs) worldwide in 2015 (1,2). The American heart association released that the occurrence of new and recurrent stroke had reached nearly 795,000 in 2016 (3). In China, the stroke had also resulted in a heavy disease burden for the family. Estimation from the nationwide population-based survey displayed that there

were 2.4 million new strokes in 2013 (4), and another report regarding cardiovascular disease revealed that 13 million individuals suffered from the stroke only in 2016 (5). More seriously, there was one-third of the global stroke deaths occurred in China (6). Stroke was already the major health problem, increased rapidly coupled with the trend of an aging population in the future (7). Available implements of stroke preventions were comprised of population-wide prevention strategy and high-risk prevention strategy (8). Compared with the population-wide strategy, high-risk prevention strategy was evidenced to be more effective and efficient to decline the incidence of stroke and save funds (9). Besides, the geographical variations could influence the distribution of stroke, causing the regional disparities by some known and unknown risk factors (4,7). Thus, the identification of the targeted regions for the control of stroke was a priority in public health.

Spatial-temporal analysis, as an effective means, had been widely applied in communicable disease to recognize the high-prevalence districts, optimize the allocation of health resources, and provide the underlying clue of some adverse factors as well (10,11). It, therefore, had unique merit over the conventional epidemiological methods (12-14). Besides, taking changing trends, periodic changes and random disturbances into account, Autoregressive Integrated Moving Average (ARIMA) model consisted of a moving average (MA) model coupled with an autoregression (AR) model could predict the disease trend, particularly in the non-stationary series (12,15). However, there was a paucity of studies using these methods to identify the epidemiology pattern in chronic diseases like stroke.

The purpose of this study was to identify the epidemiological characteristics and high prevalent regions of the first-ever stroke in Fenghua County, one chronic demonstration area in Zhejiang Province. Additionally, space-time analysis and ARIMA model were applied to identify the targeted regions and forecast the further trend of stroke, which were helpful for advancing the local prevention strategy in the future.

Materials and Methods

Study area

Fenghua county, within the jurisdiction of the Ningbo Municipality, located in the eastern coastal area of Zhejiang Province in China. The cover of Fenghua County was between longitudes 121°03'E-121°46'E and latitudes 29°25'N-29°47'N, whose land area was 1,253 km^2. It consisted of 6 towns and 5 residential districts, involving 26 communities. The permanent population was 0.51 million. As a coastal county, Fenghua County owned a subtropical monsoon climate with an annual mean temperature of 17.2 °C, and the annual precipitation was 2211.6 mm in 2015.

Data collection and case

The data of first-ever stroke cases were captured from the Internet-based Comprehensive Chronic Disease Surveillance System (ICDSS) in Zhejiang Province, established and operated in 2001 (16). ICDSS covered the common non-communicable diseases including stroke. All stroke cases included in ICDSS should meet the criterion of Monitoring Trends and Determinants in Cardiovascular Disease (MONICA), enacted by WHO in the 1980s (17). Based on the diagnostic criteria for stroke from MONICA, stroke cases from ICDSS were classified into three subtypes, haemorrhagic stroke (HS) including subarachnoid haemorrhage and intracerebral haemorrhage, ischaemic stroke (IS) including thrombosis and embolism, and the unclassifiable stroke (17). Besides, other details of cases referred to gender, age, occupation, information of individual community were obtained from ICDSS. All private information was not involved in this study.

Space-time scan statistic analysis

To perform space-time scan statistics in strokes, Fenghua County was categorized into 26 communities and all included cases were classified based on the individual community information, respectively. In this study, the SaTScan method was applied to identify the clustered communities

among specific time. Kulldorff's space-time scan statistic could be described as an active cylindrical window, in which the base of this moving window denoting the clustered areas and the height of cylinder representing the clustered time, respectively (18). Additionally, the options of maximum spatial cluster size and maximum temporal cluster size in this study were both set to the default settings. The value of relative risk (RR) was obtained by the calculation of the ratio of the observed number of strokes within the windows to the expected number of strokes outside the windows. Ultimately, the most likely cluster was determined as the maximal value of the log likelihood ratio (LLR), and the Monte Carlo test was also conducted to test the statistical significance with 999 permutations.

