Analysis about Environmental Factors of Stroke Incidence with Improved Grey Relational Model

Hanping Zhang

Computer Department, Wuhan Polytechnic, Wuhan 430074, China

Abstract. The data of stroke in a city of China and the environmental meteorological data in the same area of China were collected. The relationship between the incidence of stroke and air temperature, air pressure and humidity was analyzed by establishing an improved gray relational model. The results showed that the incidence of stroke was negatively correlated with the average temperature, the highest temperature and the lowest temperature, and the correlation degree was the highest, and was negatively correlated with the mean air pressure, followed by the correlation degree, and positively correlated with the average humidity. According to the results of the model, a targeted early warning intervention program is put forward for the risk groups of stroke.

1. Introductions

Stroke is one of the most influential diseases that threaten life of human-being currently. Its occurring is a long process, once getting sick it is difficult to reverse. This disease has been induced to be link to environmental factors closely including temperature, pressure and humidity. Wang Xu made a correlation and multiple regressions respectively between confirmed 2016 cases incidence of stroke patients in the first people's Hospital of Shenyang and 7 kinds of the meteorological factors of the previous ten days and the current ten days, which revealed that stroke incidence is associated with pressure and temperature in Shenyang [1]; Comparing and analyze the number of multiple-cases and the weather process, Dou Xinying, Fang Tingting figured out that the number of multiple-cases was negatively correlated with temperature, sunshine hours and positively correlated with barometric pressure and wind speed observably [2]. Fei Nina, Yang Youlong made a regression analysis of main component to deeply analyze the stroke incidence and environmental factors, and ultimately determine the relationship between stroke incidence and the incidence environmental factors [3]. Cheng Aiqun studied the relationship between meteorological elements and 151 cases of patients with cardiovascular disease in the first hospital of Nanjing from December 1988 to February 1989.He found that the incidence of cardiovascular diseases was correlated negatively with pressure. There is a clear correlation between cardiovascular disease and cooling of daily temperatures below the monthly average temperature and warming of daily temperatures above that [4]. The study of the literature on the environmental factors of stroke was taken by multiple linear regression method, while severe collinearity between the environmental factors has brought serious reliability to the establishment of the regression equation.In order to eliminate reliability, improved grey relational model method is presented in this paper.Impact factors of environment of stroke are much, which belongs to the information known.Some information is unknown to the system, so that grey modeling and its accuracy will be better than linear regression [6]. We will have a more accurate scientific discussion on the more obviously influenced environmental

factors from three aspects of environmental factors such as temperature, pressure and humidity through the establishment of improved grey relational model to master the rule of stroke incidence on high-risk groups so that they could be taken interventions for their own protection in time. It also has guide significance for rational allocation of medical administrative departments of public health and medical institutions and improving the medical treatment of the environment.

2. Data and Methods

2.1. Data Sources and Processing

Temperature, pressure, humidity and stroke incidence there is a long-term cointegration relationship. We chose these environmental factors for correlation analysis. The data comes from case of stroke incidence in hospitals of a city in China from January 2007 to December 2010 and local daily weather data for the period [7]. Because the climate and environment in same month but different year are general the same, 8 months meteorological indicators was collected for statistics including monthly average temperature, monthly average pressure, monthly average relative humidity, monthly average highest temperature, monthly average lowest temperature, monthly average highest pressure, monthly average lowest pressure and average lowest minimum humidity. Four-year incidence number was divided by the total number of cases to figure out the monthly incidence, as shown in Table 1.

Table 1. Morbidity and meteorological indicators statistics.

Month	Incidence	AT	HT	LT	AP	HP	LP	ARH	LRH
1	8.67	3.7	7.8	0.6	1026.6	1029.5	1023.5	50.9	50.6
2	8.09	6.3	10.2	3.2	1022.1	1025.0	1019.1	54.7	54.3
3	8.86	9.6	14.1	6.0	1019.7	1023.0	1016.4	52.1	47.0
4	8.94	14.1	18.6	10.4	1016.5	1019.5	1013.5	53.0	47.4
5	8.97	21.1	26.1	17.0	1010.1	1012.1	1007.8	54.2	42.0
6	7.89	24.2	28.2	21.3	1006.1	1007.7	1004.3	64.2	58.1
7	8.20	29.0	33.0	25.9	1004.5	1006.1	1002.7	62.7	56.0
8	7.88	29.1	33.2	26.0	1006.7	1008.4	1004.9	65.2	56.4
9	8.86	25.1	28.9	22.3	1011.6	1013.3	1009.9	65.5	59.6
10	8.39	19.1	23.2	15.7	1018.2	1020.1	1016.3	59.8	50.6
11	7.89	12.3	16.8	8.5	1022.6	1024.9	1020.3	58.7	48.2
12	7.85	6.8	11.3	2.8	1022.5	1025.5	1019.5	51.7	41.9

(AT: monthly average temperature; AP: monthly average pressure; ARH: monthly average relative humidity; HT: monthly average highest temperature; LT: monthly average lowest temperature; HP: monthly average highest pressure; LP: monthly average lowest pressure; LRH: average lowest minimum humidity; highest relative humidity is 100 %.)

