Association Between Meteorological Factors and Coronary Heart Disease in Northeast China

Jinling Huang

Shengjing Hospital of China Medical University

Liqiang Zheng

Shengjing Hospital of China Medical University

Jinghai Zhu (✉ jinghaizhu@126.com)

Public Health China Medical University <https://orcid.org/0000-0003-3541-9509>

Research article

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Abstract

Background: To investigate the effect of daily meteorological factors in northeast China on coronary heart disease and explore in depth the impact of the environment on health.

Methods: The population data primarily included daily coronary heart disease hospitalizations between January 1, 2015 and December 31, 2019, comprising a total of 25,461 patients. The meteorological data included daily temperature, barometric pressure, relative humidity, precipitation, and wind speed between January 1, 2015 and December 31, 2019. A multiple linear regression model was constructed for analyzing the relationship between meteorological factors and coronary heart disease.

Results: After controlling for confounding factors, the mean monthly temperature negatively correlated with the monthly number of coronary heart disease hospitalizations, particularly in the warm season (Apr–Sep; $\beta = -12.468$, $p < 0.05$).

Conclusions: In the warm season and during a mild weather, high temperature might be a protective factor against coronary heart disease.

1. Background

In 2016, the World Health Organization reported that an estimated 17.9 million people died of cardiovascular disease, accounting for 31% of the deaths worldwide [1]. The incidence of cardiovascular disease remains high in China. According to the 2018 China Cardiovascular Disease Report, 290 million cardiovascular disease cases were reported in China, of which 11 million were of coronary heart disease (CHD) [2]. Current research has shown that arterial hypertension, dyslipidemia, and smoking affect the incidence and mortality of cardiovascular disease, especially those of CHD [3]. In addition, meteorological factors such as air temperature, relative humidity, wind speed, and barometric pressure have been found to be related to cardiovascular diseases such as CHD [4–7]; in particular, the incidence and mortality of CHD increase in winter [8, 9]. With rapid economic and social development, the effect of atmospheric pollutants on cardiovascular diseases has been widely recognized [10–13]. However, most studies on the effect of meteorological factors on cardiovascular disease have not controlled for the effects of atmospheric pollutants on CHD, which may lead to differences in relevant research results.

In this study, we constructed a multiple linear regression model to control for the confounding effects of pollutants such as PM_{2.5}, PM₁₀, SO₂, CO, O₃, and NO₂ and to investigate the relationship between meteorological factors, such as temperature, barometric pressure, precipitation, wind speed, and relative humidity, and the number of patients hospitalized for CHD, thereby providing support for future research on atmospheric environment and cardiovascular disease.

2. Methods

2.1 Health Data

Data on CHD hospitalization between January 1, 2015 and December 31, 2019 were provided by Shengjing Hospital of China Medical University. The condition of all participants in this study was diagnosed as CHD as defined in the International Classification of Diseases, Tenth Revision (ICD-10), including the following: acute myocardial infarction (I21–I22), unstable angina (I20.0), stable ischemic heart disease (I20 except I20.0 and I25), and other types of CHD (also including acute myocardial infarction and certain current complications following acute ischemic heart disease, I23–I24), for a total of 254,661 CHD patients. This study has been approved by the Institutional Review Board of China Medical University.

2.2 Meteorological Data and Air Pollution Data

Historical climate data between January 1, 2015 and December 31, 2019 were retrieved from the Shenyang Meteorological Bureau, including temperature (°C), barometric pressure (Pa), precipitation (mm), wind speed (m/s), and relative humidity (%). Historical data on atmospheric pollutants, including PM_{2.5}, PM₁₀, SO₂, CO, O₃, and NO₂, were retrieved from the Shenyang Meteorological Bureau.

2.3 Statistical Analysis

The general characteristics of atmospheric pollutants and meteorological factors are expressed as mean $\pm$ standard deviation. The *t*-test for independent samples was used to analyze the differences in the number of CHD hospitalizations among different age groups and sexes. Air pollutant concentrations were divided into two groups based on the median values: PM_{2.5} (≤ 42.48 and ≥ 42.90), PM₁₀ (≤ 86.19 and ≥ 86.58), SO₂ (≤ 22.90 and ≥ 23.23), CO (≤ 0.89 and ≥ 0.90), O₃ (≤ 57.37 and ≥ 58.00), and NO₂ (≤ 38.87 and ≥ 39.00). A multiple linear regression model was constructed to investigate the effect of meteorological factors on CHD. Statistical analysis was performed using IBM SPSS 20.0 software, Chicago, USA. Differences with $p < 0.05$ were considered statistically significant.

3. Results

3.1 General Characteristics

As shown in Table 1, there was no statistically significant difference in the number of CHD hospitalizations between different ages or different age groups. The area in which the institute is located has a temperate, semi-humid continental climate with distinct seasons; large temperature differences; cold, long winters; short, rainy summers; and rapid temperature changes in spring and autumn, with windy springs and clear autumns (Table 2). Owing to the warm periods during the cold season, the concentrations of the atmospheric pollutants PM_{2.5}, SO₂, and CO are higher than those in the warm season; the difference is statistically significant (not shown).

