Meteorological factors and asthma in Hangzhou, China, a time-series study

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Abstract: Many studies have linked meteorological factors to asthma attacks. However, few studies have been conducted in the subtropical monsoon climate zone. The relationship between age, temperature, humidity (other meteorological factors) and asthma attacks has not been analyzed.Disease data were collected from medical records of Xinhua hospital in Gongsu district. Meteorological data were collected from Chinese terrestrial climate data daily value data sets.Poisson generalized additive models was used and combined with distributed lag nonlinear models and piecewise linear models to model associations between daily asthma hospitalizations from 2010 to 2013 and meteorological factors. Subgroup analyses by age and season were performed.Risk of asthma hospitalizations peaked at a mean daily temperature of 10℃ and declined approximately linearly until 35℃.High humidity and low humidity were both associated with more asthma admissions. Wind speed had no significant association with asthma hospitalization. No seasonal difference in associations were observed.Asthmatic patients should limit outdoor activities in low temperature, unsuitable humidity to avoid exposure to adverse conditions.

Keywords: Asthma; Meteorological Factors

1. Introduction

Asthma is one of the noncommunicable diseases whose characters are recurrent attacks of breathlessness and wheezing[1]. Asthma is a kind of airway obstructive disease, which is a kind of airway hyperreactive, reversible and remodeling disease involving a variety of inflammatory cells, immune cells and it is triggered by persistent airway inflammation. Inflammation also increases when asthma attacks occur.According to WHO estimates, over 235 million people worldwide are suffering from asthma. One prediction is that an additional 100 million people will unfortunately have this disease by 2025. The prevalence of asthma in Chinese adults was 1.09%(95%CI:0.95~1.22) .The prevalence of male asthma was 1.17%, higher than that of female asthma 1.00%. From 1990 to 2010, the incidence of asthma in children under the age of 14 increased threefold, which was more than 3% in 2010. And the control rate of childhood asthma in China is less than 1/3. This disease has become a serious public health problem, which not only brings harm to people's health, but also brings a great economic burden to the society.Previous studies have assessed risk factors for asthma, including meteorological and environmental risk factors. Some studies have reported that changes in weather and air quality have a measurable effect on the morbidity and the mortality of patients who were suffered from asthma. The earth is becoming warmer due to the concentration of many greenhouse gases increasing, especially carbon dioxide (CO2). This can lead to severe and sustained high temperatures. The continued high temperatures will increase air pollution, forest fires, droughts and floods. These adverse climate changes will increase public respiratory health risks. Preliminary evidence which was

based on a large number of epidemiological studies, suggests that environmental meteorological conditions, especially extreme temperatures, contribute to the exacerbation of adult asthma[2].

Hangzhou is located in Zhejiang province, China, and belongs to the Yangtze river delta region. It is subtropical monsoon climate and has a high population density.

While few previous studies have looked at the association between meteorological factors like temperature, humidity, wind speed and asthma and were done in areas with sub-tropical climates. Since prior studies of the inducing factors of asthma have indicated that the air pollution is an important issue, the lack of studies of temperature areas represents a significant knowledge gap.

2. Methods

2.1 Data

A time-series study has been conducted on 17497 males and 13913 females aged between 2 to 97 years from the same hospital in Hangzhou, China. Disease data were collected from medical records of Xinhua hospital in Gongsu district. Meteorological data were collected from Chinese terrestrial climate data daily value data sets. Meteorological data including daily mean temperature (°C), daily mean relative humidity percentage (RH%) and mean wind speed (m/s). The data came from a hospital in a heavily populated area.

2.2 Statistical models

Our study uses a combination of Poisson generalized additive models (GAMs) and distributed lag nonlinear models (DLNMs) to assess the potentially nonlinear association between meteorological variables and the hospitalizations of asthma allowing for lagged effects. The model was as below:

M = gam(P ~ cb.temperature + cb.relative humidity + cb.wind speed + s(t,k=28) + factor(dow)+factor(holiday), optimizer = "perf", family = negbin(c(1,100),link = log) , data=data1)

cb: cross basis of independent variables built up using the dlnm() package in R s(): smoothing function of independent variables

k: limitation of degree of freedom in smoothing function factor(): indicator of categorical independent variables

DOW: day of week (1, 2, 3, ..., 7). DOW was modeled as a categorical variable using indicator variables.

Variables relating to meteorological factors were modelled simultaneously using DLNM. The generalized cross validation (GCV) score can be minimized in the mgcv() package in R which can choose the number of degrees of freedom (df) for variable terms.

2.3 Model checking and sensitivity analyses

Sensitivity analysis was done to observe the robustness of the results by adopting different df lag terms of the model. All statistical analyses were performed with R Studio 1.1.463.