2.2. Improved Grey Relational ModelBuilding

Basic principle of grey relational method is according to the geometric similarity of curves of comparing sequence set with curves of reference sequence to determine the sequence set associated with the reference series. The more similar curves of comparing sequences are to the geometry of curves of the reference sequence, the larger correlation is, while the smaller. It equally applies to how much the samples are and whether or not the rules are as well as little computation, which is very convenient. It also does not appear the case that quantitative results are inconsistent with qualitative analysis.The specific calculation methods and steps are as follows [4].

Step 1: Determine the compare sequence and the reference sequence

What is called the reference series is a data sequence reflecting the behavior of the system.The model refers to series-month incidence, $X0 = \{X0: (k) \mid k = 1, 2, \ldots, n\}$; What is called series is a data

series consisting of factors that could influence behavior of the system.The model reference series are environmental factors of temperature, pressure, and monthly maximum, mean and minimum value of humidity.Because the maximum value of humidity for each month is 100%, which do not have the resolution, this factor is eliminated. Xi = {Xi: (k)| k = 1, 2, …, n}, i =1, 2, …, m.

$$x_i(k)=\frac{X_i(k)}{X_1(k)},\quad k=1,2,\cdots,n;\quad i=0,1,2,\cdots,m. \tag{1}$$

Get x_i（i=0, 1, 2,⋯, n） into starting point zero image, express as x_i :

$$\begin{aligned} x_0 &=(x_0(1)\text{-}x_0(1)\ ,\ x_0(2)\text{-}x_0(1)\ ,\cdots x_0(n)\text{-}x_0(1)\ )\ ,\\ x_i &=(x_i(1)\text{-}x_i(1)\ ,\ x_i(2)\text{-}x_i(1)\ ,\cdots x_i(n)\text{-}x_i(1)\ )\ ,\ \ i=1,2,\cdots m. \end{aligned} \tag{2}$$

Step 2: get thevariables into nondimensionalization and Starting point zero image

Since the data in each factor column of the system may be different in dimension due to the influence of the conclusion, it may even make it difficult to obtain the correct conclusion. Therefore, in order to make the conclusion sufficiently reliable, when carrying out the gray relational analysis, Dimensionless treatment. There are many ways to deal with nondimensionalization, we choose the following way to make nondimensionalization treatment:

$$x_i(k)=\frac{X_i(k)}{X_1(k)},\quad k=1,2,\cdots,n;\quad i=0,1,2,\cdots,m. \tag{3}$$

Get x_i（i=0, 1, 2,⋯, n） into starting point-zero, express as x_i :

$$\begin{aligned} x_0 &=(x_0(1)\text{-}x_0(1)\ ,\ x_0(2)\text{-}x_0(1)\ ,\cdots x_0(n)\text{-}x_0(1)\ )\ ,\\ x_i &=(x_i(1)\text{-}x_i(1)\ ,\ x_i(2)\text{-}x_i(1)\ ,\cdots x_i(n)\text{-}x_i(1)\ )\ ,\ \ i=1,2,\cdots m. \end{aligned} \tag{4}$$

Step 3: calculate associated coefficients of $x_0(k)$ and $x_i(k)$

Ingeneral, suppose $y=(y(1),y(2),\cdots,\ y(n))$, and then $\alpha=y(k)-y(k-1),\quad (k=2,3,\cdots,n)$ is the slope of y on the interval of $[k-1,k]$, so that we can respectively get:

The sequence consisting of the slope of x_0 and x_i on the interval $[k-1,k],k=2,3,\cdots n$ respectively is:

$$\begin{aligned} k_0 &=(k_{01},\ k_{02},\cdots,k_{0n-1})\ ,\\ k_i &=(k_{i1},\ k_{i2},\cdots,k_{in-1})\ ,\ \ i=1,2,\cdots m. \end{aligned} \tag{5}$$

The sequence consisting of the ratio of slope of each corresponding period of x_0 and x_i is:

$$k_{0i}=k(x_0/x_i)=(k_{01}/k_{i1},\ k_{02}/k_{i2},\cdots,k_{011}/k_{in-1})\ ,\ \ i=1,2,\cdots m. \tag{6}$$

The coefficient of x_0 is:

$$\delta(x_0)=\frac{s}{\bar{k}_0}\times 100\% \tag{7}$$

Among them, $\bar{k}_0 = \frac{1}{n-1}\sum_{j=1}^{n-1} k_{0j}, s_0 = \sqrt{\frac{1}{n-2}\sum_{j=1}^{n-1}(k_{0j} - \bar{k}_0)^2}$;

The coefficient $\delta(x_0 / x_i)$ of x_0 / x_i is:

$$\delta(x_0 / x_i) = \frac{s_{0i}}{\bar{k}_{0i}} \times 100\% \tag{8}$$

Among them, $\bar{k}_{0i} = \frac{1}{n-1}\sum_{j=1}^{n-1}(k_{0j} / k_{ij}), s_{0i} = \sqrt{\frac{1}{n-2}\sum_{j=1}^{n-1}(\frac{k_{0j}}{k_{ij}} - 1)^2}$.