Time series analysis

Autoregressive integrated moving average (ARIMA) model was widely used to predict the future trend of the sequence, including three sections of autoregression (p), the degree of difference (d), and the order of moving average (q) in sequence (19). Commonly, original data should be disposed by moderate finite difference (d) and/or exponential transform to make it smooth. Then, q and p were determined by the result of the autocorrelation function (ACF) and the partial autocorrelation function (PACF) (20). Ultimately, the combination of Ljung-Box tests for white noise and Bayesian Information Criterion (BIC) would be employed to select the optimal model (21).

Statistics analysis

The space-time scan statistic analysis was performed using SaTScan (version 9.1.1, Boston, MA, USA). The time series model was determined using R software (version 3.2.5) for free. All the results were considered statistically significant if $P<0.05$ with two sides.

Ethical approval

This research was approved by the Ethics Committee of Ningbo Municipality Disease Control and Prevention. All stroke cases information used in the study was kept confidential as required, and informed consent was exempted.

Results

Epidemiologic characteristics of stroke in all

Overall, 10215 first-ever strokes were reported in Fenghua County from 2009 to 2015, including 8292 IS (81.18%), 1839 HS (18.00%), and 84 unclassifiable strokes (0.82%). The average annual incidence was 301.95 per 100000 during the study period with 274.55 per 100000 in 2009, 289.56 per 100000 in 2010, 303.91 per 100000 in 2011, 306.77 per 100000 in 2012, 281.41 per 100000 in 2013, 308.44 per 100000 in 2014 and 348.87 per 100000 in 2015, respectively. The incidence of stroke was higher in male than in female. The group of elderly people whose ages were more than 60 years old was more vulnerable to stroke. Additionally, the total trend of stroke in the study time was steady, and the seasonal trend was not obvious as well. For the occupational distribution, peasants had the highest proportion (82.59%), followed by others (9.78%), workers (3.65%), professionals (2.02%), house workers (1.88%) and students (0.08%) (Fig. 1).

Epidemiological characteristics of ischemic stroke (IS) and hemorrhage stroke (HS)

Among all cases, there were 4578 males and 3714 females with a sex ratio of 1.23:1 for IS and 1099 males and 740 females with a proportion of 1.49:1 for HS. The age distribution indicated that the occurrence of HS raised at 40 age and peaked at 60 age, while IS was increased at 50 age with the top at 70 age. Interestingly, peasants in both subtypes were principally vulnerable groups. Furthermore, the incidences of both IS and HS in male exceeded female, and the incidence of IS was higher than HS in the corresponding period. The detailed information was presented in Table 1 and Table 2.