Table 1
Gender- and age-specific incidence of coronary heart disease per month

	Gender			Age (years)		
	Male (14,376)	Female (11,085)	<i>P</i>	≤ 64 (12,768)	≥ 65 (12,693)	<i>P</i>
(N)						
January	1239	1011	0.146	1140	1110	0.188
February	1139	830		1025	944	
March	1428	1098		1280	1246	
April	1231	1004		1068	1167	
May	1312	983		1169	1126	
June	1107	904		990	1021	
July	1143	773		1002	914	
August	1102	878		979	1001	
September	970	742		858	854	
October	1238	958		1084	1112	
November	1400	1068		1238	1230	
December	1067	836		935	968	

Table 2
Characteristics of air pollutants from January 2015 to December 2019

	PM _{2.5}	PM ₁₀	SO ₂	NO ₂	CO	O ₃
Mean ± SD						
Cold season						
January	77.88 ± 48.75	117.70 ± 59.44	89.60 ± 65.19	51.28 ± 17.59	1.30 ± 0.58	28.14 ± 10.41
February	69.01 ± 47.26	108.06 ± 86.35	71.72 ± 56.50	42.79 ± 17.60	1.10 ± 0.51	43.92 ± 12.98
March	67.25 ± 39.39	118.43 ± 65.95	45.39 ± 25.72	43.07 ± 16.01	0.99 ± 0.43	62.51 ± 20.36
October	50.20 ± 37.07	85.58 ± 47.15	22.95 ± 11.61	42.40 ± 16.50	0.98 ± 0.48	41.88 ± 22.56
November	67.66 ± 81.78	101.35 ± 82.49	45.84 ± 34.05	44.89 ± 14.66	1.02 ± 0.45	29.29 ± 13.22
December	73.77 ± 48.65	108.57 ± 59.62	61.90 ± 45.87	48.88 ± 15.23	1.29 ± 0.56	24.75 ± 11.39
Warm season						
April	46.50 ± 20.70	105.34 ± 48.09	20.71 ± 9.75	34.34 ± 10.46	0.79 ± 0.27	77.72 ± 24.25
May	37.09 ± 15.49	89.51 ± 44.25	17.55 ± 8.03	30.55 ± 9.68	0.72 ± 0.24	97.14 ± 33.53
June	32.35 ± 12.84	58.99 ± 21.85	16.58 ± 7.38	32.01 ± 8.77	0.82 ± 0.25	94.13 ± 33.28
July	31.37 ± 13.53	54.64 ± 20.62	12.65 ± 7.55	27.30 ± 9.30	0.81 ± 0.20	83.57 ± 27.01
August	28.30 ± 15.12	52.37 ± 22.69	15.84 ± 9.52	29.43 ± 8.01	0.79 ± 0.24	67.00 ± 23.42
September	29.89 ± 15.21	58.38 ± 23.15	19.59 ± 8.05	38.63 ± 12.93	0.88 ± 0.32	54.43 ± 21.31

Table 3
Characteristics of meteorological factors from January 2015 to December 2019

	Air pressure (Pa)	Air temperature (°C)	Humidity (%)	Precipitation (mm)	Wind velocity (m/s)
Mean ± SD					
Cold season					
January	1021.40 ± 5.54	-10.33 ± 4.71	56.57 ± 12.82	0.12 ± 0.47	2.75 ± 2.30
February	1018.43 ± 5.93	-6.01 ± 4.74	51.83 ± 14.19	0.41 ± 1.64	3.04 ± 2.53
March	1013.47 ± 5.91	3.18 ± 5.21	47.73 ± 13.08	0.37 ± 1.62	3.52 ± 2.73
October	1014.51 ± 5.47	9.40 ± 4.64	62.34 ± 12.92	1.00 ± 3.66	2.90 ± 2.74
November	1018.87 ± 6.04	0.10 ± 5.82	58.10 ± 14.28	0.56 ± 1.91	2.95 ± 2.31
December	1021.06 ± 5.82	-6.82 ± 5.34	61.27 ± 14.54	0.42 ± 1.76	2.33 ± 1.91
Warm season					
April	1007.03 ± 5.85	11.74 ± 4.62	43.49 ± 17.35	0.83 ± 3.34	3.94 ± 3.02
May	1002.35 ± 5.33	18.39 ± 3.94	49.34 ± 16.18	2.73 ± 9.67	4.01 ± 3.21
June	999.59 ± 3.31	22.27 ± 2.73	64.39 ± 13.78	3.32 ± 7.74	3.07 ± 2.72
July	999.47 ± 3.58	25.82 ± 2.47	72.64 ± 9.21	4.01 ± 16.52	2.69 ± 2.47
August	1001.07 ± 4.11	23.82 ± 3.30	77.57 ± 9.42	4.97 ± 13.61	2.23 ± 2.14
September	1008.03 ± 5.36	18.22 ± 3.33	71.59 ± 11.63	0.99 ± 3.18	0.79 ± 0.24

3.2 Relationship between meteorological factors and monthly CHD hospitalization rate

We applied multiple linear regression models to investigate the relationship between meteorological factors and CHD. As shown in Table 4, after controlling for air pollution, age, and four other meteorological factors, only temperature showed a significant negative correlation with the monthly

number of CHD hospitalizations, and only in the warm season ($\beta = -12.468$, $p < 0.05$). In model 3, other meteorological factors had no statistical significance.