3. Results

During this 4-year study period, there were a total of 31410 asthma admissions. Among these people, 72.75%, 19.76% and 7.49% were in children, adults and the elderly, respectively. The daily average numbers of hospitalizations were 21.50, 10.80 and 11.59 for the whole year, hot season and cold season, respectively. Daily mean temperatures ranged from -2°C to 35.7°C. The median daily mean temperatures (3rd, 97th per- centile) were 19.1°C (1.50°C, 32.6°C), 25.7°C (16.5°C, 33.3°C)

and 10.1°C (0.6°C, 21.4°C) for the whole year, hot and cold seasons, respectively. Table 1 shows the descriptive statistics of the total number of asthma hospitalizations and meteorological variables during the study period.

The maximum lag time for df of 3 is 15 days, respectively, for the lag parameters of temperature/relative humidity and other environmental factors in DLNM.

3.1 The whole year regression analyses

The minimum morbidity temperature (MMT) was about 30°C for the overall population. The RR for asthma admissions increased when the mean temperature rose from 5°C to about 10°C . The 95% CI of RR for temperature is less than 0 when the temperature is more than 30°C which means high temperature is a protective factor for asthma attack. And low temperature has significant association with asthma hospitalization. 95%CI of RR for temperature 10°C VS 30°C is 2.58 (1.92, 3.48).

3.2 Subgroup analyses by age group

In all age groups, lower temperature and higher or lower relative humidity were associated with more hospital admissions for asthma. Sensitivity to these three meteorological factors was similar among these three age groups. But adult has wider 95%CI between 40%~60% RH which means adult were more sensitive to relative humidity . Wind speed did not seem to correlate significantly with asthma incidence in any age group.

Subgroup analyses by season were done but the associations between the meteorological variables and asthma were similar for the hot and cold seasons so there was no need to report them in detail.

4. Discussion

Our study found that risk of asthma hospitalizations peaked at a mean daily temperature of 10℃ and declined approximately linearly until 35℃.High humidity and low humidity were both associated with more asthma admissions. Wind speed had no significant association with asthma hospitalization. No seasonal difference in associations was observed.

The nature of associations reported from past studies of asthma morbidity and temperatures have not been consistent, because of the differences in climate, study design and statistical methodology. Some studies have found positive associations between temperatures and asthma admissions, some have reported negative associations, while a few have reported significant associations with high and low temperatures . In this study, the correlation between RH and hospitalization for asthma was observed. While previous studies have only shown an association between high humidity and asthma, our study found a significant association between asthma and low humidity.

Previous studies have found that hypothermia can lead to decreased lung function, increased risk of airway inflammation, and decreased lung capacity .Low temperature and humidity can cause bronchial constriction and dry airway mucosa, which is why low temperature and low humidity can also increase the risk of acute exacerbation of asthma .Cold and dry air can reduce mucosal moisture, which increases susceptibility to respiratory bacterial and viral infections, as well as irritation from allergens and other irritants.Low temperatures and low humidity also favor the survival of viruses such as influenza and respiratory syncytial viruses, which increases the risk of infection triggers.The influence of seasonal changes on the correlation between RH and asthma may reflect the interaction between temperature and RH. High RH can aggravate the heat stress in high temperature period, while low RH may be related to asthma in low temperature period.

Airborne allergens may be another possible link between high humidity and asthma. Many airborne allergens, such as tree pollen and fungal spores, are better suited to high humidity. Mold grows more easily in moist areas. Aphids, which also produce ozone through photosynthesis, have higher concentrations at high humidity and temperatures. With the increase of the concentration of allergens and air pollutants in the air, the asthma patients will have greater stimulation of reactive

respiratory tracts and more severe airway inflammation.Air pollutants and allergens spread more widely through high wind speeds. Therefore, it is necessary to reduce the number of asthma hospital admissions by reducing exposure to irritants in severe weather conditions[3].

Compared with children's lung function, adult's airway has longer duration of inflammation which is associated with lower airway inflammation. In addition, adults are the main working population and may have a more active social life than children or the elderly. This may increase their exposure to environmental triggers because they cannot avoid going out under adverse environmental conditions.

Childhood is a high incidence and sensitive period for asthma because the immune function and respiratory system are not fully developed during that period. If the children cannot get timely and appropriate diagnosis and treatment, it may cause repeated asthma attacks. In severe cases,airway remodeling may lead to lung function damage or irreversible airway narrowing, which may have an impact on the growth and development of children and may even develop into adult asthma. Even some children suffer from asthma for a lifetime. Children are also susceptible to temperature and humidity and to respiratory disease. This is why children are more sensitive and need to be protected.

References

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