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Document Analysis of Correlation between Climate and Stroke

Hongwei Li[1*], Yonggang Qian[2*], Shubi Wang[3*], Hairong Zhang[1], Wenfang Gou[1], Mingzhu Niu[1], Di Yu[1], Ruijie Wu[1], Liqun Gao[1], Baofeng Chi[1], Qingxia Wang[1], Wenli Hao[1], Wuyuntana Li[1], Tao Yan[1], Liwei Niu[1], Yan Liu[1], Jing Zhao[1], Yuan Jin[1], Maolin Du[1#], Juan Sun[1#]

[1]Inner Mongolia Medical University, Hohhot, China
[2]Inner Mongolia Center for Disease Control and Prevention, Hohhot, China
[3]Tongliao City Hospital, Tongliao, China
Email: [#]dumaolin1959@163.com, [#]sj6840@163.com

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Abstract

Aim: The aim of the research is to determine characteristic of the correlation between climate and stroke through the analysis of relevant documents. **Methods**: We found 115 researches of temperature and season on stroke mortality/incidence and these were categorized according to location, meteorology, date span, data source and research sites' latitudes. We divided the globe into 5 temperature zones based on latitude ranges: 0 - 10, 10 - 23.5, 23.5 - 40, 40 - 50, and >50 degrees, and allotted a zone to each country. Stroke mortality by five temperature zones was calculated per 100,000 people. **Results:** 70% of the researches came from latitudes greater than 40 degrees with 92% of researches located in Europe, USA, and Asia. The mortality range was 42 - 63 per 105 individuals within latitudes 0 - 40 degrees. In latitudes 40 - 66.5 degrees, a linear upward trend ($y = 69.82x - 22.823$, $R2 = 0.99$) was noticed. More than 75% of the research reports indicated a negative correlation between climate and stroke, and the proportion was almost 6 and 7 times greater than that of the fluctuation and non-correlation, respectively. The most frequently used research methods were regression analysis and time series analysis. **Conclusion:** All of the research results confirmed that lower temperature is associated with higher mortality and incidence of stroke, while higher latitude is correlated with higher stroke mortality, consistent with the temperature zones.

Keywords

Climate, Stroke, Correlation

*Hongwei Li, Yonggang Qian, Shubi Wang, contributed equally to this paper.

1. Introduction

Stroke represents the third leading cause of death worldwide [1]. Current epidemiological data indicate that 16.9 million people suffer a stroke each year, amounting to a global incidence of 258/100,000 persons/year and accounting for 11.8% of the total deaths worldwide [2]. Previous reports have confirmed that the incidence of strokes may be influenced by meteorological variations [3]. In certain countries, the incidence of strokes and the stroke mortality have shown seasonal patterns with a peak during winter months, which are characterized by lower temperatures [4] [5]. Moreover, the mortality of stroke increases with the latitude [6]. Based on study of different temperature zones, low temperature negatively affects stroke mortality at latitudes > 40˚ [5].

Past researches have generated a large amount of data on the relationship between climate and stroke, and the results and perspectives show great diversity. The aim of our research is to analyze the differences and characteristic of these reports, and to provide theoretical basis for the study of the relationship between climate and stroke.

2. Methods

2.1. Data Source

We only obtained data on stroke deaths and population denominators in 192 countries in 2002 from WHO websites [7]. We divided the globe into 6 locations by various continents: Europe, North America, South America, Asia, Oceania, Africa. And divided the globe into 5 temperature zones based on latitude ranges: 0 - 10, 10 - 23.5, 23.5 - 40, 40 - 50, and >50 degrees, and allotted a zone to each country; the exception was Chile because it crosses 4 zones from 18 to 57 degrees, so researches from this country were not used.

We found 115 researches of climate on stroke mortality/incidence and these were categorized according to location, meteorology, method, date span, data source and research sites' latitudes. Average temperature was reported by month, season, or year, although some researches just reported season without reference to temperature. A negative relationship was defined as the lower the temperature, the higher stroke mortality/incidence; alternatively the coldest season has the highest mortality/incidence. Fluctuation was defined as a higher mortality/incidence of stroke with the temperature fluctuations with noncorrelation defined as invariant mortality/incidence stroke in respect of variation of temperature however defined temporally.

2.2. Statistical Analysis

Stroke mortalities according to the five temperature zones were calculated by per 100,000 people and represented by the line chart. The corresponding proportions of research reports on the correlation between climate and stroke by location were calculated and listed in the table. The proportions of methods for data analysis in various researches were determined and illustrated by the pie chart.

Data entry and statistical analysis were completed using Microsoft Office Excel and SPSS 16.0, respectively.