Table 4
Relationship between meteorological factors and monthly incidence of coronary heart disease

	Model 1		Model 2		Model 3	
	β	P	β	P	β	P
Cold season						
Air pressure	-6.685	0.119	-8.171	0.296	-9.406	0.296
Air temperature	3.125	0.136	0.764	0.841	0.266	0.957
Humidity	-0.701	0.697	-0.621	0.756	0.975	0.728
Precipitation	-5.65	0.852	-32.055	0.352	-28.533	0.502
Wind velocity	18.298	0.015*	17.37	0.061	16.69	0.101
Warm season						
Air pressure	2.152	0.505	5.511	0.081	-5.345	0.236
Air temperature	-4.168	0.084	-6.404	0.007*	-12.468	0.021*
Humidity	-1.95	0.021*	-1.33	0.141	1.185	0.376
Precipitation	-2.608	0.477	-1.62	0.579	1.702	0.632
Wind velocity	15.798	0.002*	7.939	0.087	4.938	0.274
Model 1: Adjusted age; Model 2: Adjusted age and the other 4 meteorological factors; Model 3: Adjusted age, the other 4 meteorological factors, and PM2.5, PM10, SO ₂ , NO ₂ , CO, O ₃ ; *: $P < 0.05$						

4. Discussion

In this study, we used multiple linear regression models to investigate the effects of meteorological factors on CHD in northeast China. The results show that temperature is associated with the monthly number of CHD hospitalizations. The study showed that it was only during the warm season that temperature was significantly and negatively correlated with daily CHD hospitalization. During the warm season, the higher the temperature, the fewer the monthly number of CHD hospitalizations.

In recent years, serious environmental pollution has caused major climate changes, and the environmental temperature has changed drastically. The effects of temperature on cardiovascular diseases has been widely studied to date [14–16]. Studies have shown that there is a negative correlation between temperature and cardiovascular disease. A study by Khanjani and Bahrampour in Kerman, Iran, showed that the rate of cardiogenic death increased by 0.6% for every 1 °C decrease in temperature. In this study, the relationship between cardiogenic death and body temperature was almost linear, and as

the temperature increased, the number of cardiogenic deaths decreased [17], which is consistent with the results of the present study. In addition, after controlling for the effects of atmospheric pollutants as confounding factors, the negative correlation between temperature and monthly CHD hospitalization was still significant. The possible reasons may be that lower ambient temperatures have significant effects on increases in cardiovascular mortality and that the average blood pressure in a colder climate is higher than that in a warmer climate. In the United Kingdom, differences in blood pressure that are caused by changes in temperature between winter and summer may account for at least 21% of CHD cases and 34% of stroke cases [18]. In addition, low temperatures may adversely change plasma lipid concentrations and lead to abnormal thrombosis and chronic atherosclerosis [19]. In addition, some studies have shown a positive correlation between temperature and cardiovascular disease mortality. A study in Beijing showed a linear relationship between temperature and cerebrovascular death, wherein every 5 °C increase in temperature increases the risk of cerebrovascular death by 6.4% [20]. The reason for these inconsistent results may be that the effect of temperature on cardiovascular disease shows a U-shaped relationship [21–24]. In addition, the lifestyle habits in the study area also cause inconsistency in the results. For example, Shenyang is a city in northeast China, where the regional diet is high in sodium. In addition, the mean temperature in the area is lower than that in Beijing, and extreme heat is rare even when the temperature is high; hence, there may be no negative environmental influence on CHD. In addition, the use of refrigeration equipment may also cause a negative correlation between the high temperature in the warm season and the number of CHD hospitalizations. For example, in summer, most people choose to turn on air conditioning to relieve themselves of the effects of high temperature, which may attenuate the effect of high temperature on cardiovascular disease.

This study also had some limitations. First, this was a cross-sectional study and a causal relationship could not be concluded. Second, the research subjects of this study were only from the Chinese population, cannot represent other races. In addition, owing to the limitations of hospitalization records, the present study did not collect the effects of confounding factors on the daily dietary habits of the study subjects, which may influence CHD.

5. Conclusions

This study provided evidence on the effect of meteorological factors on CHD. In the warm season, temperature negatively correlated with CHD. The frequency of extreme weather is low, and daily weather is relatively stable. Under stable weather conditions, our results are of great significance for planning public health interventions to deal with the effect of temperature on health.

Abbreviations

CHD: coronary heart disease

Declarations

Ethics approval and consent to participate

This study has been approved by the Institutional Review Board of China Medical University.

Consent for publication

Not applicable

Availability of data and materials

Not applicable

Competing interests

The authors declare that they have no competing interests.

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No funding was received for this analysis.

Authors' contributions

Jinling Huang contributed to data collection, analyzed the data and drafted the manuscript; Liqiang Zheng interpretation of data. All authors read and approved the final manuscript.

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