Finally the grey correlation of x_0 and x_i can be figured out is

$$\lambda(x_0, x_i) = \begin{cases} \dfrac{1 + |\delta(x_0)|}{1 + |\delta(x_0)| + |\delta(x_0, x_i)|}, \bar{k}_{0i} \geq 0 \\ -\dfrac{1 + |\delta(x_0)|}{1 + |\delta(x_0)| + |\delta(x_0, x_i)|}, \bar{k}_{0i} < 0 \end{cases} \tag{9}$$

$\lambda(x_0, x_i)$ is a coefficient of comparing series x_i and reference series x_i . Sign determines the positive and negative correlation between two numbers, and absolute value to determine the size of relevance, according which correlation can be sorted.

3. Results and Discussion

3.1. Calculation results

With the data of monthly stroke incidence and environmental factors of temperature, pressure, humidity and into the equation (1) to (7), using Excel calculation, we can getrelevance sort of the monthly stroke incidence with environmental factors of temperature, pressure, humidity. As shown in table 2.

Table 2. Gray relational table between incidence of stroke and environmental factors

Environmental Factors	AT	HT	LT	AP	HP	LP	ARH	LRH
Correlation	-0.75	-0.78	-0.74	-0.73	-0.65	-0.44	0.71	-0.59
Associated order	3	1	2	4	6	8	5	7

3.2. Results of Discussion

Related result of stroke with environmental factors is obtained by Table 2:

(1) Stroke incidence and the average temperature, the highest temperature, the lowest temperature was negatively correlated, but the correlation is large, located in the top three of the eight environmental factors. Its mechanism of action that the cold air in winter to stimulate the human sympathetic, increase excitability, increase catecholamine secretion, makevasoconstriction, high blood pressure, which induced cerebral hemorrhage. Secondly, due to arteriole spasm caused by the supply of vital organs, lack of oxygen, vascular fragility increased, it promote cerebral hemorrhage more frequently.

(2) The stroke has a negative correlation with the average air pressure, high pressure and low pressure, among which it is related with mean pressure, high pressure in the 4th and 6th.Its mechanism is the body speed up breathing and blood circulation to compensate for a lack of oxygen, and release

epinephrine when the pressure drops, which will cause blood pressure to raise, rapid heartbeat, and cerebral hemorrhage will finally appeared.

(3) Stroke is positively correlated with average humidity in the 5th position. Its mechanism considered that humidity increases, and then the weather mostly burst into rain with Earth's magnetic field making the body's autonomic nerve disorder. If the nerve function doesn't get effective regulation, it is prone to get stroke.

4. Early Warning and Intervention Proposals of Stroke

Stroke looks very fast and unpredictable. Actually, like many diseases, stroke also has a clear process of accumulation of pathological damage which gradually shifting from quantitative change to qualitative change. High pressure, low humidity and low temperature often cause a stroke in winter.Recommendations are following:

(1) Periodic medical examinations especially for blood pressure, blood glucose, blood lipids and body mass index.

(2) Consult cerebrovascular specialist to give guidance and treatment timely when there is a risk factor.

(3) Pay attention to climate change. The old should pay attention to warm the head in winter, heatstroke in summer and drinking 800raL a day at least in water. Reduce the adverse external environment stimuli and improve the ability of the human body to adapt to reduce stroke and death is an effective means.

References

[1] WANG Xu, 2006, Correlation of the incidence of cerebral apoplexy and weather factors in Shenyang area [J], Journal of Tissue Engineering Research ,Vol.36, no.10, pp. 12-13.

[2] DOU Xin-Ying, FANG Ting- Ting ,2010,The relationship between the incidence of stroke and meteorological factors and predictive models [J], Occupation and Health ,Vol.26,no.23, pp. 22-23.

[3] FEI Ni-Na,YANG You- Long ,2014,Principal component regression in-depth analysis on stroke incidence and environmental factors [J], Journal of HuaiYin Teachers College (Natural Science Edition), Vol.13,no.3, pp. 200-205.

[4] CHeng Ai-Qun, Cheng Ji-ZHuang, Lu Jian-Ping, 1994, The relationship between Nanjing weather and the hospitalization rate of cardiovascular disease [J], Acta Academiae Medicinae NanJing, Vol.14, no.3, pp. 462-463.

[5] Liu Xiao-Xu , 2009, Comparing for Grey Forecast and Forecast of One Element Linear Regression [J], Journal of Sichuan University of Science Engineering (Natural Science Edition), Vol.22, no.1, pp. 107-109.

[6] Cao Ming-Xia , 2008, A Study and Improvement on Properties of Positive and negative of Grey Incidence Degree Model [J], Systems Engineering and Electronics, Vol.30, no.6, pp. 1086-1088.

[7] Committee of the national college students' mathematical modeling competition organization, 2012, http: // www. mcm. edu. cn/ problem/ 2012/2012. html.