3. Results

Table 1 shows the 115 researches found in the world, all in latitudes > 23.5 degrees. Seventy percent of the researches came from latitudes greater than 40 degrees with 92% of researches located in Europe, USA, and Asia. Only 10 researches came from countries located in the southern hemisphere and all were in latitudes 23.5 - 40 degrees. Forty-five researches were concerned about the relationship between season and stroke. Mortality/incidence peak in winter was found in 30 researches; in spring or autumn 6 researches; in summer, 1 research; no peak was found in 6 researches and in 2 researches, which looked at different subtypes of stroke the peak was in different season. In over 70% of the research publications, the time span was ≥2 years.

Figure 1 shows stroke mortality within the 5 temperature zones. The number of countries should be reduced by 9 when dividing them according to southern and northern hemispheres, as these countries spanned the equator. The mortality range was 42 - 63 per 105 individuals within latitudes 0-40 degrees. In latitudes 40 - 66.5 degrees, a linear upward trend ($y = 69.82x - 22.823$, $R2 = 0.998$) was noticed that reached 188.05/105 for latitudes > 50 degrees only in the northern hemisphere because no countries were located in the corresponding latitudes in the southern hemisphere.

Table 2 shows the proportion of researches on the correlation between climate and stroke by location. Over 75% of these reports indicate a negative correlation between climate and stroke, and the proportion was almost 6 and 7 times more than the proportions of fluctuation and non correlation, respectively. Additionally, the proportion of researches on negative correlation between temperature or season and stroke in Europe and Asia were more than 70%.

Figure 2 illustrates the proportion of research methods used for analyzing the correlation between climate and stroke. Regression analysis and time series

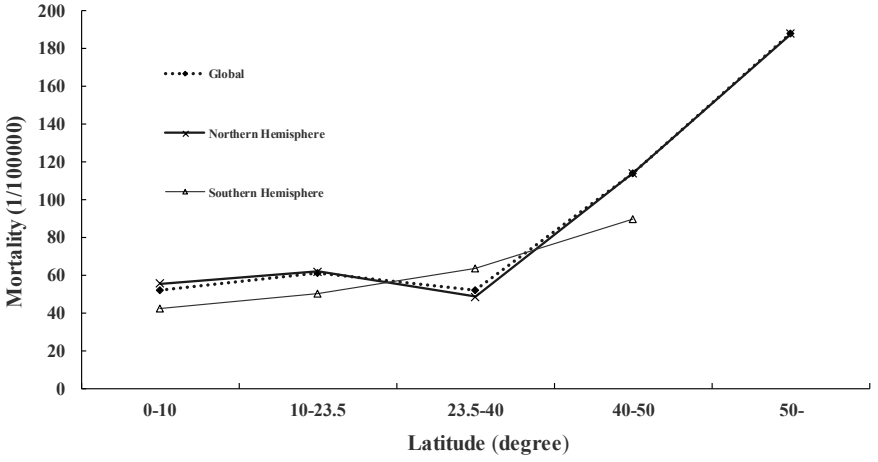

Figure 1. Stroke mortality at 5 latitudes in 2002.

Table 1. Research numbers on the association between temperature and stroke by location and latitude.

	Total	Location							Northern Hemisphere			Southern Hemisphere	
		World	Europe	North America	South America	Asia	Oceania	Africa	23.5˚ - 40˚	40˚ - 50˚	>50˚	<23.5˚	23.5˚ - 40˚
Meteorology													
Temperature	70	1	23	13	3	27	1	2	19	30	12	1	6
Season	45	1	17	13	1	8	3	2	4	27	8	0	5
Data Source													
Mortality register	29	0	15	5	1	7	1	0	5	11	12	0	3
Incidence register	50	1	17	13	2	15	1	1	8	31	5	0	4
Hospital admission	36	1	8	8	1	13	2	3	11	15	3	1	4
Years Span													
<1	16	1	7	2	0	4	0	2	3	9	1	0	2
1 - 5	46	1	15	7	4	18	0	1	14	21	5	0	5
5 - 10	33	0	12	9	0	7	4	1	2	17	9	1	4
>10	17	0	5	7	0	5	0	0	4	8	5	0	0
No	3	0	1	1	0	1	0	0	1	2	0	0	0

Table 2. Proportion of researches on correlation between climate and stroke by location.