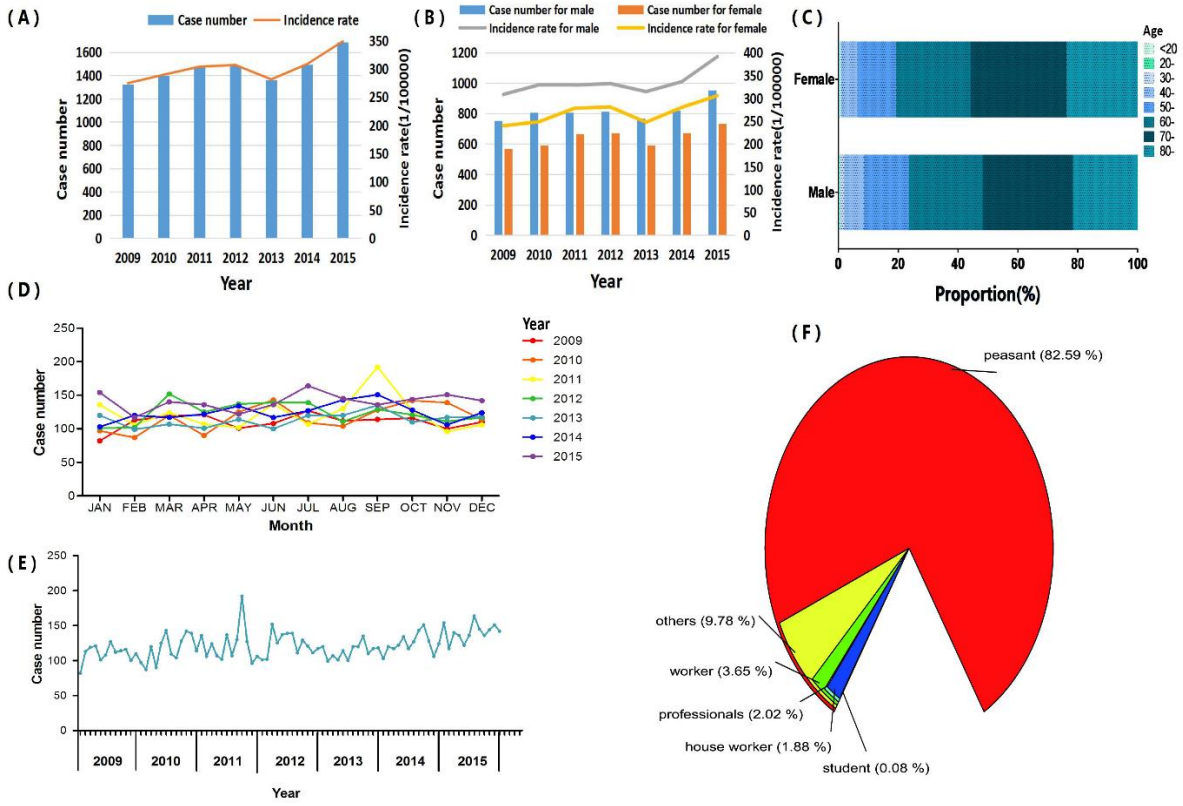

Fig. 1: Epidemiologic characteristics of first-ever stroke in Fenghua County in China from 2009-2015. (A) Incidence rate of stroke occurrence. (B) Incidence rate of stroke in different gender. (C) Age distribution of stroke cases. (D) Monthly distribution of stroke cases. (E) Time distribution of stroke cases. (F) Occupational distribution of stroke cases

Table 1: The proportion of ischemic stroke (IS) and hemorrhage stroke (HS) in Fenghua County by gender, age and occupation

Characteristics	***IS***		***HS***	
Gender	N	Proportion (%)	N	Proportion (%)
Male	4578	55.21	1099	59.76
Women	3714	44.79	740	40.24
Age				
<20	0	0.00	11	0.60
20-	10	0.12	24	1.31
30-	43	0.52	69	3.75
40-	349	4.21	271	14.74
50-	1009	12.17	415	22.57
60-	2054	24.77	452	24.58
70-	2771	33.42	377	20.50
80-	2056	24.79	220	11.96
Occupation				
Professionals	172	2.07	31	1.69
Workers	295	3.55	76	4.13
Peasants	6858	82.71	1517	82.49
Students	1	0.01	7	0.38
House workers	132	1.59	52	2.83
Others	834	10.06	156	8.48

Table 2: The incidence of ischemic stroke (IS) and hemorrhage stroke (HS) in Fenghua County by gender and age

Characteristics	*the incidence of IS (1/100000)*							*the incidence of HS (1/100000)*						
	2009	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*
Gender														
Male	243.15	257.86	258.27	276.00	238.57	276.63	324.65	62.93	68.24	70.29	56.1	73.37	54.59	64.52
Female	184.34	203.57	228.65	239.41	200.19	232.01	262.02	52.67	41.8	49.33	40.11	42.54	41.65	40.82
Age(yr)														
<20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.23	0.00	1.23	3.81	2.61	2.68	2.78
20-	4.97	0.00	1.66	1.70	3.58	3.48	1.69	8.28	9.93	3.31	5.10	7.17	1.74	5.07
30-	16.57	7.53	9.04	6.22	7.97	9.93	10.31	13.55	24.10	13.55	7.78	12.76	18.21	18.90
40-	45.06	36.61	46.00	43.13	37.35	57.88	79.02	26.28	28.16	44.12	40.38	46.20	36.17	43.90
50-	159.35	164.26	155.68	189.01	149.03	189.14	200.57	69.87	72.32	76.00	63.00	75.10	67.30	73.24
60-	458.13	537.19	555.43	550.75	443.78	469.63	561.66	123.65	117.57	141.90	113.82	110.13	108.84	84.25
70-	1414.60	1581.92	1654.17	1700.02	1295.19	1482.70	1540.84	304.22	250.98	243.37	148.17	210.57	129.44	162.39
80-	2030.46	2137.76	2368.87	2348.24	1950.76	1985.06	2157.62	321.90	264.12	288.89	212.79	235.44	127.66	188.94
Total	214.08	231.02	243.63	257.89	219.55	254.48	293.55	57.86	55.17	59.93	48.19	58.09	48.17	52.75

Space-time analysis

In this study, according to the 26 communities in Fenghua County, we performed a retrospective space-time scan analysis to identify the clustering of the first-ever stroke from 2009 to 2015. Only one most likely cluster was recognized, including 538 observed cases contrasted to 467.17 expected cases with the RR value of 1.15. These details were depicted in Table 3.