	Category	Number of researches	Negative correlation Proportion (%)	Positive correlation Proportion (%)	Fluctuation correlation Proportion (%)	Noncorrelation Proportion (%)
Total	Temperature	69	76.81	1.45	14.49	7.25
	Season	46	78.26	2.18	6.52	13.04
Location						
World	Temperature	1	100.00	0.00	0.00	0.00
	Season	1	100.00	0.00	0.00	0.00
Europe	Temperature	23	86.96	13.04	0.00	0.00
	Season	17	70.59	0.00	11.76	17.65
North America	Temperature	14	64.28	0.00	14.29	21.43
	Season	13	84.62	0.00	0.00	15.38
South America	Temperature	2	50.00	0.00	50.00	0.00
	Season	1	100.00	0.00	0.00	0.00
Asia	Temperature	26	76.92	3.85	11.54	7.69
	Season	8	75.00	0.00	12.50	12.50
Oceania	Temperature	1	0.00	0.00	100.00	0.00
	Season	4	100	0.00	0.00	0.00

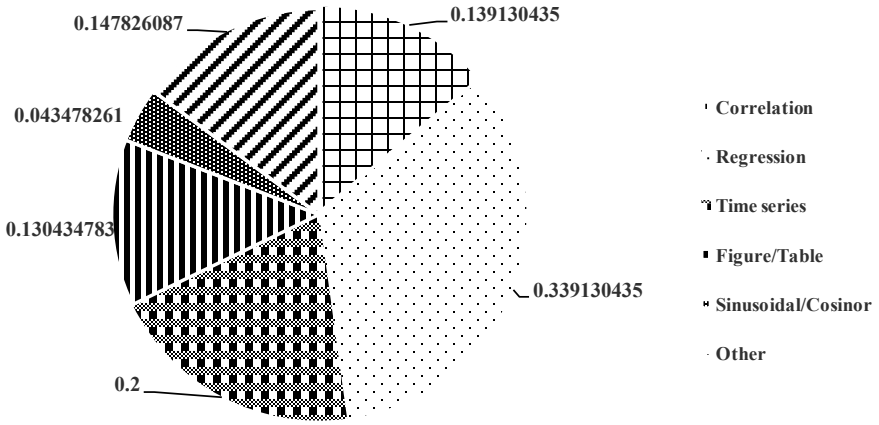

Figure 2. The proportion of methods between climate and stroke in the researches.

analysis were found to be the most frequently used research methods, accounting for 33.91% and 20%, respectively. The proportion of the sinusoidal/cosinor method was lowest (4.35%).

4. Discussion

All findings point to the fact that lower temperature is the key climatic variable for stroke. Approximately 80% of the research reports were in support of a negative correlation between the average temperature and stroke, demonstrating an increase in mortality as the temperature decreases. Stroke mortality peaks in winter, the season with the lowest temperature. Therefore, the research results of both average temperature and seasonal factors reveal that lower temperature increases the mortality and incidence of stroke.

Temperate or boreal regions include over 90% of the researches located in Europe, America, and Asia, showing that temperature of the cold regions was the main research focus. Based on the 5 temperature zones, we further calculated stroke mortality and found negative effects of temperature for stroke that at latitudes > 40 degrees, the higher latitude the higher stroke mortality. In other words, the lower temperature, the higher mortality of stroke in temperate or boreal regions. Lower temperatures in temperate and boreal regions were associated with stroke mortality that was twice as high compared to tropical and subtropical regions (126/105 vs. 58/105). Temperatures in the tropical and subtropical regions did not affect stroke mortality as mortality was stable.

It is worth noting that in the southern hemisphere stroke mortality demonstrated a smooth linear upward trend from the tropic to boreal regions. However, mortality rates in the tropic and subtropical regions of the southern hemisphere are close to those in the northern hemisphere with values of 42 - 63/105 in both hemispheres. In only 2 countries residing in the temperate and boreal region was an upward trend observed. Thus, the impact of temperature on stroke in both hemispheres is consistent.

11 of the 115 also researches demonstrated noncorrelation between temperature and stroke. Temperatures were mild in 6 of these 11 researches (regions

with warm winters), with 3 researches located geographically in maritime climate [8] [9] [10] and 3 researches located in subtropical regions [11] [12] [13]. The seventh research was in focused in a region of Canada with a warm winter, while the eighth, ninth, and tenth researches were located in the USA, representative of temperate, subtropical, and boreal climates. The last research was old only using three cases, the results of which we consider to be unreliable. These researches in turn suggest that the existence of a negative relationship between temperature and stroke was more likely in a cold region. In 13 of the 115 researches temperature fluctuation appeared to affect stroke hospitalizations. Temperature fluctuation also has an impact on other diseases [14], although we think that the fluctuation is nonspecific.

A variety of methods have been utilized to investigate the relationship between climate and stroke. Regression analysis and time series analysis were the most widely used methods, and were applied in more than half of the researches. These methods are valuable for evaluating the relationship between climate and stroke.

Global data in our analysis were derived from stroke deaths and population worldwide (rather than regional and sampling), consider the calculated results to be reliable, although researches in one region (Hong Kong) showed conflicting results [12] [15].

5. Conclusion

In summary, this document analysis confirmed that lower temperature increases the mortality and incidence of stroke, and higher latitude is associated with higher stroke mortality, in accordance with the temperature zones.

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Conflicts of Interest

We have no competing interests.

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