Table 3: Space-time analysis for clusters of stroke cases from 2009 to 2015 in Fenghua County

Type	*Location*	*Time frame*	*Number of cases*	*Expected cases*	*Relative risk*	**P-*value***
Most likely cluster	Baidu, Jinping, Nanpu, Xi-wu, Yuelin	2009	538	467.17	1.15	0.044

Time series analysis

In this research, we constructed the ARIMA (0,1,2) as the optimal ARIMA model (BIC=721.03, $P_{\text{Box-Ljung}}$>0.05 at 5, 10, 15 and 20 lags) (Fig. 2). In addition, we used the ARIMA (0,1,2) model to predict the first-ever stroke cases in 2016, and the number of stroke cases in 12 months was all within the 95% confidence interval of the predicted value.

Discussion

Stroke, as one of the most common and preventable diseases, was the leading cause of death in China (5). That is to say, the stroke had become a severe public health issue in China, causing a considerable concern by the public and government departments. In the jurisdiction of Ningbo Municipality, the incidence of stroke in Fenghua County was the top compared to another 9 counties. Thus, it was an urgent need to explore the epidemiological features of stroke and identify the clustering with high stroke incidence, which would be helpful for conducting the targeted intervention for local CDC and facilitating the decision-making for health sectors, respectively. In Fenghua County, the incidence of stroke was still increased in the study time. This could be partly explained by the aggravating trend of an aging population. The proportion of residents aged over 60 in Fenghua County was 17.32% in 2009, and it had already reached 22.99% in 2015.

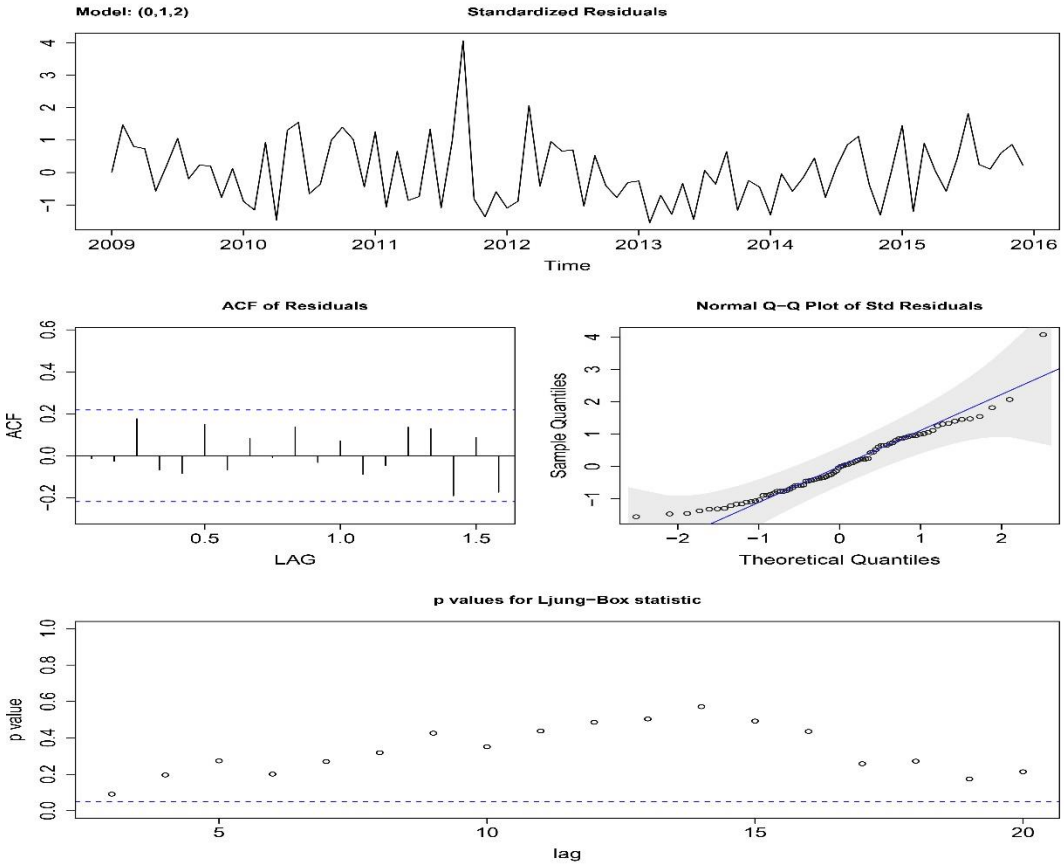

Fig. 2: The results of residuals analysis and Ljung-Box test of ARIMA (0,1,2)

Besides, with the rapid economic development and the acceleration of the life pace, the dietary patterns among residents were closer to the so-called western pattern. Given the common risk factors existing between stroke occurrence and other chronic diseases like obesity and diabetes, some actions such as advocating traditional dietary habits, taking proper exercise also should be promoted.

In this study, the incidence of IS increased gradually during the study period while an obvious downtrend was observed for HS, which was consistent with previous studies in China (22-24). However, it was distinctive from some developed countries. Some countries, like France and the United States, reported stable incidence rates for both IS and HS (25,26). In Finland, a decreasing trend for IS was observed whereas the trend for HS remained stable (27). The difference above might be explained by the discrepancies of genetic factors, lifestyle and preventive measures in different regions. Furthermore, IS was the main stroke subtype with a proportion of 81.18% in our study. Considering some reasons such as the intake of high fat and the potential metabolic syndrome for IS, we suggested that individual interventions should be taken into account (28,29). Therefore, we should pay more attention to IS and make individual interventions for its control and prevention in the future.

Similar to other studies, we found that male had a higher incidence in both stroke subtypes than female explained by some sex-specific risk factors (30,31). Besides, similar to available studies, the occupation of the peasant owned the highest risk for the occurrence of stroke in this study (32-34). Thus, as the comparatively developed county in China, the peasant group was still the critical

population that should strengthen the health intervention for stroke. Additionally, the age distribution showed that more focuses and attention should be paid among residents aged 40-79. Thus, further health education and health promotion reversing adverse behavior and bad lifestyle in these targeted populations above should be considered by local health policy-makers.

A spatio-temporal analysis proved that only one most likely cluster was identified in 2009 and no clustering was detected after that. It might be contributed to the program like the hypertension health management program. This program belonged to the project of Chinese Basic Public Health Service provided by the government for free including the function of active hypertension screening, blood pressure monitoring, follow-up and patients assessments, health education, lifestyle interventions and medication guidance as well. Available studies in China had proven that these targeted interventions were effective to decline the incidence of stroke (35-37). In Fenghua County, there was a total of 47163 hypertension patients participating in this program with the hypertension control rate of 61.63% in 2016. This project played a vital role in controlling the occurrence of stroke in the managed group of hypertension. Moreover, according to the government commitment to requiring the essential medical service within 15 minutes of walking, more primary medical organizations like community health service stations and village clinics had been established in recent years, which provided the possibility for the early prevention and intervention of stroke.

In this study, we constructed the popular ARIMA model to fit the trend of stroke number in Fenghua County and used the data of stroke cases that occurred in 2016 to test the accuracy of the model. Our results showed the ARIMA model could be used to predict the trend of the stroke and provide advanced support for the stroke in Fenghua County in the future.

However, some limitations also should be mentioned in this study. 1) Some stroke cases with mild symptoms or no obvious symptom might not go to the general hospital or community hospital, not captured by the ICDSS, causing the underestimate of its incidence. 2) In this study, included units in Fenghua County were divided into 26 communities by the administrative scoping of the community health center in spatial-time statistic analysis. Thus, more elaborate classification was not conducted, influencing the identification of potential clustering. 3) Given unavailable information such as individual behavior and lifestyle, this study was not performed to identify the relationship among them.

Conclusion

Under the trend of an aging population, the stroke incidence in Fenghua County was increased with the IS subtype as the main subtype. Peasant groups and persons in middle age and above were the targeted objects for the control and prevention of stroke. Besides, spatial-temporal analysis and the ARIMA model could be used for the identification of the clustering area of stroke occurrence and the prediction of new strokes, respectively. Furthermore, targeted interventions, like the hypertension health management program and health education, still should be strengthened in order to effectively reduce the incidence of stroke in Fenghua County in the future.

Ethical considerations

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

Acknowledgements

This study was supported by the project of promising young person in the medical field from Zhejiang province.

Conflicts of interests

The authors declared no conflict of interest.

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